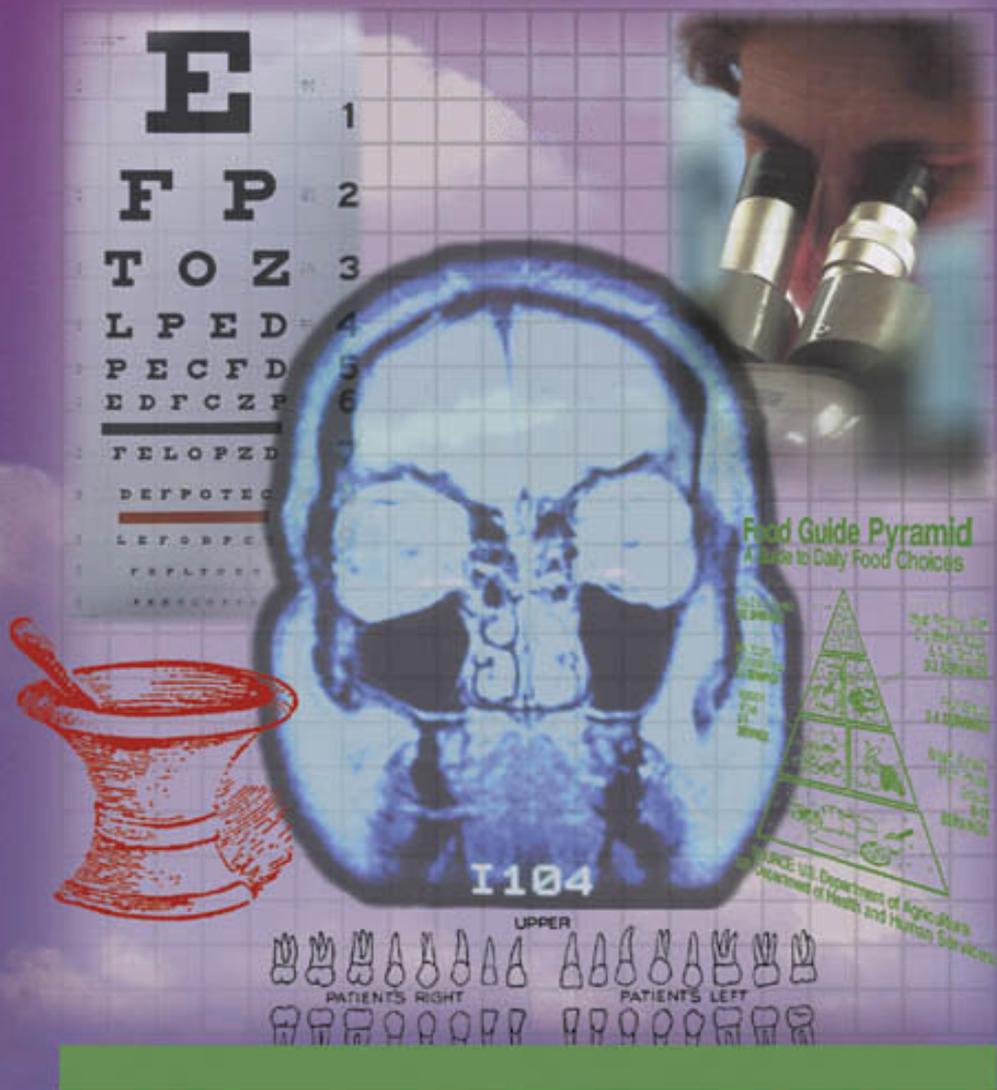


The GALE ENCYCLOPEDIA of NURSING & ALLIED HEALTH



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VOLUME 5

T-Z

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General Index

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PLEASE READ—IMPORTANT INFORMATION

The *Gale Encyclopedia of Nursing and Allied Health* is a medical reference product designed to inform and educate readers about a wide variety of diseases, treatments, tests and procedures, health issues, human biology, and nursing and allied health professions. The Gale Group believes the product to be comprehensive, but not necessarily definitive. While the Gale Group has made substantial efforts to provide information that is accurate, comprehensive, and up-to-date, the Gale Group makes no

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INTRODUCTION

The *Gale Encyclopedia of Nursing and Allied Health* is a unique and invaluable source of information for the nursing or allied health student. This collection of over 850 entries provides in-depth coverage of specific diseases and disorders, tests and procedures, equipment and tools, body systems, nursing and allied health professions, and current health issues. This book is designed to fill a gap between health information designed for laypeople and that provided for medical professionals, which may be too complicated for the beginning student to understand. The encyclopedia does use medical terminology, but explains it in a way that students can understand.

SCOPE

The *Gale Encyclopedia of Nursing and Allied Health* covers a wide variety of topics relevant to the nursing or allied health student. Subjects covered include those important to students intending to become biomedical equipment technologists, dental hygienists, dietitians, health care administrators, medical technologists/clinical laboratory scientists, registered and licensed practical nurses, nurse anesthetists, nurse practitioners, nurse midwives, occupational therapists, optometrists, pharmacy technicians, physical therapists, radiologic technologists, and speech-language therapists. The encyclopedia also covers information on related general medical topics, classes of medication, mental health, public health, and human biology. Entries follow a standardized format that provides information at a glance. Rubrics include:

Diseases/Disorders

- Definition
- Description
- Causes and symptoms
- Diagnosis
- Treatment
- Prognosis

- Health care team roles
- Prevention
- Resources
- Key terms

Tests/Procedures

- Definition
- Purpose
- Precautions
- Description
- Preparation
- Aftercare
- Complications
- Results
- Health care team roles
- Resources
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Equipment/Tools

- Definition
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Human biology/Body systems

- Definition
- Description
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Definition
 Description
 Work settings
 Education and training
 Advanced education and training
 Future outlook
 Resources
 Key terms

Current health issues

Definition
 Description
 Viewpoints
 Professional implications
 Resources
 Key terms

INCLUSION CRITERIA

A preliminary list of topics was compiled from a wide variety of sources, including nursing and allied health textbooks, general medical encyclopedias, and consumer health guides. The advisory board, composed of advanced practice nurses, allied health professionals, health educators, and medical doctors, evaluated the topics and made suggestions for inclusion. Final selection of topics to include was made by the advisory board in conjunction with the Gale editor.

ABOUT THE CONTRIBUTORS

The essays were compiled by experienced medical writers, including physicians, pharmacists, nurses, and allied health care professionals. The advisers reviewed the completed essays to ensure that they are appropriate, up-to-date, and medically accurate.

HOW TO USE THIS BOOK

The *Gale Encyclopedia of Nursing and Allied Health* has been designed with ready reference in mind.

- Straight **alphabetical arrangement** of topics allows users to locate information quickly.
- **Bold-faced terms** within entries direct the reader to related articles.
- **Cross-references** placed throughout the encyclopedia direct readers from alternate names and related topics to entries.
- A list of **Key terms** is provided where appropriate to define terms or concepts that may be unfamiliar to the student.
- The **Resources** section directs readers to additional sources of medical information on a topic.
- Valuable **contact information** for medical, nursing, and allied health organizations is included with each entry. An Appendix of Nursing and Allied Health organizations in the back matter contains an extensive list of organizations arranged by subject.
- A comprehensive **general index** guides readers to significant topics mentioned in the text.

GRAPHICS

The *Gale Encyclopedia of Nursing and Allied Health* is enhanced by over 400 black and white photos and illustrations, as well as over 50 tables.

ACKNOWLEDGMENTS

The editor would like to express appreciation to all of the nursing and allied health professionals who wrote, reviewed, and copyedited entries for the *Gale Encyclopedia of Nursing and Allied Health*.

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A number of experts in the nursing and allied health communities provided invaluable assistance in the formulation of this encyclopedia. The advisory board performed a myriad of duties, from defining the scope of coverage to reviewing individual entries for accuracy and accessibility. The editor would like to express appreciation to them for their time and their expert contributions.

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A

Abdominal thrust *see* **Heimlich maneuver**

Abdominal ultrasound

Definition

Abdominal ultrasound uses high frequency sound waves to produce two-dimensional images of the body's soft tissues, which are used for a variety of clinical applications, including diagnosis and guidance of treatment procedures. Ultrasound does not use ionizing radiation to produce images, and in comparison to other diagnostic imaging modalities, it is low cost, safe, fast, and versatile.

Purpose

Abdominal ultrasound is used in the hospital radiology department and emergency department, as well as in physician offices for a number of clinical applications. Ultrasound has a great advantage over x-ray imaging technologies in that it does not damage tissues with ionizing radiation. Ultrasound is also generally far better than plain x-rays at distinguishing the subtle variations of soft tissue structures, and can be used in any of several modes, depending on the area of interest.

As an imaging tool, abdominal ultrasound generally is indicated for patients afflicted with chronic or acute abdominal **pain**; abdominal trauma; an obvious or suspected abdominal mass; symptoms of **liver** disease, pancreatic disease, gallstones, spleen disease, kidney disease and urinary blockage; or symptoms of an abdominal aortic aneurysm.

Specifically:

- Abdominal pain. Whether acute or chronic, pain can signal a serious problem—from organ malfunction or injury to the presence of malignant growths.

Ultrasound scanning can help doctors quickly sort through potential causes when presented with general or ambiguous symptoms. All of the major abdominal organs can be studied for signs of disease that appear as changes in size, shape, and internal structure.

- Abdominal trauma. After a serious accident, such as a car crash or a fall, internal bleeding from injured abdominal organs is often the most serious threat to survival. Neither the injuries nor the bleeding may be immediately apparent. Ultrasound is very useful as an initial scan when abdominal trauma is suspected, and it can be used to pinpoint the location, cause, and severity of hemorrhaging. In the case of puncture **wounds**, from a bullet for example, ultrasound can locate the foreign object and provide a preliminary survey of the damage. (**CT scans** are sometimes used in trauma settings.)
- Abdominal mass. Abnormal growths—tumors, cysts, abscesses, scar tissue, and accessory organs—can be located and tentatively identified with ultrasound. In particular, potentially malignant solid tumors can be distinguished from benign fluid-filled cysts. Masses and malformations in any organ or part of the abdomen can be found.
- Liver disease. The types and underlying causes of liver disease are numerous, though **jaundice** tends to be a general symptom. Ultrasound can differentiate between many of the types and causes of liver malfunction, and is particularly good at identifying obstruction of the bile ducts and cirrhosis, which is characterized by abnormal fibrous growths and reduced **blood** flow.
- Pancreatic disease. Inflammation and malformation of the **pancreas** are readily identified by ultrasound, as are pancreatic stones (calculi), which can disrupt proper functioning.
- Gallstones. Gallstones are an extremely common cause of hospital admissions. These calculi can cause painful inflammation of the **gallbladder** and also obstruct the bile ducts that carry digestive enzymes from the gall-

bladder and liver to the intestines. Gallstones are readily identifiable with ultrasound.

- Spleen disease. The spleen is particularly prone to injury during abdominal trauma. It may also become painfully inflamed when infected or cancerous.
- Kidney disease. The **kidneys** are also prone to traumatic injury and are the organs most likely to form calculi, which can block the flow of urine and cause further systemic problems. A variety of diseases causing distinct changes in kidney morphology can also lead to complete kidney failure. Ultrasound imaging has proven extremely useful in diagnosing kidney disorders, including blockage or obstruction.
- Abdominal aortic aneurysm. This is a bulging weak spot in the abdominal aorta, which supplies blood directly from the **heart** to the entire lower body. A ruptured aortic aneurysm is imminently life-threatening. However, it can be readily identified and monitored with ultrasound before acute complications result.
- **Appendicitis.** Ultrasound is useful in diagnosing appendicitis, which causes abdominal pain.

Ultrasound technology can also be used for treatment purposes, most frequently as a visual aid during surgical procedures—such as guiding needle placement to drain fluid from a cyst, or to guide biopsies.

Precautions

Ultrasound waves of appropriate frequency and intensity are not known to cause or aggravate any medical condition.

The value of ultrasound imaging as a medical tool, however, depends greatly on the quality of the equipment used and the skill of the medical personnel operating it. More accurate results are obtained when ultrasound is performed by a clinician skilled in sonography. Basic ultrasound equipment is relatively inexpensive to obtain, and any physician with the equipment can perform the procedure whether specifically trained in ultrasound scanning and interpretation or not. Patients should not hesitate to verify the credentials of technologists and physicians performing ultrasound scanning, as well as the quality of the equipment used and the benefits of the proposed procedure.

In cases where ultrasound is used as a treatment tool, patients should educate themselves about the proposed procedure with the help of their doctors—as is appropriate before any surgical procedure. Also, any abdominal ultrasound procedure, diagnostic or therapeutic, may be hampered by a patient's body type or other factors, such as the presence of excessive bowel gas (which is opaque

to ultrasound). In particular, very obese people are often not good candidates for abdominal ultrasound.

Description

Ultrasound includes all sound waves above the frequency of human hearing—about 20 thousand hertz, or cycles per second. Medical ultrasound generally uses frequencies between one and 10 megahertz (1-10 MHz). Higher frequency ultrasound waves produce more detailed images, but are also more readily absorbed and so cannot penetrate as deeply into the body. Abdominal ultrasound imaging is generally performed at frequencies between 2-5 MHz.

An ultrasound scanner consists of two parts: the transducer and the data processing unit. The transducer both produces the sound waves that penetrate the body and receives the reflected echoes. Transducers are built around piezoelectric ceramic chips. (Piezoelectric refers to electricity that is produced when you put pressure on certain crystals such as quartz.) These ceramic chips react to electric pulses by producing sound waves (they are transmitting waves) and react to sound waves by producing electric pulses (receiving). Bursts of high-frequency electric pulses supplied to the transducer cause it to produce the scanning sound waves. The transducer then receives the returning echoes, translates them back into electric pulses, and sends them to the data processing unit—a computer that organizes the data into an image on a television screen.

Because sound waves travel through all the body's tissues at nearly the same speed—about 3,400 miles per hour—the microseconds it takes for each echo to be received can be plotted on the screen as a distance into the body. The relative strength of each echo, a function of the specific tissue or organ boundary that produced it, can be plotted as a point of varying brightness. In this way, the echoes are translated into an image.

Four different modes of ultrasound are used in medical imaging:

- **A-mode.** This is the simplest type of ultrasound in which a single transducer scans a line through the body with the echoes plotted on screen as a function of depth. This method is used to measure distances within the body and the size of internal organs.
- **B-mode.** In B-mode ultrasound, a linear array of transducers simultaneously scans a plane through the body that can be viewed as a two-dimensional image on screen.
- **M-Mode.** The M stands for motion. A rapid sequence of B-mode scans whose images follow each other in sequence on screen enables doctors to see and measure range of motion, as the organ boundaries that produce reflections move relative to the probe. M-mode ultra-

KEY TERMS

Accessory organ—A lump of tissue adjacent to an organ that is similar to it, but which serves no important purpose, if functional at all. While not necessarily harmful, such organs can cause problems if they grow too large or become cancerous.

Benign—In medical usage, benign is the opposite of malignant. It describes an abnormal growth that is stable, treatable, and generally not life-threatening.

Biopsy—The surgical removal and analysis of a tissue sample for diagnostic purposes. Usually, the term refers to the collection and analysis of tissue from a suspected tumor to establish malignancy.

Calculus—Any type of hard concretion (stone) in the body, but usually found in the gallbladder, pancreas, and kidneys. Calculi (pl.) are formed by the accumulation of excess mineral salts and other organic material such as blood or mucous. They can cause problems by lodging in and obstructing the proper flow of fluids, such as bile to the intestines or urine to the bladder.

Cirrhosis—A chronic liver disease characterized by the degeneration of proper functioning—jaundice is often an accompanying symptom. Causes of cirrhosis include alcoholism, metabolic diseases, syphilis, and congestive heart disease.

Common bile duct—The branching passage through which bile—a necessary digestive enzyme—travels from the liver and gallbladder into the small intestine. Digestive enzymes from the pancreas also enter the intestines through the common bile duct.

Computed tomography scan (CT scan)—A specialized type of x-ray imaging that uses highly focused and relatively low energy radiation to produce detailed two-dimensional images of soft tissue structures, particularly the brain. CT scans are the chief competitor to ultrasound and can yield higher quality images not disrupted by bone or gas. They are, however, more cumbersome, time consuming and expensive to perform, and they use ionizing radiation.

Doppler—The Doppler effect refers to the apparent change in frequency of sound wave echoes returning to a stationary source from a moving target. If the object is moving toward the source, the frequency increases; if the object is moving away, the frequency decreases. The size of this frequency shift can be used to compute the object's speed—be it a car on the road or blood in an artery. The Doppler effect holds true for all types of radiation, not just sound.

Frequency—Sound, whether traveling through air or the human body, produces vibrations—molecules bouncing into each other—as the shock wave travels along. The frequency of a sound is the number of vibrations per second. Within the audible range, frequency means pitch—the higher the frequency, the higher a sound's pitch.

Ionizing radiation—Radiation that can damage living tissue by disrupting and destroying individual cells at the molecular level. All types of nuclear radiation—x rays, gamma rays and beta rays—are potentially ionizing. Sound waves physically vibrate the material through which they pass, but do not ionize it.

Jaundice—A condition that results in a yellow tint to the skin, eyes and body fluids. Bile retention in the liver, gallbladder and pancreas is the immediate cause, but the underlying cause could be as simple as obstruction of the common bile duct by a gallstone or as serious as pancreatic cancer. Ultrasound can distinguish between these conditions.

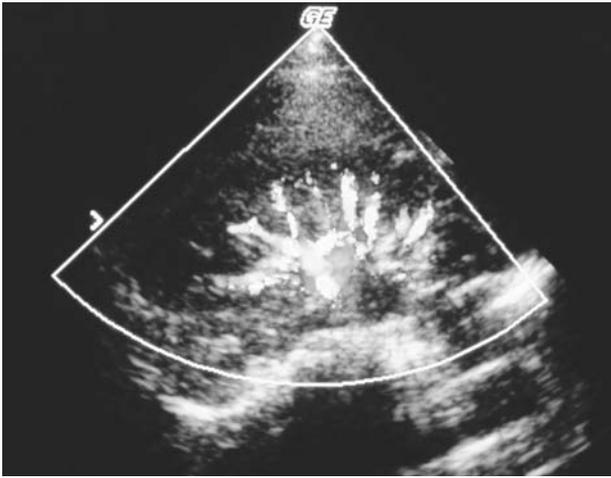
Malignant—The term literally means growing worse and resisting treatment. It is used as a synonym for cancerous and connotes a harmful condition that generally is life-threatening.

Morphology—Literally, the study of form. In medicine, morphology refers to the size, shape, and structure rather than the function of a given organ. As a diagnostic imaging technique, ultrasound facilitates the recognition of abnormal morphologies as symptoms of underlying conditions.

sound has been put to particular use in studying heart motion.

- Doppler mode. **Doppler ultrasonography** includes the capability of accurately measuring velocities of moving

material, such as blood in arteries and veins. The principle is the same as that used in radar guns that measure the speed of a car on the highway. Doppler capability is most often combined with B-mode scanning to produce



An ultrasound screen shows a patient's kidney.
(Photograph by Brownie Harris. *The Stock Market*.
Reproduced by permission.)

images of **blood vessels** from which blood flow can be directly measured. This technique is used extensively to investigate valve defects, arteriosclerosis, and **hypertension**, particularly in the heart, but also in the abdominal aorta and the portal vein of the liver.

The actual procedure for a patient undergoing an abdominal ultrasound is relatively simple, regardless of the type of scan or its purpose. Fasting for at least eight hours prior to the procedure ensures that the **stomach** is empty and as small as possible, and that the intestines and bowels are relatively inactive. This also helps the gallbladder become more visible. Prior to scanning, an acoustic gel is applied to the skin of the patient's abdomen to allow the ultrasound probe to glide easily across the skin and also to better transmit and receive ultrasonic pulses. The probe is moved around the abdomen's surface to obtain different views of the target areas. The patient will likely be asked to change positions from side to side and to hold the breath as necessary to obtain the desired views. Usually, a scan will take from 20 to 45 minutes, depending on the patient's condition and anatomical area being scanned.

Ultrasound scanners are available in different configurations, with different scanning features. Portable units, which weigh only a few pounds and can be carried by hand, are available for bedside use, office use, or use outside the hospital, such as at sporting events and in ambulances. Portable scanners range in cost from \$10,000 to \$50,000. Mobile ultrasound scanners, which can be pushed to the patient bedside and between hospital departments, are the most common configuration and range in cost from \$100,000 to over \$250,000, depending on the scanning features purchased.

Preparation

A patient undergoing abdominal ultrasound will be advised by the physician about what to expect and how to prepare. As mentioned above, preparations generally include fasting.

Aftercare

In general, no aftercare related to the abdominal ultrasound procedure itself is required. Discomfort during the procedure is minimal.

Complications

Properly performed, ultrasound imaging is virtually without risk or side effects. Some patients report feeling a slight tingling and/or warmth while being scanned, but most feel nothing at all.

Results

As a diagnostic imaging technique, a normal abdominal ultrasound is one that indicates the absence of the suspected condition that prompted the scan. For example, symptoms such as abdominal pain radiating to the back suggest the possibility of, among other things, an abdominal aortic aneurysm. An ultrasound scan that indicates the absence of an aneurysm would rule out this life-threatening condition and point to other, less serious causes.

Because abdominal ultrasound imaging is generally undertaken to confirm a suspected condition, the results of a scan often will confirm the diagnosis, be it **kidney stones**, cirrhosis of the liver, or an aortic aneurysm. At that point, appropriate medical treatment as prescribed by a patient's physician is in order.

Health care team roles

Ultrasound scanning should be performed by a registered and trained ultrasonographer, either a technologist and/or a physician (radiologist, obstetrician/gynecologist). Ultrasound scanning in the emergency department may be performed by an emergency medicine physician, who should have appropriate training and experience in ultrasonography.

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American Institute of Ultrasound in Medicine. 14750 Sweitzer Lane, Suite 100, Laurel, MD 20707-5906. (301) 498-4100. <<http://www.aium.org>>.

American Registry of Diagnostic Medical Sonographers. 600 Jefferson Plaza, Suite 360, Rockville, MD 20852-1150. (800) 541-9754. <<http://www.ardms.org>>.

American Society of Radiologic Technologists (ASRT). 15000 Central Avenue SE, Albuquerque, NM 87123-2778. (800) 444-2778. <<http://www.asrt.org>>.

Radiological Society of North America. 820 Jorie Boulevard, Oak Brook, IL 60523-2251. (630) 571-2670. <<http://www.rsna.org>>.

Society of Diagnostic Medical Sonography. 12770 Coit Road, Suite 708, Dallas, TX 75251-1319. (972) 239-7367. <<http://www.sdms.org>>.

Jennifer E. Sisk, M.A.

ABO blood typing see **Type and screen**

Abrasions see **Wounds**

Abruptio placentae see **Placental abruption**

Abscess

Definition

An abscess is an enclosed collection of liquefied tissue, known as pus, somewhere in the body. It is the result of the body's defensive reaction to foreign material.

Description

There are two types of abscesses, septic and sterile. Most abscesses are septic, which means that they are the result of an **infection**. Septic abscesses can occur anywhere in the body. Only **bacteria** and the body's **immune response** are required. In response to the invading bacteria, white **blood** cells gather at the infected site and begin producing chemicals called enzymes that attack the bacteria by first marking and then digesting it. These enzymes kill the bacteria and break them down into small pieces that can travel in the circulatory system prior to being eliminated from the body. Unfortunately, these chemicals also digest body tissues. In most cases, bacteria produce similar chemicals. The result is a thick, yellow liquid—pus—containing dead bacteria, digested tissue, white blood cells, and enzymes.

An abscess is the last stage of a tissue infection that begins with a process called inflammation. Initially, as invading bacteria activate the body's **immune system**, several events occur:

- Blood flow to the area increases.
- The temperature of the area increases due to the increased blood supply.
- The area swells due to the accumulation of water, blood, and other liquids.
- It turns red.
- It hurts, due to irritation from the swelling and the chemical activity.

These four signs—heat, swelling, redness, and pain—characterize inflammation.

As the process progresses, the tissue begins to turn to liquid, and an abscess forms. It is the nature of an abscess to spread as the chemical digestion liquefies more and more tissue. Furthermore, the spreading follows the path of least resistance, commonly, the tissue that is most easily digested. A good example is an abscess just beneath the skin. It most easily continues along immediately beneath the surface rather than traveling up through the outermost layer or down through deeper structures where it could drain its toxic contents. The contents of an abscess can also leak into the general circulation and produce symptoms just like any other infection. These include chills, **fever**, aching, and general discomfort.

Sterile abscesses are sometimes a milder form of the same process caused not by bacteria but by non-living irritants such as drugs. If an injected drug such as penicillin is not absorbed, it stays where it is injected and may cause enough irritation to generate a sterile abscess. Such an abscess is sterile because there is no infection involved. Sterile abscesses are quite likely to turn into

KEY TERMS

Cellulitis—Inflammation of tissue due to infection.

Enzyme—Any of a number of protein chemicals that can initiate chemical reactions at body temperature.

Fallopian tubes—Part of the internal female anatomy that carries eggs from the ovaries to the uterus.

Flora—Living inhabitants of a region or area.

Pyogenic—Capable of generating pus. *Streptococcus*, *Staphylococcus*, and bowel bacteria are the primary pyogenic organisms.

Sebaceous glands—Tiny structures in the skin that produce oil (sebum). If they become plugged, sebum collects inside and forms a nurturing place for germs to grow.

Septicemia—The spread of an infectious agent throughout the body by means of the blood stream.

Sinus—A tubular channel connecting one body part with another or with the outside.

hard, solid lumps as they scar, rather than remaining pockets of pus.

Causes and symptoms

Many different agents cause abscesses. The most common are the pus-forming (pyogenic) bacteria such as *Staphylococcus aureus*, which is a very common cause of abscesses under the skin. Abscesses near the large bowel, particularly around the anus, may be caused by any of the numerous bacteria found within the large bowel. **Brain** abscesses and **liver** abscesses can be caused by any organism that can travel there through the blood stream. Bacteria, amoebae, and certain **fungi** can travel in this fashion. Abscesses in other parts of the body are caused by organisms that normally inhabit nearby structures or that infect them. Some common causes of specific abscesses are:

- skin abscesses by normal skin flora
- dental and throat abscesses by mouth flora
- lung abscesses by normal airway flora, bacteria that cause **pneumonia** or **tuberculosis**
- abdominal and anal abscesses by normal bowel flora

Specific types of abscesses

Listed below are some of the more common and important abscesses.

- Carbuncles and other **boils**. Skin oil glands (sebaceous glands) on the back or the back of the neck are the ones usually infected. The most commonly involved bacteria is *Staphylococcus aureus*. Acne is a similar condition involving sebaceous glands on the face and back.
- Pilonidal cyst. Many people have as a birth defect a tiny opening in the skin just above the anus. Fecal bacteria can enter this opening, causing an infection and subsequent abscess.
- Retropharyngeal, parapharyngeal, peritonsillar abscess. As a result of throat infections such as **strep throat** and tonsillitis, bacteria can invade the deeper tissues of the throat and cause an abscess. These abscesses can compromise swallowing and even breathing.
- Lung abscess. During or after pneumonia, whether it's due to bacteria [common pneumonia], tuberculosis, fungi, parasites, or other bacteria, abscesses can develop as a complication.
- Liver abscess. Bacteria or amoeba from the intestines can spread through the blood to the liver and cause abscesses.
- Psoas abscess. Deep in the back of the abdomen, on either side of the lumbar spine, lie the psoas muscles. They flex the hips. An abscess can develop in one of these muscles, usually when it spreads from the appendix, the large bowel, or the fallopian tubes.

Diagnosis

The common findings of inflammation—heat, redness, swelling, and pain—easily identify superficial abscesses. Abscesses in other places may produce only generalized symptoms such as fever and discomfort. If an individual's symptoms and the results of a **physical examination** do not help, a physician may have to resort to a battery of tests to locate the site of an abscess. Usually something in the initial evaluation directs the search. Recent or chronic disease in an organ suggests it may be the site of an abscess. Dysfunction of an organ or system, for instance seizures or altered bowel function, may provide the clue. **Pain** and tenderness on physical examination are common findings. Sometimes a deep abscess will eat a small channel (sinus) to the surface and begin leaking pus. A sterile abscess may cause only a painful lump deep in the buttock where a shot was given.

Treatment

Since skin is very resistant to the spread of infection, it acts as a barrier, often keeping the toxic chemicals of an abscess from escaping the body on their own. Thus, the pus must be drained from the abscess by a physician. The surgeon determines when the abscess is ready for drainage and opens a path to the outside, allowing the pus to escape. Ordinarily, the body handles the remaining infection, sometimes with the help of **antibiotics** or other drugs. The surgeon may leave a drain (a piece of cloth or rubber) in the abscess cavity to prevent it from closing before all the pus has drained out.

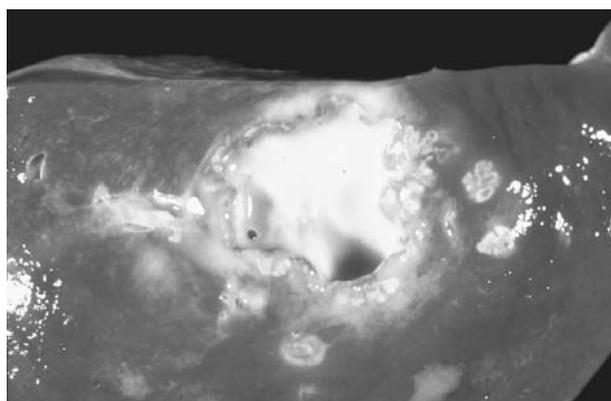
Alternative treatment

If an abscess is directly beneath the skin, it will be slowly working its way through the skin as it is more rapidly working its way elsewhere. Since chemicals work faster at higher temperatures, applications of hot compresses to the skin over the abscess will hasten the digestion of the skin and eventually result in its break down and spontaneous release of pus. This treatment is best reserved for smaller abscesses in less sensitive areas of the body such as limbs, trunk, and back of the neck. It is also useful for all superficial abscesses in their very early stages. It will “ripen” them.

Contrast **hydrotherapy**, alternating hot and cold compresses, can also help assist the body in resorption of the abscess. There are two homeopathic remedies that work to rebalance the body in relation to abscess formation, *Silica* and *Hepar sulphuris*. In cases of septic abscesses, bentonite clay packs (bentonite clay and a small amount of *Hydrastis* powder) can be used to draw an infection from the area.

Prognosis

Once an abscess is properly drained, the prognosis is excellent for the condition itself. The reason for the abscess (other diseases an individual has) will determine the overall outcome. If, on the other hand, an abscess ruptures into neighboring areas or permits the infectious agent to spill into the bloodstream, serious or fatal consequences are likely. Abscesses in and around the nasal sinuses, face, ears, and scalp may work their way into the brain. Abscesses within an abdominal organ such as the liver may rupture into the abdominal cavity. In either case, the result is life threatening. Blood **poisoning** is a term commonly used to describe an infection that has spilled into the blood stream and spread throughout the body from a localized origin. Blood poisoning, known to physicians as septicemia, is also life threatening.



An amoebic abscess caused by *Entamoeba histolytica*.
(Phototake NYC. Reproduced by permission.)

Of special note, abscesses in the hand are more serious than they might appear. Due to the intricate structure and the overriding importance of the hand, any hand infection must be treated promptly and competently.

Health care team roles

First aid providers may unknowingly initiate an abscess by using inappropriate or incorrect techniques. A physician, surgeon, physician’s assistant, or nurse practitioner usually diagnoses the presence of an abscess. Radiologists and laboratory personnel may assist in the process of establishing a diagnosis. A physician, surgeon, physician’s assistant, or nurse practitioner usually drains an abscess. Nurses provide supportive care, dress the wound, and educate patients about caring for the resulting wound. Occasionally, a physical therapist may be needed to recover lost function.

Prevention

Infections that are treated early with heat (if superficial) or antibiotics will often resolve without the formation of an abscess. It is even better to avoid infections altogether by taking prompt care of open injuries, particularly puncture **wounds**. Bites are the most dangerous of all, even more so because they often occur on the hand.

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American Academy of Family Physicians, 11400 Tomahawk Creek Parkway, Leawood, KS 66211-2672. (913) 906-6000. <<http://www.aafp.org/>>. fp@aafp.org.

American Society of Clinical Pathologists, 2100 West Harrison Street, Chicago IL 60612. (312) 738-1336. <<http://www.ascp.org/index.asp>>. info@ascp.org.

College of American Pathologists, 325 Waukegan Road, Northfield, IL 60093. (800) 323-4040. <<http://www.cap.org/>>.

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Achromatopsia see **Color blindness**

Acid-base balance

Definition

Acid-base balance can be defined as homeostasis of the body fluids at a normal arterial **blood** pH ranging between 7.37 and 7.43.

Description

An acid is a substance that acts as a proton donor. In contrast, a base, also known as an alkali, is frequently defined as a substance that combines with a proton to form a chemical bond. Acid solutions have a sour taste and produce a burning sensation with skin contact. A base is any chemical compound that produces hydroxide ions when dissolved in water. Base solutions have a bitter taste and a slippery feel. Despite variations in **metabolism**, diet, and environmental factors, the body's acid-base balance, fluid volume, and electrolyte concentration are maintained within a narrow range.

Function

Many naturally occurring acids are necessary for life. For example, hydrochloric acid is secreted by the **stomach** to assist with digestion. The chemical composition of food in the diet can have an effect on the body's acid-base production. Components that affect acid-base balance include protein, chloride, **phosphorus**, sodium, potassium, **calcium**, and magnesium. In addition, the rate at which nutrients are absorbed in the intestine will alter acid-base balance.

Cells and body fluids contain acid-base buffers, which help prevent rapid changes in body fluid pH over short periods of time, until the **kidneys** pulmonary systems can make appropriate adjustments. The kidneys and pulmonary system then work to maintain acid-base balance through excretion in the urine or respiration. The partial pressure of carbon dioxide gas (PCO₂) in the pulmonary system can be measured with a blood sample and

correlates with blood carbon dioxide (CO_2) levels. PCO_2 can then be used as an indicator of the concentration of acid in the body. The concentration of base in the body can be determined by measuring plasma bicarbonate (HCO_3^-) concentration. When the acid-base balance is disturbed, the **respiratory system** can alter PCO_2 quickly, thus changing the blood pH and correcting imbalances. Excess acid or base is then excreted in the urine by the renal system to control plasma bicarbonate concentration. Changes in respiration occur primarily in minutes to hours, while renal function works to alter blood pH within several days.

Role in human health

Production of CO_2 is a result of normal body metabolism. **Exercise** or serious infections will increase the production of CO_2 through increased respiration in the **lungs**. When oxygen (O_2) is inhaled and CO_2 is exhaled, the blood transports these gases to the lungs and body tissues. The body's metabolism produces acids that are buffered and then excreted by the lungs and kidneys to maintain body fluids at a neutral pH. Disruptions in CO_2 levels and HCO_3^- create acid-base imbalances. When acid-base imbalances occur, the disturbances can be broadly divided into either acidosis (excess acid) or alkalosis (excess base/alkali).

Common diseases and disorders

Acid-base metabolism imbalances are often characterized in terms of the $\text{HCO}_3^-/\text{CO}_2$ buffer system. Acid-base imbalances result primarily from metabolic or respiratory failures. An increase in HCO_3^- is called metabolic alkalosis, while a decrease in the same substance is called metabolic acidosis. An increase in PCO_2 , on the other hand, is known as respiratory acidosis, and a decrease in the same substance is called respiratory alkalosis.

Acidosis

Acidosis is a condition resulting from higher than normal acid levels in the body fluids. It is not a disease, but may be an indicator of disease. Metabolic acidosis is related to processes that transform food into energy and body tissues. Conditions such as diabetes, kidney failure, severe **diarrhea**, and **poisoning** can result in metabolic acidosis. Mild acidosis is often compensated by the body in a number of ways. However, prolonged acidosis can result in heavy or rapid breathing, weakness, and headache. Acidemia (arterial pH < 7.35) is an accumulation of acids in the bloodstream that may occur with severe acidosis when the acid load exceeds respiratory capacity. This condition can sometimes result in **coma**

KEY TERMS

Acid—(a) Any ionic or molecular substance that can act as a proton donor; (b) A sour-tasting substance, like vinegar; (c) A chemical compound that can react with a base to form a salt.

Acidosis—A dangerous condition where the blood and body tissues are less alkaline (or more acidic) than normal.

Alkalosis—Excessive alkalinity of the blood and body tissue.

Alkalemia—Abnormal blood alkalinity.

Base—(a) Any ionic or molecular substance that can act as a proton acceptor; (b) A bitter-tasting substance which has a soapy feel; (c) A chemical compound that can react with an acid to form a salt. A base can also be called an alkali.

Bicarbonate—A salt of carbonic acid produced by neutralizing a hydrogen ion.

Diabetic ketoacidosis—A condition characterized by excessive thirst and urination. Other symptoms may include appetite loss, nausea, vomiting, and rapid deep breathing.

Diuretic—An agent or drug that eliminates excessive water in the body by increasing the flow of urine.

Electrolyte—A substance such as an acid, bases, or salt. An electrolyte's water solution will conduct an electric current and ionizes. Acids, bases, and salts are electrolytes.

Homeostasis—An organism's regulation of body processes to maintain internal equilibrium in temperature and fluid content.

Hypochloremic alkalosis—A large loss of chloride.

Hypokalemic alkalosis—Low plasma potassium.

pH—The negative logarithm of H^+ (hydrogen) concentration.

and, if the pH falls below 6.80, it will lead to death. Diabetic ketoacidosis is a condition where excessive glucagon and a lack of insulin contribute to the production of ketoacids in the **liver**. This condition can be caused by chronic **alcoholism** and poor carbohydrate utilization.

Respiratory acidosis is caused by the lungs's failure to remove excess carbon dioxide from the body, reducing

Acid-base disturbances, causes, and compensatory mechanisms

Acid-base disturbance	Common cause	Mode of compensation
Respiratory acidosis	Respiratory depression (drugs, central nervous system trauma) Pulmonary disease (pneumonia, chronic obstructive pulmonary disease, respiratory underventilation)	Kidneys will retain increased amounts of HCO_3^- to increase pH
Respiratory alkalosis	Hyperventilation (emotions, pain, respirator overventilation)	Kidneys will excrete increased amounts of HCO_3^- to lower pH
Metabolic acidosis	Diabetes, shock, renal failure, intestinal fistula	Lungs "blow off" CO_2 to raise pH
Metabolic alkalosis	Sodium bicarbonate overdose, prolonged vomiting, nasogastric drainage	Lungs retain CO_2 to lower pH

SOURCE: Pagana, K.D. and T.J. Pagana. *Mosby's Diagnostic and Laboratory Test Reference*. 3rd ed. St. Louis: Mosby, 1997.

the pH in the body. Several conditions, including chest injury, blockage of the upper air passages, and severe lung disease, may lead to respiratory acidosis. Blockage of the air passages may be caused by bronchitis, **asthma**, or airway obstruction, resulting in mild or severe acidosis. Regular, consistent retention of carbon dioxide in the lungs is referred to as chronic respiratory acidosis. This disorder results in only mild acidosis because it is balanced by increased bicarbonate production.

The predominant symptoms of acidosis are sometimes difficult to distinguish from symptoms of an underlying disease or disorder. Mild conditions of acidosis may be asymptomatic or may be accompanied by weakness or listlessness, nausea, and vomiting. Most often, severe metabolic acidosis ($\text{pH} < 7.20$) is associated with increased respiration to compensate for a shortage of HCO_3^- . This is followed by a secondary decrease in PCO_2 that occurs as part of respiratory compensation process. Treatment options for acidosis typically require correction of the underlying condition by venous administration of sodium bicarbonate or another alkaline substance.

Alkalosis

Alkalosis is a condition resulting from a higher than normal level of base/alkali in the body fluids. An excessive loss of HCO_3^- in the blood causes metabolic alkalosis. The body can compensate for mild alkalinity, but prolonged alkalosis can result in convulsions, muscular weakness, and even death if the pH rises above 7.80. Alkalosis can be caused by drugs or disorders that upset the normal acid-base balance. Prolonged vomiting and hyperventilation (abnormally fast, deep breathing) can result in alkalosis.

The predominant symptoms of alkalosis are neuromuscular hyperexcitability and irritability. Alkalemia (abnormal blood alkalinity) increases protein binding of ionized calcium even though plasma total calcium does not change. Severe cases may induce hypocalcemia (a

low level of plasma calcium). Low plasma potassium leads to a condition called hypokalemic alkalosis. It is frequently accompanied by metabolic alkalosis, resulting in cramping, muscle weakness, polyuria, and ileus (obstruction of the intestines). Diuretic medications may cause hypokalemic alkalosis. Prolonged vomiting may induce hypochloremic alkalosis (a large loss of chloride). The kidneys may conserve bicarbonate in order to compensate for the chloride reduction. Compensated alkalosis results when the body has partially compensated for alkalosis, and has restored normal acid-base balances. However, in compensated alkalosis, abnormal bicarbonate and carbon dioxide levels persist.

Alkalosis requires correction of the underlying condition and may involve venous administration of a weak acid to restore normal balance. If the source of alkalosis is excessive drug intake, it may be appropriate to reduce intake to restore the normal acid-base balance.

Respiratory alkalosis results from decreased CO_2 levels caused by conditions such as hyperventilation (a faster breathing rate), **anxiety**, and **fever**. The pH is elevated in the body. Hyperventilation causes the body to lose excess carbon dioxide in expired air and can be triggered by altitude or a disease that reduces the amount of oxygen in the blood. Symptoms of respiratory alkalosis may include dizziness, lightheadedness, and numbing of the hands and feet. Treatments include breathing into a paper bag or a mask that induces rebreathing of carbon dioxide.

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Acid-fast culture

Definition

The term acid-fast refers to a type of organism not readily decolorized by acid after staining. An acid-fast culture is the microbiological analysis of such an organism. An acid-fast culture refers to the process of detection, growth, isolation, identification, and antibiotic susceptibility testing of mycobacteria that cause pulmonary **tuberculosis** and other infections such as skin, abdominal, and disseminated (widely spread throughout many organs).

Purpose

The acid-fast culture is used to isolate *Mycobacterium tuberculosis* when tuberculosis (TB) is suspected. More recently the test has become important for the identification of other acid-fast organisms including *Mycobacterium avium* complex (MAC), *Mycobacterium bovis*, and *Mycobacterium africanum* responsible for causing tuberculosis in **AIDS** patients and other immunosuppressed persons. Antibiotic sensitivity testing performed when cultures are positive or when patients are known to have tuberculosis determines the appropriate drugs for treatment. This is essential because of the emergence of tuberculosis strains that are resistant to many of the **antibiotics** that were once effective in treating this disease. The test is also used to differentiate tuberculosis from carcinoma and bronchiectasis that may appear similar on x ray.

Precautions

Antibiotics and some sulfonamides may interfere with test results, causing the results to be falsely negative. Sufficient organisms may not be recovered to diagnose **infection** when a single culture sample is collected. Therefore, sputum cultures should be collected on three consecutive mornings.

Special safety precautions

Health care workers involved with collection and handling of specimens from patients suspected of having tuberculosis or other mycobacterial infections should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. In addition, health care personnel working with patients and handling specimens from patients suspected of having tuberculosis must be given a skin test (e.g. Mantoux or PPD test) on a regular basis. Precautions must be followed closely when handling mycobacterial specimens. The laboratory personnel who process and handle the infectious material from the patient are at greatest risk (about three times higher than other laboratory personnel) for tuberculosis infection or skin test positivity. The hazard of working in a laboratory that handles mycobacterial specimens is greatly reduced if the personnel follow proper procedures when handling and processing the specimens. All processing should take place in a biologic safety cabinet (BSC). The biologic safety cabinets used in the clinical mycobacterial laboratory are of two types: Class I, or negative-pressure cabinets, and Class II, or vertical-laminar-flow cabinets. Correct operation of these safety devices along with proper maintenance and testing of the air flow are essential to their performance. Yearly inspection of the cabinets by trained individuals is required.

Processing specimens, testing organisms, and transferring viable cultures must be carried out within the BSC. After processing specimens or working under the BSC, the area inside the cabinet is disinfected and a UV (ultraviolet) light located within the cabinet is turned on to kill any organisms on the surface of the work area as well as any airborne **bacteria**. After performing a procedure, the work area must be decontaminated with a disinfectant solution (e.g., the use of a phenol-soap mixture containing orthophenol or phenolic derivatives with an effective contact time of 10-30 minutes).

Protective clothing including gloves, fluid-proof gowns, goggles, and face mask or respirator is recommended for laboratory personnel working in the mycobacterial laboratory. Incinerators (no bunsen burners) are used within the BSC to reduce aerosoling of bacteria from infectious material while processing and culturing.

Description

Tuberculosis is an infection caused by *Mycobacterium tuberculosis*, a disease which is a major health problem worldwide. *Mycobacterium tuberculosis* is a rod-shaped bacterium characterized by acid-fastness. It is commonly transmitted via the air to the **lungs**, where it thrives, causing **fever**, cough, and hemoptysis (coughing up blood-tainted secretions). Tuberculosis is highly con-

KEY TERMS

Bronchiectasis—The formation of dilated, enlarged bronchi that results from lower respiratory tract infection.

Granuloma—Encapsulation of infected tissue caused by phagocytic cells that surround the foci of infection.

Nosocomial—An infection acquired in a hospital setting.

tagious. Disease is spread when persons cough, releasing an aerosol of organisms that are easily inhaled by others. Although deaths from tuberculosis in the United States had declined since the 1950s, recently there has been a resurgence of the disease, with the higher incidence of infection seen in certain races, in poor socioeconomic conditions, among new immigrants, in prison inmates, and in persons infected with the human **immunodeficiency** virus.

Because it takes several weeks for most *Mycobacteria* to grow in a culture, the laboratory performs an acid-fast smear first to aid in early diagnosis; however, the acid-fast smear should not be used in place of culture, as a culture is far more sensitive. An acid-fast culture can detect as few as 10 to 100 CFU/mL of sputum. The smear can provide a presumptive diagnosis of mycobacterial disease; confirm that cultures growing on media are acid-fast; and demonstrate that antibiotic treatment is effective pending follow-up culture results.

The genus *Mycobacterium* includes organisms that are obligate parasites, saprophytes (i.e., organisms that live off dead tissue), and opportunistic pathogens. Mycobacteria cause tuberculosis as well as non-tuberculous clinical conditions; therefore, mycobacteria are divided into two major groups based upon whether they cause tuberculosis (*M. tuberculosis* complex) or non-tuberculous infections (NTM). The principle pathogen causing tuberculosis in humans is *Mycobacterium tuberculosis*. It is estimated that about one third of the world's population is infected with *M. tuberculosis*. The World Health Organization reports an estimated eight million new cases and three million deaths attributable to tuberculosis each year. Tuberculosis is a leading cause of death in developing countries.

Other organisms causing human tuberculosis that are included in the *M. tuberculosis* complex are: *M. bovis* (the cause of tuberculosis in cattle and humans, as well as other carnivores); *M. bovis BCG* (a strain used as a vaccine against tuberculosis in many parts of the world); and

M. africanum (the cause of human tuberculosis in tropical Africa). *Mycobacterium tuberculosis* causes an infection that may mimic other diseases such as **pneumonia**, neoplasm, or fungal infections. Patients may be symptomatic or asymptomatic with signs of pulmonary and other organ involvement. Symptoms include night sweats, low-grade fever, anorexia, fatigue, weight loss, and a productive cough or coughing of **blood** in pulmonary tuberculosis infections. Patients with HIV are more likely to develop active tuberculosis.

It is necessary to identify the tuberculosis-causing mycobacteria by species and determine the antibiotic sensitivity or resistance-pattern for epidemiologic and **public health** information as well as for the effective treatment of infected persons. As stated earlier, about one-third of the world's population (1.7 billion persons) are infected with *M. tuberculosis*. Therefore, it is of great concern that the emergence of epidemic multidrug-resistant strains of *M. tuberculosis* has increased at the same time as the increase in HIV infections in the United States.

The primary routes of transmission for the *M. tuberculosis* complex are via inhalation of airborne droplets from an infected person; through infectious aerosols produced when processing clinical specimens for the recovery of *Mycobacteria spp.*; and by ingestion of contaminated milk from cows (or goats) infected with *M. bovis*. *M. africanum* is also transmitted by the inhalation of droplets containing infecting organisms. In all cases, close contact with infected individuals leads to the acquisition of tuberculosis infection.

The nontuberculous mycobacteria (NTM) group, which are not transmitted by person to person contact as is the *M. tuberculosis* complex, are differentiated by rate of growth (slow-growing or rapid-growing) as well as color pigmentation (the ability or inability of the colonies to change color when exposed to light). Growth patterns are divided into two main groups: slow-growers and rapid growers. Slow growers take more than seven days to grow and form colonies on solid media; rapid-growers produce colonies on solid media within three to five days. This method of classification for the NTM, by growth patterns and exposure to light, is referred to as the Runyon Classification. Some organisms in this group are considered pathogenic, and others are potentially pathogenic or non-pathogenic.

One of the most often recovered mycobacterium species in the United States belongs to the NTM group and is referred to as the *Mycobacterium avium* complex (MAC). The MAC group consists of two main species, *M. avium* and *M. intracellulare*. These two mycobacteria are very similar and are differentiated by DNA tests. The

MAC organisms are frequently isolated from immunocompromised patients, such as patients infected with HIV and patients with pre-existing pulmonary disease. MAC infections have been found to be the most common cause of NTM (nontuberculous mycobacteria) infections in humans. The NTM organisms are found in the environment (frequently recovered from water, soil, house dust, and plants) and are sometimes found colonized in the respiratory or gastrointestinal tract of healthy individuals. In AIDS patients, MAC infections may be focal or disseminated. It is theorized that the MAC organisms, acquired from the environment, colonize the respiratory tract or gastrointestinal tract before disseminating in an HIV-positive patient. Sputum and stool samples from HIV infected patients often contain MAC organisms.

Pulmonary disease in AIDS patients due to MAC cannot be distinguished clinically or by x ray from those caused by *M. tuberculosis*. Infections caused by disseminated MAC organisms in AIDS patients usually occur about one year after the diagnosis of AIDS. Also, non-AIDS patients who are white males, 45-60 years of age, typically heavy smokers, or alcohol abusers with pre-existing lung disease are good candidates for a tuberculosis-like disease also caused by MAC organisms.

An NTM, which will not grow *in vitro* (non-cultivable), is *M. leprae*. *Mycobacterium leprae* is the cause of leprosy, or Hansen's disease. This organism causes a chronic, debilitating, and disfiguring disease involving the skin, mucous membranes, and nerve tissue. There is often extensive damage to the skin (lesions) and nerves. Infectivity is low and transmission can occur from person to person through contact with infected skin; however, inhalation of nasal secretions from the infected person (close contact) appears to be the predominant mode of transmission. Leprosy in North America is rare, and most of the cases are acquired from exposure to the organism while in a tropical country. *Mycobacterium leprae* cannot be cultured on solid or liquid media *in vitro*; therefore, it is diagnosed by DNA amplification tests such as the polymerase chain reaction (PCR) using infected tissue, or mucous membrane secretions, and by observing acid-fast bacilli (using acid-fast staining procedures) in the tissue preps or skin biopsies of infected patients.

Several other NTM (non-tuberculous mycobacteria) organisms are considered potential pathogens for humans while others are rarely implicated in disease. The following NTM are considered potential pathogens and should be identified especially if recovered from immunocompromised patients:

- *Mycobacterium kansasii*: A slow grower, causing a chronic pulmonary disease resembling classic tubercu-

losis as well as cervical lymphadenitis and cutaneous diseases; tap water is the main reservoir for humans.

- *Mycobacterium haemophilum*: A slow grower, causing skin nodules and disseminated disease in immunosuppressed patients with AIDS, Hodgkins's disease, and kidney and bone marrow transplants, as well as cervical lymphadenitis in children.
- *Mycobacterium marinum*: A slow grower, causing cutaneous infections such as "swimming pool granuloma" and "fish tank granuloma" with its natural reservoir being fresh and salt water from infected fish and other marine life.
- *Mycobacterium ulcerans*: A slow grower, infecting the skin (usually after some trauma) causing nodules and ulcers to form; infection occurs mainly in tropical and temperate climates (Africa and Australia) and is rare in the United States.
- *Mycobacterium xenopi*: A slow grower, causing pulmonary infections in adults (resembling MTB complex and MAC complex). The infection is considered nosocomial, since it is recovered from hospital water storage systems and hot and cold taps quite often.
- *Mycobacterium scrofulaceum*: A slow grower responsible for cervical adenitis in children, recovered from raw milk, soil, water, and dairy products.
- *Mycobacterium szulgai*: A slow grower causing pulmonary disease similar to *M. tuberculosis*.
- *Mycobacterium fortuitum* complex: Rapid growing microorganisms which include *M. fortuitum*, *M. abscessus*, and *M. chelonae* causing infections involving surgical **wounds**, post-traumatic wound infection, otitis media, and chronic pulmonary disease.

Mycobacterium gordonae is the non-pathogenic mycobacterium most commonly recovered from patient specimens. It is found in the environment and is called the "tap water bacillus." It is only rarely implicated as a cause of human infection.

Specimen collection

Specimens to be processed for the recovery of mycobacteria are obtained and handled using specific guidelines to ensure successful growth, isolation, and identification of the causative organism. Containers must be sterile, leak-proof, and labeled properly. After collection, if the specimen cannot be processed within one hour, refrigeration is required but no longer than overnight. However, blood samples must be placed in the proper media and incubated immediately at 35-37°C.

The most often requested specimens are pulmonary specimens (secretions) which must be obtained before

any treatment (antibiotic therapy) is given. Pulmonary specimens may be obtained in several ways: spontaneously produced (expectorated) sputum; aerosol-induced sputum; bronchoscopic aspirations, washings and brushings; gastric aspirates, and lavages (washings) from patients who have swallowed sputum through the night. Saliva is not acceptable as a specimen for the recovery of mycobacteria and is usually rejected as a contaminated specimen. A series of early morning sputum specimens are recommended over a three-day period. The ideal amount of sputum specimen for processing and recovery of mycobacteria is 5-10 mL of sputum. Upon rising in the morning, the patient is instructed to cough deeply to produce sputum (expectorated sputum). A patient who is unable to bring up any sputum is given an aerosol treatment (aerosol-induced sputum) by a respiratory therapist in order to recover a sufficient amount of sputum for culture.

Other specimens requested for culture and recovery of mycobacteria are early morning, voided urine specimens; fecal specimens; tissue and body fluids (pleural, pericardial and peritoneal fluids), cerebrospinal fluid (CSF), bone marrow aspirates, and blood. Blood and stool specimens are usually cultured from AIDS patients. These specimens reveal numerous mycobacteria when infection is present in these patients. Wound or skin lesions (abscesses) require a technique using aspiration of the specimen into a syringe rather than the use of a swab to obtain the specimen.

Specimens not suitable for culture and usually rejected are 24-hour urine specimens, pooled sputum, saliva, and swabs containing pulmonary secretions. The high rate of contamination as well as the reduced rate of mycobacteria recovery in these specimens renders them unsuitable.

Specimen processing

Decontamination and digestion of sputum specimens is necessary to recover mycobacteria for culture and identification. The process of decontamination (removing unwanted bacteria) and digestion (breaking down mucous and protein) of sputum specimens is necessary to release the mycobacteria that may be present but are trapped in the mucous, and also to kill the unwanted bacteria (normal flora). Specimens from sterile body sites (blood, tissue, and body fluids, etc.) do not need the process of decontamination and digestion as do sputum samples. If the process of decontamination and digestion is not done or done improperly, recovery of mycobacteria from sputum samples is inhibited causing a false-negative report. Mucous, cells, and normal bacterial flora (from the oral cavity) entrap and enmesh the

mycobacteria in sputum. A common decontaminant is sodium hydroxide (4%) which is also used as a mucolytic agent (for liquifaction or digestion of mucous). A combination is often used which consists of N-acetyl-L-cysteine (NALC) and a lower concentration (2%) of sodium hydroxide. This combination gives a better recovery rate when used together as a mucolytic-decontaminant. Liquifaction of the thick mucous in sputum is necessary to free the mycobacteria trapped in it without harming the mycobacteria, and decontamination kills the normal flora (bacteria from the mouth, throat and oral cavity) which interfere with the recovery of mycobacteria. The final product is reduced (concentrated) from the original 5-10 mL volume, and a portion of the resulting specimen is transferred by sterile technique to either sterile solid, tube or plate media, and liquid media, while another portion is used to make several smears on glass slides for staining.

Acid fast and fluorescent staining

The smears made after the process of decontamination and digestion of sputum are stained using either an acid-fast staining procedure or a fluorochrome stain. Mycobacteria do not stain well with the Gram staining procedure used routinely in the microbiology laboratory. Specimens obtained from sterile sites (bone marrow, tissue, etc.) do not need processing and smears are made directly from the specimen onto glass **microscope** slides. Mycobacteria are slightly curved or straight bacilli, about 0.2 to 0.6 by 1.0 to 10 micrometers in size. The cell wall of mycobacteria contains a high lipid content, and is made up of long-chain, multiply cross-linked fatty acids (mycolic acids). In the acid-fast staining procedure, a basic dye, carbolfuchsin stain, is used to stain the cell wall. The long-chain mycolic acids and waxes in the mycobacteria cell wall serve to complex the carbolfuchsin. The Ziehl-Neelsen acid fast stain for mycobacteria uses heat to fix the dye in the cell wall, while the Kinyoun staining method uses an increased concentration of basic fuchsin and phenol eliminating the heat requirement. In the Ziehl-Neelsen procedure, the carbolfuchsin stain is left on the smear for five minutes while heat is applied under the slide by a bunsen burner or a hot plate. The carbolfuchsin dye penetrates the cell wall and the excess stain is washed off with a 3% acid-alcohol mixture (95% ethanol and 3% hydrochloric acid). The mycobacteria cell wall retains the dye (a red-purple color) and will not be decolorized (washed out) by the acid-alcohol, thus the term acid-fast. A second dye, methylene blue, is used to stain any background material including any other bacteria that may be present. This dye results in a light background providing good contrast to the red-purple stain of the carbolfuchsin dye, thus aid-

ing in the detection of acid-fast bacilli. If mycobacteria are present in the smear, the appearance of red-purple short or long bacilli are observed at 1000 X magnification. Some species of mycobacteria appear “beaded” while others may appear pleomorphic (a mixture of coccoid and rod shapes), or filamentous (branching of the bacillus).

Another staining method used for the detection of mycobacteria is the auramine-rhodamine fluorochrome stain. This method requires a fluorescent microscope. Smears are scanned at a lower magnification (250 X to 400 X). The fluorochrome dyes used in this procedure complex to the mycolic acids in acid-fast cell walls. The fluorescing mycobacteria are seen as bright yellow-orange bacilli against a dark background. Fluorescent stained smears can be read more rapidly than acid-fast stains, but there are drawbacks. *Mycobacteria spp.* that are rapid-growers may not appear fluorescent with these stains; artifacts may fluoresce; material on the oil objective may have floated off a previous positive smear causing a false-positive reading for the next smear examined. All positive smears from the auramine-rhodamine fluorochrome method should be confirmed using the Ziehl-Neelsen method for acid-fast bacilli.

Acid-fast bacillus (AFB) smear report

Laboratories performing staining procedures and reporting smear results must adhere to guidelines from the U.S. Department of Health and Human Services (Public Health Service, Centers for Disease Control, Atlanta). The rule for reporting acid-fast smears for mycobacteria requires scanning the smear for a minimum of 15 minutes (at least 300 oil immersion fields) before calling the slide negative for acid-fast bacilli or “No AFB seen.” The following are recommended interpretations and ways to report smear results:

- A request for another specimen or a doubtful report is the result of seeing AFB of 1-2/300 fields for the Ziehl-Neelsen (Z-N) stain and AFB of 1-2/70 fields for the auramine-rhodamine (fluorochrome) stain.
- A “1+” report for AFB seen = 1-9/100 fields for the Z-N method and 2-18/50 fields for the fluorochrome stain.
- A “2+” report for AFB seen = 1-9/10 fields for the Z-N method and 4-36/10 fields for the fluorochrome stain.
- A “3+” report for AFB seen = 1-9/field for the Z-N method and 4-36/field for the fluorochrome stain.
- A “4+” report for AFB seen = less than 9/field for the Z-N method and less than 36/field for the fluorochrome stain.

Culture media and isolation methods

Several types of media are used for the cultivation of mycobacteria, and each facility determines which ones are most appropriate for use. A combination of culture media is often used to optimize recovery of mycobacteria as well as inhibit the growth of contaminants. Mycobacteria require a pH of 6.5-6.8 for growth and grow best at higher humidity. Commercially prepared solid culture media (in tubes with screw-top caps) consist of bovine serum albumin agar-based media (Middlebrook 7H10 and 7H11) and egg-based media (Lowenstein-Jensen). Liquid media (Middlebrook 7H9) is used to subculture stock strains or as part of a system (e.g., BACTEC 12B medium, Septi-Chek AFB) to cultivate and detect growth of acid-fast bacilli. *Mycobacterium spp.* grow more rapidly in liquid media; solid media takes approximately 17 days for the isolation of acid-fast bacilli whereas liquid media takes only about 10 days. The following are descriptions of three general types of media that are most often used.

- Lowenstein-Jensen media (L-J) is an egg-potato base solid media containing malachite green (an inhibitory agent). The use of L-J media is excellent for the recovery of *M. tuberculosis* from sterile-site specimens as well as decontaminated-digested sputum specimens.
- Petraghani media is an egg-milk-potato solid medium also containing malachite green. It is primarily used for specimens from highly contaminated areas (e.g., fecal material).
- Middlebrook 7H10 media is a liquid based media containing salts, **vitamins**, cofactors, oleic acid, albumin, catalase, glycerol, and glucose. This media enhances the recovery of MAC organisms (*Mycobacteria avium* complex).

Each culture medium described above represents a nonselective formulation, but selective formulations are also used which contain antibiotics to enhance the growth of mycobacteria and suppress the growth of contaminating bacteria. The enhanced formulas are used for specimens that are highly contaminated.

All culture tubes are incubated in an atmosphere of 5-10% CO₂ (for growth enhancement) even though mycobacteria are strict aerobes. The tubed media are kept in a high humidity incubator at 35°C in the dark in a slanted position with the caps loosened (in order for CO₂ to enter the tubes and excess fluid to evaporate). For specimens obtained from skin or superficial lesions, a lower temperature (25-30°C) is required for the recovery of *M. marinum* and *M. ulcerans*. A nutritional requirement of hemin and a temperature of 30°C are needed for the recovery of *M. haemophilum* (cultured from skin

nodule specimens). If *M. xenopi* is suspected, a temperature of 42-45°C is required (cultured from hospital hot water tanks).

AFB cultures are held for six to eight weeks before reporting “No growth of AFB.” Cultures are observed daily for the first two weeks, checking for any growth or colony formation. Rapid-growing mycobacteria usually appear on non-selective media in two to three days at temperatures between 20 to 40°C. The slow-growing mycobacteria associated with disease require four to six weeks of incubation on selective media. Since the use of liquid media allows mycobacteria to grow more rapidly and is considered the most sensitive primary isolation media, the Becton Dickinson Diagnostic Instrument Systems developed the BACTEC System. The BACTEC System utilizes Liquid Middlebrook 7H12 and 7H13 in an automated radiometric culture system. The broth is placed in commercially prepared vials containing a ¹⁴C-labeled substrate (palmitic acid) used by mycobacteria, liberating radioactive carbon dioxide (¹⁴CO₂) into the upper part of the vial. The ¹⁴CO₂ liberated is detected by the BACTEC 460 (instrument) and is recorded as a “growth index” denoting growth of mycobacteria in the vial of broth. This method of growth significantly improves the isolation rate of mycobacteria compared with conventional isolation using solid tubed media. The BACTEC vials must be checked within four days of inoculation. This method detects *Mycobacteria spp.* growth in clinical specimens in less than two weeks compared to four to six weeks for conventional methods.

Non-radiometric automated systems are also available for the detection of growth and recovery of mycobacteria from clinical specimens. An example is the Septi-Chek AFB system (BBL-Becton Dickinson Microbiology Systems) that detects, isolates, rapidly identifies, and performs antibiotic susceptibility testing. This is a biphasic media system (a bottle containing liquid media and solid media) that uses growth enhancing factors and antimicrobial agents in the liquid and three different solid media on a paddle inserted in the top of the vial. This system rapidly grows, isolates, and presumptively identifies *M. tuberculosis* (i.e., differentiates it from other mycobacteria).

Identification

Based on the volume of specimens submitted, the ability of performance, and the expertise of the clinical laboratory personnel, the American Thoracic Society (ATS) and the College of American Pathologists (CAP) have recommended levels of service for clinical laboratories testing of mycobacteria. The ATS recommends

four levels of testing while the CAP lists three levels. The three levels of service recommended by CAP are:

- Level I. Specimen collection only; no identification procedures performed with all specimens sent to other qualified laboratories.
- Level II. Perform microscopy; isolate and identify and sometimes perform susceptibility tests for *M. tuberculosis*.
- Level III. Perform microscopy; isolate, identify, and perform susceptibility testing for all species of *Mycobacterium*.

Identification of *Mycobacteria spp.* by qualified clinical laboratories entails several of the following:

- Confirmation that the isolate recovered in broth or on solid media is an acid-fast organism.
- Categorize (presumptively) the isolate by phenotypic characteristics, such as colony morphology, photoreactivity, growth rate, and optimum growth temperature.
- Identification through tests based on enzyme systems of the organism, metabolic by-products, and inhibition of growth by exposure to selected biochemicals.
- Chromatographic detection of mycolic acid.
- Identification by DNA hybridization (e.g., Gen-Probe-San Diego, Calif.)
- Identification by PCR (polymerase chain reaction) tests.

The biochemical tests most often utilized are **niacin** accumulation, nitrate reduction, TCH (inhibition of growth when exposed to thiophene-2-carboxylic acid hydrazide), growth in 5% NaCl, tellurite reduction, growth on MacConkey agar, catalase, hydrolysis of Tween 80, **iron** uptake, and tests for the enzymes aryl-sulfatase, urease, and pyrazinamidase. Biochemical testing is time consuming and may take several weeks to obtain results. Molecular methods (DNA and PCR) are becoming increasingly available commercially and allow for identification and detection of mycobacteria faster, with less cost and more specificity.

Antibiotic susceptibility testing for tuberculosis

The susceptibility testing for *Mycobacteria tuberculosis* is done on a pure culture which may take two to three weeks to prepare after the initial culture has grown. Thus, a total of five to seven weeks is not uncommon before the physician finally receives an antibiotic susceptibility report for a patient with a positive MTB culture. However, rapid testing systems mentioned previously may be used for susceptibility testing, which reduces the time considerably.

Once the physician receives the initial smear report (i.e., positive AFB on smear) and the initial culture report (presumptive *M. tuberculosis* isolated), the patient is given two or more primary drugs (first-line drugs) to initiate treatment that may require six to nine months of drug therapy. The first line (primary drugs) drugs tested *in vitro* include isoniazid (INH), rifampin, pyrazinamide, ethambutol, and streptomycin. After three months of therapy, patients are again cultured. If the cultures are still positive, re-testing of different or secondary drugs is done. The second-line drugs include ethionamide, capreomycin, cycloserine, kanamycin, pyrazinamide, amikacin, ciprofloxacin, ofloxacin, rifabutin, and para-aminosalicylic acid.

The methods used for susceptibility testing are: radiometric (BACTEC System); proportional; resistance ratio (agar dilution and disk elution); and absolute concentration methods. It is important to isolate and determine the susceptibility pattern for *M. tuberculosis* because of the increase in multidrug-resistant cases in the United States.

Preparation

Prior to breakfast, the patient will be asked to provide a 5-10 mL specimen of sputum delivered into a sterile cup with a screw top lid. Obtaining an appropriate sample will require that the patient cough deeply several times to bring up the sputum. Failure to do so will result in a specimen containing saliva or post-nasal drip, which are both considered sample contaminants.

Aftercare

There are not specific requirements for care after obtaining the specimen.

Complications

There are no complications associated with this test.

Results

The acid-fast smear report will indicate “no AFB seen” if results are negative. If positive, the report should be documented as described above. For cultures, “no growth of AFB” on any medium after eight weeks is considered a negative test. Growth on any medium is tested for acid-fastness and if positive, a preliminary report of a positive culture for *Mycobacterium spp.* is submitted. A final report of the mycobacterium species identified and antibiotic susceptibility is submitted as soon as results are available. The antibiotic susceptibility report indi-

cates one of three conditions for each drug: sensitive, equivocal, or resistant.

Health care team roles

A physician orders and interprets the report for an acid-fast culture. A nurse, physician assistant, or respiratory therapist assists in sputum or sample collection. A clinical laboratory scientist/medical technologist who is specially trained in mycobacteriology performs the microbiological testing.

Resources

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Acquired immunodeficiency syndrome see
AIDS

Activities of daily living evaluation

Definition

An activities of daily living (ADL) evaluation is an assessment of an individual's physical and sometimes

KEY TERMS

Adaptation—Altering a tool used in performing a task so that the patient is better able to function independently or with minimal assistance.

Dressing stick—A long rod with a hook attached to the end that a patient uses in place of the hands. Typically a dressing rod would be used to pull on a pair of pants or socks.

Home modification—Altering the physical environment of the home so as to remove hazards and provide an environment that is more functional for the patient. Examples of home modification include installing grab bars and no-slip foot mats in the bathroom to prevent falls.

mental skills. In the area of physical or **occupational therapy**, it reflects how well a disabled patient or someone recovering from disease or accident can function in daily life. It is also used to determine how well patients relate to and participate in their environment.

Purpose

ADL evaluations help practitioners determine how independent patients are and what skills they can accomplish on their own, as well as to gauge how independent each individual can become after intervention by a health professional. The goal of practitioners performing ADL evaluations is to help patients become as independent as possible, using appropriate adaptations if needed.

Description

Many ADL indexes exist, such as the Katz Index, Revised Kenny Self-Care Evaluation, and the Barthel Index. These indexes typically evaluate patients on their self-care skills and rate each individual according to how functional they are. Scoring is based on how independently a task can be performed and whether supervision or assistance is needed in performing the task.

Basic ADL versus Instrumental ADL

Basic activities of daily living are those skills needed in typical daily self care. An evaluation would, in part, consist of bathing, dressing, feeding, and toileting. The evaluator would examine various activities in each category to determine the patient's skill. Afterward it can be determined what, if any, changes will be necessary to allow the patient to function as independently as possible.

Instrumental activities of daily living refer to skills beyond basic self care that evaluate how individuals function within their homes, workplaces, and social environments. Instrumental ADLs may include typical domestic tasks, such as driving, cleaning, cooking, and shopping, as well as other less physically demanding tasks such as operating electronic appliances and handling budgets. In the work environment, an ADL evaluation assesses the qualities necessary to perform a job, such as strength, endurance, manual dexterity, and **pain management**.

If a person is being treated following an injury or disorder diagnosis, whether an intervention is needed depends upon how severe his or her functional ability has been affected. If an individual's ADL function is not restored, a health care professional will perform an intervention, which entails helping the individual adapt to permanent dysfunction or regain meaningful function. How well an individual must be able to perform these tasks depends upon the living setting he or she is returning to, whether it is a full custodial facility, assisted living community, or living at home on his or her own.

Complications

Returning a client to full meaningful function can be problematic for individuals who do not have the motivation to do so. A holistic approach to treatment is most important in cases such as these, and physical and occupation therapists are trained to evaluate not only the physical disability or dysfunction of an individual, but also the person's mental health and well-being. Occupational therapists can address mental health issues resulting from injury or disorder diagnosis, such as depression. However, in cases where a patient has sustained a permanent cognitive disability and is learning-impaired, it is more effective and appropriate for the occupational therapist to teach family members or a caretaker how to perform daily tasks for the patient.

Results

Interventions implemented to increase function include adaptations and home modification. Adaptations are devices that can enhance the usability of everyday items for individuals who have a limited range of motion. Home modification involves the process of making one's living environment more functional for ADL.

Adaptations

There are several ways that adaptations can be used to make common household items more functional. For example, patients commonly have a weakened grasp that is insufficient to hold heavy or small objects, so enhance-

ments such as easily gripped handles could be added to small objects, such as eating utensils or personal grooming items. Other adaptations may involve the use of unique tools to facilitate tasks, such as using a long rod with a hook at one end, known as a dressing stick, to pull on pants or socks. Adaptations may involve altering the environment to aid in other tasks, such as providing adequate lighting or magnifying lenses to compensate for a **vision** impairment.

Home modifications

Home modification has become a major area for occupational therapists to practice. In order for patients to return home or go to a group setting, the physical environment of the house or facility may have to be altered to make ADL function better. Common examples of home modifications include the installation of grab bars in the shower, toilet area and hallways; lower kitchen counters for easier access to wheelchair-bound individuals; and the elimination of potential trip points, such as loose throw rugs and slight changes in floor elevation.

Health care team roles

Occupational therapists and physical therapists are the two primary disciplines most qualified to assess ADL function and recommend the appropriate intervention and modifications in one's home and work environment. Physical therapists might focus primarily on a patient's mobility and ambulation, while the occupational therapist might focus on more specific tasks described above.

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ORGANIZATIONS

- The American Occupational Therapy Association. 4720 Montgomery Lane, Bethesda, MD 20824-1220. (301) 652-2682. <<http://www.aota.org>>.
- The American Physical Therapy Association. 1111 North Fairfax Street, Alexandria, VA 22314-1488. (703) 684-2782. <<http://www.apta.org>>.

Meghan M. Gourley

Acupressure

Definition

Acupressure is a form of touch therapy that utilizes the principles of acupuncture and Chinese medicine. In acupressure, the same points on the body are used as in acupuncture, but are stimulated with finger pressure instead of with the insertion of needles. Acupressure is used to relieve a variety of symptoms and **pain**.

Origins

One of the oldest text of Chinese medicine is the *Huang Di, The Yellow Emperor's Classic of Internal Medicine*, which may be at least 2,000 years old. Chinese medicine has developed acupuncture, acupressure, herbal remedies, diet, **exercise**, lifestyle changes, and other remedies as part of its healing methods. Nearly all of the forms of Oriental medicine that are used in the West today, including acupuncture, acupressure, **shiatsu**, and Chinese herbal medicine, have their roots in Chinese medicine. One legend has it that acupuncture and acupressure evolved as early Chinese healers studied the puncture **wounds** of Chinese warriors, noting that certain points on the body created interesting results when stimulated. The oldest known text specifically on acupuncture points, the *Systematic Classic of Acupuncture*, dates back to 282 A.D. Acupressure is the non-invasive form of acupuncture, as Chinese physicians determined that stimulating points on the body with massage and pressure could be effective for treating certain problems.

Outside of Asian-American communities, Chinese medicine remained virtually unknown in the United States until the 1970s, when Richard Nixon became the first U.S. president to visit China. On Nixon's trip, journalists were amazed to observe major operations being performed on patients without the use of anesthetics. Instead, wide-awake patients were being operated on, with only acupuncture needles inserted into them to control pain. At that time, a famous columnist for the *New York Times*, James Reston, had to undergo surgery and elected to use acupuncture for anesthesia. Later, he wrote some convincing stories on its effectiveness. Despite being neglected by mainstream medicine and the American Medical Association (AMA), acupuncture and Chinese medicine became a central to alternative medicine practitioners in the United States. Today, there are millions of patients who attest to its effectiveness, and nearly 9,000 practitioners in all 50 states.

Acupressure is practiced as a treatment by Chinese medicine practitioners and acupuncturists, as well as by massage therapists. Most massage schools in American



Therapist working acupressure points on a woman's shoulder. (Photo Researchers, Inc. Reproduced by permission.)

include acupressure techniques as part of their bodywork programs. Shiatsu massage is very closely related to acupressure, working with the same points on the body and the same general principles, although it was developed over centuries in Japan rather than in China. Reflexology is a form of bodywork based on acupressure concepts. Jin Shin Do is a bodywork technique with an increasing number of practitioners in America that combines acupressure and shiatsu principles with **qigong**, Reichian theory, and **meditation**.

Benefits

Acupressure massage performed by a therapist can be very effective both as prevention and as a treatment for many health conditions, including headaches, general aches and pains, colds and flu, arthritis, **allergies**, **asthma**, nervous tension, menstrual cramps, sinus problems, sprains, tennis elbow, and toothaches, among others. Unlike acupuncture which requires a visit to a professional, acupressure can be performed by a layperson. Acupressure techniques are fairly easy to learn, and have been used to provide quick, cost-free, and effective relief from many symptoms. Acupressure points can also be stimulated to increase energy and feelings of well-being,

reduce **stress**, stimulate the **immune system**, and alleviate **sexual dysfunction**.

Description

Acupressure and Chinese medicine

Chinese medicine views the body as a small part of the universe, subject to laws and principles of harmony and balance. Chinese medicine does not make as sharp a distinction as Western medicine does between mind and body. The Chinese system believes that emotions and mental states are every bit as influential on disease as purely physical mechanisms, and considers factors like work, environment, and relationships as fundamental to a patient's health. Chinese medicine also uses very different symbols and ideas to discuss the body and health. While Western medicine typically describes health as mainly physical processes composed of chemical equations and reactions, the Chinese use ideas like yin and yang, chi, and the organ system to describe health and the body.

Everything in the universe has properties of yin and yang. Yin is associated with cold, female, passive, downward, inward, dark, wet. Yang can be described as hot,

male, active, upward, outward, light, dry, and so on. Nothing is either completely yin or yang. These two principles always interact and affect each other, although the body and its organs can become imbalanced by having either too much or too little of either.

Chi (pronounced *chee*, also spelled *qi* or *ki* in Japanese *shiatsu*) is the fundamental life energy. It is found in food, air, water, and sunlight, and it travels through the body in channels called *meridians*. There are 12 major meridians in the body that transport chi, corresponding to the 12 main organs categorized by Chinese medicine.

Disease is viewed as an imbalance of the organs and chi in the body. Chinese medicine has developed intricate systems of how organs are related to physical and mental symptoms, and it has devised corresponding treatments using the meridian and pressure point networks that are classified and numbered. The goal of acupressure, and acupuncture, is to stimulate and unblock the circulation of chi, by activating very specific points, called pressure points or *acupoints*. Acupressure seeks to stimulate the points on the chi meridians that pass close to the skin, as these are easiest to unblock and manipulate with finger pressure.

Acupressure can be used as part of a Chinese physician's prescription, as a session of **massage therapy**, or as a self-treatment for common aches and illnesses. A Chinese medicine practitioner examines a patient very thoroughly, looking at physical, mental, and emotional activity, taking the pulse usually at the wrists, examining the tongue and complexion, and observing the patient's demeanor and attitude, to get a complete diagnosis of which organs and meridian points are out of balance. When the imbalance is located, the physician will recommend specific pressure points for acupuncture or acupressure. If acupressure is recommended, the patient might opt for a series of treatments from a massage therapist.

In massage therapy, acupressurists will evaluate a patient's symptoms and overall health, but a massage therapist's diagnostic training isn't as extensive as a Chinese physician's. In a massage therapy treatment, a person usually lies down on a table or mat, with thin clothing on. The acupressurist will gently feel and palpate the abdomen and other parts of the body to determine energy imbalances. Then, the therapist will work with different meridians throughout the body, depending on which organs are imbalanced in the abdomen. The therapist will use different types of finger movements and pressure on different acupoints, depending on whether the chi needs to be increased or dispersed at different points. The therapist observes and guides the energy flow through the patient's body throughout the session.

Sometimes, special herbs (*Artemisia vulgaris* or moxa) may be placed on a point to warm it, a process called *moxibustion*. A session of acupressure is generally a very pleasant experience, and some people experience great benefit immediately. For more chronic conditions, several sessions may be necessary to relieve and improve conditions.

Acupressure massage usually costs from \$30–70 per hour session. A visit to a Chinese medicine physician or acupuncturist can be more expensive, comparable to a visit to an allopathic physician if the practitioner is an MD. Insurance reimbursement varies widely, and consumers should be aware if their policies cover alternative treatment, acupuncture, or massage therapy.

Self-treatment

Acupressure is easy to learn, and there are many good books that illustrate the position of acupoints and meridians on the body. It is also very versatile, as it can be done anywhere, and it's a good form of treatment for spouses and partners to give to each other and for parents to perform on children for minor conditions.

While giving self-treatment or performing acupressure on another, a mental attitude of calmness and attention is important, as one person's energy can be used to help another's. Loose, thin clothing is recommended. There are three general techniques for stimulating a pressure point.

- Tonifying is meant to strengthen weak chi, and is done by pressing the thumb or finger into an acupoint with a firm, steady pressure, holding it for up to two minutes.
- Dispersing is meant to move stagnant or blocked chi, and the finger or thumb is moved in a circular motion or slightly in and out of the point for two minutes.
- Calming the chi in a pressure point utilizes the palm to cover the point and gently stroke the area for about two minutes.

There are many pressure points that are easily found and memorized to treat common ailments from headaches to colds.

- For headaches, toothaches, sinus problems, and pain in the upper body, the "LI4" point is recommended. It is located in the web between the thumb and index finger, on the back of the hand. Using the thumb and index finger of the other hand, apply a pinching pressure until the point is felt, and hold it for two minutes. Pregnant women should never press this point.
- To calm the nerves and stimulate digestion, find the "CV12" point that is four thumb widths above the navel

KEY TERMS

Acupoint—A pressure point stimulated in acupressure.

Chi—Basic life energy.

Meridian—A channel through which chi travels in the body.

Moxibustion—An acupuncture technique that burns the herb moxa or mugwort.

Shiatsu—Japanese form of acupressure massage.

Yin/yang—Universal characteristics used to describe aspects of the natural world.

in the center of the abdomen. Calm the point with the palm, using gentle stroking for several minutes.

- To stimulate the immune system, find the “TH5” point on the back of the forearm two thumb widths above the wrist. Use a dispersing technique, or circular pressure with the thumb or finger, for two minutes on each arm.
- For headaches, sinus congestion, and tension, locate the “GB20” points at the base of the **skull** in the back of the head, just behind the bones in back of the ears. Disperse these points for two minutes with the fingers or thumbs. Also find the “yintang” point, which is in the middle of the forehead between the eyebrows. Disperse it with gentle pressure for two minutes to clear the mind and to relieve headaches.

Precautions

Acupressure is a safe technique, but it is not meant to replace professional health care. A physician should always be consulted when there are doubts about medical conditions. If a condition is chronic, a professional should be consulted; purely symptomatic treatment can exacerbate chronic conditions. Acupressure should not be applied to open wounds, or where there is swelling and inflammation. Areas of scar tissue, blisters, **boils**, rashes, or **varicose veins** should be avoided. Finally, certain acupressure points should not be stimulated on people with high or low **blood pressure** and on pregnant women.

Research and general acceptance

In general, Chinese medicine has been slow to gain acceptance in the West, mainly because it rests on ideas very foreign to the scientific model. For instance, Western scientists have trouble with the idea of chi, the

invisible energy of the body, and the idea that pressing on certain points can alleviate certain conditions seems sometimes too simple for scientists to believe.

Western scientists, in trying to account for the action of acupressure, have theorized that chi is actually part of the neuroendocrine system of the body. Celebrated orthopedic surgeon Robert O. Becker, who was twice nominated for the Nobel Prize, wrote a book on the subject called *Cross Currents: The Promise of Electromedicine; The Perils of Electropollution*. By using precise electrical measuring devices, Becker and his colleagues showed that the body has a complex web of electromagnetic energy, and that traditional acupressure meridians and points contained amounts of energy that non-acupressure points did not.

The mechanisms of acupuncture and acupressure remain difficult to document in terms of the biochemical processes involved; numerous testimonials are the primary evidence backing up the effectiveness of acupressure and acupuncture. However, a body of research is growing that verifies the effectiveness in acupressure and acupuncture techniques in treating many problems and in controlling pain.

Training and certification

There are two routes to becoming trained in the skill of acupressure. The first is training in traditional acupuncture and Chinese medicine, which has many schools and certifying bodies around the country. The majority of acupressure practitioners are trained as certified massage therapists, either as acupressure or shiatsu specialists.

The Acupressure Institute provides certification and resources for acupressure practitioners. Address: 1533 Shattuck Ave., Berkeley, CA 94709, phone (510) 845-1059, website: www.acupressure.com.

The American Oriental Bodywork Therapy Association (AOBTA) certifies acupressure practitioners and has over 1,400 members. It also provides a list of schools and training programs. Address: 1010 Haddonfield-Berlin Road, Suite 408, Voorhees, NJ 08043, phone (856) 782-1616, email: AOBTA@prodigy.net.

The Jin Shin Do Foundation for Body/Mind Acupressure is an international network of teachers and practitioners. Address: 1084G San Miguel Canyon Road, Royal Oaks, CA 95076, phone (408) 763-7702.

The largest organization that certifies massage therapists, with over 40,000 members worldwide, is the American Massage Therapy Association. It also has a

member directory and lists of training programs. Website: www.amtamassage.org.

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Douglas Dupler

Acute kidney failure

Definition

Acute kidney failure (AKF) occurs when there is a sudden reduction in kidney function that results in nitrogenous wastes accumulating in the **blood** (azotemia).

Description

The **kidneys** are the body's natural filtration system. They perform the critical task of processing approximately 200 quarts of fluid in the bloodstream every 24 hours. Waste products like urea and toxins, along with excess fluids, are removed from the bloodstream in the form of urine. Kidney (or renal) failure occurs when kidney functioning becomes impaired somehow. Fluids and toxins begin to accumulate in the bloodstream. As fluids build up in the bloodstream, the patient with AKF may become puffy and swollen (edematous) in the face, hands, and feet. Their **blood pressure** typically begins to rise, and they may experience fatigue and nausea. Often urine output decreases drastically or is not produced at all.

Unlike **chronic kidney failure**, which is long term and irreversible, acute kidney failure is often a temporary condition. With proper and timely treatment, it can many

times be reversed, leaving no permanent or serious damage to the kidneys.

Causes and symptoms

Acute kidney failure appears most frequently as a complication of serious illness, like **heart** and/or **liver** failure, serious **infection**, **dehydration**, severe **burns**, and excessive bleeding (hemorrhage). It may also be caused by an obstruction to the urinary tract or as a direct result of kidney disease, injury, or an adverse reaction to medicine. These conditions divide AKF into three main categories: prerenal, postrenal, and intrinsic (inside) conditions.

Prerenal AKF does not damage the kidney, but can cause diminished kidney function and significantly decreased renal (kidney) blood flow. It is the most common type of acute renal failure, and is often the result of:

- dehydration
- extracellular fluid (ECF) volume depletion (or other acute fluid loss from the gastrointestinal tract, kidneys, or skin)
- drugs (NSAIDs, cyclosporine, radiopaque contrast materials, or any substance toxic to the kidneys)
- hemorrhage
- septicemia, or sepsis
- congestive **heart failure** (CHF)
- liver failure
- burns
- decreased intravascular volume (referred to as third spacing, also found in the presence of **pancreatitis**, post surgical patients, and patients with a nephrotic syndrome)

Postrenal AKF is the result of an obstruction of some kind somewhere in the urinary tract, often in the bladder or ureters (the tubes leading from the kidney to the bladder). The kidneys compensate to such a degree that one kidney can be completely obstructed and the other will maintain nearly normal kidney function for the body. The conditions that often cause postrenal AKF are:

- inflammation of the prostate gland in men (prostatitis)
- enlargement of the prostate gland (benign prostatic hypertrophy)
- bladder or pelvic tumors
- **kidney stones** (calculi)

Intrinsic AKF involves a type of kidney disease or direct injury to the kidneys. This type of AKF accounts

for 20-30% of AKF reported among hospitalized patients. Intrinsic AKF can result from:

- lack of blood supply to the kidneys (ischemia)
- use of radiocontrast agents in patients with kidney problems
- drug abuse or overdose
- long-term use of nephrotoxic medications, like certain **pain** medicines
- acute inflammation of the glomeruli, or filters, of the kidney (glomerulonephritis)
- kidney infections (pyelitis or pyelonephritis)
- infiltration by lymphoma, leukemia, or sarcoid carcinomas

Common symptoms of AKF include:

- **Anemia.** The kidneys are responsible for producing erythropoietin (EPO), a hormone that stimulates red blood cell production. If kidney disease causes shrinking of the kidney, red blood cell production is reduced, leading to anemia.
- **Bad breath or bad taste in mouth.** Urea in the saliva may cause an ammonia-like taste in the mouth.
- **Bone and joint problems.** The kidneys produce **vitamin D**, which helps the body absorb **calcium** and keeps bones strong. For patients with kidney failure, bones may become brittle. In children, normal growth may be stunted. Joint pain may also occur as a result of high phosphate levels in the blood. Retention of uric acid may cause gout.
- **Edema.** Puffiness or swelling in the arms, hands, feet, and around the eyes.
- **Frequent urination.**
- **Foamy or bloody urine.** Protein in the urine may cause it to foam significantly. Blood in the urine may indicate bleeding from diseased or obstructed kidneys, bladder, or ureters.
- **Cola-colored urine followed by oliguria** (decreased urine output) or **anuria** (no urine output)
- **Headaches.** High blood pressure may trigger headaches.
- **Hypertension, or high blood pressure.** The retention of fluids and wastes causes blood volume to increase. This makes blood pressure rise.
- **Increased fatigue.** Toxic substances in the blood and the presence of anemia may cause the patient to feel exhausted.
- **Itching.** **Phosphorus**, normally eliminated in the urine, accumulates in the blood of patients with kidney fail-

ure. An increased phosphorus level may cause the skin to itch.

- **Lower back pain.** Patients suffering from certain kidney problems (like kidney stones and other obstructions) may have pain where the kidneys are located, in the small of the back below the ribs.
- **Nausea.** Urea in the gastric juices may cause upset stomach.

Diagnosis

Kidney failure is diagnosed by a doctor, whether the patient is in the hospital or seen as an outpatient. He or she will take a complete medical history and make a thorough review of the patient's medical record, looking for exposure to nephrotoxic (medicines that can be hard on the kidneys) drugs or other clues to the patient's condition. The physician will then conduct a thorough **physical examination**, making a careful assessment of the patient's ECF volume and effective circulating blood volume (EBV). A nephrologist, a doctor that specializes in the kidney, may be consulted to confirm the diagnosis and recommend treatment options. He or she will look for a recent history of changes in body weight and try and determine whether the patient is taking in much more fluid than he or she is excreting. Capillary wedge pressure and cardiac output values are also effective tools in pinpointing the cause and extent of the AKF.

The patient that is suspected of having AKF will have blood and urine tests to determine the level of kidney function. A blood test will assess the levels of creatinine, blood urea nitrogen (BUN), uric acid, phosphate, sodium, and potassium. The kidney regulates these agents in the blood. Urine samples will also be collected, usually over a 24-hour period, to assess protein loss and/or creatinine clearance.

Determining the cause of kidney failure is critical to proper treatment. Prerenal or obstructive causes are often looked into first because they are the quickest types of AKF to treat. A full assessment of the kidneys is necessary to determine if the underlying disease is treatable and if the kidney failure is chronic or acute. X rays, **magnetic resonance imaging** (MRI), computed tomography scan (CT), ultrasound, renal biopsy, and/or arteriogram of the kidneys may be used to determine the cause of kidney failure and level of remaining kidney function. X rays and ultrasound of the bladder and/or ureters may also be needed.

Treatment

Treatment for AKF varies, since it is directed to the underlying, primary medical condition that triggered the

kidney failure. Prerenal conditions may be treated with replacement fluids given through a vein, diuretics, blood transfusion, restricted salt intake, or medications. Postrenal conditions and intrarenal conditions may require surgery and/or medication.

Frequently, patients in AKF require *hemodialysis*, *hemofiltration*, or *peritoneal dialysis* to filter fluids and wastes from the bloodstream until the primary medical condition can be controlled.

Hemodialysis

Hemodialysis involves circulating the patient's blood outside of the body through an extracorporeal circuit (ECC), or dialysis circuit. The ECC is made up of plastic blood tubing, a filter known as a dialyzer (or artificial kidney), and a dialysis machine that monitors and maintains blood flow and administers dialysate. Dialysate is a sterile chemical solution that is used to draw waste products out of the blood. The patient's blood leaves the body through the vein and travels through the ECC and the dialyzer, where fluid removal takes place.

During dialysis, waste products in the bloodstream are carried out of the body. At the same time, electrolytes and other chemicals are added to the blood. The purified, chemically-balanced blood is then returned to the body.

A dialysis "run" typically lasts three to four hours, depending on the type of dialyzer used and the physical condition of the patient. Dialysis is used several times a week until AKF has resolved.

Blood pressure changes associated with hemodialysis may pose a risk for patients with heart problems. **Peritoneal dialysis** may be the preferred treatment option in these cases.

Hemofiltration

Hemofiltration, also called continuous renal replacement therapy (CRRT), is a slow, continuous blood filtration therapy used to control acute kidney failure in critically ill patients. These patients are typically very sick and may have heart problems or circulatory problems. They cannot endure the rapid filtration rates of hemodialysis. They also frequently need **antibiotics**, **nutrition**, vasopressors, and other fluids given through a vein to treat their primary condition. Because hemofiltration is continuous, prescription fluids can be given to patients in kidney failure without the risk of fluid overload.

Like hemodialysis, hemofiltration uses an ECC. A hollow fiber hemofilter is used instead of a dialyzer to remove fluids and toxins. Instead of a dialysis machine, a blood pump makes the blood flow through the ECC. The volume of blood circulating through the ECC in

hemofiltration is less than that in hemodialysis. Filtration rates are slower and gentler on the circulatory system. Hemofiltration treatment will generally be used until kidney failure is reversed.

Peritoneal dialysis

Peritoneal dialysis may be used if the patient in AKF is stable and not in immediate crisis. In peritoneal dialysis (PD), the lining of the patient's abdomen, the peritoneum, acts as a blood filter. A flexible tube-like instrument (catheter) is surgically inserted into the patient's abdomen. During treatment, the catheter is used to fill the abdominal cavity with dialysate. Waste products and excess fluids move from the patient's bloodstream into the dialysate solution. After a certain time period, the waste-filled dialysate is drained from the abdomen, and replaced with clean dialysate. There are three types of peritoneal dialysis, which vary according to treatment time and administration method.

Peritoneal dialysis is often the best treatment option for infants and children. Their small size can make vein access difficult to maintain. It is not recommended for patients with abdominal adhesions or other abdominal defects (like a hernia) that might reduce the efficiency of the treatment. It is also not recommended for patients who suffer frequent bouts of an inflammation of the small pouches in the intestinal tract (diverticulitis).

Prognosis

Because many of the illnesses and underlying conditions that often trigger AKF are critical, the prognosis for these patients many times is not good. Studies have estimated overall death rates for AKF at 42-88%. Many people, however, die because of the primary disease that has caused the kidney failure. These figures may also be misleading because patients who experience kidney failure as a result of less serious illnesses (like kidney stones or dehydration) have an excellent chance of complete recovery. Early recognition and prompt, appropriate treatment are key to patient recovery.

Survival statistics also depend on the type of AKF the patient has, age at time of onset, and general health. If the patient has prerenal AKF, there is a good recovery prognosis, but the mortality rate is higher among those who fail to respond to diuretics and vasodilator therapy. Since 1980, age has become a risk factor that increased mortality in patients with acute tubular necrosis (ATN), an intrinsic form of AKF.

Up to 10% of patients who experience AKF will suffer irreversible kidney damage. They will eventually go on to develop chronic kidney failure or end-stage renal

KEY TERMS

Anuria—When the body ceases to make urine entirely or falls below 100 mls.

Azotemia—Too many nitrogenous compounds in the blood caused by the kidneys' failure to remove urea from the blood.

Blood urea nitrogen (BUN)—A waste product that is formed in the liver and collects in the bloodstream; patients with kidney failure have high BUN levels.

Capillary wedge pressure—The blood pressure inside of a capillary.

Cardiac output—The volume of blood pushed out by the ventricles.

Creatinine—A protein produced by muscle that healthy kidneys filter out.

Edema—The abnormal accumulation of fluid in the interstitial spaces of tissue.

Electrolytes—An element or a compound that can break into ions and conduct electrical current when melted or dissolved in water.

Erythropoietin (EPO)—A glycoprotein hormone made in the kidneys.

Extracellular fluid (ECF)—That part of body fluid made of interstitial fluid and blood plasma.

Extracorporeal—Outside of, or unrelated to, the body.

Glomeruli—The tiny structures that perform the actual mechanical filtering in the kidney.

Gout—A condition caused by error in uric acid metabolism.

Interstitial—The space between cells.

Intravascular volume—The volume of fluid inside a blood vessel.

Intrinsic—Starting from or situated inside an organ or tissue.

Ischemia—A lack of blood supply to an organ or tissue.

Lymphoma—Cancer of the lymph tissue.

Nephritis—Inflammation and abnormal functioning of the kidney.

Nephrologist—A physician who specializes in treating diseases of the kidney.

Nephrotoxic—Toxic, or damaging, to the kidney.

NSAIDs—Non-steroidal, antiinflammatory drug.

Oliguria—Abnormally low urine production.

Radiopaque agents—Dyes administered to a patient for the purposes of a radiologic study.

Sepsis—A bacterial infection of the bloodstream.

Urea—A systemic diuretic.

Vasopressors—Medications that constrict the blood vessels.

disease. These patients will require long-term dialysis or kidney transplantation to replace their lost renal functioning.

Health care team roles

The patient who suffers from AKF will come in contact with a number of different health care professionals during both the diagnosis and treatment phase of the illness. Patients will require (according to the type and severity of their condition) laboratory work, diagnostic radiology services, pharmaceutical and nutritional interventions, dialysis (in some cases), nursing care, and disease management by a nephrologist.

The medical history, taken by a physician in the emergency room, the patient's family doctor, a fellow nurse practitioner, physician's assistant (PA), or a nephrologist is the most essential tool in determining the

cause and type of AKF. The admitting physician or nephrologist will conduct a thorough physical, looking at the following areas for specific clues.

Skin. Checking the patient for areas of small, purple or red spots (petechiae), hemorrhage beneath the skin (purpura), and bluish discoloration of a fairly large area of the skin (ecchymosis) can lead to a diagnosis of an inflammatory or vascular cause for the AKF.

Eyes. Certain conditions in the eyes can point to a diagnosis of interstitial nephritis (inflammation between the cells and tissues of the kidney) or necrotizing vasculitis (inflamed **blood vessels**).

Cardiovascular and volume status. Evaluating the condition of the heart and the rest of the circulatory system plus volume status (**fluid balance**) is the most important part of diagnosing and managing AKF. Nurses and nurses' aides will measure and chart daily intake and

output (measuring how much fluid the patient takes in and how much he or she excretes in a 24-hour period of time). This is one of the best ways to get a good estimate of volume status. The pulse rate and blood pressure will be taken by the physician, nurses, and nurses' aides often in both the upright (standing or sitting on the side of the bed with legs dangling down) and supine (lying down) positions. The physician will also check the pulse in the neck, examine the heart and **lungs**, and check for edema (fluid buildup) in the arms and legs. Different combinations of the results of these assessments point to different causes for and types of AKF.

Abdomen. The physician will feel for signs of urinary tract obstruction by palpating (pressing) on the bladder and the upper corners of the abdomen that may reveal an obstruction in the ureter (tube between the kidney and the bladder) somewhere. If the entire abdomen is unusually swollen and filled with fluid (ascites), the AKF may be the result of liver failure.

Arms and legs (extremities). The physician and nursing staff will check the patients arms and legs for edema at the time of diagnosis and throughout treatment. Edema in the arms and legs is a sign of a decrease in oxygenated blood (ischemia), muscle tenderness from rhabdomyolysis (disease of the skeletal muscle), or arthritis. The presence and degree of edema is helpful in pinpointing the cause of AKF and in measuring the patient's progress with treatment.

Nervous system. The physician will assess the patient's degree of mental clarity and nerve responses, as abnormalities in these areas of the nervous system are often common symptoms of AKF. The nursing staff also monitors the patient's mental status during the course of treatment.

Laboratory personnel will draw blood and collect urine samples to help diagnose AKF and later, to evaluate treatment. Increases in BUN (blood urea nitrogen) and creatinine (substance formed from the **metabolism** of creatine) are indicators of AKF.

The **urinalysis** is the most important test run in the early stage of AKF evaluation. Significant color changes point to an intrinsic cause for AKF. Urine dipstick tests that prove positive for proteinuria (too much protein) and blood are helpful in diagnosing many causes of AKF. The different types of sediment readings from spun urine samples can further help to distinguish the cause and type of AKF. Urine electrolytes indicate how well the tubules (part of the kidney's nephron) are working.

Nurses and nurses' aides will keep track of fluids the patient takes in (intake) and eliminates (output) to help determine the type of AKF the patient is in and to help the physician manage the patient's course of treatment.

Fluid management is critical in the patient with AKF, regardless of the cause.

Patients in AKF may undergo further evaluation in the Radiology Department to determine the cause of their disease and to plan an appropriate plan of treatment. They may undergo an ultrasound examination, doppler scan, nuclear scan, MRI, renal **angiography**, or a renal biopsy. The ultrasound, doppler scan, and MRI are the least invasive of the procedures. Contrast material is injected for the angiogram and the renal biopsy requires taking tissue samples from the kidney itself. These procedures are performed by trained and licensed radiologic technologists and radiologists.

Nutrition is crucial to the effective management of the patient in AKF. The dietician will work closely with the patient, physician, nursing staff, and pharmacist to ensure proper **electrolyte balance**, whether the patient eats regular foods or is nourished by total **parenteral nutrition** (TPN, nutrients mixed and fed through a tube).

Some patients will require **kidney dialysis** that will be performed by nurses and technicians from the renal or urology department.

Since many different medications are eliminated through the kidneys, the physician works closely with the pharmacist to modify dosing and minimize the use of medications that are toxic to the kidneys.

Prevention

Since AKF can be caused by many things, prevention is difficult. Medications that may impair kidney function should be given cautiously. Patients with pre-existing kidney conditions who are hospitalized for other illnesses or injuries should be carefully monitored for kidney failure complications. Treatments and procedures that may put them at risk for kidney failure (like diagnostic tests requiring radiocontrast agents or dyes) should be used with extreme caution.

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<<http://www.niddk.nih.gov>>.

National Kidney Foundation (NKF). 30 East 33rd St., New York, NY 10016. (800) 622-9020.
<<http://www.kidney.org>>.

Susan Joanne Cadwallader

Acute leukemias *see* **Leukemias, acute**

ADA *see* **Americans with Disabilities Act**

ADL evaluation *see* **Activities of daily living evaluation**

Administration of medication

Purpose

The administration of medication is often a chief responsibility of the nurse. The practice of administering

medication involves providing the patient with a substance prescribed and intended for the diagnosis, treatment, or prevention of a medical illness or condition.

Description

The central action of medication administration involves actual and complete conveyance of a medication to the patient. However, there is a wider set of practices required to achieve safe, effective patient outcomes and to prepare for and evaluate the outcome of medication administration.

Laws regarding medication administration vary from state to state. Doctors, physicians, physician assistants, nurse practitioners, and nurses are generally trained and authorized to administer medication, while other medical disciplines may have a limited responsibility in this area. In certain circumstances, unlicensed personnel may be trained and authorized to administer medication in residential care settings. State and federal laws also restrict the distribution of and access to medications that can be abused (called controlled substances). Responsibility for controlled substances includes accountability for any discarded substances, double-locked storage, and counting of medication supply at regular intervals by clinician teams.

Preparation for medication administration begins with the order for medication, in most circumstances written by the physician. Nurse practitioners and physician assistants are also often authorized to write prescriptions. State laws vary regarding these privileges. A record of orders for medication and other treatments is kept in the medical chart. Universally accepted safe clinical practice guidelines and state laws govern the components of medication orders in order to ensure consistency and patient safety. All orders should contain the patient's name, the date and time when the order is written, and the signature of the ordering clinician. Caregivers administering medication are responsible for checking that these components are present and clear. The name of the medication is accompanied by the dosage, or how much of the drug should be given; the route of administration, or how the medication should be given (ie, **intramuscular injection**); and frequency, or how often the drug is to be given. Common routes of administration are discussed below.

The most common route of administration is the oral route, or swallowing of medication. This is the easiest and safest route. The physical position and swallowing abilities of the patient should be evaluated to avoid choking. Patients may also receive medication by the buccal route (through the inner cheek or gum) or the sublingual route (under the tongue).

Administration involving a needle or syringe occurs with several drug routes. These routes are referred to as parenteral. Care must be taken to maintain asepsis with all injections and injection sites. Intramuscular medications are injected into the muscle. A special injection technique called Z-track can be used when administering intramuscular medications that can be damaging to the tissue. All intramuscular injections involve the practice of landmarking, or identifying anatomical markers that indicate the correct injection site and avoid damage to bone or nerves. Subcutaneous injections are administered under the skin. Insulin is a common medication that is usually given subcutaneously. Intradermal medications are used much less frequently than subcutaneous or intramuscular injections. They are injected into the skin. Intravenous medications are given through an intravenous line into the vein. These medications may be mixed with a large amount of solution that is being infused, given in a small solution through a port in the intravenous tubing (bolus), or attached in smaller infusion containers to the larger infusion (piggyback). In all cases of administration with a needle or syringe, rotation of injection sites is required to prevent damage to tissue. It is also important that the size of the needle is selected based on the thickness of the medication to be given and the depth of the injection, while maximizing the patient's level of comfort during insertion. Needle sticks with contaminated needles are a hazard to both health professional and patient. Care is taken to dispose of needles and syringes rapidly in impervious containers. Protective systems that sheath the needle after use are commonly used to prevent inadvertent needle sticks.

Medication can also be instilled via the mucous membranes. Asepsis must be used to avoid introduction of **infection**. Rectal or vaginal medications are most often given in suppository form and must be introduced gently to avoid tearing or bleeding of tissue. Nasal medications are often instilled via spray or drops and often involve closing one nostril and asking the patient to inhale gently. The head should be tilted back to avoid aspiration. Ear or otic medications are given in liquid form. The patient's head is tilted to the side. Instruments should never enter the ear. If the medication is not instilled correctly, the patient may experience nausea or vertigo. Eye or ophthalmic medications may be given via drops or ointment. The container for the medication should not touch the eye, and drops are introduced into the inner canthus or corner of the eye.

Inhalational medications are inhaled via the respiratory tract, most often to treat respiratory conditions. Metered dose inhalers (MDI) are often used. MDIs involve pressing a specially designed canister to release a mist.



An anesthesiologist administers drugs to a patient in surgery. (Photograph by Michelle del Guercio. Science Source/Photo Researchers. Reproduced by permission.)

Topical medications are applied to the surface of the skin. The skin needs to be cleansed and assessed for breaks before administering topical medications. Topical patches that gradually release medication need to be labeled with date and time in case a second patch is inadvertently applied without removal of the first. Ointments are applied evenly. The clinician should avoid touching the topical medication, as medications that are absorbed into the system via the skin, such as nitroglycerin paste, may affect the clinician. As with all medication techniques, asepsis must be maintained to avoid introduction of microorganisms.

Frequency of administration is most often ordered on a repeating schedule (ie, every 8 hours). At times the order may be written as a STAT (give right away) order, a one-time order (give just once) or a prn (give as needed) order. Standing orders are routine hospital orders that doctors in specialized areas prescribe on admission.

Many abbreviations are used in writing medication orders. Other common abbreviations include:

- p.o.: by mouth
- IM: intramuscular injection
- SC: subcutaneous injection
- IV: intravenous
- PR: per rectum
- h.s.: at hour of sleep (bedtime)
- ac: before meals
- pc: after meals
- q: every, ie, q 8 h means every 8 hours
- q.d.: every day
- b.i.d.: twice/day
- t.i.d.: three times/day
- q.i.d.: four times/day
- q.o.d.: every other day

Some examples of medication orders using these abbreviations are:

- digoxin 0.25 mg p.o. q.d.
- diphenhydramine 25 mg p.o. q h.s. prn.

If orders are illegible, ambiguous, or confusing, the author of the order should be consulted to clarify the order before any medication administration occurs. When the order is clear, it often needs to be transcribed to another document reserved for recording administration of medications. Health care institutions have specific policies regarding methods with which to check medication orders and ensure proper transcription. Policies also dictate parameters for order renewal or medication discontinuation. Poor penmanship, misunderstanding of penmanship, and errors in transcription often contribute to medication errors. It is increasingly common for medical facilities to use a computerized system that lowers the risk of error by reducing steps in the process and validating information automatically.

Once the order has been read and verified, the caregiver needs to evaluate the order in the context of the individual patient. Some factors to consider include:

- pharmacodynamics: how the drug works in the body
- interactions: possible effects of other medication or food on the ordered medication
- allergies: patient history of hypersensitivity to drug or drug class
- contraindications: medical conditions that preclude the use of the ordered drug
- side effects: potential adverse reactions to the drug

- toxic effects: dangerous effects that often occur due to build up of drug in body or impaired metabolism
- tolerance: certain drugs require increasing doses over time to achieve the same effect
- physiological variables: sex, age, size, and physical condition may alter how a drug is processed in the body
- diet: certain foods, liquids, or nutritional states may alter the drug's effect on the body

Due to the large number of medications available and the large body of information required for appropriate drug administration, it is important to have access to a current medication reference such as the *Physician's Desk Reference* or other reference handbooks about medication. The package insert that comes with every medication is also a good resource. Pharmacists are knowledgeable resources and can answer many questions regarding medication. It is important to be familiar with the medication ordered before attempting to administer it. Procedural manuals by the institution or medical reference publishers detail the step-by-step techniques for administering various types of medication.

The patient should be notified of the order for the drug and provided with education about the medication they are to receive. Before administration, five factors often referred to as the "five rights" should be addressed. Medication records should be on hand at time of administration to ensure safe administration.

Right patient. Identify patient by name badge or bracelet. Avoid simply asking patient's name or checking the name on the door as miscommunications can sometimes occur.

Right drug. Check record for name of drug and compare with drug on hand. As many drugs have similar spellings, this needs to be checked carefully. For prevention of error, it is often recommended that three checks of the drug to be administered are made: when reaching for the package that contains the drug, when opening the drug, and when returning the packaging to its storage area. It is also recommended that clinicians only administer drugs that they have prepared, versus those prepared by another clinician.

Right route. Check medication record for how to administer the drug and check labeling of drug to ensure it matches prescribed route.

Right dose. Compare ordered dose to dose on hand. At times, calculations may need to be performed to ascertain the correct dose. For example, a scored tablet, or one that is designed and intended for dividing, may need to be halved or quartered in order to administer the correct oral dose. This requires simple division. Common situations requiring calculation include calculation of intravenous

infusion rates and the conversion of measurement units, for example, determining how many milliliters (mL) are required to give the ordered number of milligrams.

The formula for this calculation can be applied to many situations:

- dose ordered/dose on hand x amount on hand = amount to administer

Using the above medication question, 25 mg /100 mg x 2 ml = 0.5 ml (amount to administer)

Intravenous medications also require frequent calculation. For example, an intravenous anticoagulant such as heparin may be ordered as “1000 units per hour,” and the clinician may need to calculate how many drops are needed per minute or hour based on how the intravenous solution is prepared. These calculations may vary according to the infusion equipment used, for example, varying drop factor ratings or use of a device called a buretrol that carefully measures infused medication. Often a mechanical pump is used to control intravenous infusion rates.

Right time. Verify that frequency or time ordered matches current time.

All medications should be handled to ensure that they do not come into contact with potentially contaminated objects or surfaces. Medications of any sort should not be left unattended, and patients should be observed taking the medication. This avoids the disposal, hoarding, abuse, or misuse of the medication, and assures the safety of the patient.

Documentation of medication administration is an important responsibility. The medication record tells the story of what substances the patient has received and when. Like other health care records, it is also a legal document. Various institutions have policies and procedures regarding documentation. The initials of the administering nurse or other health care provider and the time and date should be documented on the record next to the appropriate order. Other information may be required, such as location and severity of **pain** when administering a pain medicine (analgesic) or pulse rate when administering certain **heart** medications (i.e., digoxin). Patient refusals of medication also need to be documented, and the prescribing clinician should be informed.

Medication errors need to be documented as well. The prescribing clinician should be notified of errors. Institutional policies usually require filing a separate form to document errors. Errors can include administering the wrong drug, wrong dose, at the wrong time, or via the wrong route. Omissions of medication are also considered errors.

It is important to evaluate the patient following medication administration and document effect. For example, many hospitals dictate that a note be written regarding pain relief within several hours after analgesic administration. Any adverse effects from medication should be reported.

Preparation

Preparation for safe medication administration requires a background of education and hands-on training. New nurses and other professionals should be supervised until they demonstrate an appropriate level of knowledge and competent skills for independent medication administration.

Aftercare

The patient should be monitored to make sure the medication has had the desired effect.

Health care team roles

In addition to the clinician who administers medication, other members of the health care team play vital roles surrounding the medication administration process. Doctors or other prescribing clinicians are responsible for writing clear, legible orders and for monitoring the response of the patient to medication. They are also responsible for responding to potential adverse effects and concerns by the patient or other clinicians. Pharmacists are responsible for evaluating the medication order for potential problems, correctly filling the order, and monitoring the medication supply. All health care professionals are responsible for complying with medication-related policies designed to protect the patient and/or staff and for maintaining current knowledge regarding medication and medication administration.

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Katherine Hauswirth, APRN

Administering medicine to the ear see **Ear instillation**

Administering medicine to the eye see

Eyedrop instillation

Administering medicine to the nose see

Nasal instillation

Administering medicine to the rectum see

Rectal medication administration

Administering medicine to the vagina see

Vaginal medicine administration

Administering medicine under the tongue see **Sublingual and buccal medication administration**

Adolescent nutrition

Definition

Adolescence is a time of increased growth and development, in which a greater need for nutrients coincides with a change in food habits that also influences nutritional needs. Due to differences in body type, physical activity, and rate of growth, every adolescent has different nutritional needs.

Purpose

It is important to meet such needs during adolescence or ramifications may extend into adulthood. For instance, because bone mass is accumulated through young adulthood and slows dramatically thereafter, inadequate **calcium** intake may lead to weaker bones throughout life.

Precautions

During adolescence, bodies are rapidly changing and growing, which often causes teens to feel uncomfortable with themselves, especially if they are different from their peers. Teenagers are more likely to miss meals. Emotional distress may cause them to either eat too much or too little and use diet pills or supplements. Such patterns can lead to the development of eating disorders, which are characterized by unhealthy eating behaviors including starvation, induced vomiting, overusing **laxatives**, and overeating. Eating disorders usually begin between ages 14 and 20 and are estimated to be the third most common chronic disorder among adolescents. It is important to provide early intervention to avoid serious long-term complications.

Description

Due to variation in physical activity, **metabolism**, and growth rate, the nutritional needs of adolescents vary from person to person, and should be based on individual needs. However, general recommendations for adolescents can provide guidance. Caloric needs are usually based on the growth rate and level of **exercise** and should average between 2,200 and 3,000 calories per day. Protein needs are based on height. To determine individual needs, divide the RDA total of protein by the individual's height in centimeters. The average is about 0.3 gm/cm of height. Mineral needs increase during adolescence, especially for calcium and **iron**. Recommended intake of calcium is 1,300 milligrams (mg) per day; iron requirements are about 10-12 mg for males and 15 mg for females. **Zinc**, which is needed for growth and sexual development, is also needed in adequate amounts. Requirements for zinc are 15 mg for males and 12 mg for females. Vitamin needs increase during adolescence and the need for supplementation can be avoided by providing a well-balanced diet.

Complications

Adolescents may also have special needs, such as chronic illness, substance abuse problems, and **pregnancy**. Drug abuse often interferes with adequate food choices, but the effects of drugs greatly depends on the substance, amount, and the nutritional status of the adolescent. Adolescents with chronic illness may have increased or decreased needs based on individual circumstances. Pregnant teenagers have increased needs, because they are still growing and developing themselves.

Results

Poor **nutrition** in adolescence can have important health consequences in adulthood. **Obesity** and excessive fat intake increases the likelihood of being an overweight adult and puts the individual at risk for cardiovascular disease and other health problems. Substituting sodas and fruit juices for milk at this time of rapid growth and bone-building may lead to **osteoporosis** and bone **fractures** during later years. Too much sugar in the diet causes cavities. A diet heavily dependent on fast food results in decreased energy intake, excess fat and sodium, and a deficiency of calcium, riboflavin, **vitamin A**, **follic acid**, and fiber.

A healthy diet in adolescence promotes adequate growth and sexual maturity. A decreased risk of cavities, as well as **hypertension** and hyperlipidemias in older years, is closely correlated with adequate nutrition during adolescence.

Health care team roles

Dietitians play an important role in educating teenagers about eating well-balanced diets to receive the proper amounts of all the nutrients. When complications such as eating disorders are present, dietitians can also provide the nutritional information necessary to treat the disorder. However, psychologists and other mental health professionals should be consulted to assess the mental and emotional status of the individual.

Resources

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Lisa M. Gourley

Adrenal glands

Definition

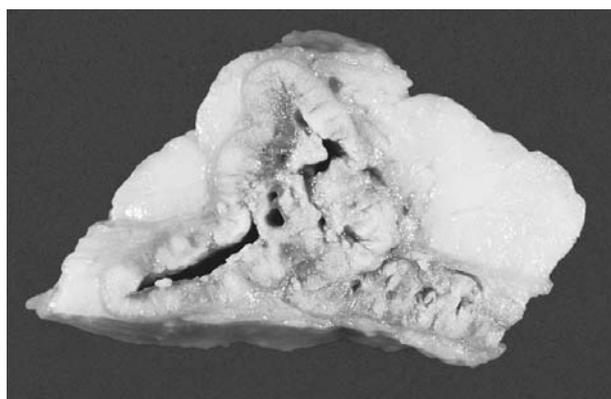
Adrenal glands produce and release several different hormones that maintain internal fluid levels, maintain sodium and potassium levels, and mediate the **stress** response.

Description

The human body contains two adrenal glands, one on top of each kidney. The gland is triangular in shape and yellowish in appearance. Subdivisions include the adrenal cortex and the medulla. The cortex is the outer layer and is responsible for the production of steroid hormones called glucocorticoids, mineralcorticoids, and androgens. The medulla forms the inner layer of the adrenal glands and releases norepinephrine and epinephrine (known commonly as noradrenaline and adrenaline) directly into the bloodstream. The adrenal cortex and medulla serve very different functions in the human body because of the different hormones that they produce and release.

Function

The adrenal cortex converts cholesterol into glucocorticoids, mineralcorticoids, and androgens. The glucocorticoids are so named due to their role in regulating body glucose levels. The major glucocorticoid produced



Cross section of human adrenal gland (triangular shape).
(Photograph by Martin M. Rotker. Phototake NYC. Reproduced by permission.)

by the adrenal is cortisol. Cortisol is also known as the stress hormone because the body releases cortisol in order to help cope with stressful situations. The immediate effects of cortisol are to increase levels of fatty acids, **proteins**, and glucose in the **blood**. Cortisol causes these increases by taking protein from muscles, fatty acids from fatty tissues, increasing gluconeogenesis (the process of making glucose), and decreasing the body's uses of glucose. Thus, in Cushing's syndrome (hyper-cortisolism), patients may experience muscle wasting (too much protein is taken from the muscles). Paradoxically, although cortisol increases the levels of free fatty acids, patients with too much cortisol over a long period of time experience an increase in fat on the upper body.

Cortisol and other glucocorticoids are also potent inhibitors of the **immune system**. Thus, it is not too surprising that synthetic glucocorticoids, like prednisone, are used to treat autoimmune diseases and allergies—diseases in which the immune system is too active. The release of cortisol is under the control of the anterior pituitary. The anterior pituitary accomplishes this by releasing the peptide hormone, adrenocorticotropin (ACTH) onto the adrenal gland.

The mineralcorticoids are so named due to their role in establishing mineral and water levels in the body. The major mineralcorticoid produced by the adrenal gland is aldosterone (although the glucocorticoid cortisol has some mineralcorticoid activity). The primary role of aldosterone is to regulate the balance of potassium, sodium, and water by affecting the absorption of all three in the kidney. Briefly, aldosterone causes the kidney to reabsorb more water and sodium, while causing potassium to be excreted in exchange for the sodium. When too much aldosterone is produced by the adrenal glands, as in primary aldosteronism, the level of potassium in the

KEY TERMS

Adrenal cortex—Outer layer of the adrenal gland that produces steroid hormones.

Adrenal medulla—Inner layer of the adrenal gland that releases adrenaline.

Androgens—Male sex hormones.

Hyperkalemia—An abnormally high level of potassium in the blood.

Hypokalemia—An abnormally low level of potassium in the blood.

Hypovolemia—An abnormally low volume of blood.

Glucocorticoid—A steroid hormone, like cortisol, that affects fat, carbohydrate, and protein levels in the blood as well as regulating the immune response.

Mineralcorticoid—A steroid hormone, like aldosterone, that regulates the excretion of salt, potassium, and water.

blood is low (hypokalemia) and the retention of sodium and water is high. Patients can experience **hypertension** and muscle weakness.

When there is too little aldosterone, potassium levels are high and there are extreme water and sodium losses. The loss of water and increased potassium levels can lead to extremely low **blood pressure** and death. A disease that might result in a loss of mineralcorticoid function is Addison's disease. In Addison's disease, the adrenals are usually at least 90% decimated before symptoms arise. The peptide, angiotensin II, and potassium levels are the main control for the release of aldosterone from the adrenals.

The adrenal glands also secrete small amounts of androgens such as testosterone. However, in the adult, that amount of androgens produced from a normally functioning adrenal gland is so small that it is unlikely to have a major effect. Nevertheless, pathology of the adrenals may result in abnormally high levels of androgens being secreted. The androgens may cause masculinization in males or females.

The adrenal medulla is really an extension of the sympathetic division of the **autonomic nervous system**. The sympathetic nervous system mediates "fight or flight" responses to environmental stimuli. Sympathetic nerves that originate in the **spinal cord** release the neu-

rotransmitter, acetylcholine, onto the adrenal glands. The adrenal glands respond by releasing dopamine, norepinephrine, and epinephrine directly into the bloodstream. Norepinephrine and epinephrine are commonly referred to as noradrenaline and adrenaline, respectively. Epinephrine makes up the majority of the substance secreted by the adrenal medulla. Circulating norepinephrine and epinephrine can increase **heart rate**, constrict **blood vessels**, dilate eye pupils, inhibit motility and digestion in the **stomach** and intestines, increase sweating, increase **metabolism**, and increase breathing. The adrenal medulla is stimulated to release norepinephrine and epinephrine under stressful situations such as **exercise** or emotional distress.

Role in human health

Thus, the adrenal glands play a significant role in mental and physical health. Not only are the adrenal glands vital for maintaining a proper balance of sodium and potassium, they mediate the body's response to stress, both short-term and long-term. In response to immediate stress, the adrenal glands produce epinephrine, norepinephrine, and the hormone cortisol. The body is prepared for flight or fight, and energy is made available for instant use. In the long term, the adrenal glands may have a negative impact on human health. Prolonged stress can produce undesirable changes in the body that range from immune system depression to fertility complications.

Diseases and disorders

Addison's disease

Addison's disease arises from a hypoactive adrenal cortex. The adrenal cortex fails to produce adequate amounts of the glucocorticoid cortisol, and sometimes the mineralcorticoid aldosterone. A lack of aldosterone causes the **kidneys** to excrete excess sodium and water while retaining potassium. This can lead to hyperkalemia (high levels of potassium), hypovolemia (low blood volume), and hypotension (low blood pressure). Hyperkalemia may cause fatal heart arrhythmias, and (severe) hypovolemia can lead to **shock** and kidney failure. Common symptoms include frequent urination, **dehydration**, fatigue, dizziness, skin discoloration, nausea, vomiting, weakness, and cold intolerance. Treatment includes oral or intravenous glucocorticoids such as prednisone, and, if necessary, administration of the oral mineralcorticoid fludrocortisone acetate to replace aldosterone. The cause of Addison's disease is not known, but in 80% of the cases there is a wasting or atrophy of the adrenal cortex.

Primary aldosteronism

Conn's syndrome is also known as primary aldosteronism. In this disease, too much of the mineralcorticoid, aldosterone, is made by the adrenal glands. The increased levels of aldosterone cause excessive potassium excretion while promoting excessive sodium and water retention. This leads to hypertension (high blood pressure) and hypokalemia (low serum potassium). Hypokalemia is an important diagnostic clue in the process of differentiating primary aldosteronism from other similar disorders. In some cases, Conn's syndrome is due to an adrenal tumor, in which case it may be surgically removed. In other cases, the diuretic drugs, spironalactone or amiloride, are given to block the effects of aldosterone.

Cushing's syndrome

The adrenal cortex is overactive in Cushing's syndrome. The adrenal cortex overproduces glucocorticoids, which can lead to high blood sugar levels and high blood pressure. Symptoms include **obesity**, muscle wasting, fatigue, irritability, excessive hair growth in women, irregular menstrual cycles, and decreased male fertility. A tumor of the adrenal gland, or an overproduction of ACTH by the pituitary, may cause Cushing's syndrome. Treatment may include **chemotherapy** or hormone-inhibiting medications.

Pheochromocytoma

Pheochromocytomas are tumors of the adrenal glands that secrete large quantities of norepinephrine and epinephrine. The most common symptom is extremely high blood pressure. Treatment is usually surgical removal of the tumor.

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ORGANIZATIONS

National Adrenal Diseases Foundation. 505 Northern Blvd, Great Neck, NY 11021. (516) 487-4992.
<<http://medhlp.netusa.net/nadf/>>.

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Adrenocortical hormone tests

Definition

Adrenocortical hormone tests measure levels of aldosterone and cortisol (also known as hydrocortisone) in **blood** and urine. These hormones are synthesized from cholesterol by the action of several enzymes. The cells responsible are located in the outer part (cortex) of the **adrenal glands**, two small organs, one sitting just above each kidney. As steroid hormones, they are an important part of the body's **endocrine system** and help to regulate body functions. The adrenal cortex also produces many other steroid hormones including androgens, primarily dehydroepiandrosterone (DHEA) and androstenedione, that are converted to testosterone and dihydrotestosterone.

Aldosterone, a mineralcorticoid, helps regulate the amounts of sodium and potassium in the blood and, because fluid follows sodium, helps maintain **fluid balance** and blood volume, which, in turn, affect **blood pressure**.

Cortisol, a glucocorticoid, helps regulate the **metabolism of proteins, fats, and carbohydrates**, especially glucose (sugar). Specifically, cortisol helps convert amino acids (subunits of proteins) into glucose within the **liver**. It raises blood sugar levels by stimulating the release of glucose from cellular glucose stores and simultaneously acts to inhibit insulin, which moderates glucose transport into the cells. Cortisol also has a number of anti-inflammatory effects, including suppressing the **immune system** and reducing **fever**.

Purpose

Aldosterone measurement is used to detect aldosteronism (hyperaldosteronism), which is the excess secretion of the hormone by the adrenal glands. It is also used to detect those cases of hypoaldosteronism that occur in the absence of a low cortisol.

The cortisol test is performed on patients who are suspected to have malfunctioning adrenal glands. It is considered to be the best indicator of adrenal activity. Blood and urine cortisol measurements, together with the determination of ACTH levels, are the three most important tests in the investigation of Cushing's syndrome (overproduction of cortisol) and Addison's disease (underproduction of cortisol). Additional tests called simulation and suppression tests may be needed to detect disease in difficult cases, or to distinguish between the causes.

Precautions

Adrenocortical function tests may be done on serum or urine. The nurse or phlebotomist performing venipuncture should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. Cortisol levels in blood are subject to diurnal variation. Test results must be evaluated with regard to the time of day the blood was collected. Physicians will determine if patients whose fluid balance may already be compromised by illness can undergo 24-hour urine tests. Physicians will also determine if patients can discontinue taking drugs that control sodium and potassium levels and fluid balance prior to testing. These tests are sometimes performed by a method called radioimmunoassay (RIA) that tags test reagents with radioactive iodide. RIA based tests may be contraindicated for patients who have had recent procedures using radiation or who have had radioactive drugs administered, because results may be altered and unreliable.

Description

Aldosterone

Aldosterone is produced by the outer area of the adrenal cortex called the zona glomerulosa. Aldosteronism, an increased secretion of aldosterone, can be primary (a malfunction in the adrenal glands or in aldosterone secretion itself) or secondary (caused by another condition). Excessive aldosterone production results in the retention of sodium, and subsequently in fluid retention and high blood pressure (**hypertension**). Because potassium can be lost in this process, muscle weakness is also a frequent symptom. Primary aldosteronism is most often caused by an adrenal tumor (adenoma) a condition referred to as Conn's syndrome. Primary aldosteronism can also be idiopathic (of unknown origin) or congenital. Secondary aldosteronism is more common and occurs as a consequence of non-adrenal conditions characterized by severe imbalances in sodium and potassium with resulting fluid imbalance, such as congestive **heart failure**, cirrhosis (liver disease) with fluid in the abdominal cavity (ascites), certain kidney diseases, excess potassium (hyperkalemia), a sodium-depleted diet, and the toxemia of **pregnancy**. To differentiate primary aldosteronism from secondary aldosteronism, a plasma renin test should be performed at the same time as the aldosterone assay. Renin, an enzyme produced in the **kidneys**, is typically elevated in secondary aldosteronism and reduced in primary aldosteronism.

Hypoaldosteronism is characterized by low serum sodium, **dehydration**, and high serum potassium (hyperkalemia). Hypoaldosteronism can occur in Addison's dis-

ease, which usually is caused by autoimmune damage to the adrenal cortex. Addison's disease is marked by decreased glucocorticoids and is detected by tests for deficient cortisol production. However, hypoaldosteronism may also occur in the absence of low glucocorticoids. This condition may result from decreased renin production by the kidney, heparin treatment, and a deficiency of an enzyme needed to produce aldosterone. In such cases, serum aldosterone and **plasma renin activity** must be measured to establish the diagnosis.

Cortisol

Cortisol and the other glucocorticoid hormones are produced in the zona fasciculata and reticularis of the cortex. Overproduction of glucocorticoids (cortisol) by the adrenal cortex is called Cushing's syndrome. Excessive cortisol production leads to high blood glucose levels, sodium retention, **obesity**, and excessive hair growth. Because cortisol production can suppress the immune system, excess levels may also cause chronic **infection** in some patients.

The release of cortisol is controlled by circulating levels of a pituitary hormone, adrenocorticotrophic hormone (ACTH). In a complex process, the hypothalamus manufactures corticotropin-releasing hormone (CRH), which, in turn, stimulates the **pituitary gland** to produce ACTH. While ACTH stimulates the adrenal glands to produce cortisol, rising levels of cortisol act by negative feedback to inhibit further production of CRH and ACTH. Disturbances in this elaborate feedback mechanism can be caused by certain types of **stress**, such as physical trauma, infection, extreme heat or cold, exhaustion from strenuous **exercise**, and extreme **anxiety**. When normal feedback becomes uncoordinated as a result of one of these conditions, excessive amounts of ACTH and, in turn, cortisol will be released. For this reason, cortisol levels in blood can vary considerably with time, a phenomenon called pulse variation.

Cushing's syndrome has four causes. The majority of cases result from the use of cortisol and related compounds for immunosuppression and treatment of inflammatory diseases. This is called iatrogenic hypercortisolism. The next most prevalent cause is Cushing's disease, also called pituitary Cushing's. This results from adenomas of the pituitary gland that secrete ACTH. Less commonly, Cushing's syndrome is caused by adrenal adenoma or carcinoma or by ACTH secreting tumors located outside the pituitary (ectopic ACTH).

Primary Addison's disease results from damage to the adrenal cortex. The most common causes are autoimmune disease and infection. Secondary Addison's disease is caused by a pituitary deficiency of ACTH. These two

conditions can often be differentiated by measuring both cortisol and ACTH. In primary Addison's disease the ACTH will usually be increased because the functional pituitary gland is responding to low blood levels of cortisol. In secondary Addison's disease, both cortisol and ACTH levels will be low.

Measurement

Cortisol is routinely measured by most laboratories. The most common method used is enzyme immunoassay. Aldosterone levels are far lower and require a more sensitive method, typically chemiluminescent immunoassay or radioimmunoassay. Measurement of cortisol intermediates such as 11-dexocortisol and 17-hydroxyprogesterone are used in conjunction with cortisol for the diagnosis of congenital adrenal hyperplasia. In this condition, an enzyme deficiency in the synthetic pathway of cortisol leads to low cortisol and accumulation of one or more steroid intermediates above the block. These compounds are measured by RIA. ACTH is typically measured by RIA because of its low concentration in plasma. Plasma renin is usually measured by determining the activity of the enzyme (renin activity) rather than by immunoassay of the hormone mass because the latter method measures both the active and inactive forms. In the assay, renin acts on angiotensinogen to produce angiotensin I, which is then measured by RIA.

Adrenocortical hormone tests are typically performed on blood plasma or 24-hour urine samples. When performed on blood, physicians may request that tests be performed on two samples, each drawn at a different time, to account for fluctuations in hormone levels at different times during the day (diurnal variation).

Tests for aldosterone are performed on blood plasma or on a 24-hour urine specimen. Levels of aldosterone peak in early morning and are at half that level by afternoon, making the time of drawing a blood sample significant. To help ensure a more reliable evaluation, two samples may be drawn for testing, one in early morning (8 AM) and one mid-afternoon (4 PM). Diet and posture (upright or lying down) may also cause aldosterone levels to fluctuate, so that a single blood sample may miss increased or decreased levels and may not accurately reflect hormone production. Because a 24-hour urine specimen reflects hormone production over an entire day, it will usually provide a more reliable aldosterone measurement. Elevated blood levels should ideally be confirmed with a 24-hour urine test.

Since posture and body position affect aldosterone production, hospitalized patients should remain in an upright position (at least sitting) for two hours before blood is drawn. Occasionally blood will be drawn before

Normal findings for aldosterone assay

Blood test

Supine	3–10 ng/dl (0.08–0.30 nmol/L)
Upright	
Adult female	5–30 ng/dl (0.14–0.80 nmol/L)
Adult male	6–22 ng/dl (0.17–0.61 nmol/L)
Newborn	5–60 ng/dl
1 week–1 year	1–160 ng dl
1–3 years	5–60 ng/dl
3–5 years	<5–80 ng/dl
5–7 years	5–70 ng/dl
7–11 years	<5–50 ng/dl
11–15 years	<5–50 ng/dl
24-hour urine test	2–80 µg/24 hr (5.5–72.0 nmol/24 hr)

SOURCE: Pagana, K.D. and T.J. Pagana. *Mosby's Diagnostic and Laboratory Test Reference*. 3rd ed. St. Louis: Mosby, 1997.

and after the patient gets out of bed. Nonhospitalized patients (outpatients) should arrive at the laboratory in time to maintain an upright position for at least two hours.

Cortisol can be measured in both blood plasma and urine. Blood levels of cortisol are most reliably measured in the morning at 8 AM, in the afternoon at 4 PM, or in the evening at 10 PM. Levels of cortisol normally peak in the morning and decline gradually during the day, reaching the lowest level in the early hours of the next day. It is important to note, however, that when the normal cycle of activity and sleep (circadian rhythm) is reversed, as in night-shift work, cortisol levels will reverse also. Physicians often order blood plasma cortisol rather than a 24-hour urine collection because the earliest sign of adrenal malfunction is sometimes the loss of diurnal variation, even though cortisol levels are not yet elevated. For example, individuals with Cushing's syndrome often exhibit peak plasma cortisol levels in the morning with no decline as the day progresses. Cortisol levels may also be elevated during pregnancy, in the presence of physical and emotional stress, and with the administration of certain drugs. A 24-hour urine test for cortisol will reflect cortisol production over the entire period of collection.

Cortisol is bound in the plasma by cortisol binding protein (transcortin) and other proteins such as albumin. Very little of the plasma cortisol is free, but when cortisol is produced in excess, the binding proteins become saturated, and excess free cortisol is excreted in the urine. Measurement of 24-hour urinary free cortisol is not influenced by serum binding protein levels and is not subject to the diurnal variation (pulse variation) seen with serum total cortisol measurements. Therefore, it is somewhat more sensitive than measurement of total

serum cortisol in detecting persons with Cushing's syndrome.

Both aldosterone and cortisol (and other hormones, such as adrenomedullary hormones) are sometimes measured with blood samples from the adrenal veins, particularly when the existence of a tumor is suspected and surgery may be an option. This procedure, called adrenal venography, is performed by an angiographer in the radiology department, although the cortisol test is still performed in the clinical laboratory. Testing adrenal vein samples helps confirm the presence of adrenal tumors by allowing blood to be drawn through a catheter from the right and left adrenal glands. High levels on one side will confirm the presence of a tumor on that side. Normal levels on both sides indicates a non-adrenal source for the patient's condition. This is a specialized rather than a standard sample collection procedure and preparation for the procedure is not discussed below.

Adrenocorticotrophic hormone (ACTH) test

Although difficult to measure, ACTH aids in the differential diagnosis of the cause of Cushing's syndrome and in distinguishing primary from secondary Addison's disease. Approximately half of persons with Cushing's disease (pituitary Cushing's) have a normal ACTH level and half will have an elevated level. Most persons with adrenal tumors will have low (less than 10 picograms/L) or undetectable ACTH in the plasma owing suppression by cortisol. Most persons with ectopic ACTH secreting tumors will have elevated levels in excess of 200 pg/L. Persons with primary Addison's disease will usually have high ACTH levels (greater than 150 picograms/L) caused by negative feedback (low cortisol) while those with secondary Addison's disease will have low or normal ACTH levels owing to pituitary failure or hypothalamic suppression.

Stimulation and suppression tests

Because measurement of cortisol may not be definitive for the diagnosis of Cushing's syndrome or Addison's disease, several stimulation and suppression tests are available. Some of these tests are used to establish a diagnosis while others are used to help distinguish the cause of the disease. The most commonly used suppression test for Cushing's syndrome is the dexamethasone suppression test. Dexamethasone is a powerful synthetic analog of cortisol and will normally inhibit the pituitary release of ACTH, and thus suppress cortisol secretion. In the low dose overnight dexamethasone suppression test 1 mg of dexamethasone is given orally at midnight and the 8 AM cortisol is measured. The cortisol level is suppressed in normals and will be less than 5

micrograms/dL. Persons with Cushing's syndrome will usually show no suppression and the plasma cortisol will be 10 micrograms/dL or higher. In the high dose overnight dexamethasone suppression test the patient is given 8 mg (other doses are sometimes used) of dexamethasone at midnight. A blood sample is collected at 8 AM and cortisol is measured. Persons with Cushing's disease show a suppression in cortisol production of at least 50% of their baseline (i.e., the initial cortisol level without the drug). Persons with adenoma or ectopic ACTH tumors remain unsuppressed. In addition to dexamethasone suppression tests, metyrapone stimulation tests and corticotropin releasing hormone (CRH) stimulation tests are sometimes used for difficult cases. The former measures the ACTH reserve of the pituitary gland and the latter measures the ACTH response to hypothalamic stimulation. Patients with Cushing's disease (pituitary Cushing's) usually have an exaggerated response (increased ACTH) to both tests. Persons with adenoma or ectopic ACTH tumors do not respond with increases over the baseline in either test.

A sensitive screening test for Addison's disease is the rapid Cosyntropin stimulation test. The patient's 8 AM cortisol is measured and followed by intravenous administration of 250 micrograms of synthetic ACTH. Plasma cortisol is measured at 30 and 60 minutes after administration of the drug. Normal individuals produce a twofold increase in the baseline ACTH level while persons with either primary or secondary Addison's disease show a subnormal response.

Preparation

Fasting is not required for aldosterone blood or urine tests. The patient should maintain a normal sodium diet (approximately 3 g/day) for at least two weeks before either test. The testing physician should decide if drugs that alter sodium, potassium, and fluid balance (e.g., diuretics, antihypertensives, steroids, oral contraceptives) should be withheld. The test will be more accurate if these are discontinued for a period of at least two weeks before the test. Renin inhibitors (e.g., propranolol) should not be taken one week before the test, unless permitted by the physician. The patient should avoid licorice for at least two weeks before the test, because of its aldosterone-like effect. Because strenuous exercise and stress can increase aldosterone levels, these should be avoided as well. Two blood samples are often drawn for aldosterone evaluation, one in the early morning and one mid-afternoon.

Fasting is not required for cortisol blood or urine tests, although cortisol levels may increase after a meal and patients should not eat for at least a two-hour period

KEY TERMS

Adrenal glands—The adrenal glands are paired triangular structures located immediately above and loosely attached to each kidney. The inner portion is called the adrenal medulla and the outer portion is called the adrenal cortex.

Adrenocortical hormones—Adrenocortical hormones are steroid hormones produced and released by the adrenal cortex. They are important in regulating certain body functions, especially fluid balance, blood pressure, and fat metabolism.

Adrenocorticotrophic hormone (ACTH)—ACTH is a pituitary hormone that directly controls the rate of release of cortisol and is also needed to maintain production of aldosterone by the adrenal glands.

Aldosterone—Aldosterone is a steroid hormone released by the adrenal cortex. It helps balance fluid levels and blood pressure by regulating the amounts of sodium and potassium in the blood.

Corticotropin-releasing hormone (CRH)—CRH is produced by the hypothalamus and, in a complex process, serves to stimulate the pituitary gland to produce ACTH.

Cortisol—Cortisol is a steroid hormone released by the adrenal cortex in response to stimulation by ACTH. It helps regulate the release of amino acids from muscles and convert them to glucose for use as energy. It releases fatty acids from body tissue for use as energy by muscles, allowing circulating glucose to be reserved for use by the brain.

Glucocorticoid—A glucocorticoid (cortisol) is released by the adrenal cortex to help regulate the release and utilization of glucose.

Hyperaldosteronism—Hyperaldosteronism, known also as aldosteronism, is the excess secretion of the hormone aldosterone by the adrenal glands. It may be caused by an adrenal tumor or may occur secondary to non-adrenal conditions such as congestive heart failure, cirrhosis of the liver, certain kidney diseases, excess potassium, a sodium-depleted diet, and toxemia of pregnancy.

Mineralcorticoid—A mineralcorticoid (aldosterone) is released by the adrenal cortex to help regulate mineral levels in the blood, especially sodium and potassium.

prior to testing. For cortisol tests on blood or urine, the testing physician may discontinue the patient's regular medications for up to two weeks prior to testing. Drugs that may increase levels of cortisol include estrogen, oral contraceptives, amphetamines, cortisone, and spironolactone (Aldactone). Drugs that may decrease cortisol levels include androgens, aminoglutethimide, betamethasone, and other steroid medications, as well as danazol, lithium, levodopa, metyrapone and phenytoin (Dilantin). The patient may eat a normal diet but must not eat for at least two hours before blood samples are drawn, since cortisol levels may rise after meals. Two blood samples are usually drawn for cortisol evaluation, one in the early morning and one mid-afternoon.

The clinical laboratory will provide instructions and containers for patients collecting their own 24-hour urine samples for the measurement of aldosterone or cortisol. Patients should be advised to avoid touching the preservative, if any, in the collection container. If the preservative comes in contact with the skin, the area should be rinsed with water immediately. Collection should begin in the morning on any day except Friday or Saturday to ensure that samples will be delivered to the laboratory on a work day. Urine samples must be refrigerated continuously in the patient's home or in the nursing facility. The

specimen should be delivered to the laboratory promptly at the end of the 24-hour period.

Aftercare

Following venipuncture for blood plasma hormone tests, the nurse or phlebotomist drawing the sample should inspect the venipuncture site to make sure that the wound has closed and no bleeding is present. The site should be covered with an adhesive bandage. There is no notable aftercare for patients undergoing 24-hour urine hormone tests. Patients can be reminded to resume foods and medications (according to the physician's orders) that were restricted prior to testing.

Complications

Complications for blood hormone tests are minimal, but may include slight bleeding from the venipuncture site, fainting or feeling lightheaded after venipuncture, or the development of a hematoma (blood accumulating under the puncture site). There are no complications for the urine test, although patients should be instructed to drink clear fluids regularly to maintain fluid balance while collecting the 24-hour urine specimen. Adrenal

venography used to obtain adrenal vein samples has many potential complications, including allergic reactions to iodinated dye used in the procedure, adrenal hemorrhage, blood clots, and infection. This procedure is usually reserved for pre-surgical patients with suspected adrenal tumors and is not discussed here in detail.

Results

Aldosterone

Normal results for the aldosterone assay are laboratory-specific and vary according to test methodology used and the source of the specimen. Blood plasma levels, urine levels, and adrenal vein levels will be different. Results will also vary between patients depending upon average sodium intake, time of day, source of specimen, age, sex, and posture. Reference ranges are shown below for radioimmunoassay, the most common assay method for aldosterone.

Reference ranges for blood plasma levels:

- Supine (lying down): 3-10 ng/dL.
- Upright (sitting for at least two hours): Female: 5-30ng/dL; Male: 6-22 ng/dL.

Reference ranges for urine: 2-80 micrograms/24 hr.

Abnormal results. Increased levels of aldosterone are found in Conn's disease (aldosterone-producing adrenal tumor), and in Bartter's syndrome (overexcretion of potassium, sodium, and chloride by the kidneys resulting in low blood levels of potassium and high blood levels of aldosterone and renin). Elevated levels are also seen in secondary aldosteronism (in primary conditions such as congestive **heart** failure, cirrhosis of the liver, certain kidney diseases, hyperkalemia, a sodium-depleted diet, and toxemia of pregnancy), stress, and malignant hypertension.

Decreased levels of aldosterone are found in aldosterone deficiency, steroid therapy, high-sodium diets, certain antihypertensive therapies, and Addison's disease (an autoimmune disorder also involving abnormal cortisol and ACTH levels).

Cortisol

Normal results for the cortisol assay are laboratory-specific and vary according to the test methodology used and the source of the specimen. Blood serum levels, urine levels, and adrenal vein levels will be different.

Reference ranges for blood serum levels:

- Adults (8 A.M.): 6-28 micrograms/dL; adults (4 P.M.): 2-12 mcg/dL.

- Child 1-6 years (8 A.M.): 3-21 mcg/dL; child 1-6 years (4 P.M.): 3-10 mcg/dL.
- Newborn: 1/24 mcg/dL.

Reference ranges for urine (free cortisol):

- Adult: 10-100 micrograms/24 hr.
- Adolescent: 5-55 mcg/24 hr.
- Child: 2-27 mcg/24 hr.

Abnormal results. Increased levels of cortisol are found in Cushing's syndrome, hyperthyroidism (excess thyroid activity), obesity, ACTH-producing tumors, pregnancy, and high levels of physical or emotional stress.

Decreased levels of cortisol are found in Addison's disease, conditions of hypothyroidism (reduced thyroid activity), and **hypopituitarism** (diminished pituitary activity).

Drugs that may increase the levels of cortisol include estrogen, oral contraceptives, amphetamines, cortisone, and spironolactone (Aldactone). Drugs that may decrease the levels of cortisol include androgens, aminoglutethimide, betamethasone, other steroid medications, danazol, lithium, levodopa, metyrapone, and phenytoin (Dilantin).

Health care team roles

The testing physician will typically instruct the patient about preparatory steps for adrenocortical hormone tests, making recommendations for diet and for discontinuing medications. A nurse or a phlebotomist will perform a venipuncture to obtain blood samples. The phlebotomist or nurse should mark the laboratory slip with the time each blood sample was drawn and indicate any medications the patient may be taking. Laboratories will provide containers for urine collection and should help ensure compliance by providing written instructions for 24-hour urine collection. Laboratory technologists or nursing staff interacting with the patient may gently question the patient at the time of the blood test or urine collection to make sure they have discontinued medications prior to the test according to their doctor's instructions. When the 24-hour urine collection is completed, health care providers may remind the patient to resume medications if the testing physician has instructed them to do so. Measurements of adrenal hormones are performed by clinical laboratory scientists/medical technologists. Results are interpreted by a physician. In most cases, an endocrinologist is usually consulted.

Patient education

Patients must be instructed regarding changes in medications or diet, sources of sodium in the diet, and

maintaining an upright position prior to testing. Outpatients who will be collecting their urine specimens at home should have written instructions for the 24-hour urine collection. Health care providers should also encourage the patient to drink clear fluids regularly throughout the urine collection process.

Training

Laboratory technologists performing adrenocortical hormone tests will have studied biochemistry, enabling them to understand the role of these hormones in the body and the chemical basis for expression of the hormones in body fluids. Hands-on clinical laboratory training will prepare technologists to perform radioimmunoassay or other methods of measuring aldosterone and cortisol in blood and urine. Nursing personnel responsible for patients undergoing hormone testing for will understand the critical nature of preparation for these tests and help to encourage patient compliance. They will note any areas of non-compliance and inform the testing physician. Laboratory and nursing staff will be responsible for noting abnormal results and calling them to the attention of physicians.

Resources

BOOKS

- Jacobs, David S. *Laboratory Test Handbook*, 4th ed. Hudson, Ohio: Lexi-Comp Inc., 1996.
- Pagana, Kathleen D. and Timothy J. *Manual of Diagnostic and Laboratory Tests*. St. Louis: Mosby, Inc., 1998.

ORGANIZATIONS

- American Nurses Association. 600 Maryland Ave. SW, Ste. 100 West, Washington, DC 20024. (800)274-4ANA. <<http://www.nursingworld.org>>.
- American Society of Clinical Pathologists. 2100 West Harrison St., Chicago, IL 60612 (312) 738-1336. <<http://www.ascp.org>>.

OTHER

- “Adreno Cortical Hyperfunction.” *Merck Manual Online*, 17th ed. Whitehouse Station, NJ.: Merck & Co., Inc. 2001. <<http://www.merck.com/pubs>>.
- “Adrenal Cortical Hypofunction.” *Merck Manual Online*, 17th ed. Whitehouse Station, NJ.: Merck & Co., Inc. 2001. <<http://www.merck.com/pubs>>.

L. Lee Culvert

Adrenocorticotrophic hormone test see
Pituitary hormone tests

Adrenomedullary hormone tests

Definition

Adrenomedullary hormone tests measure levels of the hormones epinephrine, norepinephrine, and dopamine found in **blood** and urine. This group of tests also includes urine tests for the catabolic products (break-down products) of these hormones, known alternately as metabolites. Epinephrine, norepinephrine, and dopamine, collectively called catecholamines, are manufactured by chromaffin cells in the medulla (center) of the **adrenal glands** and are derived from the amino acid tyrosine. They help ready the body for the “fight-or-flight” response, also known as the alarm reaction. When adrenomedullary hormones are released at times of **stress**, the **heart** beats stronger and faster, **blood pressure** rises, blood flow is increased to the **brain** and muscles, and the **liver** releases glucose (sugar) as energy the body can readily use. Simultaneously, the rate of breathing increases, airways in the **respiratory system** widen, and digestive activity slows. These reactions quickly direct more oxygen and fuel to the brain, heart, and **skeletal muscles**, the organs most active in responding to stress.

The adrenomedullary hormone tests (also called catecholamines, dopamine, norepinephrine, epinephrine, or adrenalin tests) may be performed on blood or urine specimens. Urine tests are also used to measure the metabolites vanillylmandelic acid (VMA), metanephrine and normetanephrine, and homovanillic acid (HVA). Catecholamines are released from the adrenal gland in pulses causing blood levels to be quite variable. Measurements of catecholamines and their metabolites in 24-hour urine samples are generally preferred because they are not subject to pulse variation.

Purpose

Only small amounts of adrenomedullary hormones are found in the urine of healthy people. Excessive levels may be secreted in conditions that affect hormone production, such as pheochromocytoma (a tumor of the chromaffin cells of the adrenal gland) and rare tumors of the nervous system (neuroblastomas, ganglioneuroblastomas, and ganglioneuromas). Elevated hormone levels often result in constant or intermittent high blood pressure (**hypertension**). Episodes of high blood pressure may be accompanied by symptoms such as headache, sweating, palpitations, and **anxiety**. The adrenomedullary hormone test can be ordered to help determine if high blood pressure is related to abnormal hormone secretion

and to either exclude a tumor as the underlying cause or to identify the type of tumor that may be increasing hormone levels.

Description

Adrenomedullary hormone tests are typically performed by medical technologists in the clinical laboratory on either blood plasma or 24-hour urine samples. If performed on blood, the test may require drawing one or two samples, depending on the physician's request. The objective may be to measure changes in adrenomedullary hormone production over a specific time period or in certain conditions, such as changes in temperature, posture, diet, or medications. The first blood sample will usually be drawn after the patient has been lying down in a warm, comfortable environment for at least 30 minutes. If a second sample is needed, the patient will be asked to stand for 10 minutes before the blood is drawn. Instead of a venipuncture, which can be stressful for the patient and can actually increase adrenomedullary hormone levels in the blood, a catheter (a small plastic tube-like device) may be inserted in a vein 24 hours in advance. This allows the blood sample to be collected without the stress of needle puncture at the time of the test.

Because blood levels of adrenomedullary hormones commonly go up and down in response to factors such as temperature, stress, postural change, diet, smoking, **obesity**, and certain drugs, abnormally high blood levels should be confirmed with a 24-hour urine test. It is also important to consider that hormone secretion from a tumor may not be steady, but may occur periodically during the day. Consequently, an elevation in hormone levels potentially could be missed if only the blood test is performed. By contrast, the urine test requires that all urine passed during a 24-hour period must be collected by the patient or a healthcare professional, ensuring that the urine specimen reflects hormone production over an entire day.

The recommended procedure for measuring catecholamines and their metabolites is chromatography. High-performance liquid chromatography with electrochemical detection (HPLC-EDC) or liquid chromatography with mass spectrometry detection (LC-MS) are both sensitive and specific and have the advantage of being able to measure epinephrine, norepinephrine, and dopamine simultaneously. HPLC-EDC is also the method of choice for simultaneous measurement of VMA and HVA, although this procedure requires different extraction and separation conditions than are used for catecholamines. VMA can also be measured by a column-diazo method that is free of interference from dietary vanillin. The VMA is extracted from the urine

and isolated on a silica gel column. The column is washed to remove interfering substances and the VMA is eluted and reacted with a diazonium salt to form a purple colored complex. Metanephrines are most often measured by HPLC-EDC or by gas chromatography-mass spectrometry. Immunoassay and radioenzymatic assays are also used for the measurement of catecholamines and metanephrines. These methods require enzymatic conversion to a derivative before measuring the catecholamine or metabolite.

Precautions

There are no notable precautions with either blood or urine tests for adrenomedullary hormones. Physicians will determine if restrictions for the tests are appropriate for patients being treated with medications for high blood pressure or heart disease. When blood is used, **universal precautions** should be followed for the prevention of transmission of bloodborne pathogens.

Preparation

Physicians will instruct patients to discontinue use of certain medications for up to two weeks before the test or will write orders to this effect for patients in nursing facilities. Drugs that may increase catecholamine levels include **caffeine**, nicotine, levodopa, lithium, amphetamine, clonidine, erythromycin, insulin, methyl dopa, tetracyclines, and nitroglycerin. Drugs that may decrease catecholamine levels include clonidine, imipramine, MAO inhibitors, phenothiazines, salicylates, and reserpine. The patient should fast (nothing to eat or drink) for 10 to 24 hours before the blood test and should cease smoking for 24 hours before testing. Other restrictions may be required either by individual physicians or by the laboratory, depending on the tests requested. Vigorous physical **exercise** and emotional stress should be avoided before the test to prevent alteration of test results by increasing secretions of epinephrine and norepinephrine.

The clinical laboratory will provide instructions and containers for patients collecting their own 24-hour urine samples. Catecholamines and their metabolites are rapidly degraded above pH 2.0. Therefore, 10 mL of 6N hydrochloric acid or concentrated sulfuric acid will be present in the container. Patients should be advised to avoid touching the preservative in the collection container. If the preservative comes in contact with the skin, the area should be rinsed with water immediately. Collection should begin in the morning on any day except Friday or Saturday to ensure that samples will be delivered to the laboratory on a work day. Urine samples must be refrigerated continuously in the patient's home or in the nurs-

ing facility. The specimen should be delivered to the laboratory promptly at the end of the 24-hour period.

Aftercare

Following venipuncture for blood plasma hormone tests, the laboratory technologist, nurse, or phlebotomist drawing the sample should inspect the venipuncture site to make sure that the wound has closed and no bleeding is present. The site should be covered with an adhesive bandage. There is no notable aftercare for patients undergoing 24-hour urine hormone tests. Patients can be reminded to resume foods and medications that were restricted prior to testing.

Complications

Complications from drawing blood are minimal and may include slight bleeding from the venipuncture site, fainting, or lightheadedness after the blood sample is drawn. Blood may accumulate under the puncture site (hematoma) if pressure is not applied to the site immediately after drawing blood. There are no complications for the urine test, although patients must avoid touching the preservative in the collection containers.

Results

Reference ranges are laboratory-specific and vary with age and according to the test methodology used. Normal values for blood and urine tests are different. High performance liquid chromatography (HPLC) is the most common test method. Other methods especially spectrophotometric and fluorometric determinations are less specific and give higher results. Urinary levels are influenced by renal function and it has become customary to report urinary catecholamines and their metabolites per gram of creatinine excreted especially when a random urine is used. Typical adult values for HPLC blood and urine tests follow.

Reference ranges for blood plasma hormone levels:

- Supine (lying down): Epinephrine less than 50 picograms per milliliter (pg/mL), norepinephrine less than 410 pg/mL, and dopamine less than 30 pg/mL.
- Standing: Values for blood specimens taken when the subject is standing are higher than the ranges for supine posture for epinephrine (less than 140 pg/mL) and norepinephrine (less than 1700 pg/mL), but not for dopamine.

Reference ranges for urine hormone levels:

- Epinephrine: 0.5 to 20 micrograms per 24 hours (mcg/24 hrs) or 0 to 20 micrograms per gram creatinine.

- Norepinephrine: 15 to 80 mcg/24 hrs or 0-45 mcg per gram creatinine.
- HVA: 65 to 400 mcg/24 hrs or 0 to 8 mg per gram creatinine.
- Total catecholamines: 14 to 110 mcg/24 hrs.
- VMA: 2 to 7 milligrams(mg)/24 hrs or 0 to 6 mg per gram creatinine.
- Metanephrine: 24 to 96 mcg/24 hrs or 0 to 300 mcg per gram creatinine.
- Normetanephrine: 75 to 375 mcg/24 hrs or 0 to 400 mcg per gram creatinine.

Elevated levels of the individual adrenomedullary hormones can indicate different conditions and/or causes, depending on which hormone or combination of hormones is elevated:

- Pheochromocytoma most commonly causes an increase in norepinephrine, metanephrines, and VMA although other catecholamines may also be increased. Measurement of 24-hour urinary metanephrines is considered the most sensitive test for this condition. When both metanephrines and VMA are used, the test approaches 100% in its clinical sensitivity. Neuroblastomas most frequently produce dopamine, norepinephrine, HVA, and VMA. HVA is the most specific marker since it is least likely to be increased in pheochromocytoma. The sensitivity with HVA alone is about 70%. The recommended initial tests for neuroblastoma includes both HVA and VMA to increase diagnostic sensitivity.
- Elevations of catecholamines and their metabolites are possible with, but do not directly confirm, thyroid disorders, low blood sugar (hypoglycemia), or heart disease.
- Electroshock therapy, or shock resulting from hemorrhage or exposure to toxins, can raise hormone levels.
- In the patient with normal or low baseline hormone levels, failure to show an increase in the sample taken after standing suggests an **autonomic nervous system** dysfunction (the division of the nervous system responsible for the automatic or unconscious regulation of internal body functioning).
- In the absence of a tumor or other clinical findings, elevated adrenomedullary hormones may indicate prolonged stress or acute anxiety. They may also be elevated during serious physical illness.

Health care team roles

A physician orders adrenomedullary hormone tests and will typically instruct the patient about preparatory

KEY TERMS

Catabolic—Catabolism and catabolic refer to the breakdown of complex substances in the body into simpler ones, which are called catabolic products.

Catecholamines—A collective term for the major adrenomedullary hormones epinephrine, norepinephrine, and dopamine. Catecholamines are known to be elevated in the presence of certain tumors, in severe stress, strenuous exercise, acute anxiety, and serious illness.

Dopamine—A precursor of epinephrine and norepinephrine. It is a neurotransmitter (transmits impulses between cells) primarily found in the brain.

Epinephrine—Also called adrenalin, is a naturally occurring hormone released by the medulla of the adrenal glands in response to signals from the sympathetic nervous system. These signals are triggered by stress, exercise, or by emotions such as fear.

Ganglioneuroma—A tumor composed of mature nerve cells.

Homovanillic acid (HVA)—A catabolic product or metabolite of the major adrenomedullary hormone dopamine.

Metanephrine—A catabolic product or metabolite of the adrenomedullary hormones epinephrine and norepinephrine.

Neuroblastoma—A rare tumor of the adrenal glands or sympathetic nervous system. Neuroblastomas can range from being benign (relatively harmless) to malignant.

Norepinephrine—A hormone secreted by nerve endings of the sympathetic nervous system and by the adrenal medulla. It is a neurotransmitter whose primary function is to help maintain constant blood pressure by stimulating certain blood vessels to constrict when blood pressure falls below normal.

Normetanephrine—A catabolic product or metabolite of the adrenomedullary hormone norepinephrine and epinephrine.

Pheochromocytoma—A tumor that originates from the overproduction of powerful adrenomedullary hormones by the chromaffin cells of the adrenal glands.

Vanillylmandelic acid—A product of catabolism of the adrenomedullary hormones metanephrine and normetanephrine.

steps required. A laboratory technologist, nurse, or a phlebotomist (someone specifically trained in venipuncture technique) will perform a venipuncture to obtain blood samples, collecting blood in a tube that contains anticoagulant. If two samples are drawn, this may take about 45 minutes. Health care providers may help encourage the patient to remain quiet and calm prior to the test and between the drawing of samples. Laboratories will provide containers for urine collection and should help ensure compliance by providing written instructions for 24-hour urine collection. Laboratory technologists or nursing staff interacting with the patient may gently question the patient at the time of the blood test or urine collection about fasting or about having discontinued the use of caffeine, nicotine, prohibited foods and medications prior to the test. Testing is performed by a clinical laboratory scientist/medical technologist.

Patient education

Because tests for adrenomedullary hormones are especially sensitive, patient compliance with restrictions is essential. It is important for outpatients undergoing the adrenomedullary hormone tests to receive written

instructions regarding dietary restrictions, changes in medications, and instructions for 24-hour urine collection. These instructions can be prepared by the laboratory and supplied to physicians and nursing units in health care facilities. Urine collection instructions should be written in a step-wise manner. Laboratory and nursing staff can explain each step, reminding the patient to refrigerate the urine at all times and deliver the container to the laboratory promptly at the end of the 24-hour period. Health care providers should also encourage the patient to drink clear fluids regularly throughout the urine collection process.

Training

Laboratory technologists performing adrenomedullary hormone tests will have undergone education and training in biochemistry, enabling them to understand the role of these hormones in the body and the chemical basis for expression of the hormones in body fluids. Hands-on clinical laboratory training will prepare technologists to perform HPLC or other methods of measuring adrenomedullary hormones in blood and urine. Nursing personnel responsible for patients undergoing testing for

adrenomedullary hormones must understand the critical nature of the preparation for these tests and help to encourage patient compliance. Laboratory and nursing staff will be responsible for noting abnormal results and calling them to the attention of physicians.

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L. Lee Culvert

Adult day care

Definition

Adult day care describes programs, services, and facilities intended to assist physically or mentally impaired adults who might otherwise require institutionalization, allowing them to remain in the community. It is generally considered an alternative to institutional long-term care and rehabilitation.

Description

There are two general types of adult day care programs—a medical model and a social model. The medical model provides comprehensive medical, therapeutic, and rehabilitation day treatment. The social model offers supervised activities, peer support, companionship, and recreation. Both models assist older adults and those with chronic conditions to remain as independent as possible, for as long as possible.

Programs organized along the medical model lines are often called adult day health care to distinguish them from social programs. Adult day health care programs

offer health services such as physician visits, nursing care, and podiatry, as well as rehabilitation services such as physical, occupational, and speech therapy in a secure environment. This model of adult day care is offered to clients with a variety of chronic medical conditions including:

- adults with **Alzheimer’s disease**, other dementias, or depression
- patients recovering from stroke or head or **spinal cord** injuries
- patients with chronic diseases such as diabetes or cardiovascular disease
- adults with developmental disabilities such as Down syndrome
- adults suffering from mental illnesses
- frail older adults requiring nursing care and assistance daily living activities

The social model of adult day care emphasizes supervised group activities such as crafts, gardening, music, and **exercise**. Participants in this model may require some assistance with the activities of daily living (e.g., eating, bathing, dressing) but they generally do not require skilled nursing care. Like adult day health care facilities, these social programs generally provide transportation and a midday meal for clients, as well as caregiver support groups, information and referral services, and community outreach programs.

In 2005, there will be an estimated 36 million Americans aged 65 or older. According to U.S. Department of Labor statistics, the fastest growing segment of older adults is the population age 85 and older. About 80% of the frail elderly remain in the community and are cared for by relatives, most commonly by adult daughters. Today, however, an increasing number of women aged 35 to 54 are in the workforce and unable to care for aging parents or disabled adult children at home.

Though the clients of adult day care are the adults who attend the programs daily or several times each week, adult day care also meets the needs of families and other caregivers. Before women entered the workforce, they were available to care for relatives at home. Today, adult day care provides a secure, alternative source of care for women who work outside the home. It also offers respite, or much needed breaks, for caregivers. Older adults caring for spouses, or children caring for aging parents find adult day care helps ease the burden of caring for an ill, confused, or disabled family member.

The first adult day care centers opened in England during the 1940s and 1950s. Established by psychiatric hospitals, these centers were designed to reduce the fre-

KEY TERMS

Alzheimer's disease—Progressive dementia characterized by worsening memory and other cognitive impairment.

Geriatrician—Physician specializing in the care and treatment of older adults.

quency of hospital admissions. The first adult day care centers in the United States appeared during the early 1970s, and today there are more than 4,000 services and centers. Most centers and programs operate during business hours, Monday through Friday, but some offer weekend and evening care.

According to a 1997 survey conducted by the National Adult Day Service Association (NADSA), 34 states offer licensure of adult day care, but only 25 require licensure. Adult day care services or programs may be affiliated with hospitals, **nursing homes**, home health agencies, or senior centers, but many are unaffiliated, independent programs. They may be located in storefronts, senior centers, community health and medical centers, and nursing homes.

Among centers responding to the NADSA survey, the average enrollment (number of clients) was about 40; the average client age was 76; and about three quarters of clients lived with family. Nearly 80% of adult day centers offered nursing services, and approximately 90% are not-for-profit. Fees ranged from \$1 to \$200 per day, with an average of \$28 to \$43 dollars per day. As of 2001, **Medicare** does not pay for any type of adult day care; however, in 35 states, **Medicaid** can be used to pay for adult day care.

Viewpoints

Though fees for adult day care vary widely, the service is generally considered cost effective when compared with the cost of institutional care, such as skilled nursing facilities or even home health care. More importantly, adult day care enables older adults, persons with physical disabilities, and those with cognitive impairments to maintain their independence. Research has demonstrated that adult day care also reduces the risks and frequency of hospitalization for older adults. Adult day care satisfies two requirements of care; it provides a secure, protected environment and is often the least restrictive setting in which care may be delivered.

Quality and standards of care vary from state to state and from one center or program to another. NADSA and

the National Council on the Aging have developed standards and benchmarks for care, but adherence to these standards is voluntary. NADSA is currently developing a certification program for adult day center administrators and directors; there is already a certification process for program assistants. Since no uniform national standards exist, it is difficult for consumers to know whether a program or center is staffed by qualified personnel or provides appropriate services.

Generally, quality adult day care centers or programs conduct thorough assessments of each client and develop individualized plans of care and activities to meet the needs of the impaired, disabled, or frail older adults. The plans for each client describe objectives in terms of improvement or maintenance of health status, functional capabilities, and emotional well being. Centers must have high caregiver to client ratios to ensure safety, supervision, and close attention. Further, all personnel and volunteers should be qualified, trained, and sensitive to the special needs of the client population. For example, centers and services for persons with Alzheimer's disease or other dementias must take special precautions to ensure that clients can not wander away from the facility.

Professional implications

The aging population in the United States, the increasing incidence of Alzheimer's disease, and rising popularity of adult day care have created new and additional opportunities for health professionals and other care-giving and service personnel.

Along with nurses, physical, occupational, and speech therapists, adult day care centers employ:

- administrators, program, and activity directors
- recreational therapists and assistants
- health aides and program aides
- bus and van drivers
- social workers and counselors
- teachers and trainers

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Barbara Wexler

Advanced practice nurses

Definition

Advanced practice nurses are typically those nurses prepared at the master's or doctoral level, and they fall into four categories of clinicians: clinical nurse specialists, certified **registered nurse** anesthetists, nurse practitioners, and certified nurse-midwives.

Description

Clinical nurse specialists

Clinical nurse specialists (CNSs) are licensed registered nurses (RNs) with additional master's or doctorate-level training in CNS. These advanced practice nurses are clinical experts in theory-based or research-based nursing, focusing on specific specialty areas.

CNSs have broadened patient care roles because of their advanced training. In some states, they have the authority to prescribe medications.

CNSs assume many roles within the health care delivery system. While many are in the clinical setting, others work as educators, administrators, consultants, researchers, change agents, and case managers. CNSs can become specialized in the areas of adult psychiatry, child psychology, community health, home health, gerontology, and medical-surgical, as well as oncology, perinatal critical care, critical care, and rehabilitation. Some nurses in areas of specialty certification classify themselves as CNSs, others use the umbrella term of advanced practice nursing

In March 2000, the number of RNs prepared to practice in at least one advanced practice role was estimated to be about 7.3% of the total RN population. The largest group among the advanced practice nurses was the nurse

practitioners, followed by the CNSs. These two groups together made up about 80% of all advanced practice nurses. Although about 36.9% of the CNSs were employed in nursing, only about 24% were practicing under the position title of CNS. Nearly 25% of CNSs reported working in **nursing education** positions.

Certified registered nurse anesthetist

Nurse anesthesia is the oldest of the advanced nursing specialties. These advanced clinical nurses, called certified registered nurse anesthetists (CRNAs), administer about 65% of the anesthetics given to patients annually in the United States.

Nurse anesthetists make up the third largest group of advanced practice nurses, and were the first professional group in the United States to provide anesthesia services in the 1800s. Their role in surgery is to keep patients as comfortable, **pain** free, and safe as possible. Nurse anesthetists perform patient physical assessments; take part in preoperative teaching; develop, prepare, and implement the anesthesia plan; select, obtain, and administer anesthesia and other medications and fluids needed to manage the anesthetic; maintain anesthesia throughout the operation and manage the patient's airway and pulmonary status; respond as necessary to emergency situations ensuring **airway management**, administering emergency fluids or medications, and performing cardiac life support techniques; and follow patients through recovery and into the patient care unit. Essentially, they take care of patients before, during, and after having surgery or giving birth.

CRNAs can sub-specialize in pediatric, obstetric, cardiovascular, plastic, dental, or neurosurgical anesthesia. Some have credentials in critical care nursing and respiratory care.

Nurse practitioner

Nurse practitioners (NPs) are registered nurses who have advanced academic and clinical experience. Because of this additional training, NPs can diagnose and manage common and chronic illnesses, independently or as part of a health care team. Nurse practitioners often can provide primary care previously offered only by doctors and, in many states, they prescribe medications. While in many cases NPs work in collaboration with physicians, NPs have the authority to practice without a physician collaboration or supervision in 18 states.

NPs perform physical exams; diagnose and treat many acute illnesses and injuries; provide immunizations; manage high **blood pressure**, diabetes, and other chronic conditions; order and interpret x rays and other lab tests; and counsel and educate patients about how

they can live healthy lifestyles. NPs focus much of their practice on health maintenance, disease prevention, **patient education**, and counseling. While they have a strong emphasis on primary care, NPs practice in a wide variety of specialties, including neonatology, ob-gyn, pediatrics, school health, family and adult health, mental health, **home care**, geriatrics, and acute care.

Certified nurse-midwife

Certified nurse-midwives (CNMs) focus on the independent management of women's health care, particularly on **pregnancy**, **childbirth**, the postpartum period, care of the newborn and the family planning, and gynecological needs of women. They have the authority to write prescriptions. CNMs deliver babies in all types of health care settings, as well as in private homes, and provide primary health care to women, often helping them to realize personal fulfillment through labor and birth. CNMs work independently and in collaboration with other health care providers. They also teach and conduct research.

The trend seems to be that more people are choosing CNMs. As of 1998, there were nearly 278,000 CNM-attended births in the United States. About 400 nurse-midwives pass the national certification exam each year. The practice of nurse-midwifery is legal in all states and the District of Columbia. These advanced practice nurses have prescription-writing ability in 50 states and jurisdictions. Ninety percent of all visits to CNMs are for primary and preventive care. Seventy percent of that was for care during pregnancy and after birth, while 20% was for care outside of the maternity cycle.

Work settings

Clinical nurse specialists

CNSs work in the acute care, long-term care, and intermediate care settings. They work in clinical education within health care facilities, as well as in nursing education programs as faculty teaching nursing. Other settings in which CNSs work include outpatient and ambulatory care, private practice, home health, physician office practice, sub-acute care, government or military service, community health centers, health care administration, private industry (working for drug companies or manufacturers, in managed care and other areas of the private sector), and nurse-managed centers. Within these categories, CNSs work in assisted living facilities; specialized hospital areas, such as **cardiac catheterization** labs; correctional facilities; dialysis units; parish nursing; and psychiatric hospitals.

Certified registered nurse anesthetist

Nurse anesthetists can work with an physician anesthesiologist, independently or in groups as providers of anesthetics. They work as part of a medical team or independently in any setting in which anesthesia is given, including doctors' and dentists' offices, pain clinics, operating rooms of hospitals, and ambulatory surgery settings. CRNAs who work independently or in groups might have contracts with physicians or hospitals. Some CRNAs work in private practices, while others choose the public sector or the U.S. military. They work in universities as instructors and in research settings as investigators, collaborators, consultants, assistants, interpreters, and researchers. CRNAs also work in surgical and obstetric environments in MRI units, cardiac catheterization labs, and **lithotripsy** units. In these environments, they provide consultation and implementation of respiratory and ventilatory care, manage emergency situations, and start or participate in airway maintenance, ventilation, and tracheal intubation during **CPR**.

Nurse practitioner

Nurse practitioners work in metropolitan area clinics and hospitals, as well as in rural areas, inner cities, and medically underserved locations. They work in schools, caring for children, and in **nursing homes** and assisted living facilities, caring for the elderly and others. NPs work in pediatric, family health, women's health, and other specialty settings. Some work in private practices or in nurse-run group practices.

Certified nurse-midwife

CNMs work in clinical practice in public, university, and military hospitals. They also work in health maintenance organizations, private practices, and birthing centers. Many practice in public health clinic, and some provide home birth services. More than 50% of CNMs work most often in the office or clinic environment, listing a hospital or physician practice as their employer.

Education and training

Clinical nurse specialists

Nurses must have a baccalaureate degree or its equivalent to enroll in a CNS program. To use the title of CNS, the CNS must have a minimum of a master's degree from an education program that prepares CNSs. The training is graduate-level education. Some universities have a fast track program whereby they will accept individuals who do not have a baccalaureate and move them into a master's program. CNSs also take a certifica-

tion exam in a specialty, offered by one of the nationally recognized certification entities.

CNS students go through advanced theory and practice training, revolving around the three areas of influence that impact on direct patient care, supervising direct patient care, and patient care systems.

The American Nurses Credentialing Center certifies CNSs as adult psychiatric, child psychology, community health, home health, gerontology, and medical-surgical CNSs. There also are other certifying bodies, including the Rehabilitation Nursing Certification Board, Oncology Nursing Certification Corporation, and American Association of Critical Care Nurses Certification.

The doctoral-level CNS typically focuses on research.

Certified registered nurse anesthetist

Nurse anesthetists are registered nurses who complete two to three years of higher education, beyond the bachelor's of nursing degree or other appropriate baccalaureate degree. They attend accredited nurse anesthesia education programs, covering all areas of anesthesia. After completing an accredited program, nurse anesthetists must pass a national certification exam to obtain the CRNA designation.

The education for a **nurse anesthetist** involves about 24 to 36 months of graduate course work. It includes classroom and clinical experience.

In most cases, to be accepted into an accredited school, those who aspire to become nurse anesthetists must have an appropriate four-year degree, an RN license, and at least one year of acute care nursing experience, which varies by program.

Nurse practitioner

NPs receive their advanced educations through programs that award master's degrees. RNs who aspire to become NPs should have extensive clinical experience before applying to an NP program. NP programs include the components of an intensive preceptorship under the direct supervision of a physician or experienced NP and instruction in nursing theory. An increasing number of nurses are becoming prepared as both NPs and CNSs. Those prepared in both roles are more likely to function as nurse practitioners.

Certified nurse-midwife

CNMs are educated in the two disciplines of nursing and midwifery. They must possess evidence of certification according to the requirements of the American College of Nurse-Midwives. Being an RN is a require-

ment to become a certified nurse-midwife. In some cases, those with baccalaureate degrees in other fields are considered. Upon graduation, CNMs can receive MS (master's of science), MSN (master's of science in nursing), MPH (master's of **public health**) degrees or a doctoral degree. About 68% of CNMs have master's degrees, while 4% have doctoral degrees. There are also those who graduate with a certificate or from a nurse-midwifery education program. However, the number of states and employers who require master's-prepared CNMs is increasing. Once in the program, student CNMs receive labor and delivery experience in different types of settings. They must pass a national certification exam to call themselves CNMs.

Advanced education and training

All advanced practice nurses with master's degree can go on to get their doctorate degrees. Often, those with doctorate-level training go into research, administration, or teaching at the university level.

Future outlook

The outlook is good for all types of nurses, especially those at the RN level or higher. It is projected that if current trends continue, demand will exceed supply of RNs by about 2010. It is possible that as many as 114,000 jobs for full-time-equivalent RNs are going to go unfilled nationwide by 2015. This is due to a growing elderly population with mounting health care needs, an aging RN workforce, the expansion of primary care, and technological advances that require more highly trained nurses.

There is a growing demand for RNs with advanced clinical skills. Almost all who graduate have jobs waiting for them.

Resources

ORGANIZATIONS

- American Association of Colleges of Nursing. One Dupont Circle, NW, Suite 530, Washington, DC 20036. (202) 463-6930. <<http://www.aacn.nche.edu>>.
- American Association of Nurse Anesthetists. 222 South Prospect Avenue, Park Ridge, IL 60068-4001. (847) 692-7050. <<http://www.aana.com>>.
- American College of Nurse-Midwives. 818 Connecticut Ave. NW, Suite 900, Washington, DC 20006. (202) 738-9860. <<http://www.acnm.org>>.
- American College of Nurse Practitioners. 503 Capitol Ct. NE, #300, Washington, DC 20002. (202) 546-4825. <<http://www.nurse.org>>.
- American Nurses Association. 600 Maryland Avenue, SW, Suite 100 West, Washington, DC 20024. (800) 274-4ANA. <<http://www.ana.org>>.

National Association of Clinical Nurse Specialists. 3969 Green Street, Harrisburg, PA 17110-1575. (717) 234-6799. <<http://www.nacn.org>>.

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Lisette Hilton

Aerobic testing see **Endurance testing**

Aerosol drug administration

Definition

Aerosol drug administration is the administration of a drug via air particles delivered by an appropriate device that is inhaled and absorbed into the patient's body via the **lungs**.

Purpose

Aerosol administration of drugs is indicated in circumstances where rapid absorption and localization effects of the drug are required to produce the appropriate response. Aerosol administration methods are most commonly used in asthmatic conditions or specific lung conditions that cause difficulty in breathing. Diseases including **emphysema**, **asthma**, chronic obstructive pulmonary disease (COPD), and other similar conditions warrant and necessitate the use administration of drugs by this route of administration.

Precautions

Aerosol administration in itself is generally a safe practice, as long as the health care provider or client is well educated in its use. It is contraindicated in conditions where complete obstruction of the airway is present, as the administration route is completely blocked. Such conditions, however, are usually resolved rapidly in emergency situations.

Description

Aerosol drug administration, also known as inhalation therapy, or in some cases, nebulized drug therapy, is the method by which drugs are dispersed into the lungs or bronchial airways in the form of tiny droplets—often

bound to water, oxygen, or another gaseous substance. Drugs are generally delivered by two means. The first is via a device called a nebulizer. The nebulizer is a mechanical pump (of which there are many types) that produces a fine mist in which the drug is dispersed via an appropriate nebulizer-compatible face mask. This fine mist is inhaled deep into the lungs for maximum effect. The second method of delivery is via a hand-held, nebulized aerosol device. These devices, also known as “puffers,” use the effects of a pressurized gas to create and disperse the drug into a fine mist or spray, which is then inhaled.

Both methods of aerosol inhalation are very effective when used correctly. In cases of extreme breathlessness or dyspnea (labored or difficult breathing), the mechanical pump nebulizers are generally more effective, as they disperse the drug over a longer time period; this, in turn, gives the recipient a longer time period, allowing the airways to open more effectively.

In terms of medical treatment costs and medication costs, aerosol drug administration is relatively inexpensive. Nebulized therapy via a mechanical pump is usually completed within five to ten minutes. Delivery of drug via hand-held devices is completed within a few seconds.

Procedure for effective mechanical pump nebulization

- The nebulizer solution and equipment specific to the type of pump being used should be prepared. If necessary, the instruction guides should be consulted. (Detailed instruction is beyond the scope of this guide due to the vast number and variety of pumps available.)
- An appropriate face mask is obtained.
- The recipient should be placed in a comfortable, upright position that is greater than 45 degrees. This will enable maximum breathing efficiency. A hospital bed with an adjustable backrest, or a chair with good back support, is adequate. The comfort of the recipient should be ensured and maintained throughout the procedure.
- The client should be reassured. Often, when a patient is suffering from breathing difficulty, he or she becomes anxious and frightened. The nurse should do his or her best to relax and reassure the patient as much as possible. When relaxed, the airway has the best chance of recovery, and inhalation of the nebulized drug is assured.
- When patient is comfortable and in a suitable position, the nebulizer pump can be turned on. The nurse must

confirm that a steady mist is flowing from the mask or application device.

- When a steady flow of mist is achieved, the nurse should fit the mask or application device correctly to the patient's face or trachea (if applicable).
- While nebulization and delivery of drug is occurring, the patient should be monitored for signs of reaction to the drug and for improvements or deterioration in breathing patterns.
- Once the procedure is complete, the patient's oxygen saturation level should be measured, if equipment is available. This measurement should be recorded and reported along with any other documentation.
- The recipient should be asked if the medication has had a positive effect. If not, further advice or orders should be sought from the physician.
- The nurse should provide education about delivery of the drug by inhalation to the recipient. He or she should also answer questions the recipient may have.

Procedure for inhalation from hand-held devices

- Again, there are many devices available that operate in different manners. A detailed description of each, however, is beyond the scope of this guide.
- For effective delivery of drug from these type of devices, it is essential that the medication is prepared properly, using the instructions supplied with the device.
- Once the medication has been prepared, the recipient must hold his or her lips one to two inches (3-5 cm) from the open mouth. The patient needs to breathe in deeply (powdered-drug-type devices), or breathe in deeply while depressing the canister (for canister/barrel type devices); this will allow the drug to be inhaled deeply into the airways and lung tissue.
- Positive responses should be observed or measured by the nurse.
- All data, as appropriate, must be recorded by the nurse. If treatment is not effective, further advice or orders should be sought.

Preparation

Generally, there are no specific pretreatment procedures, except for the set-up of equipment used for the procedure. The recipient generally requires no personal preparation in common use of this procedure.

Aftercare

Recipients should be monitored for signs of positive response to the drug. It is important to rinse the mouth

following inhalation therapy, as drug residue can remain in the mouth and cause oral problems and tooth decay in some instances.

Complications

Complications are almost always related to the type of drug being delivered. Complications may also arise due to drug **overdose**. It is important in a hospital or clinic emergency environment, particularly with asthma sufferers, that the health care provider assess how much, and what type of medication, has been administered prior to the patient's arrival in the emergency department, to avoid such complications.

Results

Anticipated outcome for symptom-relieving drugs

In a lung or breathing condition, the desired outcome from symptom-relieving aerosol drugs is a complete cessation of such symptoms or at least an improvement in symptoms following completion of the treatment. Failure to relieve symptoms indicates ineffective drug delivery, incorrect drug choice or strength, or deterioration of the patient's condition.

Anticipated outcome for preventive drugs

While more difficult to measure (as effects can be both short- or long-term), the goal of using preventive medications via this specific delivery route is to prevent or reduce presentation of symptoms. A reduction in the occurrence of symptoms, or a complete cessation of associated symptoms, indicates a successful preventive treatment regime.

Health care team roles

The health care team roles for successful treatment include:

- All equipment used in the procedure should be maintained and used according to the manufacturers' specifications.
- All treatment options must be explained to the patient.
- The recipient should be monitored during delivery of inhalation therapy.
- All events and observations for the procedure should be recorded.
- The recipient must be educated in all aspects of his or her condition, including the reasons for the use of specific treatments and drugs.

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Aging and the aged

Definition

Aging is the process of growing older, a process that includes physical changes and, sometimes, mental changes. “The aged” refers to elderly people, those who have reached an advanced age.

Description

The concept of aging and the aged has changed, as record numbers of people around the world are living longer, a trend expected to continue throughout the twenty-first century and beyond.

The word “elderly” used to refer to an older person, generally someone age 65 or older. At the beginning of the twentieth century, 65 was considered an advanced age. The life expectancy for a baby born in 1900 was 51 years for a girl and 48 years for a boy. That year, approximately one in 25 Americans was over 65.

By the 1930s, legislation set older adults apart from the rest of American society. Social Security laws declared that people had to retire from work by age 65. The ruling affected about 7.5 million people during the 1930s.

At the end of the twentieth century, the older population had increased 10 times since 1900. In 2000, approximately 35 million people age 65 and older accounted for 13% of America’s population, according to *Older Americans 2000: Key Indicators of Well-Being*, a

2000 report from the Federal Interagency Forum on Aging Related Statistics. According to the report, by 2030 70 million Americans will be 65 or older.

Since the late twentieth century, the age group growing fastest in many countries has been the “very old” or the “oldest old.” Opinions vary about the age classification for this group. The United States federal government defines this group as people 85 and older. The United Nations (U.N.) classifies people 80 and older in this demographic group.

The oldest age group includes the rapidly increasing number of centenarians, people age 100 or older. In the United States, the number of centenarians is projected to grow from about 60,000 in 2000 to some 2 million by the middle of the twenty-first century.

The demographic revolution

Advances in areas such as health care, medicines like **antibiotics**, and **nutrition** during the twentieth century mean that more people are living longer. An American baby born at the turn of the twenty-first century is expected to live nearly 30 years longer than one born a century earlier, according to *Older Americans 2000*.

The increase in life expectancy during the late twentieth century is believed to be as high or higher than any increase from recorded time until 1900. In many countries, one out of 10 people was 60 or older in 2000, according to *The Ageing of the World’s Population*, a 2000 report from the U.N. Division for Social Policy and Development. The ratio of people over 60 was projected to change to one out of five in 2050 and one out of three in 2150, according to the report.

At the same time that more people are living longer, people around the world are having fewer children. The lower birth rate is attributed to the availability of family planning methods. The combination of a growing older population and a declining birth rate has produced a demographic revolution that the U.N. predicts will continue into subsequent centuries.

These demographic trends affect what the U.N. calls the “old-age dependency balance,” the relationship between the number of people age 65 and older and the number of working people age 15 to 64.

Traditionally in the United States, younger workers have supported older people through wage deductions for programs such as Social Security. During the first half of the twenty-first century, the U.N. estimated that the old-age dependency ratio will double in more developed areas and triple in less developed areas.

With a smaller pool of workers, organizations around the world are studying methods to ease the

Commonly used instruments for geriatric patients

Instrument	Administered by	Answered by	Score range (poor–good)
Folstein mini mental state	Interviewer	Subject	0–30
Katz activities of daily living	Interviewer	Proxy	0–6
Lawton instrumental activities of daily living	Interviewer, self-administered	Proxy or subject	9–27
Tinetti balance & gait evaluation	Interviewer, self-administered	Subject	0–28
Yesavage geriatric depression scale	Interviewer, self-administered	Subject	15–30

SOURCE: Abrams, W.B., et al., eds. *Merck Manual of Geriatrics*. 2nd ed. Whitehouse Station, NJ: Merck Research Laboratories, 1995.

dependency burden. One method of accomplishing this is to help older adults remain healthy and independent for as long as possible. Not only does this benefit the aging person, but health care costs are also reduced.

The demographic revolution has political, social, and economic significance. Of primary concern is how to provide health care for the growing number of older people, especially those 85 and older. Generally, the oldest old need more health services than younger people.

The aging process

It used to be thought that as people aged, their bodies became “worn out” over time and then they died. As the body deteriorates, a person may experience signs of aging, resulting in the need for dentures or the presence of a chronic disease. Although methods of prolonging life are well-known, opinions vary about why people age.

A range of factors is thought to contribute to aging, either alone or in combination. For example, a healthy person whose parents led long lives could expect to live many years. The probability of a long life would be increased if the population receives adequate health care, and modifies unhealthy lifestyle behaviors.

FACTORS AFFECTING THE AGING PROCESS. Factors that affect the aging process include:

- **Heredity.** A person whose parents and grandparents lived to an advanced age could expect to live longer. On the other hand, a person could inherit the susceptibility to a disease that shortens life. In addition, **stress** affects health, and the ability to cope with stress is also believed to be inherited.
- **Senescence.** Theories about aging focus on the reason cells stop dividing and age. Some scientists believe that cells begin to age when a person is fully grown. Others theorize that excess DNA accumulates and obstructs cell activity. Another theory is based on the effect of chemical compounds called free radicals on the system. The compounds located in the body and the environ-

ment can accelerate conditions such as **heart** attacks and diabetes.

- **Physiology.** The collective functioning of the body’s components affects how long a person lives.
- **Biology.** Traditionally, women live longer than men. Scientists believe this is due to the female sex hormones.
- **Lifestyle.** The choices a person makes when younger can affect health later in life. A person who smoked cigarettes, took drugs, did not eat nutritionally, or failed to get enough **exercise** or sleep may suffer poor health years later. For example, smoking is attributed to numerous conditions ranging from **cancer** to gum diseases.
- **Psychological factors.** Feelings of self-confidence are linked to a longer life. Conversely, low self-esteem and negative attitudes about being old may impair health. This can lead to feelings of depression and loneliness.

PHYSICAL SIGNS OF AGING. How a person ages varies, however, the aging process includes some general characteristics such as:

- Lowering of the basal **metabolism** (the rate of energy production in the body cells). People may tire more easily and be more sensitive to changes in the weather.
- Reduction of strength, endurance, and ability.
- Change in eyesight. People who wear glasses may experience **presbyopia**, a form of farsightedness. Bifocals or reading glasses allow the person to read print that appears too small. Other aging people who never needed corrective lenses may need to wear eyeglasses. Some older people may be diagnosed with eye conditions such as **glaucoma** and **cataracts**.
- Change in **hearing**. Generally, older people have more difficulty hearing high tones but can hear low tones. A hearing aid may be prescribed.
- **Dental changes.** Gums may recede, and this can lead to tooth decay. Lack of proper **oral hygiene** earlier in life may result in the removal of all or some of the natural teeth. Dentures may be required.

Leading causes of death in persons 65 and older

Cause of death	Number of deaths	Percentage of all deaths in those ≥ 65 years old
All causes	1,542,493	100.0
Heart disease	594,858	38.6
Malignant neoplasms, including neoplasms of lymphatic and hematopoietic tissues	345,387	22.4
Cerebrovascular diseases	125,409	8.1
Chronic obstructive pulmonary disease and associated conditions	72,755	4.7
Pneumonia and influenza	70,485	4.6
Diabetes mellitus	35,523	2.3
Accidents and adverse effects	26,213	1.7
Motor vehicle accidents	7,210	0.5
All other accidents and adverse effects	19,003	1.2
Nephritis, nephrotic syndrome, and nephrosis	17,306	1.1
Atherosclerosis	17,158	1.1
Septicemia	15,351	1.0
All other causes	222,048	14.4

SOURCE: National Center for Health Statistics, 1993.

- **Osteoporosis** (a condition characterized by reduced bone density and brittle bones). This condition, more common in women, can lead to bone fractures.
- Muscle strength and body tone may diminish.
- Organ function may slow down.
- As skin ages, cells hold less water, and there is less fat tissue. Skin becomes dry and wrinkled.
- Hair loses its pigment (color) and turns white or gray.
- Sexual desire and ability may decrease. Drugs such as Viagra allow men to perform, and products such as lubricants can help women.
- Reproduction. Aging men can still father children. After **menopause**, women are usually unable to bear children.
- The senses of **taste**, touch, and **smell** may diminish over time.

MENTAL SIGNS OF AGING. Generally, age has little effect on the mind. While it is true that older people do not learn as quickly, once something is learned, the information is retained more accurately. However, the **brain** like the body, must be exercised. That exercise can take the form of learning something new. However, most adults, not just the aging, may experience **anxiety** about returning to classes. People who teach adults effectively

make their students feel welcome. They also realize that adults remember more of what is relevant to them.

As people advance in age, they may experience **memory** loss. This is frequently treatable. In addition, a stimulated mind is thought to help avoid the memory loss that has been associated with aging. Emotional health can affect physical health, with conditions such stress, loneliness, and depression leading to illness in people of all ages.

DEMENTIA AND ALZHEIMER'S DISEASE. One-third or more people age 85 and older have moderate or severe memory impairment. Memory loss can be a symptom of **Alzheimer's disease**, a progressive condition that is not reversible. Before more was known about Alzheimer's, the disease was thought to be a natural symptom of aging. It is still not easy to diagnose and can be mistaken for **dementia**. Although many of those diagnosed with Alzheimer's are older than 65, the disease also affects people in their 40s and 50s. There was no known cure as of the spring of 2001.

AGE-RELATED HEALTH CONDITIONS. Advanced age doesn't cause disease in itself, but the possibility that some chronic conditions will develop increases as a person ages. These conditions include arthritis and other musculoskeletal disorders that could affect mobility.

However, the prevalence of arthritis and other chronic diseases like **hypertension**, heart disease, cancer, diabetes, and stroke varies by ethnicity in the United States. Furthermore, an ongoing healthy lifestyle can help prevent illness and disease later in life. For an older adult, that lifestyle should include exercise, a proper diet to avoid malnutrition, and vaccinations such as flu shots.

Viewpoints

Retirement brings many changes to aging people. After working throughout their lives, they may want to relax and get into a routine of sitting and watching television. They may experience a loss of identity after defining themselves by their work for so many years.

The aging lifestyle

After retirement, it is crucial to overall health for a person to find hobbies, social activities, or interests that challenge both mind and body. Most cities in the United States have senior centers that offer lunch programs where people can socialize. Center classes range from line dancing to journal writing. In addition, volunteer opportunities for older adults include serving with law enforcement and as tutors. Many older people remain socially active through contact with friends, family, and neighbors. In addition, more older people are physically active.

Agism and activism

For centuries, cultures including the Native Americans, Samoans, and Chinese honored the older members of their societies. These people respected their elders for their wisdom and experience. However, negative attitudes about the aged date back to ancient times. The Greek philosopher Socrates cited his age as one reason that he planned to commit suicide by taking hemlock. He was 70 years old.

Furthermore, some primitive societies regarded the aged and ailing as burdens. In some situations, people were murdered or given assistance in committing suicide. Assisted suicide was the subject of much debate during the late twentieth century and remains an issue in the twenty-first century, with people divided about whether or not a person has the right to choose to die.

Health issues are just one factor for those who view older people as a burden to society. Negative stereotypes about the aged include the view that they are useless because they don't work and therefore don't contribute to society. This prejudice against older people is known as agism, sometimes spelled "ageism." This negative attitude can be traced in part to the fact that older people are visual reminders of aging and death. In addition, during the second half of the twentieth century, the media celebrated youth as a valued commodity. The appearance of an older person was seen as a rarity, as when Renee Russo appeared in the 1999 movie, *The Thomas Crown Affair*. Much was made of the fact that she was in her 40s.

Older people took a stand during the 1970s. Maggie Kuhn founded the Gray Panthers, a group that continues to fight agism. The American Association of Retired Persons campaigned and continues to advocate for older people. Both groups champion older adults as vital people with much to contribute to society.

The older population of the late twentieth century now includes Baby Boomers. The first Boomers turned 50 in the late 90s, and this group is expected to vigorously campaign for the rights of the aging and the aged.

Furthermore, with mandatory retirement abolished, people in their 90s and 100s worked at jobs that they enjoyed in 2000, according to the *New York Times*. However, that same year, agism surfaced after the U.S. presidential election. Disputed election results in Florida led to jokes on TV and the Internet about the incompetence of older voters.

National trends

While older people may share a chronological age, they vary according to their ethnic heritage, economic

status, interests, and education. Some are healthy and active; others are frail and not as active. According to *Older Americans 2000*, the ethnic make-up of people age 65 and older in 2000 was 84% non-Hispanic white, 8% non-Hispanic black, 6% Hispanic, 2% non-Hispanic Asian and Pacific Islander, and less than 1% American Indian and Alaska native. Population percentages are predicted to change by the year 2050 to 64% non-Hispanic white, 16% Hispanic, 12% non-Hispanic black, 7% non-Hispanic Asian and Pacific Islander, and less than 1% American Indian and Alaska native.

The report indicated that older Americans in 2000 were better educated than older people in 1950. The higher education level "positively" influenced health and socio-economic status.

People age 85 and older are the most likely to live in **nursing homes**. About three-fourths of nursing home residents are women, which reflects their predominance in the population.

A NATIONAL MODEL. Government, the medical community, and numerous organizations are studying issues associated with the ever-increasing aging population. An overview of the issues facing the aging and the aged is demonstrated by the scope of the activities of the U.S. Department of Health and Human Services (HHS) in 2000. Programs and projects included research on the aging process, aging and disease, Alzheimer's, and the relationship between the aging and society. Other HHS activities included a seniors nutrition program, and services and studies related to care at home and long-term care facilities.

International trends

Globally, the average lifespan increased by 20 years during the last half of the twentieth century, according to the U.N. At the end of the century, a 60-year-old woman living in a developed region could expect to live 22 years longer. A man that age could expect to live 18 years longer. In a less developed region, a woman who reaches age 60 could expect to live 16 years longer, while a 60-year-old man in that area could expect to live 14 years longer.

A sampling of other international trends includes:

- People age 60 and older accounted for one in five Europeans and one in 20 Africans in 2000. In developing countries, the growth of the aging population is more rapid than in developed countries. Therefore, developing countries have less time to adjust to the expansion of their aging populations.
- In developing countries, older people continue to work. In Zimbabwe, 82% of men and 70% of women age 60

KEY TERMS

Chronic disease—A condition lasting a long time.

Cognitive—Able to know or perceive.

Geriatrics—The branch of medicine concerned with the prevention, diagnosis, and treatment of conditions in aging people and the aged.

Gerontology—The study of the aging process and conditions associated with this process.

and older worked during the year 2000. Some non-wage earners worked at home caring for children, worked on farms, or did other household projects that allowed other relatives to work for pay.

- More than 25% of people age 75 and older live in China and India.
- In many Asian and African countries, more than half of women age 60 and older are widowed. Only 10–20% of men in that age group outlived their spouses.
- Women outlive men almost everywhere. At age 60, there are 99 men for every 100 women. By age 90, there are only 69 men for every 100 women.

A EUROPEAN MODEL. Concern about promoting health and preventing illness led the European Commission to start the Megapoles Project in 1997. Part of the project involved looking at the elderly in the capital cities of Amsterdam, Athens, Brussels, Copenhagen, Dublin, Helsinki, Lisbon, London, Madrid, Oslo, Stockholm, and Vienna. The review, “Growing Old in Metropolitan Areas” (GOMA), found three major issues in those cities:

- Prevention of social isolation and loneliness. The goals include promoting individual self-confidence that would lead to a more positive perception by others.
- Early detection of dementia, Alzheimer’s disease, and the implementation of a project to provide individual competence. The project involves the elderly, their relatives, and caregivers.
- Providing a safer environment that protects older people from accidental **falls**, road traffic, and “firm vigilance” towards violence directed at the elderly.

A 2001 report on GOMA included examples of successes. Cities such as Vienna have day centers that offer therapeutic and health promotion services. Stockholm has a special bus with wheelchair ramps that transports seniors to their destinations after morning rush hour. Furthermore, programs in London reach out to older people

who may feel isolated for various reasons, for example, a lack of language skills. Intergenerational projects can serve three groups targeted by Megapoles Project: the elderly, the disadvantaged, and youth and young families. For example, one facility serves as a day center for the elderly and a kindergarten. Young and old interacted and socialized.

Another London project linked older people to social services through their milkman. This was aimed at people who didn’t leave their homes. Isolation can lead to impaired mobility and cognitive skills, so the milkman “casually” checks in daily and may encourage visits from social service workers. This delivery person calls for help if milk isn’t taken indoors.

Furthermore, senior centers in Madrid and Helsinki provide information about topics such as health, nutrition, exercise, and home safety.

IMPLICATIONS ACROSS BORDERS. The GOMA report acknowledged that not all senior projects can be exported to other cities. And for those living in the United States, most programs are recognizable. Handicapped-accessible public transportation is required by law. National, state, and city agencies are concerned with the elderly. Senior centers in many cities offer health programs, physical activities, and classes.

The GOMA report maintained that dialog throughout the world about the aged and implementation of programs for this group are crucial. The goal of dialog and programs is to help the aged feel secure, socially integrated, and mentally healthy. Not only do these dialogs and programs benefit the aging population, they provide some relief to health providers and caregiving institutions.

Professional implications

In 1965 the federal government created **Medicare**, a health insurance program for people age 65 and older. In 1999, Medicare spending totaled \$181 million for the 39 million older and disabled people enrolled in the program.

The cost of health care for the aging population is among the issues that will be debated throughout the twenty-first century as the old-age dependency burden shifts to fewer younger people. This could lead to further discussion of health care rationing, i.e. whether the decision to provide some health care should be limited because of a person’s advanced age. This issue was discussed in an article titled “Does Ageism Affect Health Care Rationing?” (found on the Novartis Foundation web site <www.healthandage.com>). The author cited an incident described in a 1998 issue of the medical journal, the

Lancet. Both articles concerned an 88-year-old woman who stopped breathing three minutes after admission to a hospital emergency room. At issue was whether the woman should be revived since the admitting physician thought she would die anyway. The doctor revived the woman, who was still doing well several years later.

The Novartis Foundation writer pointed out that rationing wouldn't have been an issue with a younger patient. The writer maintained that age should not be an issue when determining whether to provide health care. The author warned that this issue is complex. In some cases, a patient may face a lingering death.

Debate will continue about **euthanasia**, mercy killing, and the right-to-die. Opponents of these procedures fear that patients may be pressured to end their lives. In some cases, this pressure may be based on rising health care costs.

Such debates will affect some members of the medical profession as they are faced with patients and families needing guidance. In addition, the shift to an ever-growing older population will affect health care in the twenty-first century.

On a more positive note, strategies to delay illness later in life benefit the elderly and help keep costs down. For example, delaying the onset of Alzheimer's disease by five years would cut its incidence in half and result in a saving of \$50 billion annually in the United States.

This preventive treatment should focus on patients of all ages. The healthcare team should emphasize to patients that aging is an ongoing process, so that lifelong preventive measures such as diet and exercise are the best tools for long-term health.

Treating the older patient

For the older patient, the goal of treatment is to help a patient remain physically, mentally, and socially active for as long as possible. To achieve this goal:

- Patients above the age of 60 should have an annual comprehensive health assessment.
- Vitamins and inoculations are important.
- Patients should be advised that **calcium** from sources such as milk and dairy products is crucial for fighting osteoporosis and keeping teeth and bones strong.
- Diet should maintain the recommended body weight, so that a patient is not overweight or too thin. A low-fat diet is recommended because aging results in a lessening of fat-digesting enzymes.
- Patients should be reminded that regular exercise produces benefits that include well-being, good circulation, and good respiration. Exercise helps a person

maintain coordination and mobility. Even if a person is in a wheelchair or bed, exercise will produce beneficial results.

- Early treatment to help prevent or lessen a risk of conditions such as cataracts or glaucoma.

The future

Since the aging population is growing and continues to increase, all health care professionals and staffs should receive geriatric training. The demographic trend also creates a demand for people with expertise in gerontology and geriatrics. Other career opportunities include work in long-term care facilities, health education for the aged, and home health care.

In addition, working with the aged prompts people in the nursing and allied health fields to take a look at their lives and those of their relatives. In doing so, they can make adjustments so that they can attempt to live long and healthy lives.

Resources

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- Honn Qualls, Sara, and Norman Abeles, eds. *Psychology and the Aging Revolution: How We Adapt to Longer Life*. Washington, D.C.: American Psychological Association, 2000.
- Powell, Douglas H. *The Nine Myths of Aging: Maximizing the Quality of Later Life*. Thorndike, ME: Thorndike Press, 1998.
- Safford, Florence, and George I. Krell, eds. *Gerontology for Health Professionals: A Practice Guide*. Washington, D.C.: National Association of Social Workers, 1997.
- Wei, Jeanne Y., and Sue Levkoff. *Aging Well: The Complete Guide to Physical and Emotional Health*. New York: Wiley, 2000.

PERIODICALS

- Martin, Douglas. "To Be Old, Gifted and Employed is No Longer Rare." *The New York Times*, January 14, 2001.

ORGANIZATIONS

- AARP (American Association of Retired Persons). 601 E St., NW, Washington, D.C. 20049. (800) 424-3410. <<http://www.aarp.org>>.
- American Geriatrics Society. The Empire State Building, 350 Fifth Ave., Suite 801, New York, NY 10118. (212) 308-1414. <<http://www.americangeriatrics.org>>.
- Federal Interagency Forum on Aging-Related Statistics. 6525 Belcrest Road, Room 790, Hyattsville, MD 20782. (301) 458-4460. <<http://www.agingstats.gov>>.
- Global Action on Aging. P.O. Box 20022, New York, NY 10025. (212) 557-3163. <<http://www.globalaging.org>>.

Gray Panthers. 733 15th Street, NW, Suite 437. Washington, D.C. 20005. (800) 280-5362. <<http://www.graypanthers.org>>.

Novartis Foundation for Aging and Gerontology. Novartis Foundation for Gerontology, Lichtstrasse CH-4002, Basel, Switzerland. Tel: +41-61-324-7353. <<http://www.healthandage.com>>.

United Nations. 2 UN Plaza, New York, NY 10017. (212)759-5950. <<http://www.un.org>>.

U.S. Department of Health and Human Services, 200 Independence Avenue, S.W., Washington, D.C. 20201.(877) 696-6775. <<http://www.hhs.gov>>.

OTHER

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Liz Swain

AICD see **Implantable cardioverter-defibrillator**

AIDS

Definition

Acquired immune deficiency syndrome (AIDS) is an infectious disease caused by the human **immunodeficiency virus (HIV)**. AIDS is the advanced form of **infection** caused by HIV and typically only manifests itself after a long latency period after initial HIV infection. AIDS is a fatal disease for which there is currently no cure.

Description

First recognized in the United States in 1981, AIDS is considered one of the most devastating **public health** problems in recent history. The Centers for Disease Control and Prevention (CDC) has estimated that, as of June 2000, between 800,000 and 900,000 people in the United States were HIV-positive, and 312,000 were living with AIDS. Of adult AIDS cases, 47–53% were believed to have contracted HIV from same sex male intercourse, 25–31% from intravenous drug use, and 10% from heterosexual contact. There are an estimated 40,000 new HIV infections each year in the U.S. The Joint United Nations Program on HIV/AIDS estimates that, worldwide during the year 2000, an estimated 3 million people had died of AIDS, and 34.7 million adults

and 1.4 million children were living with HIV/AIDS. Approximately 95% of persons with HIV/AIDS were living in developing countries.

Risk factors

HIV/AIDS can be transmitted in several ways. The various routes of transmission (and associated risk factors) include:

- Sexual contact. Persons at greatest risk are those who do not practice safe sex (sex with a condom), those who are not monogamous, those who engage in anal intercourse, and those who have sex with a partner with symptoms of advanced HIV infection and/or other sexually transmitted diseases (STDs). In the United States and Europe, most cases of sexually transmitted HIV infection arise via same sex contact, whereas in Africa the disease is spread primarily through heterosexual intercourse.
- Transmission in **pregnancy**. High-risk mothers include women who use intravenous drugs, women who have sex with bisexual men, women who are married to men who have an abnormal **blood** condition called **hemophilia** (a condition requiring blood transfusions), and women living in areas with a high rate of HIV infection among heterosexuals. The chances of transmitting HIV from mother to child are higher in women who are in advanced stages of the disease. Breast feeding increases the risk of transmission by 10%-20%, and vaginal delivery doubles the risk of transmitting HIV to the child. Zidovudine (AZT) given to the mother during pregnancy and given to the baby soon after delivery have been shown to decrease the risk of HIV transmission to the child.
- Exposure to contaminated blood or blood products. With the introduction of blood product screening in the mid-1980s, the incidence of HIV transmission in blood transfusions has dropped to 1 in 100,000. Among users of intravenous drugs, risk increases with the duration of injection use, the frequency of needle sharing, the number of persons who share a needle, and the number of AIDS cases in the local population.
- Exposure of health care professionals to infected blood. Studies have shown that 0.32% of highly exposed health care workers have become infected with HIV through occupational exposure. Needle injuries are the most common exposure route. Risk factors for contracting HIV from a needle injury include a deep injection, a needle that has been used in an artery or vein, blood visibly apparent on the needle prior to injury, and blood from a patient with end-stage AIDS. There is evidence that administration of zidovudine (AZT) to the

injured worker soon after HIV exposure decreases risk of infection.

HIV is not transmitted by handshakes, coughing, sneezing, or other casual non-sexual contact. There is currently no evidence that HIV can be transmitted through bloodsucking insects such as mosquitoes.

AIDS in women

HIV remains an important cause of death and illness in women. In the US, AIDS was the fifth leading cause of death among women aged 25-44 in 1998. In 1999, 32% of new HIV diagnoses were in women. Although HIV infected women have been observed to die earlier than men, it is believed that this difference in survival rates is caused by differences in access to care and delayed treatment rather than biological differences in disease progression.

AIDS in children

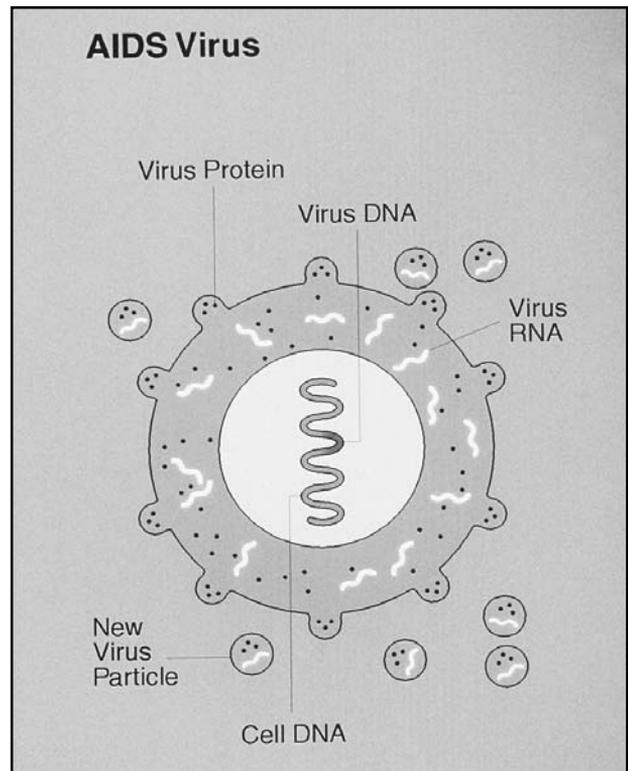
Since AIDS can be transmitted from an infected mother to the child during pregnancy, during the birth process, or through breast milk, all infants born to HIV-positive mothers are a high-risk group. In 1999, 78% of new HIV cases in women were in females of childbearing age. Without prenatal intervention, between 20-40% of children born to HIV-positive women will become infected with the virus.

AIDS is one of the 10 leading causes of death in children between one and four years of age. The interval between exposure to HIV and the development of AIDS is shorter in children than in adults. Infants infected with HIV have a 20-30% chance of developing AIDS within a year and dying before age three. In the remainder, AIDS progresses more slowly; the average child patient survives to seven years of age. Some survive into early adolescence.

Causes and symptoms

Because HIV destroys **immune system** cells, AIDS is a disease that can affect any of the body's major organ systems. HIV attacks the body through three disease processes: immunodeficiency, autoimmunity, and nervous system dysfunction.

Immunodeficiency describes the condition in which the body's **immune response** is damaged, weakened, or is not functioning properly. In AIDS, immunodeficiency results from the way that the virus binds to a protein called CD4, which is found on the surface of certain subtypes of white blood cells, including helper T cells, macrophages, and monocytes. Once HIV attaches to an immune system cell, it can replicate within the cell and



The AIDS virus. (National Institutes of Health. Reproduced by permission.)

kill the cell in ways that are still not completely understood. In addition to killing some lymphocytes directly, the AIDS virus disrupts the functioning of the remaining CD4 cells. Because the immune system cells are destroyed, many different types of infections and cancers that take advantage of a person's weakened immune system (opportunistic) can develop.

Autoimmunity is a condition in which the body's immune system produces antibodies that work against its own cells. Antibodies are specific **proteins** produced in response to exposure to a specific, usually foreign, protein or particle called an antigen. In this case, the body produces antibodies that bind to blood platelets that are necessary for proper blood clotting and tissue repair. Once bound, the antibodies mark the platelets for removal from the body, and they are filtered out by the spleen. Some AIDS patients develop a disorder, called immune-related thrombocytopenia purpura (ITP), in which the number of blood platelets drops to abnormally low levels.

HIV also infects some susceptible cells in the **central nervous system**. The exact mechanism of HIV entry into the **brain** is unknown. Possible modes of entry across the blood-brain barrier include HIV entry as a single cell-free viral particle (virion), entry via infected

monocyte or lymphocyte, and infection of endothelial cells (cells forming brain border). Regardless of the mechanism, evidence suggests that the cerebral spinal fluid is seeded with HIV very early in the infection process.

Although not all patients will follow them precisely, the course of AIDS generally progresses through the three stages (acute retroviral syndrome, latency period, and late-stage AIDS) that follow.

Acute retroviral syndrome

Acute retroviral syndrome is a term used to describe a group of symptoms that can resemble mononucleosis and that may be the first sign of HIV infection in 50-70% of all patients and 45-90% of women. The symptoms may include **fever**, fatigue, muscle aches, loss of appetite, digestive disturbances, weight loss, skin rashes, headache, and chronically swollen lymph nodes (lymphadenopathy). Approximately 25-33% of patients will experience a form of **meningitis** during this phase in which the membranes that cover the brain and **spinal cord** become inflamed. Acute retroviral syndrome develops between one and six weeks after infection and lasts for two to three weeks. Blood tests during this period will indicate the presence of virus (viremia) and the appearance of the viral p24 antigen in the blood.

Latency period

After the HIV virus enters a patient's lymph nodes during the acute retroviral syndrome stage, the disease becomes latent for as many as 10 years or more before symptoms of advanced disease develop. During latency, the virus continues to replicate in the lymph nodes, where it may cause one or more of the following conditions.

PERSISTENT GENERALIZED LYMPHADENOPATHY (PGL). Persistent generalized lymphadenopathy, or PGL, is a condition in which HIV continues to produce chronic painless swellings in the lymph nodes during the latency period. The lymph nodes that are most frequently affected by PGL are those in the areas of the neck, jaw, groin, and armpits. PGL affects between 50-70% of patients during latency.

CONSTITUTIONAL SYMPTOMS. Many patients will develop low-grade fevers, chronic fatigue, and general weakness. HIV may also cause a combination of food malabsorption, loss of appetite, and increased **metabolism** that contribute to the so-called AIDS wasting or wasting syndrome.

OTHER ORGAN SYSTEMS. At any time during the course of HIV infection, patients may suffer from a yeast infection in the mouth called thrush, open sores or ulcers,

or other infections of the mouth; **diarrhea** and other gastrointestinal symptoms that cause malnutrition and weight loss; diseases of the **lungs** and **kidneys**; and degeneration of the nerve fibers in the arms and legs. HIV infection of the nervous system leads to general loss of strength, loss of **reflexes**, and feelings of numbness or burning sensations in the feet or lower legs.

Late-stage AIDS

Late-stage AIDS is usually marked by a sharp decline in the number of CD4+ lymphocytes, followed by a rise in the frequency of opportunistic infections and cancers. Doctors monitor the number and proportion of CD4+ lymphocytes in the patient's blood in order to assess the progression of the disease and the effectiveness of different medications. About 10% of infected individuals never progress to this overt stage of the disease.

OPPORTUNISTIC INFECTIONS. Once the patient's CD4+ lymphocyte count falls below 200 cells/mm³, the patient is at risk for a variety of opportunistic infections. The infectious organisms may include the following:

- **Fungi.** The most common fungal disease associated with AIDS is *Pneumocystis carinii* **pneumonia** (PCP). About 70%-80% of AIDS patients will have at least one episode of PCP prior to death. PCP is the immediate cause of death in 15-20% of AIDS patients. It is an important measure of a patient's prognosis. Other fungal infections include a yeast infection of the mouth (candidiasis or thrush) and cryptococcal meningitis.
- **Protozoa.** Toxoplasmosis is a common opportunistic infection in AIDS patients that is caused by a protozoan. Other diseases in this category include amebiasis and cryptosporidiosis.
- **Mycobacteria.** AIDS patients may develop **tuberculosis** or MAC infections. MAC infections are caused by *Mycobacterium avium-intracellulare*, and occur in about 40% of AIDS patients.
- **Bacteria.** AIDS patients are likely to develop bacterial infections of the skin and digestive tract.
- **Viruses.** AIDS patients are highly vulnerable to cytomegalovirus (CMV), herpes simplex virus (HSV), varicella zoster virus (VZV), and Epstein-Barr virus (EBV) infections. Another virus, JC virus, causes progressive destruction of brain tissue in the brain stem, cerebrum, and cerebellum (multifocal leukoencephalopathy or PML), which is regarded as an AIDS-defining illness by the Centers for Disease Control and Prevention.

AIDS DEMENTIA COMPLEX AND NEUROLOGIC COMPLICATIONS. AIDS **dementia** complex is a late complication of the disease. It is unclear whether it is caused by

the direct effects of the virus on the brain or by intermediate causes. AIDS dementia complex is marked by loss of reasoning ability, loss of **memory**, inability to concentrate, apathy and loss of initiative, and unsteadiness or weakness in walking. Some patients also develop seizures. There are no specific treatments for AIDS dementia complex.

MUSCULOSKELETAL COMPLICATIONS. Patients in late-stage AIDS may develop inflammations of the muscles, particularly in the hip area, and may have arthritis-like pains in the joints.

ORAL SYMPTOMS. In addition to thrush and painful ulcers in the mouth, patients may develop a condition called hairy leukoplakia of the tongue. This condition is also regarded by the CDC as an indicator of AIDS. Hairy leukoplakia is a white area of diseased tissue on the tongue that may be flat or slightly raised. It is caused by the Epstein-Barr virus.

AIDS-RELATED CANCERS. Patients with late-stage AIDS may develop Kaposi's sarcoma (KS), a skin tumor that primarily affects homosexual men. KS is the most common AIDS-related malignancy. It is characterized by reddish-purple blotches or patches (brownish in persons with darker skin) on the skin or in the mouth. About 40% of patients with KS develop symptoms in the digestive tract or lungs. KS may be caused by a herpes virus-like sexually transmitted disease agent rather than HIV.

The second most common form of **cancer** in AIDS patients is a tumor of the **lymphatic system** (lymphoma). AIDS-related lymphomas often affect the central nervous system and develop very aggressively.

Invasive cancer of the cervix is an important diagnostic marker of AIDS in women.

Diagnosis

Because HIV infection produces such a wide range of symptoms, the CDC has drawn up a list of 34 conditions regarded as defining AIDS. The physician will use the CDC list to decide whether the patient falls into one of these three groups:

- definitive diagnoses with or without laboratory evidence of HIV infection
- definitive diagnoses with laboratory evidence of HIV infection
- presumptive diagnoses with laboratory evidence of HIV infection

Physical findings

Almost all the symptoms of AIDS can occur with other diseases. The general **physical examination** may

range from normal findings to symptoms that are closely associated with AIDS. These symptoms are hairy leukoplakia of the tongue and Kaposi's sarcoma. When the doctor examines the patient, he or she will look for the overall pattern of symptoms rather than any one finding.

Laboratory tests for HIV infection

BLOOD TESTS (SEROLOGY). The first blood test for AIDS was developed in 1985. At present, patients who are being tested for HIV infection are usually given an enzyme-linked immunosorbent assay (ELISA) test for the presence of HIV antibody in their blood. Positive ELISA results are then tested with a Western blot or immunofluorescence (IFA) assay for confirmation. The combination of the ELISA and Western blot tests is more than 99.9% accurate in detecting HIV infection within four to eight weeks following exposure. Indeterminate test results are possible (positive ELISA but non-confirmatory Western blot result) if the tests are given within the window period after infection (up to eight weeks after infection, but may be longer). In these indeterminate cases, the ELISA and Western blot should be repeated every three months until a definitive result is made. The patient should be considered HIV positive until proven otherwise. The polymerase chain reaction (PCR) test can be used to detect the presence of viral nucleic acids in the very small number of HIV patients who have false-negative results on the ELISA and Western blot tests.

OTHER LABORATORY TESTS. In addition to diagnostic blood tests, other blood tests are used to track the course of AIDS in patients that have already been diagnosed, including blood counts, viral load tests, p24 antigen assays, and measurements of β_2 -microglobulin (β_2M).

Doctors will use a wide variety of tests to diagnose the presence of opportunistic infections, cancers, or other disease conditions in AIDS patients. Tissue biopsies, samples of cerebrospinal fluid, and sophisticated imaging techniques, such as **magnetic resonance imaging** (MRI) and computed tomography scans (CT) are used to diagnose AIDS-related cancers, some opportunistic infections, damage to the central nervous system, and wasting of the muscles. Urine and stool samples are used to diagnose infections caused by parasites. AIDS patients are also given blood tests for **syphilis** and other sexually transmitted diseases.

Diagnosis in children

Diagnostic blood testing in children older than 18 months is similar to adult testing, with ELISA screening confirmed by Western blot. Younger infants can be diagnosed by direct culture of the HIV virus, PCR testing, and p24 antigen testing.

KEY TERMS

Acute retroviral syndrome—A group of symptoms resembling mononucleosis that often are the first sign of HIV infection in 50-70% of all patients and 45-90% of women.

AIDS dementia complex—A type of brain dysfunction caused by HIV infection that causes difficulty thinking, confusion, and loss of muscular coordination.

Antibody—A specific protein produced by the immune system in response to a specific foreign protein or particle called an antigen.

Antigen—Any substance that stimulates the body to produce antibody.

Autoimmunity—A condition in which the body's immune system produces antibodies in response to its own tissues or blood components instead of foreign particles or microorganisms.

CD4—A type of protein molecule in human blood, sometimes called the T4 antigen, that is present on the surface of 65% of immune cells. The HIV virus infects cells that have CD4 surface proteins, and as a result, depletes the number of T cells, B cells, natural killer cells, and monocytes in the patient's blood. Most of the damage to an AIDS patient's immune system is done by the virus' destruction of CD4+ lymphocytes.

Hairy leukoplakia of the tongue—A white area of diseased tissue on the tongue that may be flat or slightly raised. It is caused by the Epstein-Barr virus and is an important diagnostic sign of AIDS.

Hemophilia—Any of several hereditary blood coagulation disorders occurring almost exclusively in males. Because blood does not clot properly, even minor injuries can cause significant blood loss that may require a blood transfusion, with its associated minor risk of infection.

Human immunodeficiency virus (HIV)—A transmissible retrovirus that causes AIDS in humans. Two forms of HIV are now recognized: HIV-1, which causes most cases of AIDS in Europe, North and South America, and most parts of Africa; and HIV-2, which is chiefly found in West African patients. HIV-2, discovered in 1986, appears to be less virulent than HIV-1 and may also have a longer latency period.

Immunodeficient—A condition in which the body's immune response is damaged, weakened, or is not functioning properly.

Kaposi's sarcoma—A cancer of the connective tissue that produces painless purplish red (in people with light skin) or brown (in people with dark skin) blotches on the skin. It is a major diagnostic marker of AIDS

Latent period—Also called incubation period, the time between infection with a disease-causing agent and the development of disease.

Lymphocyte—A type of white blood cell that is important in the formation of antibodies and that can be used to monitor the health of AIDS patients.

In terms of symptoms, children are less likely than adults to have an early acute syndrome. They are, however, likely to have delayed growth, a history of frequent illness, recurrent ear infections, a low blood cell count, failure to gain weight, and unexplained fevers. Children with AIDS are more likely to develop bacterial infections, inflammation of the lungs, and AIDS-related brain disorders than are HIV-positive adults.

Treatment

Because AIDS is a fatal disease, AIDS therapies focus on improving the quality and length of life for AIDS patients by slowing or halting the replication of the virus, and treating or preventing infections and cancers

that take advantage of a person's weakened immune system. No vaccine is effective in preventing HIV infection.

Treatment for AIDS covers four considerations:

TREATMENT OF OPPORTUNISTIC INFECTIONS AND MALIGNANCIES. Most AIDS patients require complex long-term treatment with medications for infectious diseases. This treatment is often complicated by the development of resistance in the disease organisms. AIDS-related malignancies in the central nervous system are usually treated with radiation therapy. Cancers elsewhere in the body are treated with **chemotherapy**.

PROPHYLACTIC TREATMENT FOR OPPORTUNISTIC INFECTIONS. Prophylactic treatment is treatment that is given to prevent disease. AIDS patients with a history of *Pneumocystis pneumonia*; with CD4+ counts below 200

KEY TERMS CONTINUED

Lymphoma—A cancerous tumor in the lymphatic system that is associated with a poor prognosis in AIDS patients.

Macrophage—A large white blood cell, found primarily in the bloodstream and connective tissue, that helps the body fight off infections by ingesting the disease-causing organism. HIV can infect and kill macrophages.

Monocyte—A large white blood cell that is formed in the bone marrow and spleen. About 4% of the white blood cells in normal adults are monocytes.

***Mycobacterium avium* (MAC) infection**—A type of opportunistic infection that occurs in about 40% of AIDS patients and is regarded as an AIDS-defining disease.

Non-nucleoside reverse transcriptase inhibitors—A newer class of anti-retroviral drugs that work by inhibiting the reverse transcriptase enzyme necessary for HIV replication.

Nucleoside analogue reverse transcriptase inhibitors—The first group of effective anti-retroviral medications. They work by interfering with HIV synthesis of its viral DNA.

Opportunistic infection—An infection by organisms that usually do not cause infection in people with healthy functioning immune systems.

Persistent generalized lymphadenopathy (PGL)—A condition in which HIV continues to produce chronic painless swellings in the lymph nodes during the latency period.

***Pneumocystis carinii* pneumonia (PCP)**—An opportunistic infection caused by a fungus that is a major cause of death in patients with late-stage AIDS.

Progressive multifocal leukoencephalopathy (PML)—A disease caused by a virus that destroys white matter in localized areas of the brain. It is regarded as an AIDS-defining illness.

Protease inhibitors—A new class of anti-retroviral drugs used to treat AIDS that works by preventing the HIV protease enzyme from generating new functioning HIV viruses.

Protozoan—A single-celled, usually microscopic organism that is eukaryotic and, therefore, different from bacteria (prokaryotic).

Retrovirus—A virus that contains a unique enzyme called reverse transcriptase that allows it to replicate within new host cells.

T cells—Lymphocytes that originate in the thymus gland. T cells regulate the immune system's response to infections, including HIV. CD4 lymphocytes are a subset of T lymphocytes.

Thrush—A yeast infection of the mouth characterized by white patches on the inside of the mouth and cheeks.

Viremia—The measurable presence of virus in the bloodstream that is a characteristic of acute retroviral syndrome.

Wasting syndrome—A progressive loss of weight and muscle tissue caused by the AIDS virus.

cells/mm³ or 14% of lymphocytes; weight loss; or thrush should be given prophylactic medications. The three drugs given are trimethoprim-sulfamethoxazole, dapsone, or pentamidine in aerosol form.

ANTI-RETROVIRAL TREATMENT. In recent years researchers have developed drugs that suppress HIV replication, as distinct from treating its effects on the body. These drugs fall into three classes:

- **Nucleoside reverse transcriptase inhibitors (NRTIs).** These drugs work by looking very similar to the molecules acted upon by the HIV enzyme reverse transcriptase. Reverse transcriptase binds to these drugs, which in turn stop the viral replication process. These drugs include zidovudine, didanosine (ddi), zalcitabine (ddC),

stavudine (d4T), lamivudine (3TC), and abacavir (ABC).

- **Non-nucleoside reverse transcriptase inhibitors (NNRTIs).** These drugs de-activate the HIV enzyme reverse transcriptase. This class of drugs includes nevirapine (NVP), delavirdine (DLV), and efavirenz (EFV).

Protease inhibitors. A new class of drugs, protease inhibitors are effective against HIV strains that have developed resistance to nucleoside analogues and are used in combination with them. These compounds include saquinavir (SQV), ritonavir (RJV), indinavir (IDV), nelfinavir (NFV), and amprenavir (APV).

New combinations of therapies are also being developed, primarily to improve adherence. Trizivir for the treatment of HIV in adults and adolescents is a fixed-

Risk of acquiring HIV infection by entry site

Entry site	Risk virus reaches entry site	Risk virus enters	Risk inoculated
Conjunctiva	Moderate	Moderate	Very low
Oral mucosa	Moderate	Moderate	Low
Nasal mucosa	Low	Low	Very low
Lower respiratory	Very low	Very low	Very low
Anus	Very high	Very high	Very high
Skin, intact	Very low	Very low	Very low
Skin, broken	Low	High	High
Sexual:			
Vagina	Low	Low	Medium
Penis	High	Low	Low
Ulcers (STD)	High	High	Very high
Blood:			
Products	High	High	High
Shared needles	High	High	Very high
Accidental needle	Low	High	Low
Traumatic wound	Modest	High	High
Perinatal	High	High	High

SOURCE: Hopp, J.W. and E.A. Rogers. *AIDS and the Allied Health Professions*. Philadelphia: F.A. Davis Co., 1989.

dose combination of abacavir, zidovudine, and lamivudine. Another combination therapy, Combivir, combines lamivudine and zidovudine. Both Trizivir and Combivir are combinations of NRTIs that combine drugs into a single dosage, making it easier for patients to comply with their dosage regimens.

Treatment guidelines for these agents are continually being modified as new medications are developed and introduced. Guidelines for when to start anti-retroviral therapy have been published separately by the International AIDS Society—United States and U.S. Department of Health and Human Services. These guidelines are very similar and base their recommendations on a patient's CD4 counts, viral load, and clinical symptoms.

In terms of specific treatment approaches, the January 2000 guidelines from the U.S. Department of Health and Human Services suggest two strategies for initial treatment, both of which use combinations of drugs: two nucleosides and a protease inhibitor, or two nucleosides and a non-nucleoside drug. Over time, treatment changes may be required; factors that must be considered when changing treatment regimens include drug toxicity, clinical symptoms, viral load, CD4 counts, adherence to current and future medications, and other viable treatment options.

STIMULATION OF BLOOD CELL PRODUCTION. Because many patients with AIDS suffer from abnormally low levels of both red and white blood cells, they may be given medications to stimulate blood cell production.

Epoetin alfa (erythropoietin) may be given to anemic patients. Patients with low white blood cell counts may be given filgrastim or sargramostim.

Treatment in women

Treatment of pregnant women with HIV is particularly important because anti-retroviral therapy has been shown to reduce transmission to the infant by 65%.

Prognosis

No cure for AIDS has been discovered. Treatment stresses aggressive combination drug therapy for those patients with access to the expensive medications and who tolerate them adequately. The use of these multi-drug therapies, called highly active antiretroviral therapies or HAART, has significantly reduced the numbers of deaths in the United States resulting from AIDS. The data is still inconclusive, but the potential exists to prolong life indefinitely using these and other drug therapies to boost the immune system, keep the virus from replicating, and ward off opportunistic infections and malignancies.

Prognosis after the latency period depends on the patient's specific symptoms and the organ systems affected by the disease. Patients with AIDS-related lymphomas of the central nervous system die within two to three months of diagnosis; those with systemic lymphomas may survive for eight to ten months.

Health care team roles

The physician oversees the treatment strategy and patient evaluation for patients who are HIV-positive and/or have AIDS. Adherence to treatment is a critical aspect of clinical care in AIDS, and nurses play a key role in educating patients and providing them with adherence tools. Nurses, social workers, and psychologists can also be trained as HIV counselors to advise patients about HIV testing and, if necessary, to assist and guide patients in adjusting to a life with HIV. During end-stage AIDS, nurses, social workers, and other hospice workers ensure that patients do not experience unnecessary **pain** and discomfort.

Prevention

As of 2000, there is no vaccine effective against HIV/AIDS. Several vaccines are being investigated, however, both to prevent initial HIV infection and as a therapeutic treatment to prevent HIV from progressing to full-blown AIDS.

Several types of prevention programs have been found to be effective in reducing sexual transmission of HIV. These include:

- targeted education for at-risk groups, emphasizing preventive practices such as condom use, monogamy, and HIV testing prior to beginning a sexual relationship
- counseling with or without testing for HIV and other sexually transmitted diseases
- education programs in institutions such as the military, prisons, and the workplace
- greater access to condoms

Preventive measures for other modes of transmission include:

- Making clean needles more available and discouraging intravenous drug users from sharing needles.
- Encouraging health care professionals to take all necessary precautions by wearing gloves and masks when handling body fluids.
- Encouraging health care institutions to provide safer medical devices such as self-sheathing needles and retracting and/or needleless intravenous systems.
- Informing individuals who are planning to undergo major surgery that they can donate blood in advance to prevent a risk of infection from a blood transfusion. (However, blood and blood products are carefully monitored.)
- Encouraging testing for HIV infection if there has been suspected exposure to HIV. If HIV infection is confirmed, sexual partners should be informed and, if necessary, receive medical attention.

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- Summers, T. "Public Policy for Health Care workers Infected with the Human Immunodeficiency Virus." *Journal of the American Medical Association* 285, no. 7 (February 21, 2001): 882.

ORGANIZATIONS

- Gay Men's Health Crisis. The Tisch Building, 119 West 24th Street, New York, NY 10011. (800) 243-7692. <<http://www.gmhc.org/>>.
- HIV/AIDS Treatment Information Service (ATIS). P.O. Box 6303, Rockville, MD 20849-6303. (800) 448-0440. <<http://www.hivatis.org/>>.
- National AIDS Hot Line. (800) 342-AIDS/2437 (English). (800) 344-SIDA (Spanish). (800) AIDS-TTY (hearing-impaired).

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Genevieve Pham-Kanter

AIDS counseling

Definition

AIDS counseling is a specialized branch of counseling or social work that deals with the prevention of the disease and the treatment of clients who have been diagnosed with human **immunodeficiency** virus (HIV) or acquired immunodeficiency syndrome (AIDS).

KEY TERMS

AIDS—Acquired immunodeficiency syndrome, caused by infection with HIV.

BSW—Baccalaureate degree in social work.

HIV—Human immunodeficiency virus, a pathogen that gradually destroys the immune system and eventually causes death.

Lay person—Person who performs a job effectively with little or no special training.

Long-term care—A facility that provides nursing and basic needs care when a client is no longer able to receive that care at home.

MSW—Master's degree in social work.

Needs assessment—Interview conducted by a counselor with client and family, to review charts and interview other health workers to determine what specific services are required by client.

Description

The AIDS epidemic created a specialized niche for the treatment of the disease. Counselors and social workers who work in this particular field help clients who are directly affected by HIV and AIDS meet their personal, medical, financial and emotional needs. They also educate both patients and the public about the disease.

AIDS counselors teach the general public about the causes and risk factors of AIDS, and the steps necessary to prevent HIV **infection**. Education is also required for the people who have already been infected with HIV. AIDS counselors teach their clients how to prevent the spread of the disease via safe sexual practices, responsible **prenatal care**, and treatment for drug addiction.

Education about the disease, although very important, is only a small part of AIDS counseling. Because AIDS affects a wide spectrum of the population, counseling needs are as varied as those of the clients. AIDS counseling may cover substance abuse, mental health problems, preparation for death, medication and treatment approaches, financial needs, prenatal care, child care, family dynamics, and homelessness. Some of these needs require licensed professionals such as physicians, pharmacists, and psychologists to help the client; others simply require a caring lay person to help the client find the right services.

Social workers are highly involved in AIDS counseling because of the nature of their profession. Social

workers act as advocates for patient's rights, arrange for community support, make arrangements for patients to go to long-term care facilities, find funds to pay for housing and medication, link the patients to social service and community outreach programs, arrange and lead support groups, plan for **home care**, and counsel the patients and their families.

Work settings

AIDS counselors work in a variety of locations, including hospitals, community outreach clinics, **public health** clinics, **hospices**, or mental health and substance abuse facilities.

AIDS counselors work varying hours, depending upon the requirements of the facility in which they work. Often the hours are 8 A.M. to 5 P.M., Monday through Friday, but counselors or social workers may be required to work evenings or weekends, and may be on call for hospices and hospitals.

Education and training

Professional counselors are required to have at least a master's degree in counseling, although education, training, and licensing requirements vary from state to state. Psychologists must have a master's degree or a Ph.D in psychology. Professional counselors are required to have 900 hours of field work or an internship.

The minimum educational requirement for social workers is a bachelor's degree in social work (BSW). However, people who hold a undergraduate degrees in another discipline such as psychology or sociology may also qualify for entrance-level jobs in AIDS counseling.

BSW programs prepare students for direct care of clients. Students who major in social work must complete 400 hours of supervised field work in addition to courses in social work practice, social work policies, human behavior and social environment, research methods, social work values and ethics, study of populations at risk, and the promotion of social justice.

An advanced degree is the standard for many positions in social work including positions within the field of health care. A master's degree in social (MSW) allows the social worker to be certified for clinical and supervisory work.

Advanced education and training

The National Association of Social Workers requires social workers to complete 90 hours of continuing education classes every three years to continue their certification in the profession. Licensed professionals with

advanced degrees may be required to complete more than 90 hours of continuing-education classes.

Future outlook

AIDS counseling is a growing profession. The national Bureau of Labor Statistics predicts that growth will continue at a rate exceeding that for other occupations until at least 2008. There are several reasons why AIDS counseling continues to grow:

- increased awareness of AIDS and increased funding for prevention and treatment
- advanced medical treatment of AIDS patients
- longer life expectancy of patients
- growth of home health care and agencies now serving AIDS patients
- replacement of workers seeking career change
- stress and burnout among counselors and social workers, causing them to leave profession
- increase in population of people living with AIDS

Resources

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ORGANIZATIONS

National Association of Social Workers. 750 First Street NE, Suite 700, Washington, D.C. 20002-4241.
<<http://www.naswdc.org>>.

National Minority AIDS Council. 1931 13th Street NW, Washington, D.C. 20009.

Peggy Elaine Browning

AIDS tests

Definition

AIDS tests, short for acquired **immunodeficiency** syndrome tests, cover a number of different procedures used in the diagnosis and treatment of HIV-infected patients. Tests that measure antibodies to the human immunodeficiency virus (HIV) are called AIDS serology tests. Serology is the branch of immunology that deals

with the identification and measurement of antibodies in serum which indicate the presence of disease or immunity to disease. Serum is the normally clear light yellow noncellular portion of **blood** that forms after the sample is allowed to clot. Some AIDS tests measure HIV antigens or nucleic acid rather than antibodies produced in response to HIV **infection**. AIDS tests evaluate the presence of HIV in blood serum, and the effects of HIV infection on the patient's **immune system**.

Purpose

AIDS serology tests have several uses. Some AIDS tests are used to diagnose patients or confirm a diagnosis; others are used to measure the progression of the disease or the effectiveness of specific treatment regimens. Some AIDS tests can also be used to screen blood donations for safe use in transfusions.

In order to understand the different purposes of the blood tests used for AIDS patients, it is helpful to understand how HIV infection affects the immune system. HIV is a retrovirus that enters the blood stream of a new host in the following ways:

- sexual contact, including oral and anal intercourse
- entry of HIV infected body fluids (such as blood or urine) through a cut or break in the skin
- transmission during **pregnancy**
- using or being pricked by a needle that had previously been used by or on an infected person
- transfusion of infected blood products

A retrovirus is a virus that contains two identical strands of RNA and a unique enzyme called reverse transcriptase that converts the viral RNA to DNA within the host cell. Another viral enzyme called integrase inserts this proviral DNA into the host cell genome. Other viral **proteins** control the process of transcription which forms RNA copies of the inserted DNA, production of structural viral proteins, assembly of immature virus particles, maturation, and release (budding) from the host cell. The entire process takes 12-24 hours.

The primary host cell for HIV is the T helper cell. The HIV envelope contains a glycoprotein called gp120, which binds to a surface molecule on the T helper cell called CD4. Other types of lymphocytes which lack the CD4 molecule are not infected. In addition to T helper cells, HIV can infect phagocytic cells (macrophages, monocytes, and dendritic cells) which serve as reservoirs and spread the virus throughout the body. The virus can also infect certain tissue cells such as **neurons**, which in part accounts for some of the underlying pathology of HIV disease.

HIV disease begins as a flu-like illness two to six weeks after infection which subsides without treatment. Antibodies to the viral envelope appear eight to 12 weeks after infection. Most patients enter a phase of clinical latency, which on average lasts eight to 10 years. This is followed by gradual loss of CD4 positive lymphocytes (T helper cells). T helper cells produce a substance called interleukin-2 (IL-2), which stimulates other cells (T cells and B cells) in the human immune system to respond to infections. Without the IL-2, the **immune response** collapses and patients become susceptible to a wide range of infections. Depletion of T helper cells signals the onset of opportunistic infections, malignancy, **dementia**, and a constellation of other diseases associated with AIDS.

There are no medical restrictions on administering AIDS tests. Most tests are performed on blood, but a screening test using urine is available. Health care professionals should always follow standard precautions recommended by the Centers for Disease Control (CDC) to reduce the possibility of accidental needlestick injury or exposure to the patient's blood and body fluids. This includes wearing latex gloves, washing hands before and following venipuncture, and using disposable needles and safety devices.

Description

Diagnostic tests

Diagnostic blood tests for AIDS are usually given to persons in high-risk populations, pregnant females, health care and public service workers who have been exposed to HIV, or those who have symptoms associated with AIDS. The condition of testing positive for HIV antibody in the blood is called seroconversion, and persons who are HIV-positive are called seroconverters.

AIDS tests used to diagnose infection fall into two categories, screening tests and confirmatory tests. It is possible to diagnose HIV infection by isolating the virus from the blood. However, viral culture is expensive, not widely available, and time consuming. Screening tests detect the presence of antibodies to several HIV antigens. These tests are inexpensive, widely available, and accurate in detecting 99.9% of HIV infections. However, approximately 0.2% of persons without HIV infection will test positive. In order to eliminate these false positives, persons should be tested in duplicate and positive results followed by a confirmatory test.

ENZYME-LINKED IMMUNOSORBENT ASSAY (ELISA). This test is the most commonly used method to screen blood for transfusions as well as to diagnose patients. An ELISA test for HIV works by attaching two or more HIV antigens to a plastic well or beads. A sample of the

patient's blood serum is added and incubated. If antibodies to HIV antigens are present, they will bind to the tube, or bead. After washing to remove excess proteins, an anti-human immunoglobulin conjugated to an enzyme is added. After incubation, excess antibody is washed away and a chemical called a substrate is added. The enzyme reacts with the substrate to form a colored product that indicates a positive test.

The latest generation of ELISA tests are 99.5% sensitive to HIV. Occasionally, the ELISA test will be positive for a patient without symptoms of AIDS from a low-risk group. Because this result is likely to be a false positive, the ELISA must be repeated *on the same sample of the patient's blood*. If the second ELISA is positive, the result should be confirmed by the Western blot or other confirmatory test.

WESTERN BLOT (IMMUNOBLOT). The Western blot or immunoblot test is used as a reference procedure to confirm the diagnosis of HIV infection. In Western blot testing, HIV antigens of different size are purified from HIV cultures and separated from each other by the process of electrophoresis. (In electrophoresis, protein molecules are suspended in a gel and separated by applying an electric current through the gel.) The HIV antigens are transferred to a nylon membrane or nitrocellulose filter. The patient's serum is added to this, and if antibodies are present they will bind to the corresponding viral antigens. The membrane is washed and anti-human immunoglobulin conjugated to an enzyme is added. After washing again, the color-developing substrate is added, which causes colored bands to appear where the serum antibodies are attached to the membrane. Western blots can detect antibodies to several HIV antigens, but results must be interpreted with caution because antibodies produced against other **viruses** may cross-react. A test is considered positive when antibodies are seen against antigens from at least two of the three major HIV antigens (p24, gp41, and gp120/160).

When used in combination with ELISA testing, Western blot testing is 99.9% specific. It can, however, yield false negatives in patients with very early HIV infection and in those infected by HIV-2. In some patients the Western blot yields indeterminate results.

IMMUNOFLUORESCENCE ASSAY (IFA). This method is sometimes used to confirm ELISA results instead of the Western blot test. An IFA test detects the presence of HIV antibody in a sample of the patient's serum by incubating the serum with H9 cells infected with HIV virus. The cells are grown in tissue culture and transferred to glass slides, which are frozen. After incubating with the patient's serum, the slide is washed to remove the serum and fluorescein-conjugated anti-human immunoglobulin

is added. After incubation, the unbound conjugate is removed by washing the slide. The slide is examined using a fluorescent **microscope**. The conjugate causes the HIV-infected cells coated with antibody to have a green fluorescence. This test can detect antibody of the IgM class that is produced within seven to 10 days after infection.

RADIOIMMUNOPRECIPITATION ASSAY (RIPA). A third confirmatory HIV testing method is the radioimmunoprecipitation assay (RIPA). This test also uses H9 lymphocytes infected with HIV. The cells are grown in tissue culture media containing radioactive methionine. This causes the viral antigens to be radioactive. A lysate is prepared from the cultured cells and incubated with serum. If antibodies are present in the serum they will bind to the radioactive viral antigens. These radioactive immune complexes are isolated onto sepharose beads coated with Staphylococcal protein-A. The beads are precipitated and tested for radioactivity, the presence of which indicates a positive test.

VIRAL LOAD TESTS. Tests for viral load measure the amount of virus in the blood either by quantifying nucleic acid or p24 antigen (p24 antigen capture assay). They may be used as confirmatory tests for HIV infection, but are more often used to determine the progression of HIV disease to AIDS and to determine the onset of drug resistance, both of which are signaled by an increase in the concentration of circulating viruses. The nucleic acid based tests for viral load include the reverse transcriptase-polymerase chain reaction (RT-PCR) test, branched DNA signal amplification method (bDNA), and the nucleic acid sequence-based amplification method (NASBA). DNA amplification methods can detect as little as 50 copies of viral RNA per mL of plasma and can detect infection during the “window phase,” when antibody levels are too low to produce a positive test result. In the RT-PCR assay, guanidinium isothiocyanate is added to the patient’s serum or plasma. The RNA is precipitated with isopropanol, and the RNA is resuspended and incubated in a medium containing reverse transcriptase, heat stable DNA polymerase (Taq polymerase), oligonucleotide primers tagged with **biotin**, and nucleotide triphosphates. The reverse transcriptase produces a double stranded DNA copy of the viral RNA. This DNA copy serves as the template for the polymerase chain reaction. Heat is used to separate the target DNA strand, a process known as denaturation. The temperature is lowered and the primers bind to the target sequence, a process called annealing. Heat stable DNA polymerase fills in the sequence by adding nucleotide triphosphates to the 3’ end of the primer, a process called extension. This makes a new copy of the double stranded DNA. The cycle is repeated, making use of the newly synthesized

DNA molecule as a template. If the process is repeated 30 times there will be over one billion copies of the target DNA. The amplified DNA, called amplicons, are denatured into single strands and are detected by means of an enzyme-conjugated DNA probe which hybridizes to the amplicons.

P24 ANTIGEN CAPTURE ASSAY. The p24 antigen capture assay is also used to measure viral load. Found in the viral core of HIV, p24 is a protein that can be measured by enzyme immunoassay. Generally, p24 is detected early in infection (before antibody production) but then falls to undetectable levels shortly after antibody production. The p24 assay is useful in detecting HIV infection before seroconversion, and for this reason it is used along with ELISA when testing donor blood for HIV. A return to detectable levels occurs when the virus becomes activated. Therefore, the test is used to identify patients who have become unresponsive to antiviral therapy and to indicate progression to AIDS. The test is not a useful screening test for HIV, since only about 20-30% of patients are positive in the early stages of HIV infection. Beads coated with monoclonal antibodies against p24 antigen are mixed with serum and incubated. After washing to remove unbound serum proteins, the beads are mixed with a second antibody to p24 derived from a rabbit. The beads are washed again, and an enzyme-conjugated anti-rabbit immunoglobulin is added. A final wash step is performed and substrate is added. The amount of color formed is proportional to the p24 antigen level of the serum.

BLOOD DONOR TESTING. Blood donated for transfusion is tested for HIV-1 and HIV-2 by ELISA, p24 antigen capture, and RT-PCR. For the latter, donor samples are pooled and tested for the presence of virus. This process detects the rare donors units that are negative for anti-HIV but potentially infective. This process has reduced the window phase from 22 days (ELISA alone) down to 11 days. It is estimated that the risk of receiving a transfusion of HIV positive blood in the United States is less than 1 in 562,500 when ELISA and p24 antigen testing are both used.

In 1999, the U.S. Food and Drug Administration (FDA) approved an HIV home testing kit. The kit contains multiple components, including material for specimen collection, a mailing envelope to send the specimen to a laboratory for analysis, and provides pre- and post-test counseling. It uses a finger prick process for blood collection. The results are obtained by the purchaser through a toll-free telephone number using a personal identification number (PIN). Post-test counseling is provided over the telephone by a licensed counselor. The only kit approved by the FDA as of 2001 was the Home Access test system.

KEY TERMS

Antibody—A protein in the blood that identifies and helps remove disease organisms or their toxins. Antibodies are secreted by B cells. AIDS diagnostic tests work by demonstrating the presence of HIV antibody in the patient's blood.

Antigen—Any substance that stimulates the body to produce antibodies.

B cell—A type of white blood cell derived from bone marrow. B cells are sometimes called B lymphocytes. They secrete antibody and have a number of other complex functions within the human immune system.

CD4—A type of protein molecule in human blood that is present on the surface of 65% of human T cells. CD4 is a receptor for the HIV virus. When the HIV virus infects cells with CD4 surface proteins, it depletes the number of T cells, B cells, natural killer cells, and monocytes in the patient's blood. Most of the damage to an AIDS patient's immune system is done by the virus' destruction of CD4+ lymphocytes. CD4 is sometimes called the T4 antigen.

Complete blood count (CBC)—A routine analysis performed on a sample of blood taken from the patient's vein with a needle and vacuum tube. The measurements taken in a CBC include a white blood cell count, a red blood cell count, the red cell distribution width, the hematocrit (ratio of the volume of the red blood cells to the blood volume),

and the amount of hemoglobin (the blood protein that carries oxygen).

Electrophoresis—A method of separating complex protein molecules suspended in a gel by running an electric current through the gel.

Enzyme-linked immunosorbent assay (ELISA)—A diagnostic blood test used to screen patients for AIDS or other viruses. The patient's blood is mixed with antigen attached to a plastic tube or bead surface. A sample of the patient's blood serum is added, and excess proteins are removed. A second antibody coupled to an enzyme is added, followed by a chemical that will cause a color reaction that can be measured by a special instrument.

Human immunodeficiency virus (HIV)—A transmissible retrovirus that causes AIDS in humans. Two forms of HIV are now recognized: HIV-1, which causes most cases of AIDS in Europe, North and South America, and most parts of Africa; and HIV-2, which is chiefly found in West African patients. HIV-2, discovered in 1986, appears to be less virulent than HIV-1, but may also have a longer latency period.

Immunofluorescent assay (IFA)—A blood test sometimes used to confirm ELISA results instead of using the Western blotting. In an IFA test, HIV antigen is mixed with a fluorescent compound and then with a sample of the patient's blood. If HIV antibody is present, the mixture will fluoresce when examined under ultraviolet light.

Prognostic tests

In addition to tests for viral antigens and antibodies, other blood tests are needed to evaluate and manage patients with HIV disease. The most important of these is the CD4 positive lymphocyte count. This test measures the number of T helper cells in the blood. A CD4 count of less than 200/microL or 14% of the total lymphocyte count in a person who is HIV positive constitutes a diagnosis of AIDS. A falling CD4 positive lymphocyte count parallels a rise in viral replication and correlates with both a risk of opportunistic infection and drug resistance in patients receiving highly active antiviral therapy (HAART).

It is important for doctors treating AIDS patients to measure the CD4 positive lymphocyte count on a regular

basis. Experts consulted by the U.S. Public Health Service recommend the following frequency of serum testing based on the patient's CD4+ level:

- CD4+ count more than 600 cells/microL: Every six months.
- CD4+ count between 200-600 cells/microL: Every three months.
- CD4+ count less than 200 cells/microL: Every three months.

When the CD4+ count falls below 200 cells/microL, the doctor will put the patient on a medication regimen to protect him or her against opportunistic infections.

BETA₂-MICROGLOBULIN (β₂M). Beta₂-microglobulin is a protein found on the surface of all human cells with a nucleus. It is released into the blood when a cell dies.

KEY TERMS CONTINUED

Lymphocyte—A type of white blood cell that is important in the formation of antibodies. Doctors can monitor the health of AIDS patients by measuring the number or proportion of certain types of lymphocytes in the patient's blood.

Macrophage—A large white blood cell, found primarily in the bloodstream and connective tissue, that helps the body fight off infections by ingesting the disease organism. HIV can infect and kill macrophages.

Monocyte—A large white blood cell that is formed in the bone marrow and spleen. About 4% of the white blood cells in normal adults are monocytes.

Opportunistic infection—An infection that develops only when a person's immune system is weakened, as happens to AIDS patients.

Polymerase chain reaction (PCR)—A test performed to evaluate false-negative results to the ELISA and Western blot tests. In PCR testing, numerous copies of a gene are made by separating the two strands of DNA containing the gene segment, marking its location, using DNA polymerase to make a copy, and then continuously replicating the copies. The amplification of gene sequences that are associated with HIV allows for detection of the virus by this method.

Retrovirus—A virus that contains a unique enzyme called reverse transcriptase that allows it to replicate within new host cells.

Seroconversion—The change from HIV-negative to HIV-positive status during blood testing. Persons who are HIV-positive are called seroconverters.

Serology—The analysis of the contents and properties of blood serum.

Serum—The part of human blood that remains liquid when blood cells form a clot. Human blood serum is clear light yellow in color.

T cells—Lymphocytes that originate in the thymus gland. T cells regulate the immune system's response to infections, including HIV. CD4 lymphocytes are a subset of T lymphocytes.

Viral load test—A new blood test for monitoring the speed of HIV replication in AIDS patients. The viral load test is based on PCR techniques and supplements the CD4+ cell count tests.

Western blot—A technique that is used to confirm ELISA results. HIV antigen is purified by electrophoresis and attached by blotting to a nylon or nitrocellulose filter. The patient's serum is reacted against the filter, followed by treatment with developing chemicals that allow HIV antibody to show up as a colored patch or blot. If the patient is HIV-positive, there will be stripes at specific locations for two or more viral proteins. A negative result is blank.

WBC differential—A white blood cell count in which the technician classifies the different white blood cells by type as well as calculating the number of each type. A WBC differential is necessary to calculate the absolute CD4+ lymphocyte count.

Although rising blood levels of $\beta_2\text{M}$ are found in patients with cancer and other serious diseases, a rising $\beta_2\text{M}$ blood level can be used to measure the progression of AIDS.

GENOTYPIC DRUG RESISTANCE TEST. Genotypic testing can help determine whether specific gene mutations, common in people with HIV, are causing drug resistance and drug failure. The test looks for specific genetic mutations within the virus that are known to cause resistance to anti-viral drugs. For example the drug 3TC, also known as lamivudine (Epivir), is not effective against strains of HIV that have a mutation at a particular position, known as M184V, in their reverse transcriptase enzyme. If the genotypic resistance test shows a mutation at position M184V, it is likely that person is resistant to 3TC and not likely to respond to treatment. Genotypic

tests are only useful when the patient is already taking antiviral medication, and the viral load is greater than 1,000 copies per mL of plasma. The cost of the viral drug resistance testing is usually between \$300 and \$500, and is usually not covered by insurance plans, including Medicare.

PHENOTYPIC DRUG RESISTANCE TESTING. Phenotypic testing directly measures the *in vitro* sensitivity of a patient's HIV strains to particular drugs and drug combinations. The test measures the concentration of a drug required to inhibit viral replication by 50% and 90%. This is the same method used by researchers to determine whether a drug might be effective against HIV before using it in human clinical trials. Phenotypic testing is a more direct measurement of resistance than genotypic testing. Unlike genotypic testing, phenotypic

testing does not require a high viral load, but it is recommended that persons already be taking **antiretroviral drugs**. The cost is between \$700 and \$900 and is usually not covered by insurance plans, including Medicare.

AIDS serology in children

Children born to HIV-infected mothers may acquire the infection through the mother's placenta or during the birth process. Public health experts recommend the testing and monitoring of all children born to mothers with HIV. Diagnostic testing in children older than 18 months is similar to adult testing, with ELISA screening confirmed by Western blot. Younger infants can be diagnosed by direct culture of the HIV virus, PCR testing, and p24 antigen testing. These techniques allow a pediatrician to identify 50% of infected children at or near birth, and 95% of cases in infants three to six months of age.

Preparation

In addition to diagnostic testing for HIV infection, many laboratory tests are important to the proper management and treatment of patients with HIV disease and AIDS. These include the **complete blood count** (CBC), cultures and serological tests for opportunistic infections, Pap smear for cervical cancer, imaging studies, nerve conduction studies, and tests for nutritional status.

Preparation and aftercare are important parts of AIDS diagnostic testing. Doctors are now advised to take the patient's emotional, social, economic, and other circumstances into account and to provide counseling before and after testing. Patients are generally better able to cope with the results if the doctor has spent some time with them before the blood test explaining the basic facts about HIV infection and testing. Many doctors now offer this type of informational counseling before performing the tests.

Complications

The risks of AIDS testing are primarily related to disclosure of the patient's HIV status rather than to any physical risks connected with blood testing. Some patients are better prepared to cope with a positive diagnosis than others, depending on their age, sex, health, resources, belief system, and similar factors.

Results

Normal results for ELISA, Western blot, IFA, and PCR testing are negative for HIV antibody.

Normal results for CD4+ lymphocytes: 500-1200/microL, 34-67% of all lymphocytes.

The following abnormal results of AIDS tests indicate progression of the disease:

- Percentage of CD4 positive lymphocytes: less than 14% of all lymphocytes.
- CD4+ lymphocyte count: less than 200 cells/microL.
- Viral load test: Levels more than 5000 copies/mL.

Health care team roles

Nurses and phlebotomists (workers who draw blood) are usually the health care professional that draw the blood for AIDS tests. However, it is the physician that recommends specific treatment and prescribes needed medication. HIV tests are performed by clinical laboratory scientists, CLS (NCA) or medical technologists, MT (ASCP). It is often the role of a trained counselor to tell the patient the test results. Regardless of the results, nurses, health care educators, and counselors often are responsible for educating the patient about safe sex practices and risk factors for contracting HIV, along with the possible need for periodic repeat testing.

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National Association of People with Aids. 1413 K St.N.W., Washington, DC 20005-3442. (202)898-0414.

National Institute of Health. Office of Aids Research. (301)496-0357. <<http://www.nih.gov/od/oar/index.htm>>.

OTHER

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Ken R. Wells

Air embolism *see* **Gas embolism**

Airway management

Definition

Airway management involves ensuring that the patient has a patent airway through which effective ventilation can take place.

Purpose

An obstructed airway means that the body is deprived of oxygen. If ventilation is not reestablished,

brain death will occur within minutes. The primary purpose of airway management is to provide a continuously open airway along with a continuous source of oxygen. When a patient is critically ill and requires an artificial airway and mechanical ventilation, it is the responsibility of the healthcare professionals caring for the patient to ensure that the airway is secure.

Another goal of airway management is to provide an artificial airway that is as close to the patient's natural airway as possible. This may mean mechanically performing physiological functions such as humidifying inspired air and removing secretions.

Precautions

Airway management is a necessity for any patient who has an artificial airway. If the patient is restless or agitated, it is recommended that activities such as suctioning or endotracheal tube care be postponed until either the patient is calm or a sedative has been given. This is to avoid inadvertent removal of the airway. However, if the patient's respiratory status is unstable, suctioning or repositioning the endotracheal tube should be done if it will stabilize the patient.

Description

Airway management consists of much more than just keeping the breathing tube in the correct position. The tube must be managed so that it allows optimal ventilation with the fewest complications.

Humidification

Humidification of inspired air normally takes place in the upper respiratory tract. When this area is bypassed by an artificial airway (such as an endotracheal or tracheostomy tube), humidification must be performed outside the body. If supplemental oxygen is used, it will require humidification to prevent drying and irritation of the respiratory tract and to facilitate removal of secretions. There are humidification devices available that can be attached to oxygen flow meters or **ventilators**.

Suctioning

Suctioning consists of inserting a sterile catheter into the endotracheal or tracheostomy tube in order to remove secretions. This is an extremely important part of caring for a patient with an artificial airway, since the reflex of coughing, which would normally remove these secretions, is not effective. The patient will experience respiratory distress if the tube is obstructed by sputum. Suctioning should be performed only when the patient

KEY TERMS

Bag-valve-mask device—Device consisting of a manually compressible bag containing oxygen and a one-way valve and mask that fits over the mouth and nose of the patient.

Endotracheal tube—Tube inserted into the trachea via either the oral or nasal cavity for the purpose of providing a secure airway.

Hypoxemia—Abnormal deficiency of oxygen in the arterial blood.

Oxygen flow meter—Meter attached to a oxygen source that controls the amount of supplemental oxygen the patient receives.

Pulse oximeter—Noninvasive machine that measures the amount of hemoglobin that is saturated with oxygen.

Tracheostomy tube—Surgically created opening in the trachea for the purpose of providing a secure airway. This is used when the patient requires long-term ventilatory assistance.

Ventilator (mechanical ventilation)—Device used to provide assisted respiration and positive pressure breathing.

needs it; however, the need should be assessed at least every two hours.

A number of studies have been done to find ways to minimize the complications of suctioning. Equipment should be sterilized to decrease the risk of **infection**. There are now closed suction systems available that are attached to the ventilator tubing on one end and to the artificial airway on the other. The catheter remains protected inside a sterile plastic sleeve that is changed every 24 hours. This system limits the amount of times the tubing must be disconnected from the airway, thus reducing exposure of the trachea to environmental contaminants.

Suctioning causes oxygen deprivation for the time that the suction is applied. Hypoxemia can be minimized by preoxygenating the patient with 100% oxygen prior to suctioning and between each pass of the suction catheter. (This can be done by either pushing the 100% oxygen button on the ventilator or by using a bag-valve-mask device.) The patient's pulse oximetry should be monitored while suctioning. The duration of each suction pass should be limited to 10 seconds and the number of passes should be limited to three or less if possible. This decreases hypoxemia and airway trauma. Studies have

shown that using intermittent suction is no more beneficial than continuous suction.

Installation of a small amount of saline prior to suctioning was a common procedure in the past. It was thought that saline helped to loosen secretions and to facilitate their removal, but studies have shown this is not the case. On the contrary, saline installation has been shown to increase infection rates and to cause decreased oxygen levels for longer periods than suctioning without saline use. This procedure is no longer regarded as beneficial.

Preparation

Preparation for airway management includes explaining all procedures that will be performed to the patient. Often, patients who are receiving mechanical ventilation are kept sedated or even paralyzed to facilitate optimal ventilation. The level of sedation should be assessed. If patients are not receiving continuous infusions of a sedating drug, they may have a physician's order for sedation as needed. If they are agitated, they should be given the prescribed dose of sedation prior to performing any airway-related procedures, to ensure that the airway is not inadvertently removed.

Patients receiving mechanical ventilation also often have bilateral soft wrist restraints applied to prevent accidental removal of the artificial airway. It is recommended that these be securely fastened before starting an airway-related procedure, or that another healthcare professional be at the bedside to help calm and hold the patient. Also, all needed supplies should be at the bedside prior to starting a procedure, so as to not cause excess discomfort or **stress** for the patient.

Aftercare

After the procedure is finished, the patient should be reassured if necessary and their respiratory status should be reassessed. The insertion point of the airway should be confirmed to be at the same place as prior to the procedure, unless the purpose was to change the depth of the tube. If the airway has been manipulated since suctioning, the patient may require suctioning again. Any waste should be disposed of in the garbage or in a biohazard container if there is a large amount of **blood**. Prior to the healthcare professional leaving the room, the patient should be made comfortable, further sedation or **pain** medication should be administered as needed and the patient should be confirmed to be stable.

Complications

The greatest risk of airway management is that the airway may be inadvertently removed, causing the

patient to have respiratory distress. Procedures that require manipulating the airway may cause fear or agitation for patients if they feel that they do not have control over their breathing. If the patient becomes combative, it can be very difficult to finish the procedure without disturbing the airway.

Results

The anticipated outcomes of airway management are a continuously open airway through which effective ventilation can take place, and prevention of infection.

Health care team roles

The nurse and respiratory therapist are equally responsible for monitoring and managing artificial airways. Both perform sterile suctioning and both document their assessment of the patient's respiratory status. The respiratory therapist is generally responsible for managing the ventilator, adding humidification, and changing ventilator tubing.

If the patient is accidentally extubated (the airway is removed), both the nurse and respiratory therapist must assist in reinsertion. This is usually done by an anesthesiologist, a certified **registered nurse anesthetist (CRNA)**, a medical resident, or another physician. The respiratory therapist is generally responsible for ventilating the patient with a bag-valve-mask device until reintubation (reinsertion of the airway), while the nurse gathers equipment, administers medications, and monitors the patient's pulse oximetry, **vital signs**, and cardiac rhythm.

The nurse and respiratory therapist are also responsible for finding alternative means for the patient to communicate. Artificial airways are inserted through the vocal cords, making speaking impossible. The patient should be encouraged to try alternative methods such as mouthing words, writing, or pointing to letters, words, or pictures on a communication board. Communicating with these patients takes great patience and creativity, as well as dedication to helping them feel like their needs are being met.

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Airway suctioning see **Airway management**

Alanine aminotransferase test see **Liver function tests**

Albumin test see **Liver function tests**

Alcohol-related neurologic disease see **Alcoholic paralysis**

Alcohol abuse see **Alcoholism**

Alcohol dependence see **Alcoholism**

Alcoholic neuropathy see **Alcoholic paralysis**

Alcoholic paralysis

Definition

Alcohol **paralysis**, or alcohol-related neurological disease, is an umbrella term for a wide variety of nervous system disorders that are directly caused by the ingestion of toxic amounts of alcohol.

These can be grouped into four categories:

- effects of acute alcohol intoxication
- withdrawal from alcohol
- diseases and neurological damage related to **alcoholism**
- **fetal alcohol syndrome**

Description

Effects of acute intoxication

Alcohol, or ethanol, has long-demonstrated direct toxic effects on nerve and muscle cells. Depending on which nerve and muscle pathways are involved, alcohol can have far-reaching effects on different parts of the **brain**, peripheral nerves, and muscles. When a person drinks alcohol, it is absorbed by **blood vessels** in the **stomach** lining and flows rapidly throughout the body and brain. Ethanol freely crosses the blood-brain barrier that ordinarily keeps large molecules from escaping from the **blood** vessel to the brain tissue. Drunkenness, or intoxication, may occur at blood alcohol concentrations of as low as 50-150 mg per 100 milliliters (0.02-0.05 oz per qt) in what are usually called social drinkers. Sleepiness, stupor, **coma**, or even death from respiratory depression and low **blood pressure** occur at progressively higher concentrations.

Although alcohol is broken down by the **liver**, the toxic effects from a high dose of alcohol are most likely a direct result of alcohol itself rather than of its breakdown products. The fatal dose varies widely because people who drink heavily develop a tolerance to the effects of alcohol with repeated use. In addition, alcohol tolerance results in the need for higher levels of blood alcohol to achieve intoxicating effects, which increases the likelihood that habitual drinkers will be exposed to high and potentially toxic levels of ethanol. This is particularly true when binge drinkers fail to eat, because fasting decreases the rate of alcohol clearance and causes even higher blood alcohol levels.

Recent research indicates that alcohol's toxicity may be a component of violence and aggression. A National Institute on Alcohol Abuse and Alcoholism (NIAAA) study showed that an estimated 86 percent of homicide offenders, 37 percent of assault offenders, 60 percent of sexual offenders, and 13 percent of child abusers were drinking at the time of the offense. Forty-two percent of violent crimes reported to police involved alcohol, and 51 percent of victims interviewed believed that the person who had assaulted them had been drinking.

A December 1999 NIAAA study suggests that because they absorb and metabolize alcohol differently than men, women may be more susceptible to its adverse effects. This was based on **magnetic resonance imaging** (MRI) studies of the brains of alcoholic women, compared with both non-alcoholic women and alcoholic men. Imaging showed that the brain regions involved in coordinating brain functions were markedly smaller in the alcoholic women than either of the other two groups.

Two separate studies, conducted in February and August of 2000, proposed and showed evidence that even early drinking can seriously affect **memory**. Researchers at Duke University and the University of California both found that adolescence, especially between the ages of 15 and 16, are important years in brain development, and this development is adversely affected by alcohol and drug use. It is as yet unknown whether such impairment is reversible.

Withdrawal

When a chronic alcoholic suddenly stops drinking, withdrawal of alcohol leads to a syndrome of increased excitability of the **central nervous system**, called *delirium tremens* or "DTs." Symptoms begin six to eight hours after abstinence, and are most pronounced 24-72 hours after abstinence. They include body shaking (tremulousness), insomnia, agitation, confusion, hearing voices or seeing images that are not really there (such as crawling bugs), seizures, rapid **heart** beat, profuse

sweating, high blood pressure, and **fever**. Alcohol-related seizures are reported in approximately 15 percent of alcoholics, and the chance of having seizures, as well as the severity of the seizures, increases with the number of withdrawal incidences. In structural imaging, it was found that alcoholics that had had seizures showed shrinkage on both sides of the brain behind the frontal lobe.

Diseases and brain damage related to alcoholism

Wernicke-Korsakoff syndrome is caused by deficiency of the B-vitamin **thiamine**, and can also be seen in people who don't drink but have some other cause of thiamine deficiency, such as chronic vomiting, that prevents the absorption of this vitamin. Patients with this condition have the sudden onset of Wernicke encephalopathy; the symptoms include marked confusion, delirium, disorientation, inattention, memory loss, and drowsiness. Examination reveals abnormalities of eye movement, including jerking of the eyes (nystagmus) and double **vision**. Problems with balance make walking difficult. People may have trouble coordinating their leg movements, but usually not their arms. If thiamine is not given promptly, Wernicke encephalopathy may progress to stupor, coma, and death.

If thiamine is given and death averted, Korsakoff's syndrome may develop in some patients, who suffer from memory impairment that leaves them unable to remember events for a period of a few years before the onset of illness (retrograde amnesia) and unable to learn new information (anterograde amnesia). Most patients have very limited insight into their memory dysfunction and have a tendency to make up explanations for events they have forgotten (confabulation).

Severe alcoholism can cause cerebellar degeneration, a slowly progressive condition affecting portions of the brain called the anterior and superior *cerebellar vermis* causing a wide-based gait, leg incoordination, and an inability to walk heel-to-toe in tightrope fashion. The gait disturbance usually develops over several weeks, but may be relatively mild for some time, and then suddenly worsen after binge drinking or an unrelated illness.

Fetal alcohol syndrome

Fetal alcohol syndrome (FAS) occurs in infants born to alcoholic mothers when prenatal exposure to ethanol retards fetal growth and development. Alcohol is a known teratogen (an agent capable of causing physical abnormalities in developing fetuses) that affects both the infant's body and brain. It can cause this damage across the entire **pregnancy**, not just the first trimester. Affected infants often have a distinctive appearance with a thin

upper lip, flat nose and mid-face, short stature and small head size. Almost half are mentally retarded, and most others are mildly impaired intellectually or have problems with speech, learning, and behavior.

Up to three births of every thousand in the industrialized countries of the world will produce a child born with FAS. This condition is considered more apt to occur following continuous, heavy alcohol intake by the mother, but has also been seen following intermittent or binge drinking. A study by Dr. John W. Olney, of Washington University School of Medicine, found that because brain cells building the connections necessary for memory, learning and thought begin to develop in the sixth month in-utero, one brief (four-hour) drinking binge during that period of time can damage millions of developing cells.

Causes and symptoms

Acute excess intake of alcohol can cause drunkenness (intoxication) or even death, and chronic or long-term abuse leads to potentially irreversible damage to virtually any level of the nervous system. Any given patient with long-term alcohol abuse may have no neurologic complications, a single alcohol-related disease, or multiple conditions, depending upon the genes they have inherited, how well nourished they are, and other environmental factors, such as exposure to other drugs or toxins.

Neurologic complications of alcohol abuse may also result from nutritional deficiency, because alcoholics tend to eat poorly and may become depleted of thiamine or other **vitamins** important for nervous system function. Persons who are intoxicated are also at higher risk for **head injury** or for compression injuries of the peripheral nerves. Sudden changes in blood chemistry, especially sodium, related to alcohol abuse may cause central pontine myelinolysis, a condition of the brainstem in which nerves lose their myelin coating. Liver disease complicating alcoholic cirrhosis may cause **dementia**, delirium, and movement disorder.

Alcoholic myopathy, or weakness secondary to breakdown of muscle tissue, is also known as alcoholic rhabdomyolysis or alcoholic myoglobinuria. Males are affected by acute (sudden onset) alcoholic myopathy four times as often as females. Breakdown of muscle tissue (myonecrosis) can come on suddenly during binge drinking or in the first days of alcohol withdrawal. In its mildest form, this breakdown may cause no noticeable symptoms, but may be detected by a temporary elevation in blood levels of an enzyme found predominantly in muscle, called the MM fraction of creatine kinase.

The severe form of acute alcoholic myopathy is associated with the sudden onset of muscle **pain**, swelling, and weakness; a reddish tinge in the urine caused by myoglobin, a breakdown product of muscle excreted in the urine; and a rapid rise in muscle enzymes in the blood. Symptoms usually worsen over hours to a few days, and then improve over the next week to 10 days as the patient is withdrawn from alcohol. Muscle symptoms are usually generalized, but pain and swelling may selectively involve the calves or other muscle groups. The muscle breakdown of acute alcoholic myopathy may be worsened by crush injuries, which may occur when people drink so much that they compress a muscle group with their body weight for a long time without moving, or by withdrawal seizures with generalized muscle activity.

In patients who abuse alcohol over many years, chronic alcoholic myopathy may develop. Males and females are equally affected. Symptoms include painless weakness of the limb muscles closest to the trunk and the girdle muscles, including the thighs, hips, shoulders, and upper arms. This weakness develops gradually, over weeks or months, without symptoms of acute muscle injury. Muscle atrophy, or decreased bulk, may be striking. The nerves of the extremities may also begin to break down, a condition known as alcoholic peripheral neuropathy, which can add to the person's difficulty in moving. Symptoms of peripheral neuropathy, too, typically develop slowly, over a period of months.

The way in which alcohol destroys muscle tissue is still not well understood. Proposed mechanisms include muscle membrane changes affecting the transport of **calcium**, potassium, or other **minerals**; impaired muscle energy **metabolism**; and impaired protein synthesis. Alcohol is metabolized (broken down) primarily by the liver, with a series of chemical reactions in which ethanol is converted to acetate. Acetate is metabolized by skeletal muscle, and alcohol-related changes in liver function may affect skeletal muscle metabolism, decreasing the amount of blood sugar available to muscles during prolonged activity. Because not enough sugar is available to supply needed energy, muscle protein may be broken down as an alternate energy source. However, toxic effects on muscle may be a direct result of alcohol itself rather than of its breakdown products.

Although alcoholic peripheral neuropathy may contribute to muscle weakness and atrophy by injuring the motor nerves controlling muscle movement, alcoholic neuropathy more commonly affects sensory fibers. Injury to these fibers can cause tingling or burning pain in the feet, which may be severe enough to interfere with walking. As the condition worsens, pain decreases but numbness increases.

KEY TERMS

Abstinence—Refraining from the use of alcoholic beverages.

Atrophy—A wasting or decrease in size of a muscle or other tissue.

Cerebellum—The part of the brain involved in coordination of movement, walking, and balance.

Degeneration—Gradual, progressive loss of nerve cells.

Delirium—Sudden confusion with decreased or fluctuating level of consciousness.

Delirium tremens—A complication that may accompany alcohol withdrawal. The symptoms include body shaking (tremulousness), insomnia, agitation, confusion, hearing voices or seeing images that are not really there (hallucinations), seizures, rapid heart beat, profuse sweating, high blood pressure, and fever.

Dementia—Loss of memory and other higher functions, such as thinking or speech, lasting six months or more.

Myoglobinuria—Reddish urine caused by excretion of myoglobin, a breakdown product of muscle.

Myopathy—A disorder that causes weakening of muscles.

Neuropathy—A condition affecting the nerves supplying the arms and legs. Typically, the feet and hands are involved first. If sensory nerves are involved, numbness, tingling, and pain are prominent, and if motor nerves are involved, the patient experiences weakness.

Thiamine—A B vitamin essential for the body to process carbohydrates and fats. Alcoholics may suffer complications (including Wernicke-Korsakoff syndrome) from a deficiency of this vitamin.

Wernicke-Korsakoff syndrome—A combination of symptoms, including eye-movement problems, tremors, and confusion, that is caused by a lack of the B vitamin thiamine and may be seen in alcoholics.

Diagnosis

The diagnosis of alcoholic paralysis depends largely upon the practitioner taking a thorough history and finding characteristic symptoms in patients who abuse

alcohol. Other possible causes should be excluded by the appropriate tests, which may include blood chemistry, **thyroid function tests**, brain MRI or computed tomography (CT) scan, and/or cerebrospinal fluid analysis.

Acute alcoholic myopathy can be diagnosed by finding myoglobin in the urine and increased creatine kinase and other blood enzymes released from injured muscle. The surgical removal of a small piece of muscle for microscopic analysis (muscle biopsy) shows the scattered breakdown and repair of muscle fibers. Doctors must rule out other acquired causes of muscle breakdown, which include the abuse of drugs such as heroin, cocaine, or amphetamines; trauma with crush injury; the depletion of phosphate or potassium; or an underlying defect in the metabolism of **carbohydrates** or **lipids**. In chronic alcoholic myopathy, serum creatine kinase often is normal, and muscle biopsy shows atrophy, or loss of muscle fibers. **Electromyography** (EMG) may show features characteristic of alcoholic myopathy or neuropathy.

Treatment

Acute management of alcohol intoxication, delirium tremens, and withdrawal is primarily supportive, to monitor and treat any cardiovascular or **respiratory failure** that may develop. In delirium tremens, fever and sweating may necessitate treatment of fluid loss and secondary low blood pressure. Agitation may be treated with benzodiazepines such as chlordiazepoxide, beta-adrenergic antagonists such as atenolol, or alpha 2-adrenergic agonists such as clonidine. Because Wernicke's syndrome is rapidly reversible with thiamine, and because death may intervene if thiamine is not given promptly, all patients admitted for acute complications of alcohol, as well as all patients with unexplained encephalopathy, should be given intravenous thiamine.

Withdrawal seizures typically resolve without specific anti-epileptic drug treatment, although status epilepticus (continual seizures occurring without interruption) should be treated vigorously with injections of phenytoin (Dilantin), diazepam (Valium), or phenobarbital. Acute alcoholic myopathy with myoglobinuria requires monitoring and maintenance of kidney function, and correction of imbalances in blood chemistry including potassium, phosphate, and magnesium levels.

Chronic alcoholic myopathy and other chronic conditions are treated by correcting associated nutritional deficiencies and maintaining a diet adequate in protein and carbohydrate. The key to treating any alcohol-related disease is helping the patient overcome alcohol addiction. Behavioral measures and social supports may

be needed in patients who develop broad problems in their thinking abilities (dementia) or remain in a state of confusion and disorientation (delirium). People with walking disturbances may benefit from **physical therapy** and assistive devices. Doctors may also prescribe drugs to treat the pain associated with peripheral neuropathy.

Prognosis

Complete recovery from Wernicke's syndrome may follow prompt administration of thiamine. However, repeated episodes of encephalopathy or prolonged alcohol abuse may cause persistent dementia or Korsakoff psychosis. Most patients recover fully from acute alcoholic myopathy within days to weeks, but severe cases may be fatal due to **acute kidney failure** or disturbances in heart rhythm secondary to increased potassium levels. Recovery from chronic alcoholic myopathy may occur over weeks to months of abstinence from alcohol and correction of malnutrition. Cerebellar degeneration and alcoholic neuropathy may also improve to some extent with abstinence and balanced diet, depending on the severity and duration of the condition.

Prevention

Prevention requires abstinence from alcohol. Persons who consume small or moderate amounts of alcohol might theoretically help prevent nutritional complications of alcohol use with dietary supplements including B vitamins. Historically, it is known that the incidence of neurological damage to people afflicted with alcoholism was even greater before bakeries began to enrich bread with vitamins and minerals. However, proper **nutrition** cannot protect against the direct toxic effect of alcohol or of its breakdown products. Patients with any alcohol-related symptoms or conditions, pregnant women, and patients with liver or neurologic disease should abstain completely. Based upon several recent studies, persons with family history of alcoholism or alcohol-related conditions may be considered at increased risk for both alcoholism and the neurologic complications of alcohol use.

Health care team roles

Because alcohol is the most widely abused drug in our society, there is a prevalence of people with alcohol-related consequences in all treatment settings. Nearly every member of the health care team, across a broad spectrum of places including hospitals, **nursing homes**,

clinics and even homes will be involved with the patient with alcohol-related neurological disease.

- Physicians, especially primary care physicians, have long been the front line of diagnosis and care for alcoholics, long before a neurologist (a physician who specializes in diseases of the nervous system) becomes involved. In the past education regarding alcoholism was not considered to be adequate, but this has changed considerably over the past two decades. Health care providers should take a comprehensive drinking history as part of any initial examination of a patient, and be aware that people suffering from alcoholism, a disease of denial, often say they drink less than they actually do.
- Nurses will be involved in the day to day treatment of people with alcohol-related neurological disease who are temporarily unable, or no longer able at all, to care for themselves. This may involve caring for and monitoring people in withdrawal or DT's, as well as providing supportive physical and emotional care, which may include administering medications, monitoring **vital signs** (blood pressure and pulse), providing fluids either by mouth or intravenously, preventing injuries during seizures or from **falls**, and encouraging sobriety through a calm, non-judgmental attitude.
- Physiotherapists may often become involved in helping the person with an alcohol-related neurological condition to restore their ability to walk safely. This may involve repetitively practicing various steps and providing encouragement to the person.
- Certified alcoholism counselors (CACs) can help the alcoholic patient to come to terms with this most baffling, difficult disease. The CAC can provide information not only on the disease of alcoholism, but the many programs available to help deal with it, including Alcoholics Anonymous and Rational Recovery.

Resources

BOOKS

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ORGANIZATIONS

Canadian Paediatric Society and Canadian Center on Substance Abuse. <<http://www.HealthCanada.org>>.
National Institute on Alcohol Abuse and Alcoholism. 6000 Executive Boulevard, Willco Building, Bethesda, MD 20892-7003. <<http://silk.nih.gov/silk/niaaa1>>.

Joan M. Schonbeck

Alcoholism

Definition

Alcoholism is the popular term for alcohol abuse and alcohol dependence. The hallmarks of both of these disorders involve repeated life problems that can be directly tied to a person's abuse of alcohol. Alcoholism has serious consequences, affecting an individual's health and personal life, as well as having a negative impact on society at large. Alcoholism is the use of alcohol in any harmful way.

Description

The effects of alcoholism are quite far reaching. Alcohol affects every body system, causing a wide range of health problems. Such problems include poor **nutrition**, **memory** disorders, difficulty with balance and walking, **liver** disease (including cirrhosis and hepatitis), high **blood pressure**, weakness of muscles (including the **heart**), disturbances of heart rhythm, anemia, clotting disorders, weak immunity to infections, inflammation and irritation along the entire gastrointestinal system, acute and chronic problems with the **pancreas**, low **blood** sugar, high blood fat content, interference with reproductive fertility, and weak bones.

On a personal level, alcohol can be responsible for marital and other relationship difficulties, depression, unemployment, **child abuse**, and general family dysfunction.

Alcoholism causes or contributes to a variety of severe social problems: homelessness, murder, suicide, injury, and violent crime. Alcohol is a contributing factor in 50% of all deaths due to motor vehicle accidents. In fact, more than 100,000 deaths occur each year due to the effects of alcohol, of which 50% are due to injuries of some sort. In the United States, the annual economic cost of alcoholism and alcohol abuse is estimated at more than \$160 billion.

Causes and symptoms

There are probably a number of factors that work together to cause a person to become an alcoholic. Genetic studies have demonstrated that close relatives of an alcoholic are more likely to become alcoholics themselves. This risk appears to hold true even for the child adopted away from his or her biological family at birth and raised in a non-alcoholic adoptive family—with no knowledge of the biological family's difficulties with alcohol. More research is being conducted to determine whether genetic factors can account for differences in

alcohol **metabolism**, thereby increasing the risk of an individual becoming an alcoholic—or whether the involvement of genetics is less direct, perhaps producing personality traits that render people susceptible to alcoholism. Many investigators believe that environmental factors, such as availability and acceptance of alcohol, peer pressure, or stressful lifestyle are at least as important as genetic factors. At the time of this writing in early 2001, researchers were seeking the location of specific genes that affect susceptibility to alcoholism.

The symptoms of alcoholism can be broken down into two major categories, symptoms of acute alcohol abuse and symptoms of long-term alcohol abuse.

Immediate (acute) effects of alcohol abuse

Alcohol exerts a depressive effect on the **brain**. The blood-brain barrier does not prevent alcohol from entering the brain, so the brain-alcohol level will quickly become equivalent to the blood-alcohol level. Alcohol's depressive effects result in difficulty walking, poor balance, slurred speech, and generally poor coordination (i.e., accounting, in part, for the increased likelihood of injury). At higher alcohol levels, a person's breathing and heart rates will be slowed, and vomiting may occur, with a high risk of the vomit being inspired (breathed) into the **lungs**; this can result **pneumonia**, or in choking and death (especially if the person is unconscious). Extremely high blood alcohol levels may result in **coma** and death.

Effects of long-term (chronic) alcoholism

Long-term abuse of alcohol affects virtually every organ system of the body:

- Nervous system. An estimated 30-40% of all men in their teens and twenties have experienced alcoholic blackouts, which occur when drinking a large quantity of alcohol. This can also result in loss of memory of the time surrounding the episode of drinking. Alcohol is well known to cause sleep disturbances, so that overall sleep quality is affected. Numbness and tingling may occur in the arms and legs. Two syndromes, which can occur together or separately, are known as Wernicke's and Korsakoff's syndromes. Both are due to the low thiamin levels found in the blood of alcoholics. Wernicke's syndrome results in disordered eye movements, very poor balance and difficulty walking; Korsakoff's syndrome severely affects memory, preventing new learning from taking place.
- Gastrointestinal system. Alcohol causes loosening of the muscular ring that prevents the stomach's contents from re-entering the esophagus. Therefore, the acid from the **stomach** can flow backwards into the esophagus, thereby burning those tissues and causing **pain**

and bleeding. Inflammation of the stomach can also result in bleeding and pain, and decrease the appetite. A major cause of severe, uncontrollable bleeding (hemorrhage) in an alcoholic is the development of enlarged (dilated) **blood vessels** within the esophagus, called esophageal varices. These varices are actually developed in response to liver disease, and are extremely prone to bursting and hemorrhaging. **Diarrhea** is also a common affect of alcohol abuse due to alcohol's effect on the pancreas. Another condition, inflammation of the pancreas (**pancreatitis**) can be a serious and painful consequence of alcoholism. Throughout the intestinal tract, alcohol interferes with the absorption of nutrients, creating a malnourished state. Alcohol is broken down (metabolized) in the liver, which is profoundly affected by consistently high alcohol levels. Alcohol interferes with a number of important chemical processes that also occur in the liver. As a result, the liver begins to enlarge and fill with fat (i.e., fatty liver), fibrous scar tissue interferes with the liver's normal structure and function (cirrhosis), and the liver may become inflamed (hepatitis).

- Blood alcohol can cause changes to all types of blood cells. Red blood cells become abnormally large. The number of white blood cells (WBCs) (important for fighting infections) decreases, resulting in a weakened **immune system**. This places alcoholics at increased risk for infections; it is thought to account, in part, for the increased risk of **cancer** in alcoholics (i.e., ten times the normal risk). Platelets and blood clotting factors are negatively affected, causing an increased risk of hemorrhage.
- Heart. Small amounts of alcohol can cause a drop in blood pressure. With increased use, however, alcohol begins to move blood pressure into a dangerously high range. High levels of **fats** circulating in the bloodstream increase the risk of heart disease. Heavy drinking results in an increase in heart size, weakening of the heart muscle, abnormal heart rhythms, and risk of the formation of blood clots within the chambers of the heart. These factors greatly increase the risk of stroke, which can occur if a blood clot from the heart enters the circulatory system, goes to the brain, and blocks one of its blood vessels.
- Reproductive system. Heavy drinking has a negative effect on fertility in both men and women. It decreases testicle and ovary size, thereby interfering with both sperm and egg production. When an alcoholic woman becomes pregnant, she assumes the great risk of giving birth to a baby who has **fetal alcohol syndrome**. This causes distinctive facial defects, lowered IQ, and behavioral problems.

Diagnosis

Two different types of trouble with alcohol are identified. The first is called alcohol dependence, and refers to a person who is physiologically dependent on the use of alcohol. According to the *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV)*, an individual must have three of the following traits to be diagnosed with alcohol dependence:

- Tolerance, meaning that a person becomes accustomed to a particular dose of alcohol and must increase the dose in order to obtain the desired effect.
- Withdrawal, meaning that a person experiences unpleasant physical and psychological symptoms when he or she does not drink alcohol.
- The tendency to drink more alcohol than one intends (i.e., once an alcoholic starts to drink, he or she finds it difficult to stop).
- Being unable to avoid drinking or stop drinking once started.
- Having large blocks of time taken up by alcohol abuse.
- Choosing to drink at the expense of other important tasks or activities.
- Drinking despite evidence of negative effects on one's health, relationships, education, or job.

Under DSM-IV, a diagnosis of alcohol abuse requires that one of the following four criteria is met within a 12-month period. Because of drinking, a person repeatedly:

- Fails to live up to his or her most important responsibilities.
- Physically endangers himself, herself, or others (e.g., by drinking when driving).
- Gets into trouble with the law.
- Experiences difficulties in relationships or jobs.

Diagnosis is often brought about when family members relate the alcoholic's difficulties to a physician. A physician may become suspicious when a patient suffers repeated injuries or begins to experience medical problems that seem related to alcohol abuse. Alcohol abuse is so widespread that some estimates suggest that about 20% of a physician's patients will be alcoholics.

Diagnosis is aided by the answers to questionnaires that try to determine what aspects of a person's life may be affected by his or her abuse of alcohol. Determining the exact quantity of alcohol that a person drinks is much less important than learning how drinking affects his or her relationships, jobs, educational goals, and family life. In fact, because the metabolism of alcohol (how the body

KEY TERMS

Blood-brain barrier—A membrane that separates the circulating blood from reaching the brain and the fluid that surrounds it and the spinal cord. It prevents many damaging substances from reaching the brain, but alcohol is able to cross the barrier.

Dependence—A state in which a person requires a steady amount of a particular drug in order to avoid experiencing symptoms of withdrawal.

Detoxification—The phase of treatment during which a patient stops drinking and is monitored and cared for while he or she experiences withdrawal from alcohol.

Relapse—A return to a disease state, after recovery appeared to be occurring; in alcoholism, relapse refers to a patient beginning to drink alcohol again after a period of avoiding alcohol.

Tolerance—A phenomenon whereby a drug abuser becomes physically accustomed to a particular quantity of alcohol (or dosage of a drug), and requires ever-increasing quantities in order to obtain the same effects.

Withdrawal—Those signs and symptoms experienced by a person who has become physically dependent on a drug, experienced upon decreasing the drug's dosage or discontinuing its use.

breaks down and processes alcohol) is so unique, the quantity of alcohol consumed is not a criterion for diagnosing either alcohol dependence or alcohol abuse.

One very simple tool for beginning to diagnose alcoholism is the CAGE questionnaire. It consists of four questions, with the first letters of each key word spelling the word CAGE:

- Have you ever tried to *Cut* down on your drinking?
- Have you ever been *Annoyed* by anyone's comments about your drinking?
- Have you ever felt *Guilty* about your drinking?
- Do you ever need an *Eye-opener* (a morning drink of alcohol) to start the day?

There are other, longer lists of questions that help to determine the severity and effects of a person's alcohol abuse. Given the evidence of genetic involvement in alcoholism, it is important to ascertain whether any relative of the person has ever suffered from alcoholism.

Physical examination may reveal signs suggestive of alcoholism: evidence of old injuries; a visible network of enlarged veins just under the skin around the navel (called caput medusae); fluid in the abdomen (ascites); yellowish tone to the skin; decreased testicular size; and poor nutritional status. Lab work may reveal an increase in the size of red blood cells; abnormalities in WBCs (responsible for fighting **infection**) and platelets (particles responsible for clotting); and an increase in certain liver enzymes.

Treatment

Treatment of alcoholism has two parts. The first step in the treatment of alcoholism, called detoxification, involves helping the person stop drinking and ridding his or her body of the harmful (toxic) effects of alcohol. Because the person's body has become accustomed to alcohol, he or she will need to be supported through withdrawal. Withdrawal will be different for different patients, depending on the severity of the alcoholism (as measured by the quantity of alcohol ingested daily and the length of time the patient has been an alcoholic). Withdrawal symptoms can range from mild to life-threatening. Mild withdrawal symptoms include nausea, aches, diarrhea, difficulty sleeping, sweats, **anxiety**, and trembling. This phase is usually over in about three to five days. More severe effects of withdrawal can include hallucinations, seizures, an unbearable craving for more alcohol, confusion, **fever**, fast heart rate, high blood pressure, and delirium (a fluctuating level of consciousness). Patients at highest risk for the most severe symptoms of withdrawal (referred to as delirium tremens) are those with other medical problems, including malnutrition, liver disease, or Wernicke's syndrome. Delirium tremens usually begins approximately three to five days after the patient's last drink, progressing from the more mild symptoms to the more severe, and may last a number of days.

Patients going through only mild withdrawal are simply monitored carefully to ensure that more severe symptoms do not develop. However, no medications are necessary. Treatment of a patient suffering the more severe effects of withdrawal may require sedating medications to relieve the discomfort of withdrawal and to avoid the potentially life-threatening complications of high blood pressure, fast heart rate, and seizures. Benzodiazepines are helpful in those patients suffering from hallucinations. If the patient is nauseated, fluids may need to be given through a vein (intravenously), along with some necessary sugars and salts. It is crucial that thiamin be included in the fluids, because of its usu-

ally quite low in alcoholic patients. Further, thiamin deficiency can lead to Wernicke-Korsakoff syndrome.

After cessation of drinking has been accomplished, the next steps involve helping the patient avoid ever taking another drink. This phase of treatment is referred to as rehabilitation. The best programs incorporate the family into the therapy; it has no doubt been severely affected by the patient's drinking. Some therapists believe that family members, in an effort to deal with their loved one's drinking problem, sometimes develop patterns of behavior that unintentionally support or "enable" the patient's drinking. This situation is referred to as "codependence," and must be addressed in order to successfully treat a person's alcoholism.

Sessions led by peers, where recovering alcoholics meet regularly and provide support for each other's recoveries, are considered to be among the best methods of preventing a return to drinking (relapse). Perhaps the most well-known group of this kind is called Alcoholics Anonymous, which uses a "12-step" model to help people avoid drinking. These steps involve recognizing the destructive power that alcohol has held over the alcoholic's life, looking to a higher power for help in overcoming the problem, and reflecting on the ways in which the abuse of alcohol has hurt others and, if possible, making amends to those people.

There are also medications that may help an alcoholic avoid returning to drinking. These have been used with varying degrees of success. Disulfiram (Antabuse) is a drug that, when mixed with alcohol, causes a very unpleasant reaction that includes nausea and vomiting, diarrhea, and trembling. Naltrexone (Revia) and acamprosate (**calcium** acetylhomotaurinate) seem to be helpful in limiting the effects of a relapse. None of these medications would be helpful unless the patient is also willing to work very hard to change his or her behavior.

Alternative treatments can be a helpful adjunct for the alcoholic patient once the medical danger of withdrawal has passed. Because many alcoholics have very stressful lives (whether because of or leading to the alcoholism is sometimes a matter of debate), many of the treatments for alcoholism involve dealing with and relieving **stress**. These include massage, **meditation**, and hypnotherapy. The malnutrition of long-term alcohol abuse is addressed by nutrition-oriented practitioners, with careful attention being given to a healthy diet and the use of nutritional supplements, such as **vitamins** A, B complex, and C—as well as certain fatty acids, amino acids, **zinc**, magnesium, and selenium. Herbal treatments include milk thistle (*Silybum marianum*), which is thought to protect the liver against damage. Other herbs believed to be helpful for the patient suffering through

withdrawal include lavender (*Lavandula officinalis*), skullcap (*Scutellaria lateriflora*), chamomile (*Matricaria recutita*), peppermint (*Mentha piperita*), yarrow (*Achillea millefolium*), and valerian (*Valeriana officinalis*). Acupuncture is believed to both decrease withdrawal symptoms and to help improve a patient's chances for continued recovery from alcoholism.

Prognosis

Recovery from alcoholism is a lifelong process. In fact, the person who has suffered from alcoholism is encouraged to refer to himself or herself ever after as "a recovering alcoholic," never a recovered alcoholic. This is because most researchers in the field believe that one can never fully recover from alcohol because the vulnerability to alcoholism is still part of the individual's biological and psychological makeup. The potential for relapse (returning to illness) is always there, and must be acknowledged and respected. Statistics suggest that, among middle-class alcoholics in stable financial and family situations who have undergone treatment, 60% or more can be successful at an attempt to stop drinking for at least a year, and many for a lifetime.

Health care team roles

The International Nurses Society on Addictions (IntNSA) says that it is appropriate for nurses to assess patients for alcohol-related problems in any setting, and to initiate discussion of such problems with not only the patient, but also the family, significant others, and appropriate members of an interdisciplinary health team. Nurses have a responsibility to educate and counsel alcoholic patients, their families, and significant others. Nurses with special knowledge or experience in the subject can play an important role in educating both the community and fellow health-care professionals. General-care nurses might wish to seek help or advice from a clinical specialist in alcoholism. According to IntNSA, the nurse's role in treating alcoholism is not restricted to psychiatric and mental health nursing, as it involves every other clinical nursing specialty. It is important that nurses be aware of community resources so that they can make appropriate treatment referrals. IntNSA offers Certified Addiction Registered Nurse certification to nurses who pass rigorous testing.

Prevention

Prevention must occur at a relatively young age, since the first experience with alcohol intoxication usually occurs during the teenage years. It is particularly important that teenagers who are at high risk for alco-

holism—those with a family history of alcoholism, early or frequent abuse of alcohol, a tendency to drink to drunkenness, alcohol abuse that interferes with school work, a poor family environment, or a history of domestic violence—are educated about alcohol and its long-term effects. How this is best achieved, without irritating the youngsters and losing their attention, is a matter of debate and study.

Resources

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ORGANIZATIONS

- Al-Anon, Alanon Family Group, Inc. P.O. Box 862, Midtown Station, New York, NY 10018-0862. (800)356-9996. <<http://www.recovery.org/aa>>.
- International Nurses Society on Addictions. 1500 Sunday Drive, Suite 102, Raleigh, NC 27607. (919)783-5871. <<http://www.nnsa.org>>.
- National Clearinghouse for Alcohol and Drug Information. <<http://www.health.org>>.

David L. Helwig

Aldosterone assay *see* **Adrenocortical hormone tests**

Allergies

Definition

Allergies are abnormal reactions of the **immune system** that occur in response to otherwise harmless substances.

Description

Allergies are among the most common of medical disorders. About one quarter of all Americans suffer from some form of allergy, such as **asthma**, allergic rhinitis

(hay fever), or atopic dermatitis (eczema). Allergy is the single largest reason for school absence; allergic rhinitis alone is responsible for two million school day absences annually. Allergies cause one out of nine physician visits and are responsible for significant losses of productivity in the workplace.

An allergy is a type of immune reaction. Normally, the immune system responds to **bacteria**, **viruses**, or particles—such as pollen or dust—by producing antibodies (specific **proteins**) capable of binding to antigens (identifying molecules) on the foreign particle. The interaction between the antibody and antigen sets off a series of reactions designed to protect the body from **infection**. When this same series of reactions is triggered by harmless, everyday substances, it is known as an allergy, and the offending substance is called an allergen.

Allergens enter the body through four main routes: the airways, skin, gastrointestinal tract, and the circulatory system.

- Airborne allergens cause the sneezing, runny nose of allergic rhinitis. Airborne allergens can also affect the lining of the **lungs**, causing asthma, or the conjunctiva of the eyes, causing conjunctivitis (pink eye).
- Allergens in food may cause itching and swelling of the lips and throat, cramps, and **diarrhea**. When absorbed into the bloodstream, they may cause urticaria (**hives**) or more severe reactions such as swelling of the skin, mucous membranes, organs, and **brain** (angioedema). Some food allergens may cause **anaphylaxis**, a potentially life-threatening condition marked by tissue swelling, airway constriction, and a sudden drop in **blood pressure**.
- Allergens that come in direct contact with the skin can cause reddening, itching, and blistering (contact dermatitis). Skin reactions can also occur from allergens introduced through the airways or gastrointestinal tract. This reaction is known as atopic dermatitis or eczema.
- Injection of allergens, from insect **bites and stings** or drug administration, can introduce allergens directly into the circulatory system. There they may cause system-wide responses (including anaphylaxis), as well as local reactions of swelling and irritation at the injection site.

Individuals with allergies are not equally sensitive to all allergens. For example, some may have severe allergic rhinitis but no food allergies, others are extremely sensitive to nuts but not to any other food. Allergies may worsen over time. For example, childhood ragweed allergy may progress to year-round dust and pollen allergy. On the other hand, an individual may lose allergic sensitivity. Infant or childhood atopic dermatitis almost always disappears with advancing age. More commonly,

an individual's apparently diminished sensitivity may instead be attributable to reduced exposure to allergens or an increased tolerance for allergy symptoms.

Causes and symptoms

Causes

Mast cells involved in allergic reactions capture and display an antibody, called immunoglobulin E (IgE), that binds to allergens. After the allergen is bound, mast cell granules release a variety of potent chemicals, including histamine, that are responsible for some of allergic symptoms.

Immunologists distinguish allergic reactions into two main types: immediate hypersensitivity reactions, which are mainly mast cell-mediated and occur within minutes of contact with allergen, and delayed hypersensitivity reactions, mediated by T cells (a type of white **blood** cells) and occurring hours to days after exposure.

Inhaled or ingested allergens usually cause immediate hypersensitivity reactions. Allergens bind to IgE antibodies on the surface of mast cells, which release the contents of their granules onto neighboring cells, including **blood vessels** and nerve cells. Histamine binds to the surfaces of these other cells through special proteins called histamine receptors. Interaction of histamine with receptors on blood vessels causes increased leakage, thereby producing fluid collection, swelling, and redness. Histamine also stimulates **pain** receptors, making tissue more sensitive and irritable. Symptoms last from one to several hours following contact.

In the upper airways and eyes immediate hypersensitivity reactions cause the runny nose and itchy, blood-shot eyes typical of allergic rhinitis. In the gastrointestinal tract these reactions lead to swelling and irritation of the intestinal lining, causing the cramping and diarrhea typical of food allergy. Allergens that enter the circulatory system may cause hives, angioedema, anaphylaxis, or atopic dermatitis.

Allergens on the skin usually cause delayed hypersensitivity reaction. Roving T cells contact the allergen, setting in motion a more prolonged **immune response**. This type of allergic response may develop over several days following contact with the allergen, and symptoms may persist for a week or more.

THE ROLE OF INHERITANCE. While allergy to specific allergens is not inherited, the likelihood of developing some type of allergy seems to be, at least for many people. If neither parent has allergies, then the chances of a child developing allergy is approximately 10–20%; when one parent has allergies, it is 30–50%; and when both have allergies, it is 40–75%. Allergy patients share a

genetic predisposition to produce higher levels of IgE in response to allergens. Those who produce more IgE will develop a stronger allergic sensitivity.

COMMON ALLERGENS. The most common airborne allergens are the following:

- plant pollens
- animal fur and dander
- body parts from house mites (microscopic creatures found in all houses)
- house dust
- mold spores
- cigarette smoke
- solvents
- cleaners

Common food allergens include the following:

- nuts, especially peanuts, walnuts, and Brazil nuts
- fish, mollusks, and shellfish
- eggs
- wheat
- milk
- food additives and preservatives

The following types of drugs commonly cause allergic reactions:

- penicillin or other antibiotics
- flu vaccines
- tetanus toxoid vaccine
- gamma globulin

Common causes of contact dermatitis include:

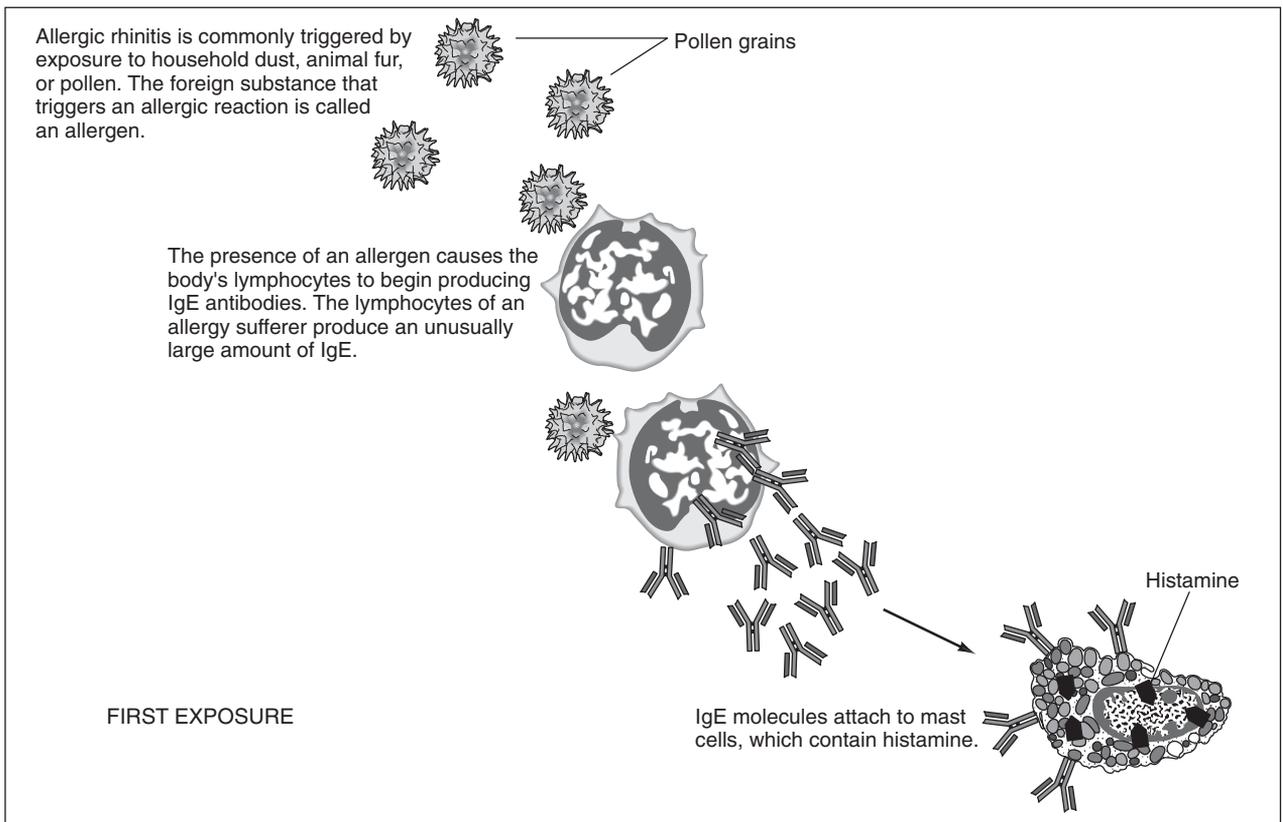
- poison ivy, oak, and sumac
- nickel or nickel alloys
- latex

Insects and other arthropods whose bites or stings typically cause allergy include:

- bees, wasps, and hornets
- mosquitoes
- fleas
- scabies

Symptoms

Symptoms depend on the specific type of allergic reaction. Allergic rhinitis is characterized by an itchy, runny nose, often with a scratchy or irritated throat due to post-nasal drip. Allergic conjunctivitis (inflammation of



The allergic response. (Illustration by Hans & Cassidy.)

the thin membrane covering the eye) causes redness, irritation, and increased tearing in the eyes. Asthma causes wheezing, coughing, and shortness of breath. Symptoms of food allergies depend on the tissues most sensitive to the allergen and whether it is spread systemically by the circulatory system. Gastrointestinal symptoms may include swelling and tingling in the lips, tongue, palate or throat, and nausea, cramping, diarrhea, and gas. Contact dermatitis is marked by reddened, itchy, weepy skin blisters.

Systemic reactions may occur from any type of allergen, but are more common following ingestion or injection of an allergen. Skin reactions include hives and angioedema (a deeper and more extensive skin reaction) involving more extensive fluid collection. Anaphylaxis is marked by airway constriction, blood pressure drop, widespread tissue swelling, **heart** rhythm abnormalities, and, in some cases, loss of consciousness.

Diagnosis

Allergies may often be diagnosed by taking a detailed medical history, matching the onset of symptoms to the exposure to possible allergens. **Allergy tests** may be used to identify potential allergens. These tests usually begin with prick tests or patch tests that expose the skin

to small amounts of allergen to observe the response. Reaction will occur on the skin even if the allergen is normally encountered in food or in the airways.

RAST testing, performed by a laboratory technologist, is a blood test that measures the level of reactive IgE antibodies in the blood. Provocation tests, most commonly done with airborne allergens, present the allergen directly through the route normally involved. Food allergen provocation tests require abstinence from the suspect allergen for two weeks or more, followed by ingestion of a measured amount.

Treatment

A variety of prescription and over-the-counter drugs are available for treatment of immediate hypersensitivity reactions. Most work by decreasing the ability of histamine to provoke symptoms. Other drugs counteract the effects of histamine by stimulating other systems or reducing immune responses in general.

Drugs

ANTIHISTAMINES. **Antihistamines** block the histamine receptors on nasal tissue, decreasing the effect of

histamine released by mast cells. They may be used after symptoms appear, though they may be even more effective when used before symptoms appear. A wide variety of antihistamines are available.

Some antihistamines produce drowsiness as a major side effect. These include:

- diphenhydramine (Benadryl and generics)
- chlorpheniramine (Chlor-trimeton and generics)
- brompheniramine (Dimetane and generics)
- clemastine (Tavist and generics)

Antihistamines that do not cause drowsiness are available by prescription and include the following:

- astemizole (Hismanal)
- loratidine (Claritin)
- fexofenadine (Allegra)
- azelastin HCl (Astelin)

Hismanal has the potential to cause serious heart arrhythmia when taken with the antibiotic erythromycin, the antifungal drugs ketoconazole and itraconazole, or the antimalarial drug quinine. Exceeding the recommended dose of Hismanal may also cause arrhythmia.

DECONGESTANTS. Decongestants constrict blood vessels to counteract the effects of histamine. Nasal sprays, applied directly to the nasal lining and oral systemic preparations are available. Decongestants are stimulants and may cause increased heart rate and blood pressure, headaches, and agitation. Use of topical decongestants for longer than several days can cause loss of effectiveness and rebound congestion, in which nasal passages become more severely swollen than before treatment.

TOPICAL CORTICOSTEROIDS. Topical **corticosteroids** reduce mucous membrane inflammation and are available by prescription. Allergies tend to worsen as the season progresses because the immune system becomes sensitized to particular antigens and can produce a faster, stronger response. Topical corticosteroids are especially effective at reducing this seasonal sensitization because they work more slowly and last longer than most other medication types. As a result, they are best started before allergy season begins. Side effects are usually mild, but may include headaches, nosebleeds, and unpleasant **taste** sensations.

MAST CELL STABILIZERS. Cromolyn sodium prevents the release of mast cell granules, thereby preventing the release of histamine and other chemicals contained in them. It acts as a preventive treatment if it is begun several weeks before the onset of the allergy season. It also may be used for year round allergy prevention.

Cromolyn sodium is available as a nasal spray for allergic rhinitis and in aerosol (a suspension of particles in gas) form for asthma.

Immunotherapy

Immunotherapy, also known as desensitization or allergy shots, alters the balance of antibody types in the body, thereby reducing the ability of IgE to cause allergic reactions. Immunotherapy is preceded by allergy testing to determine the precise allergens responsible. Injections involve very small but gradually increasing amounts of allergen, over several weeks or months, with periodic boosters. Full benefits may take as long as several years to achieve, and are not seen at all in about one in five patients. Patients are monitored closely following each shot because of the small risk of anaphylaxis.

Bronchodilators

Because allergic reactions involving the lungs cause the airways or bronchial tubes to narrow (as in asthma), bronchodilators, which cause the smooth muscle lining the airways to dilate, can be very effective. Some bronchodilators used to treat acute asthma attacks include adrenaline, albuterol, or other adrenergic stimulants, most often administered as aerosols. Theophylline, naturally present in coffee and tea, is another drug that produces bronchodilation. It is usually taken orally, but in a severe asthma attack it may be administered intravenously. Other drugs, including steroids, are used to prevent asthma attacks and in the long-term management of asthma.

Treatment of contact dermatitis

Calamine lotion applied to affected skin can reduce irritation. Topical corticosteroid creams are more effective, though overuse may lead to dry and scaly skin.

Treatment of anaphylaxis

The emergency condition of anaphylaxis is treated with injection of adrenaline, also known as epinephrine. Patients prone to anaphylaxis in response to food or insect allergies often carry an “Epi-pen” containing adrenaline in a hypodermic needle. Prompt injection may prevent a more serious reaction from developing.

Prognosis

Allergies may improve over time, although they often worsen. While anaphylaxis and severe asthma are life threatening, other allergic reactions are not. Learning to recognize and avoid allergy-provoking situations allows most patients with allergies to lead normal lives.

KEY TERMS

Allergen—A substance that provokes an allergic response.

Allergic rhinitis—Inflammation of the mucous membranes of the nose and eyes in response to an allergen; also known as hay fever.

Anaphylaxis—Increased sensitivity caused by previous exposure to an allergen that can result in blood vessel dilation and smooth muscle contraction. Anaphylaxis can result in sharp blood pressure drops and difficulty breathing.

Angioedema—Severe non-inflammatory swelling of the skin, organs, and brain that can also be accompanied by fever and muscle pain.

Antibody—A specific protein produced by the immune system in response to a specific foreign protein or particle called an antigen.

Antigen—A foreign protein to which the body reacts by making antibodies.

Asthma—A lung condition where the airways become constricted due to smooth muscle contraction, causing wheezing, coughing, and shortness of breath.

Atopic dermatitis—Inflammation of the skin as a result of exposure to airborne or food allergens; also known as eczema.

Conjunctivitis—Inflammation of the thin lining of the eye called the conjunctiva.

Contact dermatitis—Inflammation of the skin as a result of contact with a substance.

Delayed hypersensitivity reactions—Allergic reactions mediated by T cells that occur hours to days after exposure.

Granules—Small packets of reactive chemicals stored within cells.

Histamine—A chemical released by mast cells that activates pain receptors and causes cells to become leaky.

Immune hypersensitivity reaction—Allergic reactions that are mediated by mast cells and occur within minutes of allergen contact.

Mast cells—A type of immune system cell found in the lining of the nasal passages and eyelids, with an antibody called immunoglobulin type E (IgE) on its cell surface; mast cells release histamine from intracellular granules.

Health care team roles

Diagnosis and effective management of allergy symptoms involves cooperation and collaboration between the patient and an interdisciplinary team of health care professionals. The patient's primary care physician or pediatrician, allergy and immunology specialists, laboratory technologists, respiratory therapists, pharmacists, pharmacy assistants, and health educators are involved in helping patients and families gain an understanding of how to prevent effectively manage symptoms.

Patient education

Nurses, respiratory therapists, and health educators help patients learn how to prevent and manage allergy symptoms. They teach patients how to distinguish mild allergy symptoms from those requiring immediate medical attention. Pharmacists and pharmacy assistants may offer additional instruction about medication use and reiterate the importance of adhering to prescribed treatment.

Prevention

Avoiding allergens is the best means of limiting allergic reactions. For food allergies, there is no effective treatment except avoidance. By determining the allergens that cause reactions, most patients can learn to avoid allergic reactions from food, drugs, and contact allergens such as poison ivy or latex. Airborne allergens are more difficult to avoid, although keeping dust and animal dander from collecting in the house may limit exposure. Cromolyn sodium can prevent mast cell degranulation, thereby limiting the allergic response.

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Barbara Wexler

Allergy elimination diet see **Elimination diet**

Allergy tests

Definition

Allergy tests may be of two general types. *In vivo* tests that measure the **immune response** to an agent called an allergen that induces an allergic (atopic) reaction, and *in vitro* tests that measure the antibodies that mediate an allergic response. Such antibodies are those of the immunoglobulin E class (IgE) which have epsilon heavy chains which attach to mast cells.

Purpose

Allergy tests are performed to determine the cause of a person's allergic reaction. An allergic reaction is caused by the production of specific IgE antibodies against one or more antigens. Those antigens that elicit IgE production are termed allergens and are usually harmless substances. Some common allergens are described below.

- house dust mites and their waste
- hair, dander, and saliva of animals with fur or feathers
- cockroaches and their waste
- weed, grass, and tree pollens
- mold and mildew spores
- stinging insects such as bees, wasps, yellow jackets, hornets, and fire ants
- drugs such as penicillin, and sulfa drugs
- foods such as eggs, milk, nuts, and seafood
- ingredients found in dyes, cosmetics, and latex

Precautions

While allergy tests are safe for most people, there is always a possibility that the subject will experience a severe allergic reaction to an allergen used for *in vivo* testing. For this reason, the subject should be exposed to the lowest dose of allergen in the first phase of testing. *In vitro* **blood** tests are particularly appropriate for persons who have a history of severe allergy. *In vitro* testing may also be more appropriate for persons taking **antihistamines**, neuroleptics, or antidepressants, and for those with skin conditions all of which may interfere with skin test results.

Description

An allergic reaction is caused when a person's **immune system** produces IgE antibodies in response to a foreign antigen (allergen). IgE molecules are tightly

bound to the surface of mast cells (and basophils in blood). These cells contain granules that have a high concentration of histamine and other substances that are responsible for the allergic reaction. Upon subsequent exposure to the same antigen, an immediate (type 1) hypersensitivity reaction called the atopic or allergic reaction ensues. The allergen binds to the IgE and the crosslinking of antigen and antibody molecules causes the mast cell to degranulate. The histamine and other allergic mediators are released and cause local swelling (**edema**) and redness (vasodilation). These reactions occur immediately and may be sufficient in intensity to cause constriction of the bronchi and **shock**. Such a systemic response to an allergen is called an anaphylactic reaction. Allergens most often responsible for anaphylactic reactions are insect bites and penicillin in persons who are allergic to these agents.

Allergies may be seasonal or chronic depending upon the exposure to the allergen. An allergy may be influenced by factors such as emotional **stress**, fatigue, **infection**, air pollution, and weather changes that can cause day to day variation in the severity of symptoms. These triggering factors add to what doctors call the "allergic load," the amount of allergens the body can tolerate at any given time without the occurrence of symptoms.

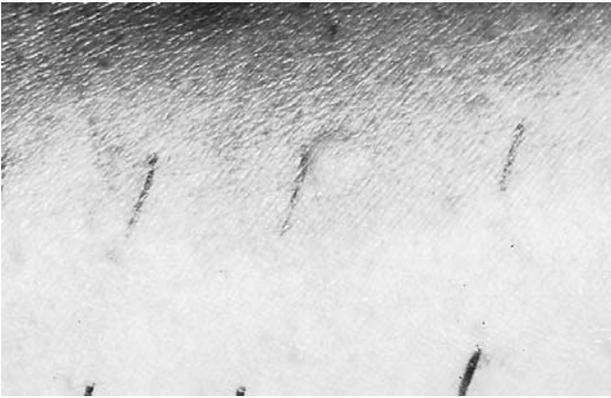
Allergies can manifest themselves in several ways. Conditions commonly caused by allergies include rhinitis, **asthma**, contact dermatitis, allergic **gastritis**, urticaria (**hives**), and conjunctivitis. Allergy tests are used to identify the allergen(s) responsible for the allergy. Once the allergen is known, avoidance and desensitization (**subcutaneous injection** of allergen extract) can be added to the treatment modality.

Types of allergy tests

IN VIVO TESTING. Known as a skin or scratch test, this method is most commonly performed by pricking the skin at multiple sites. Each site is tested by scratching the skin surface with a sterile needle laden with an allergen extract or placing allergen extract on the skin and then pricking the skin with a needle.

The advantages of this testing method include speed (results are immediately available), cost-effectiveness, and a high degree of sensitivity. The disadvantages of this method include patient discomfort, a high incidence of false positives, interference from antihistamines, other drugs and skin conditions.

IN VITRO TESTING. Immunoassays that measure total and specific IgE antibodies are used for *in vitro* allergy testing. The most commonly used method for specific IgE testing is called the RAST test (radioallergosorbent test). This test is a variation of an indirect antiglobulin



A close-up of a patient's arm after allergy testing. (Custom Medical Stock Photo. Reproduced by permission.)

test. The allergen is bound to a solid phase such as a plastic test tube or disc. Serum is added and incubated with the allergen. If IgE antibodies specific for the allergen are present, these bind to the tube or disc. The tube is washed, and anti-human IgE tagged with radioactive iodide is added. This attaches to the allergen-antibody complexes. After incubation, the tube is washed again, and its radioactivity is measured. The amount of radioactivity is directly proportional to the IgE concentration. This can be quantified by comparing the radioactivity of the test to standards. Standards consist of a specific IgE of known concentration (e.g., anti-birch) that is reacted with the respective purified allergen (birch extract). The RAST test can be prepared as a screening test by combining groups of allergens onto a single disc. Results are compared to a low-level IgE standard which serves as a positive cutpoint. Radioactivity above the standard indicates a positive test for allergy, and subsequent tests are performed using the individual allergens to determine the cause of a positive screen.

The immunoassay most commonly used for measuring total IgE is called the PRIST test (paper radioimmunosorbent test). This test is a double antibody sandwich type radioimmunoassay in which the IgE is the antigen. Total IgE in serum can also be determined by immunoassay methods. A positive test for total IgE indicates a diagnosis of allergy when allergic symptoms are present. However, serum IgE levels may be increased in persons with parasitic infections and malignant diseases in the absence of allergy.

In vitro tests have the advantage of being sensitive and specific although they are somewhat less sensitive than skin tests. The reagent quality is highly consistent from lot to lot. The methods are more reproducible and accuracy can be monitored with quality control. *In vitro* methods can be used for persons who are being treated

with antihistamines and other medications. One venipuncture replaces multiple skin scratches that are painful and not well tolerated by young children. Disadvantages of *in vitro* tests are higher costs and longer turnaround time than skin tests (specific IgE tests require 1-2 days before results are available because of long incubation times).

OTHER TESTING. Provocation testing may be performed to positively identify suspected allergens after preliminary skin testing. A purified preparation of the allergen is inhaled or ingested in increasing concentrations to determine if it will provoke a response.

Inhalation testing is performed only after a patient's lung capacity and response to the medium used to dilute the allergen has been determined. Once this has been determined, the patient inhales increasingly concentrated samples of a particular allergen, followed each time by measurement of the exhalation capacity. Only one allergen is tested per day.

Provocation testing with food is more tedious than inhalation testing. First the suspect food is removed from the patient's diet for two weeks; then the patient eats a single portion of the suspect food and is monitored for a reaction.

A double-blind food challenge may also be used for diagnosis of food allergy. During this test, various foods, some of which are suspected of inducing an allergic reaction, are each placed in individual capsules; the patient swallows a capsule and is then watched to see if a reaction occurs. Persons with a history of severe allergic food reactions cannot be tested this way.

Preparation

Skin testing is preceded by a brief examination of the skin. The patient should refrain from using allergy medications for at least 48 hours before testing.

Immunoassay and RAST tests require a sample of blood, which is obtained via venipuncture by a nurse or phlebotomist following standard precautions for the prevention of transmission of bloodborne pathogens.

Aftercare

Patients receiving skin tests should be monitored for 30 minutes following testing, and treated promptly should they develop signs of a severe allergic reaction. Occasionally, a delayed anaphylactic response may occur that will require immediate care; therefore, **patient education** regarding how to recognize delayed **anaphylaxis** is vital. The generalized redness and swelling that may occur in the skin test area will usually resolve within a

day or two. More severe reactions may require topical or antihistamine therapy.

Inhalation tests may cause delayed asthma attacks, even if the antigen administered in the test initially produced no response. Severe initial reactions may justify close professional observation for at least 12 hours after testing.

Complications

Intradermal testing may inadvertently result in the injection of the allergen into the circulation, with an increased risk of adverse reactions. Inhalation tests may provoke an asthma attack. Exposure to new or unsuspected allergens in any test carries the risk of anaphylaxis.

Results

Skin testing

Lack of redness or swelling on a skin test indicates no allergic response. A wheal (an area of redness and swelling) exceeding 7 mm in diameter or larger than the histamine control, has a higher diagnostic value than smaller wheals.

Immunoassay testing

SPECIFIC IGE. Quantitative specific IgE cutoffs are the lowest radioactivity levels encountered in the highest dilution of standard used. The IgE level may be reported in RAST units, or as positive, equivocal, or negative.

TOTAL IGE. The upper limit of normal for total IgE is highly age dependent for children. The upper limit increases over the first 10 years, then levels off. The cutoff for adults varies with the test methodology. For the PRIST test the cutoff is approximately 25 kU/L IgE when the standard used is traceable to the 2nd International Reference Preparation of the World Health Organization.

Inhalation testing

In an inhalation test, the exhalation capacity should remain unchanged. Following allergen inhalation, reduction in exhalation capacity of more than 20%, and for at least 10-20 minutes, indicates a positive reaction to the allergen.

Food testing

In a food challenge, no symptoms should occur. Gastrointestinal symptoms within 24 hours following the ingestion of a suspected food allergen indicates a positive response.

KEY TERMS

Allergen—A substance that provokes an allergic response.

Anaphylaxis—Increased sensitivity caused by previous exposure to an allergen that can result in blood vessel dilation (swelling) and smooth muscle contraction. Anaphylaxis can result in shock caused by a sharp fall in blood pressure.

Antibody—A specific protein produced by the immune system in response to a specific foreign protein or particle called an antigen.

Antigen—A foreign protein to which the body reacts by making antibodies.

Histamine—A chemical released by mast cells that causes vasodilation and bronchial constriction.

Mast cells—A tissue analog of the blood basophil, mast cells are prevalent near small blood vessels in the skin, membranes, and bone marrow. Mast cells bind a type of antibody called immunoglobulin E (IgE) on their surface, and participate in the allergic response by releasing histamine from intracellular granules.

Health care team roles

Allergy tests are ordered by a physician. Skin tests and inhalation tests are performed in a doctor's office by a nurse or healthcare worker specially trained to administer the test. A physician, nurse, or physician assistant should monitor patient for signs of anaphylaxis for 30 minutes after testing.

In vitro allergy tests are performed by clinical laboratory scientists CLS(NCA)/medical technologists MT(ASCP). Results are interpreted by a physician usually a specialist in immunologic and allergic diseases.

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Victoria E. DeMoranville

Alpha-fetoprotein test see **Triple marker screen test**

Alpha-1 antitripsin test see **Plasma protein tests**

Aluminum hydroxide see **Antacids**

Alzheimer's disease

Definition

Alzheimer's disease (AD) is the most common form of **dementia**, a neurologic disease characterized by a progressive loss of mental ability severe enough to interfere with normal activities of daily living, lasting at least six months, and not present from birth. AD usually occurs in old age and is marked by a decline in cognitive functions such as remembering, reasoning, and planning.

Description

A person with AD usually has a gradual decline in mental functions, often beginning with slight **memory** loss, followed by losses in the ability to maintain employment, to plan and execute familiar tasks, and to reason and **exercise** judgment. Communication ability, mood, and personality may also be affected. Most people who have AD die within eight years of their diagnosis, although that interval may be as short as one year or as long as 20 years. AD is the fourth leading cause of death in adults after **heart** disease, **cancer**, and stroke.

In 2001, four million Americans have been diagnosed with AD. That number is expected to grow to as many as 14 million by the middle of the twenty-first century as the baby-boomer population ages. These numbers may be seriously underestimated due to new research that suggests mild cognitive impairment may be early stages of AD.

While a small number of people in their 40s and 50s develop the disease (called early-onset AD), AD predominantly affects the elderly. AD affects about 10% of all people over the age of 65 and nearly half of those over 85. Slightly more women than men are affected with AD, since women tend to live longer and occupy a larger proportion of the most affected age groups.

The costs for caring for loved ones with AD is considerable, and has been estimated at approximately \$174,000 per person over the course of the disease. More than 70% of people with AD are cared for at home at an estimated annual cost of \$196 billion. These costs are not supplemented by outside sources. If patients are cared for by paid home caregivers or are placed in **nursing homes**, the total annual out-of-pocket costs by families or third party payees account for \$83 billion and \$32 billion respectively.

Causes and symptoms

Causes

The cause of Alzheimer's disease is unknown. Some strong leads have been found through recent research, however, and these have also given some theoretical support to several new experimental treatments.

AD affects **brain** cells responsible for learning, reasoning, and memory. Autopsies of people with AD indicate that these regions of the brain become clogged with two abnormal structures, neurofibrillary tangles and senile plaques. Neurofibrillary tangles are twisted masses of protein fibers inside nerve cells (**neurons**). Senile plaques are composed of parts of neurons surrounding a group of brain **proteins** called beta-amyloid deposits. While it is not clear exactly how these structures cause problems, some researchers now believe that their formation is responsible for the mental changes of AD, presumably by interfering with the normal communication between neurons in the brain. Drugs approved by the Food and Drug Administration (FDA) increase the level of chemical signaling molecules in the brain, known as neurotransmitters, to make up for this decreased communication ability.

What triggers the formation of plaques and tangles is unknown, although there are several possible candidates. Restriction of **blood** flow may be part of the problem, perhaps accounting for the beneficial effects of estrogen, which increases blood flow in the brain. However, studies in 2001 do not show estrogen as a protection against the development of AD.

Highly reactive molecular fragments called free radicals damage cells of all kinds, especially brain cells, which have smaller supplies of protective antioxidants

thought to protect against free radical damage. **Vitamin E** is one such antioxidant, and its use in AD is showing some benefit.

Several genes have been implicated in AD, including the gene for amyloid precursor protein (APP) responsible for producing amyloid. Mutations in this gene are linked to some cases of the relatively uncommon early-onset forms of AD. Other cases of early-onset AD are caused by mutations in the gene for another protein, presenilin. AD eventually affects nearly everyone with **Down syndrome**, caused by an extra copy of chromosome 21. Other mutations on other chromosomes have been linked to other early-onset cases.

Potentially the most important genetic link was discovered in the early 1990s on chromosome 19. A gene on this chromosome, apoE, codes for a protein involved in transporting **lipids** into neurons. ApoE occurs in at least three forms: apoE2, apoE3, and apoE4. Each person inherits one apoE from each parent, and therefore can either have one copy of two different forms or two copies of one. Compared to those without ApoE4, people with one copy are about three times as likely to develop late-onset AD, and those with two copies are almost four times as likely to do so. Despite this important link, not everyone with apoE4 develops AD, and people without it can still have the disease. Why apoE4 increases the chances of developing AD is not known.

Promising research in 2001 has discovered a protein, apoptosis-inducing factor, that kills cells by disrupting the genetic material at their cores. This discovery could lead to drugs that could turn off this protein that triggers apoptosis or biologically regulated cell death, which is important in **fetal development** but is also implicated in stroke, heart disease, and AD. It is thought that this protein runs out of control and shuts off otherwise healthy cells.

There are several risk factors that seem to increase a person's likelihood of developing the disease. The most significant one is, of course, age; older people develop AD at much higher rates than younger ones. Another risk factor is having a family history of AD, Down syndrome, or **Parkinson's disease**. People who have had head trauma or hypothyroidism may manifest the symptoms of AD sooner.

Many environmental factors have been suspected of contributing to AD, but population studies generally have not borne these out. A study in early 2001, however, showed a specific link between aluminum in drinking water and the incidence of AD. Other suspected risk factors were other pollutants in drinking water, aluminum in any form, and mercury in **dental fillings**. To date, none

of these other factors has been shown to cause AD or to increase its likelihood.

Lifestyle factors, moreover, may prove to be better indicators of risk. Lack of stimulation, mentally and physically, between the ages of 20 and 60 seems linked to the incidence of AD. Studies have not shown, though, that a sedentary lifestyle early in life causes AD or whether it is a marker for the incidence of the disease.

Another study of African Americans and their Nigerian counterparts shows AD appearing more often in the American population than the African one. Researchers suggest that environmental or cultural factors may play a role in the formation of AD. Here, physical activity or diet may play a part.

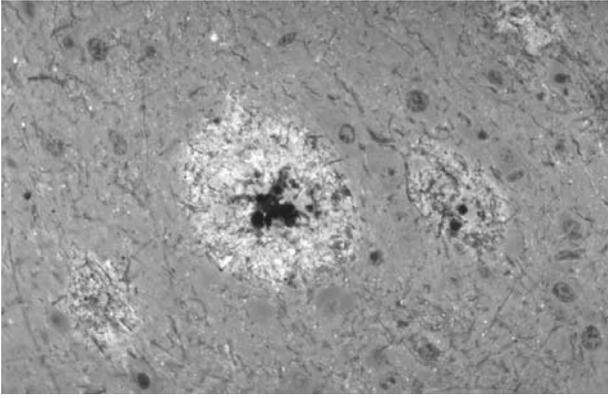
Symptoms

The symptoms of Alzheimer's disease begin gradually, usually with memory lapses. Occasional memory lapses are common to everyone and do not, by themselves, signify any change in cognitive function. The person with AD may begin with only the routine sort of memory lapse—forgetting where the car keys are—but progresses to more profound or disturbing losses such as forgetting how to even drive a car. Being lost or disoriented on a walk around the neighborhood becomes more likely as the disease progresses. A person with AD may forget the names of family members, or forget what was said at the beginning of a sentence by the end of the sentence.

As AD progresses, other symptoms appear, including inability to perform routine tasks, loss of judgment, and personality or behavior changes. Some patients have trouble sleeping and may suffer from confusion or agitation in the evening, known as sunseting. In some cases, people with AD repeat the same ideas, movements, words, or thoughts, a behavior known as perseveration. There may be delusional thinking or even hallucinations. In the final stages people may have severe problems with eating, communicating, and controlling their bladder and bowel functions.

The Alzheimer's Association has developed a list of 10 warning signs of AD. A person with several of these symptoms should see a physician for a thorough evaluation:

- memory loss that affects job skills
- difficulty performing familiar tasks
- problems with language, as in word-find problems or inappropriate word substitutions
- disorientation about time and place
- poor or decreased judgment



Diseased tissue from the brain of an Alzheimer's patient showing senile plaques within the brain's gray matter.

(Photograph by Cecil Fox, Photo Researchers, Inc. Reproduced by permission.)

- problems with abstract thinking
- misplacing things
- changes in mood or behavior
- changes in personality
- loss of initiative

Other types of dementia, including some that are reversible, can cause similar symptoms. It is important for the person with these symptoms to be evaluated by a professional who can weigh the possibility that the symptoms may have another cause. Approximately 20% of those originally suspected of having AD actually have some other disorder; about half of these cases are treatable.

Diagnosis

Diagnosis of Alzheimer's disease is complex and may require visits to several different specialists over several months before a determination can be made. With new diagnostic tools and criteria, it is possible to make a provisional diagnosis that is about 90% accurate. A positive confirmation of these findings can be made only through **autopsy**.

Early diagnosis is essential in helping the patient and the family make decisions about treatment, long-term care, and financial matters. Finding out that a loved one's behavior is based on a degenerative mental disease can help a family avoid unnecessary anger and feelings of impotence when dealing with the progression of the disease.

There are two diagnoses the clinical team can make for a patient. They are probable AD or possible AD. Probable AD is determined when physicians and psychiatrists rule out all other disorders that might produce similar symptoms. A diagnosis of possible AD is made when

AD is considered the primary reason for the symptoms but is complicated with the presence of another disorder that might confuse the general progression of the disease.

Diagnosis for AD begins with the elimination of other physical and psychological causes for the patient's behavior. This is done through a multi-step process that tests for other disorders and measures the amount of deficit the patient is experiencing.

Patient history

A detailed medical history should be taken, noting a list of the patient's medicines (prescription and over the counter), **vitamins**, and herbs. Since there are many pharmaceuticals that can cause the same mental changes as AD, a careful review of the patient's medication, alcohol, and herbal use is important. If the patient's symptoms are related to any of these, most likely the condition can be reversed through adjustments in the patient's medications or herbal use. Any illicit drugs should also be reported.

Next, the physician should take a detailed report of any changes in the patient's mental functioning and memory. This will determine the mode of onset of symptoms, the progression of the deficits, and the impact of the impairment on daily functioning.

Physical exam and lab tests

AD-like symptoms can also be provoked by other medical conditions, including tumors, **infection**, thyroid malfunctioning, and dementia caused by mild strokes (multi-infarct dementia). These possibilities must be ruled out through blood screens, urine tests, electroencephalographs (EEGs), and a variety of imaging techniques.

A genetic test for the ApoE4 gene is available, but is not used for diagnosis, since possessing even two copies does not ensure that a person will develop AD.

Cognitive functioning evaluation

Several types of oral and written tests are used in AD diagnosis and disease progression, including tests of mental status, language ability, functional ability, memory, and concentration. In the early stages of the disease, the results of these tests are usually normal. It should be noted that the widely-used Mini-Mental State Examination (MMSE) may not be accurate for highly educated or poorly educated individuals, or cultural minorities.

Neuropsychiatric evaluation

A detailed cognitive evaluation can be done by a psychologist or psychiatrist. These tests of memory and

mental functioning provide a quantitative measure of the patient's deficits.

One of the most important parts of the diagnostic process is the evaluation of depression and delirium, since these can be present with AD or may be mistaken for it. (Delirium involves a decreased consciousness or awareness of one's environment.) Depression and memory loss are both common in the elderly, and the combination of the two can often be mistaken for AD. Depression can be treated with drugs, although some antidepressants can worsen dementia if it is present, further complicating both diagnosis and treatment.

Imaging studies

Several imaging techniques can assess brain function and pathology, thus eliminating these as causes of the patient's symptoms. Most frequently used imaging scans are **magnetic resonance imaging (MRI)** or computed tomography (CT) scans, which detect structural changes in the brain. Brain function can be assessed through MRI, **positron emission tomography (PET)**, and single-photon emission CT (SPECT). These tests help rule out stroke, subdural hematoma, and **brain tumor** as possible causes for the patient's symptoms.

Treatment

Alzheimer's disease is currently incurable, though a number of pharmaceuticals and **home care** strategies can manage the disease. The mainstay of AD treatment continues to be good nursing care, providing both physical and emotional support, as the patient gradually is able to do less independently and whose behavior becomes more erratic. Modifications of the home to increase safety are often necessary. Creative strategies to help the patient stay as independent as possible are also indicated. The caregiver also needs support to minimize anger, despair, and burnout.

Drugs

Donepezil hydrochloride (Aricept), rivastigmine (Exelon), and galantamine (Reminyl) have been approved for use in AD treatment. These drugs increase the levels of the neurotransmitter acetylcholine in the brain, thereby increasing the communication ability of the remaining neurons. They do this by inhibiting the enzymes, acetylcholinesterase and butylcholinesterase, which normally break down acetylcholine and butylcholine released by neurons. These drugs modestly increase attention span, concentration, mental acuity, and information processing. Tacrine (Cognex), the first drug used, is no longer used due to the risk of **liver** toxicity.

All cholinesterase inhibitors have mild gastric side effects such as nausea and vomiting.

The antioxidant, vitamin E, is also thought to delay AD onset because it prevents neuron damage caused by free radicals. Vitamin E therapy, in combination with cholinesterase inhibitors, has become a practice standard in the treatment of AD.

Drugs that have been found ineffective are Selegiline (used in the treatment of Parkinson's disease), prednisone, and the anti-inflammatory NSAID diclofenac. Estrogen, once thought to be the keystone in treatment and prevention of AD in women, was found to be ineffective in mitigating symptoms in 2001. There is still some discussion about estrogen's ability to delay the onset of AD.

Depression may be treated with selective serotonin reuptake inhibitors (SSRIs) such as citalopram and sertraline. Physicians may also prescribe typical antipsychotics for agitation, aggression, or hallucinations, such as olanzapine, quetiapine, or risperidone. It should be noted that AD patients have more side effects from most medications, especially psychoactive drugs, and care should be taken in their selection.

Alternative treatment

Several substances are currently being tested for their ability to slow the progress of Alzheimer's disease. Among them are ginkgo extract, derived from the leaves of the Ginkgo biloba tree, and huperzine A, from the moss Huperzia serrata. Ginkgo extract has antioxidant, anti-inflammatory, and neuroprotective effects and has been used for many years in China and is widely prescribed in Europe for treatment of circulatory problems. It has been shown to modestly improve cognitive function. Huperzine A is a natural cholinesterase inhibitor. It is reported to produce greater improvement than the synthetic cholinesterase inhibitors and has few side effects. Since neither herbal is regulated, they may have inconsistent levels of their active ingredients per dosage.

Nursing care and safety

The person with Alzheimer's disease will gradually lose the ability to dress, groom, feed, bathe, or use the toilet without help; in the late stages of the disease, the individual may be unable to move or speak. In addition, the person's behavior becomes increasingly erratic. A tendency to wander may make it difficult to leave the patient unattended for even a few minutes, which would make even the home a potentially dangerous place. In addition, some patients may exhibit inappropriate sexual behaviors.

Nursing care required for AD patients is simple enough to learn. The difficulty for many caregivers comes in the constant but unpredictable nature of the demands put on them. Additionally, the personality changes presented in AD can be heartbreaking for family members as a loved one deteriorates, seeming to become a different person. Not all AD patients develop negative behaviors: some become gentle, spending increasing amounts of time in dream-like states.

A loss of grooming skills may be one of the early symptoms of AD. Mismatched clothing, unkempt hair, and decreased interest in personal hygiene become more common. Caregivers, especially spouses, may find these changes socially embarrassing and difficult to cope with. The caregiver will begin to assume more and more grooming duties for the patient as the disease progresses.

Ensuring proper **nutrition** for the AD patient may require using a colored plate to focus the patient's attention on the food. Finger foods may be preferable to those foods requiring utensils. Later, the caregiver may need to feed the patient. As movement and swallowing become difficult, a feeding tube may be placed into the **stomach** through the abdominal wall, which will require special attention.

For many caregivers, incontinence becomes the most difficult problem to deal with at home, and is a principal reason for pursuing nursing home care. In the early stages, limiting fluid intake and increasing the frequency of toileting can help. Careful attention to hygiene is important to prevent skin irritation and infection from soiled clothing.

Safety will become of prime importance. In all cases, a person diagnosed with AD should not be allowed to drive, because of the increased potential for accidents and the increased likelihood of wandering far from home while disoriented. In the home, grab bars in the bathroom, bed rails on the bed, and clutter-free passageways can greatly increase safety. Electrical appliances should be unplugged and put away when not in use, and matches, lighters, knives, or weapons should be stored out of reach. The hot water heater temperature should be set lower to prevent accidental scalding. A list of emergency numbers, including the poison control center and the hospital emergency room, should be posted by the phone.

A calm, structured environment with simple orientation aids such as calendars and clocks may reduce **anxiety** and increase safety. Labeling cabinets and drawers may keep the patient's attention focused. Scheduling meals, bathing, and other activities at regular times and places will provide emotional security and routine, since unfamiliar places and activities can be disorienting for the patient. Sleep disturbances may be minimized by

keeping the patient engaged in activities during the day, offering structure and providing physical activities.

Care for the caregiver

Family members or others caring for a person with AD have a difficult and stressful job, which becomes harder still as the disease progresses. It is common for caregivers to develop feelings of anger, resentment, guilt, and hopelessness, in addition to the sorrow they feel for their loved one and for themselves. Depression is an extremely common consequence of being a full-time caregiver for an AD patient. Support groups are an important way to deal with the **stress** of caregiving. The location and contact numbers for AD caregiver support groups are available from the Alzheimer's Association; they may also be available through a local social service agency, the patient's physician, or pharmaceutical companies that manufacture the drugs used to treat AD. Medical treatment for depression may be an important adjunct to group support.

Outside help, nursing homes, and governmental assistance

Most families eventually need outside help to relieve some of the burden of around-the-clock care for an AD patient. Personal care assistants, either volunteer or paid, may be available through local social service agencies. Adult daycare facilities are becoming increasingly common. Meal delivery, shopping assistance, or respite care may be available as well.

Providing the total care required by a person with late-stage AD can become an overwhelming burden for a family, even with outside help. At this stage, many families consider nursing home care. This decision is often one of the most difficult for the family, since it is often considered an abandonment of the loved one and a failure of the family. Counseling with a physician, clergy, or other trusted adviser may ease the difficulties of this transition. Selecting a nursing home may require a difficult balancing of cost, services, location, and availability. Keeping the entire family involved in the decision may help prevent further stress from developing later on.

Several federal government programs may ease the cost of caring for a person with AD, including Social Security Disability, **Medicare**, and Supplemental Security Income. Each of these programs provides some assistance for care, medication, or other costs, but none of them will pay for nursing home care indefinitely. **Medicaid** is a state-funded program that may provide for some or all of the cost of nursing home care, although there are important restrictions. Details of the benefits and eligibility requirements of these programs are avail-

able through the local Social Security or Medicaid office, or from local social service agencies. Long-term care insurance can also be another option, if taken out prior to the diagnosis.

Prognosis

Alzheimer's disease can weaken the aging body, making it more susceptible to life-threatening infections such as **pneumonia**. In the late stages of the disease, autonomic body functions may be impaired, the patient falling into a **coma**, and death following. In addition, other diseases common in old age—cancer, stroke, and heart disease—may lead to more severe consequences in a person with AD. On average, people with AD live eight years past their diagnosis, with a range from one to 20 years.

Health care team roles

Treatment of AD is a team effort, involving primary care physicians, nurses, imaging and laboratory technicians, gerontology specialists, psychiatrists, psychologists, nursing staff, and caregivers. Physicians order tests that aid in the diagnosis and treatment of AD. These experts must educate the patient and the caregivers in the nature of the disease and its progression, although this burden usually falls on the nursing staff. Nurses are also the first line of access to medical care and support groups. Social workers, counselors, and support group facilitators may also provide emotional support, practical advice, and information about community resources. Special Alzheimer's disease facilities may be used for either respite day care or as permanent long-term care placements.

Prevention

There is currently no proven way to prevent Alzheimer's disease, though some of the drug treatments may delay the development of the disease. The most likely current candidate is estrogen. However, staying active mentally and physically throughout life may be key to prevention.

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KEY TERMS

Acetylcholine—One of the substances in the body that helps transmit nerve impulses.

Dementia—Impaired intellectual function that interferes with normal social and work activities.

Donepezil hydrochloride (Aricept)—A drug that increases the brain level of the neurotransmitter acetylcholine, which is given once a day to treat AD.

Ginko—An herb from the Ginko biloba tree that some alternative practitioners recommend for the treatment of AD.

Neurofibrillary tangle—Twisted masses of protein inside nerve cells that develop in the brains of people with AD.

Senile plaque—Structures composed of parts of neurons surrounding brain proteins called beta-amyloid deposits and found in the brains of people with AD.

Sunsetting—Confusion or agitation in the evening.

Tacrine (Cognex)—A drug that may help improve memory in people with mild to moderate cases of AD.

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- National Institute of Aging, Alzheimer's Education, and Referral Center. (800) 438-4380.

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Janie F. Franz

Ambulatory electrocardiography

Definition

Ambulatory **electrocardiography** (ECG or EKG) is the continuous monitoring on an outpatient basis of the electrical activity of the **heart**, with a device called a Holter monitor, while the patient undergoes their usual daily activities.

Purpose

Ambulatory EKG has the ability to detect a number of heart problems that do not show up during standard electrocardiography tests in a doctor's office or during a **stress test** (electrocardiography performed during **exercise**, also in a doctor's office or EKG laboratory). It is commonly used in the evaluation of palpitations (unpleasant awareness of the heartbeats) or **syncope** (fainting) or to detect electrical symptoms of cardiac ischemia, a deficiency of oxygen to the heart due to reduced **blood** flow. This disease is sometimes called "silent" ischemia because there are often no outward symptoms of the oxygen deprivation.

Because ambulatory EKG involves 24 hour monitoring, it is also particularly useful in detecting conditions that occur periodically, such as during sleep or at times of emotional or physical **stress**. The test can be used to screen for arrhythmias (abnormal heartbeats) and is routinely done in patients after myocardial infarctions that resulted in decreased function of the left ventricle. Ambulatory EKG can also detect transient arrhythmias in patients with idiopathic (unknown cause) dilated cardiomyopathy, hypertrophic cardiomyopathy or congestive **heart failure**.

The long-term nature of the test makes it useful in evaluating the effectiveness of medications used to control irregular heartbeats or arrhythmia or the effectiveness of other cardiac treatments. Because of the compact nature of the device, this test was used by astronauts on

the space shuttle to study how the heart adapts to the weightlessness of space.

Precautions

There are no particular precautions for this test.

Description

Ambulatory electrocardiography, also called continuous ambulatory electrocardiography or Holter monitoring, involves being attached to a portable recorder for 24 to 48 hours. The electrical signals are generally recorded on a magnetic tape for later review. To begin the test, an electrodiagnostic technician attaches five adhesive electrodes to the skin of the chest. Typically, electrodes are placed under each collarbone and each bottom rib, and several electrodes are placed across the chest in a rough outline of the heart. Wires snap onto each of these electrodes and connect them to a small recorder that looks like a wearable radio. The electrodes detect the heart's electrical pattern throughout the day and will store information in the recording box for doctors to interpret later. A small purse with a shoulder strap is used to hold this recorder or it is placed on a belt around the waist.

During the test, patients perform normal activities except they cannot take showers or baths and should avoid electric blankets while wearing the monitor. Often patients are given a small diary to record their various activities, such as exercise, eating, sleeping, straining, breathing too hard (hyperventilating), and any stressful situations. The patient also notes the time and circumstances of any symptoms—especially chest **pain**, dizziness, shortness of breath, heart palpitations, and any other signs of heart trouble. Some Holter monitors allow patients to record their symptoms electronically, highlighting the portion of the electrocardiogram recorded while the symptoms are occurring. Additionally, some monitors can also perform **electroencephalography** (EEG), a measurement of the electrical activity of the **brain**. These dual monitors can be useful in the diagnosis of unexplained loss of consciousness (syncope).

A device similar to a Holter monitor, called an event or loop recorder, can be used to perform ambulatory EKG when the symptoms are very periodic. Generally, these devices have only two electrodes and are the size of a beeper. The event recorder can continuously monitor the heartbeat, but will permanently store the patient's heartbeat only after the patient has pushed a button that freezes the recording process. The device can only store about 30 seconds to two minutes of signal. The button system does allow physical symptoms to be directly correlated with the electrical signals of the heart during the event. Stored

signals can be sent through the telephone to the doctor for analysis.

Additionally, because events often last more than a minute and electrodes can be rapidly positioned, the patient can attach to the machine only when a cardiac event occurs. The continuous monitoring issue is completely avoided with newer devices, such as a credit card-sized monitor that is pressed to the chest wall only when the patient detects symptoms.

Preparation

Patients are asked not to apply creams or lotions to the chest before the test, as this may inhibit the attachment of the electrodes. Sometimes the chest will be shaved of hair to improve electrode function. Wearing loose, comfortable clothing will also make the monitoring process easier.

Aftercare

The electrodes are removed after the monitoring period is completed and the patient may return to normal activities. Results are generally available a few days after the test is complete.

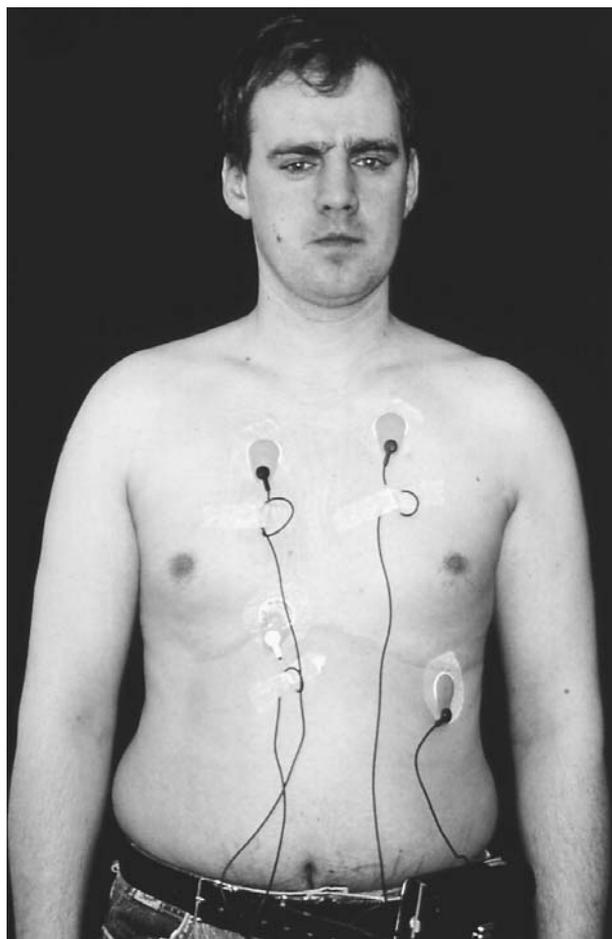
Complications

The only limitations to these monitoring procedures is the need to have recorded the heartbeat during an abnormal event. There are no physical complications that result from the monitoring.

Results

A standard ambulatory EKG will record all the beats of the heart for the period that the device is connected to the patient, while an event recorder will have signals recorded only for a short period after the event button was depressed. Computers are often used as a first stage review the lengthy tapes produced by standard ambulatory EKG testing. The program will highlight abnormal rhythms or abnormal signal shape for closer inspection by the doctor. Some standard monitors are equipped with an event button that highlights electrical output during symptoms. This helps the doctor correlate symptoms with electrical signals, similar to what occurs with a event recorder.

“Silent” ischemia is detected by a change in the shape of the heartbeat signal. In electrocardiography, the five different waves seen in a normal heartbeat are labeled PQRST. Reduced oxygen to the heart often changes the shape of the ST portion of the electrical signal.



A male patient wears electrodes attached to his chest, which are connected to a Holter monitor at his waist.

(Photograph by Dr. P. Marazzi, Photo Researchers, Inc. Reproduced by permission.)

If the purpose of the test is screening for arrhythmias, the recording will be reviewed for any atypical electrical patterns. Among the abnormal patterns that can be seen are transient bradycardia (sporadic abnormally slow heartbeats), atrial fibrillation (rapid, unproductive contraction of the atria), atrial tachycardia (abnormally fast beating of the atria), and paroxysmal supraventricular tachycardia (PSVT), a sporadic fast heartbeat that starts above the ventricles.

If the test is performed to evaluate a treatment, the doctor or technician will scan the record for a return to normal rate and graphic shape of heartbeats.

Health care team roles

Specially trained assistants known as electrocardiograph technicians often prepare patients for ambulatory EKG testing in larger hospital and cardiology group

KEY TERMS

Arrhythmia—An abnormal rhythm of the heart, if transient (periodic) it is often diagnosed using ambulatory EKG.

Cardiomyopathy—A disease of the muscle of the heart.

Ischemia—A lack of oxygen to a tissue, cardiac ischemia is often due to clogging of the coronary arteries.

Palpitation—An unpleasant awareness of the heart beating, can also encompass skipped beats or rapid beats.

Syncope—A loss of consciousness, fainting, a condition that can be caused by heart disease.

practice settings. In small settings, nurses and medical assistants set up the test. A doctor, often aided by a computer, usually does the final interpretation of the tracing.

Training

Many persons learn how to perform ambulatory EKG monitoring through on the job training. However, training programs for EKG work in general, that includes ambulatory techniques, are available through out-sourcing companies or in vocational and community colleges. The usual length of these college-based programs is 465 hours (four months). Program content includes classroom instruction in anatomy and physiology with an emphasis on the cardiac and vascular system, **medical terminology**, cardiovascular medications, patient care techniques, interpretation of cardiac rhythm, **medical ethics**, and a clinical practicum.

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Michelle L. Johnson, M.S., J.D.

American sign language

Definition

ASL is an autonomous linguistic system independent of English. It is a visual/spatial/gestural language that is very expressive and dependent on visual cues of the hands, body and face. ASL contains all the features that are part of a unique communication system: it is symbolic and systematic; it has its own morphology and syntax; and there is a community of users of ASL. ASL is understood to be the "natural" language of deaf people, especially those who are second or third generation deaf. In large part because of its visual and spatial nature, there is no standardized written form of ASL.

Description

In its most basic form ASL originated in the United States in the late 1700s. Over the next two centuries it was transformed into a true language that has been taught to many deaf people. Laurent Clerc and Thomas Gallaudet adapted approximately 60% of Abbe de l'Epee's French Sign Language (FSL) to conform to American customs and manners and incorporated the basic ASL already in use in 1817. Clerc and Gallaudet also opened the American Asylum, the first school for the deaf in North America based on the goal of teaching ASL. Over the centuries the topic of teaching ASL has been quite controversial, with some believing that it should not be taught to deaf children. For example, influential people such as Alexander Graham Bell stressed the importance of oral communication in children who are deaf. Others, however, such as E.M. Gallaudet (nephew of Tomas Gallaudet) were strong proponents of the continued teaching of ASL. From this support of ASL, a deaf community and culture evolved across North America where approximately 2 million members of the deaf community share in the use of this language.

Linguistic structure

Like all other languages, ASL uses arbitrary symbols as its "words." Word order (syntax) of ASL varies according to emphasis, giving the user many expressive possibilities. Information about nouns, subjects or objects, is incorporated into directional verbs by the use of classifiers, and facial/bodily expressions are used as grammatical markers. The syntax of ASL is more closely related to the Navajo language than to the syntax of English. The small meaning units of ASL (its morphology), such as past tense or plural markers, are different

from other languages. ASL does not provide tense marking for each verb in a sentence; rather the tense is marked at the beginning of the conversation and requires no further marking.

Acquisition of ASL

DEAF CHILDREN OF DEAF PARENTS. Only 10% of all deaf children are born to deaf parents, and these children are clearly a minority in the deaf population. However these children have a linguistic advantage over deaf children of **hearing** parents. Deaf children of deaf parents have an accessible language available to them from an early age. Consequently, they develop language at about the same rate as their hearing counterparts. Deaf parents often sign in front of their deaf infants and may often enlarge their children's signs just as hearing parents elongate spoken words in "baby talk." When ASL is acquired first and speech second by these children it is called bilingual acquisition.

DEAF CHILDREN OF HEARING PARENTS. Deaf children of hearing parents typically begin **language acquisition** later as a result of parents not knowing that their child is deaf, often until the child is two to four years old. Therefore, a manual form of language is not used in front of the infant, nor is the child receiving another type of effective communication training, because the infant cannot hear information presented orally. After diagnosis, some of these children may eventually first learn a manual coding of English in the home along with speech. This type of bilingualism is known as bimodal presentation and acquisition. Other deaf children of hearing parents begin to learn ASL soon after diagnosis and learn the language quickly when they are in an environment promoting the use of ASL.

ASL and deaf culture

Deaf culture is "a social, communal, and creative force of, by and for deaf people based on American Sign Language." Deaf culture, however, is not restricted to deaf people; families, friends and advocates of the deaf community may also be a part of deaf culture. Deaf/ASL culture arose during the civil-rights era in the 1960's. It involves deaf people partaking in "visual literature" (for example, ASL poetry, plays, story telling, or humor) as well as, sports and many other physical and visual activities. As a result, the psychosocial basis of deaf culture is understood to mean that deaf people, especially those attending residential schools, regardless of mode of communication taught in the school, will seek out other deaf people and use sign language as a primary mode of communication.

ASL and education

Across North America the majority of deaf children attend public schools. Some of these children may rely on lip reading and other people as note takers, while others may have an ASL interpreter in the classroom. A significant minority of deaf children attend residential schools where communication philosophies vary. Some promote the use of sign language (most often signed English, and fewer, ASL) while others may promote oral communication. However, most children attending residential schools do learn ASL, often from their peers, rather than, or in addition to, their teachers. It is important to note that for deaf children, ASL, as well as signed English, appear to serve, equally well, the same roles in thinking as spoken language does for hearing children.

Implications in healthcare

In the last decade advocates in both the United States and Canada have been promoting better laws that provide ways for deaf people to access health care services more easily in hospitals and government settings. Currently hospitals in the United States are required to provide Tele-Type (TTY) telephone machines that allow deaf patients to make calls, as well as to provide ASL interpreters upon request. Further, the rights of the deaf patient are promoted by hospital regulations that demand that all efforts are to be taken to ensure communication between patients and staff and that the needs of the deaf patient are being met. The above have yet to become laws in Canada. However, efforts are made to provide TTYs and interpreters for Canadian deaf patients. Advocates for the Canadian deaf community continue to push for the implementation of the same laws that protect the American deaf community.

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Timothy E. Moore

Americans with Disabilities Act

Definition

The Americans with Disabilities Act (ADA) was a bill passed by the United States Congress signed into law by President George Bush on July 26, 1990.

Description

The purpose of the ADA was to make society more accessible to people with disabilities. The ADA applies to qualified individuals with disabilities who (1) have physical or mental impairments that substantially limit one or more major life activities; (2) have a record of such impairments; or (3) are regarded as having such impairments. In addition, the ADA protects persons from discrimination based on an association or relationship with an individual with a disability.

A qualified individual with a disability is defined as a person who meets legitimate skill, experience, education, or other requirements for a position, and who is able to perform the essential functions of the position with or without reasonable accommodation. Requiring that an individual be capable of performing essential functions assures that such an individual will not be disqualified simply due to an inability to perform marginal job functions. If the individual is qualified to perform essential job functions, except for limitations caused by a disability, the employer must consider whether the individual could perform these functions with a reasonable accommodation. A written job description, prepared prior to advertising or interviewing applicants for a job, may be considered evidence of the job's essential functions.

Examples of major life activities may include seeing, **hearing**, speaking, walking, breathing, performing manual tasks, learning, self-care, and working. The ADA covers, for instance, individuals with epilepsy, **paralysis**, HIV, **AIDS**, substantial hearing or **vision** impairment, mental retardation, or specific learning disabilities. It also covers the individual with a record of a disability—for example, a person who has recovered from **cancer** or mental illness.

The ADA protects individuals who are regarded as having a substantially limiting impairment, even though they may not have such an impairment. For example, the ADA protects a qualified individual with a physical disfigurement from being denied employment because an employer is concerned how customers or coworkers might react.

The ADA also protects individuals from company or organization actions based on assumptions that an employee/member's relationship with a person with a disability would affect his or her job performance, and from actions resulting from bias or misinformation concerning certain disabilities. For example, the ADA protects a person whose spouse has a disability from being denied employment because the employer assumes that the applicant would require excessive leave to care for the spouse. The individual who is involved in volunteer work with people who have AIDS is also protected from employment discrimination by the ADA, if such discrimination is motivated by that relationship or association.

Civil rights protections similar to other legislation that provides protection on the basis of race, color, sex, national origin, age, and religion are also provided by the ADA; it also guarantees equal opportunity for individuals with disabilities in public accommodations, employment, transportation, government services, and telecommunications. Discrimination in all employment practices, including job application procedures, hiring, firing, advancement, compensation, training, recruitment, advertising, tenure, layoff, leave, fringe benefits, and all other employment-related activities, is controlled by the ADA.

With regard to both private and public sector employment, including state and local government services, companies with 15 or more employees are also subject to the ADA. Specifically, businesses must accommodate employees or customers with disabilities unless doing so represents an undue hardship or a direct threat to the health or safety of others.

Although the ADA is intended to protect those with disabilities from discrimination, employers are not expected to give preference to a qualified applicant with a disability over other applicants. An employer remains free to select the most qualified applicant available and to make decisions based on reasons unrelated to a disability.

Financial assistance for employers

To enable smaller employers to make reasonable accommodations, a special tax credit is available. A tax credit of up to \$5,000 per year for accommodations, made to comply with the ADA, may be taken by an eligible small business. A full tax deduction of up to \$15,000 per year is available to any business for expenses incurred during the removal of qualified architectural or transportation barriers. Covered expenses include removing barriers created by steps, narrow doors, inaccessible parking spaces, restroom facilities, and transportation vehicles.

U.S. government agencies providing assistance with Americans with Disabilities Act

For questions about:	Consult these agencies:	Contact information:
Employment (Title I)	Equal Employment Opportunity Commission (R,TA,E) National Institute on Disability and Rehabilitation Research, Dept. of Education (TA) President's Committee on Employment of People with Disabilities (TA) Small Business Administration, Office of Advocacy, Office of Economic Research (TA) Social Security Administration, Office of Disability (P)	1801 L Street NW, Washington, DC 20554. 400 Maryland Ave. SW, Washington, DC 20202-2572 1331 F Street NW, Third Floor, Washington, DC 20004 409 Third Street NW, Fifth Floor, Washington, DC 20416 Room 545, Altmeier Building, 6401 Security Blvd., Baltimore, MD 21235 P.O. Box 66118, Washington, DC 20035-6118 400 Seventh Street SW, Room 10424, Washington, DC 20590
Public services (Title II)	Office on the AD Act, Civil Rights Division, Dept. of Justice (R,TA,E) Dept. of Transportation (R,TA,E)	1331 F Street NW, Suite 1000, Washington, DC 20004-1111 PO Box 66118, Washington, DC 20035-6118 400 Seventh Street SW, Room 10424, Washington, DC 20590
Public accommodations (Title III)	Architectural and Transportation Barriers Compliance Board (G,TA) Office on the AD Act, Civil Rights Division, Dept. of Justice (R,TA,E) Dept. of Transportation (R,TA,E)	1919 M Street NW, Washington, DC 20554 1331 F Street NW, Suite 1000, Washington, DC 20004-1111 400 Maryland Ave. SW, Washington, DC 20202-2572 1111 Constitution Ave., Ben Franklin Station, Washington, DC 20224
Telecommunications (Title IV) Accessibility	Federal Communications Commission (R,TA,E) Architectural and Transportation Barriers Compliance Board (G,TA)	
Rehabilitation and independent living services	National Institute on Disability and Rehabilitation Research, Dept. of Education (P)	
Tax law provisions	Internal Revenue Service, Dept. of Treasury (TA)	

E=has enforcement authority; G=issues guidelines; P=administers programs relevant to successful implementation of the Act; R=issues regulations; TA=provides technical assistance on how to comply.

SOURCE: Rothstein, J.M., S.H. Roy, and S.L. Wolf. *The Rehabilitation Specialist's Handbook*. 2nd ed. Philadelphia: F.A. Davis Co., 1998.

Enforcement

The ADA's employment provisions are enforced under the same procedures now applicable to race, color, sex, national origin, and religious discrimination under title VII of the Civil Rights Act of 1964 and the Civil Rights Act of 1991. Available remedies include hiring, reinstatement, promotion, back pay, front pay, restored benefits, reasonable accommodation, attorneys' fees, expert witness fees, and court costs. Compensatory and punitive damages also may be available in cases of intentional discrimination or where an employer fails to make a good faith effort to provide a reasonable accommodation.

Viewpoints

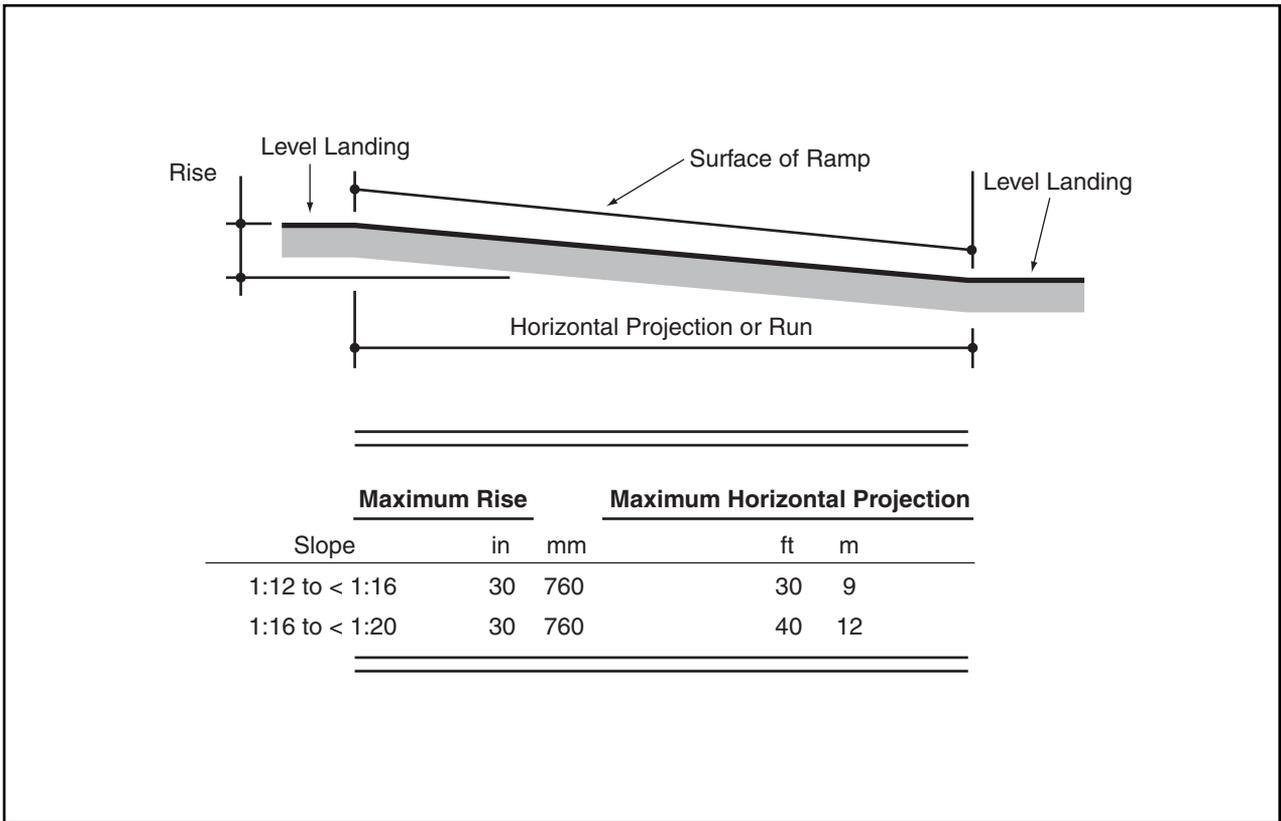
Despite the ADA's laudable intentions, it is not without critics. It is pointed out by those who find fault with the ADA that its definitions are too broad, vague, or ill-defined. Others suggest that unnecessary litigation has been spawned by the ADA, which has not been effective in moving those with disabilities from welfare to the workforce, and requires employers to shoulder burdensome costs to accommodate individuals with disabilities despite available tax credits available from the federal government.

American Disabilities Act defenders point out an example of a recent study reporting that companies' insurance costs rarely rise because of hiring individuals with disabilities. Obvious benefits generated by the ADA are also observed by supporters. Among these benefits are increased attention to pervasive discrimination against and widespread unemployment of people with disabilities, and their willingness and potential to contribute to society. Stereotypes about people with disabilities have been revealed by studies. It is clear that people with disabilities are hired less and fired more than other employees.

Professional implications

Medical examinations

According to the ADA, employers may conduct employee medical examinations when there is evidence of a job performance or safety problem, when it is required by federal law, when it is necessary to determine an individual's fitness to perform a particular job, or when voluntary examinations are part of employee health programs. However, information from medical examinations must be kept confidential. According to the ADA,



Wheelchair ramp measurements are regulated to keep the incline from being too steep. (Illustration by Argosy. Courtesy of Gale Group.)

testing for illegal drug use is not considered part of a medical examination.

An employer may not ask or require an applicant to take a medical examination before extending a job offer. Furthermore, pre-employment inquiries about a disability or the nature or severity of a disability cannot be made by an employer. However, questions may be asked by the employer about the individual’s ability to perform specific job functions. In addition, an individual with a disability may be asked by an employer to describe or demonstrate how he or she would perform such functions.

An employer may qualify a job offer based on a satisfactory post-offer medical examination or medical inquiry, provided this is required of all employees in the same job category. A post-offer examination or inquiry does not have to be job related.

In the event that a post-offer medical examination or inquiry reveals a disability and the individual is not hired, the reason for the rejection must be job related. An employer must show that reasonable accommodations were not available to enable the individual to perform the essential job functions, or that such accommodations

would have imposed an undue hardship. A post-offer medical examination may disqualify an individual. If the employer can demonstrate that a direct threat in the workplace—that is, that a significant risk or substantial harm to the health or safety of the individual would also pose a direct threat in the workplace—a significant risk of substantial harm to the health or safety of the individual or others that cannot be eliminated or reduced below the direct threat level through reasonable accommodation. Such a disqualification must be job related and consistent with business necessity. In addition, an individual with a disability who is able to perform essential job functions may not be disqualified due to speculation that the disability may cause a risk of future injury.

Reasonable accommodation

A reasonable accommodation is any modification or adjustment to a job or the work environment that enables a qualified applicant or employee with a disability to participate in the application process or to perform essential job functions. A reasonable accommodation includes adjustments to assure that a qualified individual with a

disability is provided with the same employment rights and privileges extended to employees without disabilities.

Reasonable accommodation may include making existing facilities used by employees readily accessible to, and usable by, an individual with a disability. In addition, it may involve restructuring a job; modifying work schedules; acquiring or modifying equipment; providing qualified readers or interpreters; or appropriately modifying examinations, training, or other programs. Reasonable accommodation also may include reassigning a current employee to a vacant position for which he or she is qualified, if the person is unable to do the original job because of a disability even with an accommodation. However, an employer is not obligated to find a position for an applicant who is not qualified for the position sought, nor are employers required to lower quality or quantity standards as an accommodation.

Appropriate accommodation decisions must be based on the facts in each case—that is, whether the accommodation will provide an opportunity for a person with a disability to achieve the same level of performance and the potential to enjoy benefits equal to those of a person without a disability. However, the accommodation does not have to ensure equal results or provide exactly the same benefits.

An employer is only required to accommodate a known disability of a qualified applicant or employee. The requirement is typically initiated by a request from an individual with a disability. Accommodations must be made on an individual basis since the nature and extent of a disabling condition and the requirements of a job vary with each case. If the individual does not request an accommodation, the employer is not obligated to provide one except where an individual's known disability impairs the ability to know of, or effectively communicate a need for, an accommodation obvious to the employer. If an appropriate accommodation is requested by a person with a disability (but not suggested by the employer, who cannot "suggest" this), the employer and the individual should work together to identify one. There are a number of resources that provide assistance without cost.

An employer is not required to make an accommodation if it would impose an undue hardship on the employer's business. Undue hardship is defined as an "action requiring significant difficulty or expense." This includes the nature and cost of the accommodation in relation to the size, resources, nature, and structure of the employer's operation. Undue hardship is determined on an individual basis. In general, a larger employer with greater resources would be expected to make accommo-

dations requiring greater effort or expense than a smaller employer with fewer resources.

If an accommodation represents an undue hardship, the employer must try to identify another accommodation that will not pose such a hardship. Also, if the cost of an accommodation would impose an undue hardship on the employer, the individual with a disability should be given the option of paying that portion of the cost that would constitute an undue hardship or provide the accommodation.

The employer is obligated to provide access for an individual applicant to participate in the job application process, and for an individual employee with a disability to perform the essential functions of the job, including access to a building, the work site, necessary equipment, and all facilities used by employees.

However, an employer is not required to make existing facilities accessible until an employee with a disability needs an accommodation. The employer does not have to make changes to provide access in places or facilities that will not be used by that individual for employment-related activities or benefits.

Testing

Accommodations may be needed to assure that tests or examinations measure the actual ability of an individual to perform job functions, rather than reflect limitations caused by the disability. Tests should be given to people who have sensory, speaking, or manual impairments in a manner that does not require the use of the impaired skill, unless the test is designed to measure a job-related skill.

Resources

PERIODICALS

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- Fisher, A. "Readers Weigh in on the ADA and Finding Mentors." *Fortune* 140 no. 1 (July 5, 1999): 192.
- Goldfein, R. and S. Velazquez. "AIDS and the ADA: Protection from Perception." *Trial* 35 no. 10 (October 1999): 42-45.
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- Kazanjian, L. and S. Weinhaus. "Should Correctable Conditions Count as Disabilities Under the ADA?" *Business and Health* 17 no. 8 (August 1999): 47-48.
- Shellenbarger, S. "A Little-Known Part of the Disabilities Act Protects Caregivers." *Wall Street Journal* (August 23, 2000).
- Van Detta, J. A. "Typhoid Mary Meets the ADA: A Case Study of the Direct Threat Standard Under the Americans

with Disabilities Act.” *Harvard Journal of Law and Public Policy* 27 no. 3 (Summer 1999): 849-958.

ORGANIZATIONS

Americans with Disabilities Act Document Center. <<http://jan-web.icdi.wvu.edu/kinder/index.htm>>.

Americans with Disabilities Act of 1990, 42 U. S. C. 12101-12213 (1990). <<http://www.usdoj.gov/crt/ada/pubs/ada.txt>>.

U.S. Department of Justice. Americans with Disabilities ADA Homepage. <<http://www.usdoj.gov/crt/ada/adaohm1.htm>>.

Bill Asenjo, M.S., C.R.C.

Amino acid disorders screening

Definition

Amino acid disorders screening is performed to detect inherited and acquired disorders in amino acid **metabolism**. Tests are most commonly done in the neonatal period.

Purpose

Twenty of the 100 known amino acids are the main building blocks for human **proteins**. Of these 20 amino acids, ten (essential amino acids) are not made by the body and must be acquired through diet. Proteins regulate every aspect of cellular function. The goal of amino acid disorder screening is early detection and intervention. Errors of amino acid metabolism range from asymptomatic or benign to life-threatening. In some cases, management by dietary restriction of the amino acid(s) involved can prevent damage or symptoms.

Precautions

All neonates should be screened for the most prevalent aminoacidurias within a few days of birth. Usually this includes tests for phenylketonuria, tyrosinemia, lysinemia, maple syrup urine disease, and homocystinuria using a dried spot of **blood** collected on a paper card. When an infant displays symptoms such as failure to thrive, repeated vomiting, or nervous system impairment and an amino acid disorder is suspected, testing may be done on either plasma or urine. The patient should be fasting for the blood test. Blood samples are usually collected by heel puncture. The nurse or phlebotomist should observe **universal precautions** for the

prevention of transmission of bloodborne pathogens when collecting the sample. Blood samples show considerable variance depending upon the time of sampling, and urine testing avoids this problem. Urine testing should be performed on a first morning voided sample or a 24-hour urine sample. Some drugs may affect the results of amino acid tests by certain methods of analysis. Any medications being given to the patient should be reported to the laboratory performing the test. **Antibiotics** will adversely affect the growth of the bacterium used in the Guthrie bioassay test for phenylalanine. Mothers of breastfeeding infants should report any medications they are taking, since these can pass from mother to child in breast milk.

Description

An enzyme deficiency that blocks the metabolism of an amino acid is called a primary aminoaciduria. An error in absorption or transport of an amino acid is called a secondary aminoaciduria. Both primary and secondary aminoacidurias may be inherited (congenital) or acquired. Aminoacidurias may be grouped into two types, overflow and renal, based on the mechanism by which the amino acids accumulate. In the overflow type, the plasma level of one or more amino acids will be increased (aminoacidemia). The most common overflow type is phenylketonuria (PKU). The incidence of PKU varies with race and ethnic origin and there are 5 different forms of the disease. The most prevalent is type I which occurs in approximately 1 in 10,000 births in the United States, and accounts for about 50% of PKU cases. Because of its high prevalence all states screen newborns for PKU. This condition is caused by an inherited deficiency of the enzyme phenylalanine hydroxylase. The enzyme is needed to convert phenylalanine to tyrosine. Phenylalanine accumulates in the plasma and is oxidized by phenylalanine transaminase to phenylpyruvic acid which is excreted in the urine. Phenylpyruvic acid is a ketoacid, hence the name phenylketonuria. Mental retardation occurs as a consequence of PKU, but can be prevented by withholding phenylalanine from the diet. There are many other primary aminoacidurias. Several are caused by enzyme deficiencies of the urea cycle. These give rise to increased blood ammonia levels and an increase of one or more amino acids.

In renal type aminoacidurias, one or more amino acids are excreted in excess in the urine but plasma levels are not increased. Some renal type aminoacidurias are inherited, but many are acquired or secondary to other diseases. A common inherited renal type aminoaciduria is cystinuria which results from a defect in the reabsorption of dibasic aminoacids by the kidney.

Measurement

Newborn screening for PKU, tyrosinemia, lysinemia, maple syrup urine disease, and homocystinuria are often performed on a spot of whole blood collected from a heelstick. The test most often used is a bioassay called the Guthrie test. The test is based upon the ability of blood with an excess of the respective amino acid to overcome the effect of a specific inhibitor of the bacterium *B. subtilis*. For example, *B. subtilis* requires phenylalanine for growth. The growth of a culture of the organism can be prevented by adding thienylalanine to the culture medium. However, if excessive phenylalanine is present in the blood, it will overcome the effect of the inhibitor permitting the organism to grow. An alternative screening procedure for excessive phenylalanine that can be performed on a blood spot is the measurement of fluorescence after extraction and reaction with a reagent containing ninhydrin.

Young children with acidosis (accumulation of acid in the body), severe vomiting and **diarrhea**, or urine with an abnormal color or odor, are also tested for abnormal levels of amino acids. The most widely used method is high-performance liquid chromatography because it separates and quantifies all amino acids in the sample. Urine is usually the preferred specimen since it will detect both overflow and renal type aminoacidurias. The most common approach is to separate the amino acids on an ion exchange column using stepwise elution by changing the pH of the mobile phase. As amino acids emerge from the column they are reacted with ninhydrin and the absorbance of derivative formed is measured using a photometric detector.

Preparation

Before the blood test, the patient must not eat or drink for at least four hours. Failure to fast will alter the results of the test. The patient should eat and drink normally before the urine test.

Aftercare

The patient may feel discomfort when blood is drawn from a heel capillary or vein. Bruising may occur at the puncture site or the person may feel dizzy or faint. Pressure should be applied to the puncture site until the bleeding stops to reduce bruising. Warm packs can also be placed over the puncture site to relieve discomfort.

Complications

There are no particular risks associated with either blood or urine tests for amino acids. Occasionally minor bruising may occur at the site where the blood was taken.

KEY TERMS

Amino acid—An organic compound containing both an amino group and an acidic carboxyl group; amino acids are the basic building blocks of proteins.

Aminoacidopathy—A condition involving abnormal amino acid levels in the blood or urine.

Chromatography—A family of laboratory techniques that separate mixtures of chemicals into their individual components.

Enzyme—A biological catalyst that increases the rate of a chemical reaction without being used up in the reaction.

Metabolism—The sum of all the chemical and energy reactions that take place in the human body.

Results

Guthrie test results are reported as either positive or negative. Results of quantitative assay for each amino acid should be compared to age-related reference ranges. Representative normal ranges for phenylalanine are shown below.

- Guthrie test: Negative or less than 2 mg/dL.
- Plasma: neonate 1.2-3.4 mg/dL (40-110 micromol/L) (premature infant 2.0-7.5 mg/dL).
- Urine: neonate 1.2-1.7 mg/day (0-200 micromol/gram creatinine).

Health care team roles

Amino acid tests are ordered and interpreted by a physician. The heel stick or venipuncture is performed by a nurse or phlebotomist. Amino acid analysis is performed by a clinical laboratory scientist/medical technologist. If an aminoacidopathy is suspected, the family is typically referred to a genetic counselor to discuss prognosis and recurrence risks. DNA tests are available for prenatal testing of some aminoacidurias.

Resources

BOOKS

Fischbach, Frances. *A Manual of Laboratory and Diagnostic Tests*. 5th ed. Philadelphia: Lippincott, 1996.

Scriver, Charles R., et al. *The Metabolic and Molecular Bases of Inherited Disease*. 7th ed. New York: McGraw-Hill, Inc.

PERIODICALS

Chace D.H., et al. "Use of Penylalanine-to-Tyrosine Ratio Determined by Tandem Mass Spectrometry to Improve Newborn Screening for Phenylketonuria of early discharge specimens collected in the first 24 Hours." *Clinical Chemistry* (December 1999): 2405-9.

ORGANIZATIONS

Association for Neuro-Metabolic Disorders (ANMD), PO Box 0202/L3220, 1500 Women's Medical Center Drive, Ann Arbor, MI 48109-0202. (313) 763-4697.

Children's PKU Network (CPN), 1520 State Street, Suite #240, San Diego, CA 92101. (619) 233-3202. magol@gte.net.

National Phenylketonuria Foundation, 6301 Tejas Drive, Pasadena, TX 77503. (713) 487-4802.

Rachael Brandt, MS

Ammonia (blood) test see **Liver function tests**

Amniocentesis

Definition

Amniocentesis is an optional but reliable procedure offered to pregnant women in order to obtain more information about a developing fetus in the second trimester of **pregnancy**. It is primarily offered to pregnant women who are at increased risk, based on their age, family history, or other factor, of having a child with a genetic condition. Amniocentesis provides accurate information about fetal chromosomes or the likelihood of certain physical abnormalities. Additional specialized studies may be performed on an as-needed basis. Women who undergo amniocentesis typically do so either to obtain reassurance about fetal well-being or, if the results are abnormal, to plan for the remainder of their **prenatal care**. The procedure is associated with a slightly increased chance for pregnancy loss.

Purpose

Amniocentesis has been considered a standard of obstetrical care since the 1970s. It is not, however, offered to all pregnant women. The American College of Obstetricians and Gynecologists (ACOG) recommends that amniocentesis be offered to all expectant mothers age thirty-five and older. This age cut-off has been selected because advancing maternal age is associated with an increasing risk of having a baby with a numeri-

cal chromosome abnormality. At age 35, this risk is approximately one in 200 births roughly equivalent to the risk of pregnancy loss associated with amniocentesis.

Amniocentesis is performed for the following reasons:

- Detection of structural chromosome abnormalities or an increased number of chromosomes in the fetus when the mother is in a high risk group. This includes a maternal age of 35 or more; a mother who is known to carry an abnormal chromosome such as a 21/14 translocation; family history of chromosome abnormalities; a genetic disease such as sickle cell anemia for which a DNA test is available; or abnormal triple marker screening test for **Down syndrome** (i.e., a low serum alpha fetoprotein or estriol or a high chronic gonadotropin level).
- Determination of the sex of the fetus when the mother is a carrier of an X-linked genetic disease such as **hemophilia**.
- Confirmation of an elevated maternal serum alpha fetoprotein result. Alpha fetoprotein is increased in amniotic fluid in pregnancies associated with open neural tube defects such as spina bifida and several other abnormalities that allow the fluid to leak from the fetus into the amniotic fluid.
- To evaluate the severity of hemolytic disease of the newborn (HDN). In this condition, maternal antibodies, usually anti-Rho (D), cross the placenta and facilitate destruction of Rh positive fetal red **blood** cells.
- Evaluation of fetal lung maturity (FLM). **Respiratory distress syndrome** results from collapse of the infant's **lungs** during expiration if the level of pulmonary surfactants is insufficient. This may occur immediately after birth especially in premature deliveries and when the mother is a diabetic. Measurement of surfactants excreted by the fetus into the amniotic fluid is used to determine the maturity of the fetal lungs.

Evaluation studies of HDN and FLM are performed in the second half of pregnancy, whereas tests for alpha fetoprotein (AFP), chromosome karyotyping, and abnormal genes are performed during the first half of pregnancy, typically between weeks 15 and 18.

Precautions

Amniocentesis is associated with a slightly increased chance of pregnancy loss (approximately 0.5%). Each woman should discuss the potential risks and benefits of amniocentesis with a doctor or genetic counselor and make her own decision about whether or not she desires this testing.

Early amniocentesis, or procedures performed before the thirteenth week of pregnancy, has been associated with an increased risk of clubfoot and of procedure-related pregnancy loss. When collecting amniotic fluid **universal precautions** should be followed for the prevention of transmission of bloodborne pathogens. Bloody fluid or fluid containing meconium may interfere with the tests for amniotic fluid bilirubin performed to evaluate the severity of HDN. These substances may also interfere with the interpretation of some FLM tests such as the L:S ratio (which is used to determine the level of the fetus's lung development). Some tests such as the amniotic fluid bilirubin test and alpha fetoprotein test must be interpreted with regard to gestational age.

Description

According to the National Center for Health Statistics (NCHS), 112,776 amniocentesis procedures were performed in the United States in 1998, the most recent year for which data is available. The annual birth rate that year was approximately 3.9 million infants. Thus, approximately 3% of pregnant women in the United States had this procedure performed. It is likely that this is an underestimate. The NCHS obtains information from birth certificates registered in each state and the District of Columbia. Although almost all deliveries are registered in the United States, records are still submitted with incomplete information. It is also not possible to know how many amniocentesis procedures were performed for **genetic testing**, as compared to other indications, as this information is not requested.

Normal persons have a total of 46 chromosomes in each body cell, with the exception of sperm or egg cells that should have only 23. As women get older, there is an increased risk of producing an egg cell with an extra chromosome. This leads to an egg cell with 24 chromosomes rather than the normal 23. Pregnancies with an abnormal number of chromosomes are referred to as aneuploid. Aneuploidy results in a conceptus with either too much or too little genetic material. This, in turn, leads to abnormal development. Aneuploidy results from failure of the chromatids to separate either during meiosis or in the germ line cells of the embryo. Common effects of aneuploidy include an increased risk for pregnancy loss or, in living fetuses, for mental retardation and physical abnormalities.

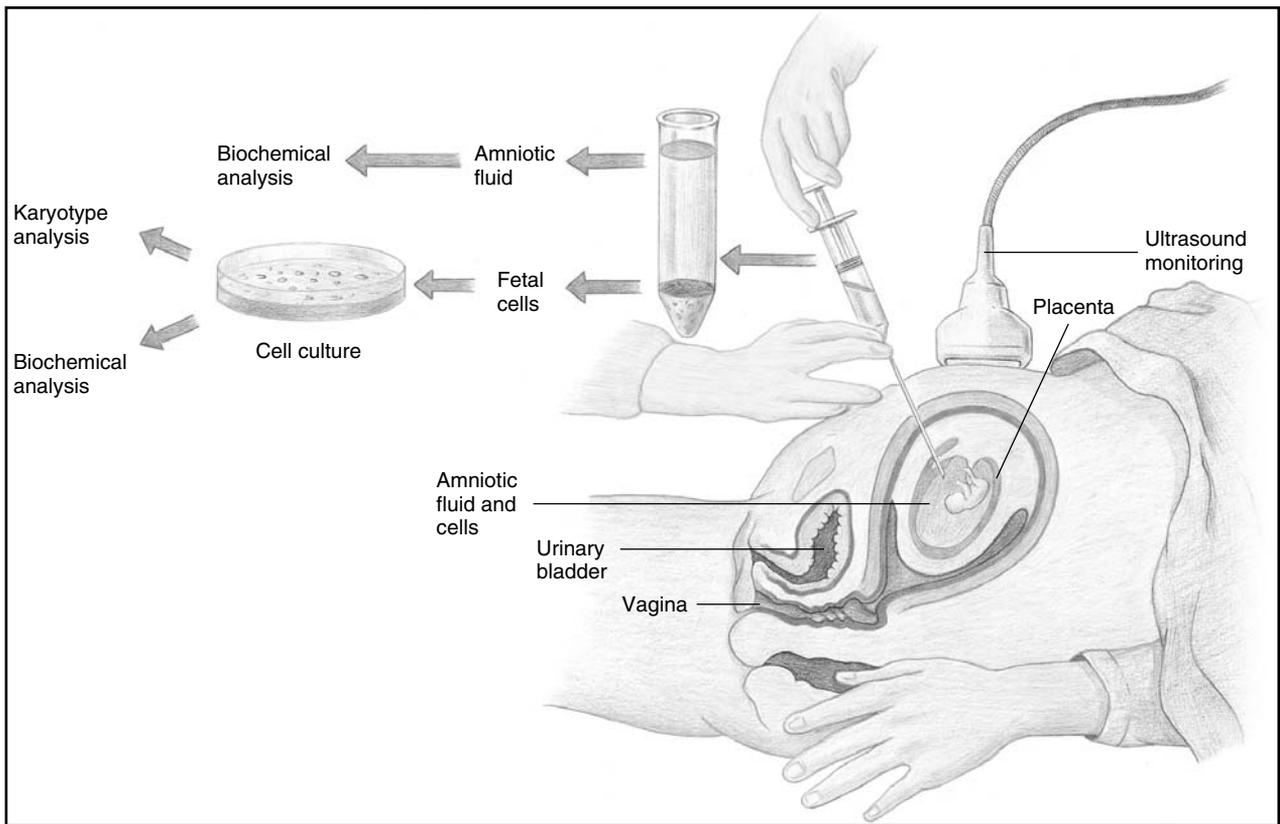
Down syndrome is the most common form of aneuploidy in live born infants, occurring in approximately one in 800 births, regardless of maternal age. The most common form of Down syndrome is 21 trisomy. One of the gametes contains an extra chromosome number 21 resulting in three number 21 chromosomes following fer-

tilization. In women who are 35 years old, the risk of having a child with Down syndrome is higher, roughly one in 385 at delivery. It is important to realize that Down syndrome is not the only chromosome abnormality that may occur. Other numerical abnormalities are possible, yielding genetic conditions that may be either more or less severe than Down syndrome. Thus, a woman is often at risk, based solely on her age, of having a child with any type of chromosome abnormality. At age 35, this total risk is approximately one in 200. By age 40, this risk has increased to one in 65, and, at age 45, this risk is one in 20. These numbers reflect the risk at the time of delivery.

Women younger than 35 years may also have children with chromosomal or other genetic disorders. Therefore, other indications for amniocentesis or other forms of prenatal diagnosis include a family history of or a previous child with a known genetic condition, abnormal prenatal screening results, such as ultrasound or a blood test, or one parent with a previously identified structural chromosome rearrangement. All of the above may make it more likely for a couple to have a child with a genetic condition.

Amniocentesis is the most common invasive prenatal diagnosis technique offered to pregnant women. Its safety and accuracy are well-established, and it is generally considered the standard by which other prenatal diagnosis techniques are measured. To perform the procedure, a doctor inserts a thin needle into the mother's uterus and the amniotic sac. A continuous ultrasound evaluation is typically used so that the doctor can avoid touching either the baby or the umbilical cord with the needle. The amniotic sac is made up of two membranes: the inner amnion and the outer chorion. The amnion and chorion both develop from the fertilized egg. They are initially separate but begin to fuse early in pregnancy. This fusion is usually completed by approximately the fourteenth to fifteenth week of pregnancy.

Amniocentesis is usually performed in the second trimester, usually during weeks fifteen to eighteen (mid-trimester). The amniotic sac holds the fetus suspended within the amniotic fluid, an almost colorless fluid that protects the fetus from harm, helps maintain a consistent temperature, and prevents the fetus, or parts of it, from becoming attached to the amnion. The amniotic fluid is produced and absorbed by the fetus and the mother throughout pregnancy. Fetal cells, primarily derived from the skin, **digestive system**, and urinary tract, are suspended within the fluid. A smaller number of cells from the amnion and placenta are also present. Finally, the fetus produces a number of different chemical substances that also pass into the amniotic fluid. One of these substances is bilirubin, a breakdown product of hemoglobin.



Amniocentesis is performed at 16–18 weeks of pregnancy. (Delmar Publishers, Inc. Reproduced by permission.)

Bilirubin in amniotic fluid is measured to determine the extent of fetal red cell destruction in HDN. Pulmonary surfactants are used in some higher-risk pregnancies to assess fetal lung maturity, and alpha-fetoprotein is used to screen for certain structural birth defects.

It is possible to perform amniocentesis in a twin pregnancy. Amniocentesis in some higher-order pregnancies, such as triplets, has also been reported. In a **multiple pregnancy**, it is important to ensure that a separate sample of amniotic fluid is obtained from each fetus. To accomplish this, a doctor injects a small amount of harmless blue dye into the amniotic sac of the first baby after a sample has been withdrawn. The dye will temporarily tinge the fluid blue-green. A second needle is inserted into the next amniotic sac with ultrasound guidance. If the fluid withdrawn is pale yellow, a sample from the next fetus has been successfully obtained. Since monoamniotic twins share the same amniotic sac, the second sample will be blue.

Chorionic villus sampling

Mid-trimester amniocentesis has been available for nearly thirty years. **Chorionic villus sampling (CVS)** has been available in the United States since the 1980s.

CVS is usually performed between ten and twelve weeks of pregnancy. It involves the removal of a small sample of the developing placenta, or chorionic villi. It has been an attractive alternative to amniocentesis, particularly for those women who desire both testing and results earlier in their pregnancies. Some of the benefits of earlier testing include reassurance sooner in pregnancy and fewer physical complications following first trimester pregnancy termination, for those couples with abnormal babies who choose this option. CVS is, however, associated with a higher risk of **miscarriage** than mid-trimester amniocentesis and because it is performed earlier than amniocentesis more fatal chromosome abnormalities are detected that would not come to term. At experienced centers, this risk is approximately 1% (or one in 100).

Early amniocentesis

Early amniocentesis is performed before the thirteenth completed week of pregnancy. It has been considered investigational for many years. The results of the largest early amniocentesis trial, published in 1998, have, however, caused physicians worldwide to reconsider the benefit and risks of this earlier procedure. The Canadian Early and Mid-trimester Amniocentesis Trial (CEMAT)

is the largest, multi-center, randomized clinical trial of early amniocentesis conducted to date. The purpose of the trial was to examine and compare the safety and accuracy of early amniocentesis (EA) versus mid-trimester amniocentesis (MTA). In order to accomplish this, 4,374 pregnant women were identified and enrolled in the study. Ultrasound was performed in the first trimester to confirm the gestational age of all pregnancies. Computer randomization was used to evenly divide the women into either the EA or MTA groups. Ultimately, 1,916 women underwent EA and 1,775 women had MTA. Follow-up was obtained on nearly all pregnancies. Two striking conclusions were reached: EA is associated with an increased incidence of clubfoot and an increased risk of procedure-related pregnancy loss. EA was also linked to an increased number of laboratory culture failures (no growth of cells and no results) compared to MTA. The total waiting time for results was slightly longer in the EA group. This is not entirely a surprise. A smaller amount of fluid is obtained when EA is performed. Hence, there are fewer cells, and culture times take longer.

Chromosome tests

Genetic testing is available on amniotic fluid obtained by amniocentesis. The most common test is a complete analysis of the fetal chromosomes called karyotyping. This procedure detects only those chromosome abnormalities that produce either a structurally abnormal chromosome (e.g., a long or short arm deletion) or aneuploidy. It does not detect mutations within genes that are responsible for specific diseases or inborn errors of **metabolism** (e.g., **cystic fibrosis**). However, many DNA based tests are available that will detect disease genes that are caused by point mutations (single base substitutions) within the genes.

After a sample of amniotic fluid is obtained, the cytogenetic laboratory isolates the cells, referred to as amniocytes, out of the fluid. The cells are placed into two or more containers filled with liquid nutrients, establishing different cultures in which the cells will continue to grow. The cells are cultured anywhere between seven to 10 days before the actual analysis begins. Culture time can be reduced to five to six days by growing a monolayer of fetal cells directly onto a coverglass. Culture is performed in order to obtain sufficient metaphase cells and to synchronize the growth of the cells. Cells in metaphase are selected for analysis because at this stage the chromatids have duplicated but not separated and the individual chromosomes are most visible under the **microscope**.

Once there appears to be an adequate number of cells to study, the cultures are harvested. Harvesting prevents additional cell growth and stops the cells at whatever point they were in the cell cycle. Cells are washed, exposed to hypotonic saline, and fixed with methanol and acetic acid. The cells are spread on a glass slide, heat fixed and treated with trypsin and stained with Giemsa or other chromosome stain. Smears are examined under 400x magnification and the modal chromosome count is recorded. Large clear metaphase cells are selected for photography or image analysis using chromosome-sorting software. Chromosomes are classified by size, centromere position, banding pattern, secondary constriction, and satellite appendages. The karyotype or chromosome map that results identifies translocations, aneuploidy, deletions, and other abnormalities in the appearance of the chromosomes. Typically, chromosome results are available within seven to 14 days after amniocentesis. Results may be delayed by slow-growing cultures. This rarely reflects an abnormal result but does extend the time until final results are available.

Many laboratories now perform a technique called fluorescence in situ hybridization (FISH) into their chromosome studies. This adjunct testing provides limited information about certain chromosomes within one to two days after amniocentesis. It does not replace a complete chromosome study using amniocyte cultures. In fact, FISH results are often reported as preliminary, pending confirmation by cultured results. They can, however, be very useful, particularly when there is already a high level of suspicion of a fetal chromosome abnormality.

FISH is performed using a small sample of uncultured amniotic fluid cells. Special molecular tags consisting of single-stranded DNA that are attached (covalently conjugated) to fluorescent dyes are used. Each tag is bound to a different combination of dyes. When excited by ultraviolet light, the fluorochromes emit visible light of characteristic colors. Tags are available that recognize a specific segment of DNA from chromosomes 13, 18, 21, X, and Y. Abnormalities of these five chromosomes account for nearly 95% of all chromosomal abnormalities. The cells are prepared onto slides as described for karyotyping, denatured to separate the DNA strands, and the probe mixture is added. Each probe hybridizes with the complementary DNA sequence of the target chromosome. When the fetal cells are examined under a fluorescent microscope, a small spot of a specific color will appear on each of these chromosomes. If an extra autosomal chromosome is present, three colored spots appear within the nucleus of the cell instead of two. In addition to determining sex, FISH detects extra sex chromosomes such as 47,XXY which is responsible for Klinefelter syndrome or the absence of one sex chromosome, and 45,X0

which is responsible for Turner syndrome. Other chromosomal abnormalities will not be detected unless a full chromosome evaluation on cultured cells is performed.

A new fluorescent mapping technique called spectral karyotyping (SKY) is available to aid in identifying chromosomes. A DNA probe specific for each chromosome is tagged with between one to five fluorescent dyes. Hybridization between the tag and DNA of the specific chromosome produces a unique color for each one. Using fluorescent microscopy, and a color camera, the karyotype showing each of the 24 different colored chromosomes is constructed. Chromosomes in which translocations occur are bi-colored. The color coding facilitates the identification of the regions of each of the chromosomes involved.

DNA tests are offered to those couples who, based on their family history or other information, are at increased risk of having a child with a single gene, or Mendelian, disorder. Testing for disease genes is primarily accomplished using the polymerase chain reaction (PCR). This technique permits a small segment of DNA within a gene to be amplified exponentially. Within two hours, the target DNA sequence can be copied over one million times, yielding sufficient DNA to identify with a radiolabeled or enzyme-conjugated probe. An example of this technique has been applied extensively to the prenatal diagnosis of cystic fibrosis. There are over 200 different point mutations identified in the CF gene, a segment of 27 coding regions called exons. Various probes may be used to identify most of these. For example, approximately 85% of all CF genes can be identified in the North American white population. DNA tests are available for **sickle cell disease**, **muscular dystrophy**, retinoblastoma, hyperlipoproteinemia, Huntington's chorea, Tay-Sachs disease, congenital adrenal hyperplasia, hemophilia, and many other conditions.

Biochemical testing of amniotic fluid is performed using the same methods as are applied to other body fluids. For example, fluorescence polarization and thin layer chromatography are techniques used to measure pulmonary surfactants. Bilirubin in amniotic fluid is analyzed by direct absorbance measurement using a scanning or diode array spectrophotometer. Bilirubin absorbs light maximally at 450 nm, and if present in the amniotic fluid, it will produce an absorbance peak at this wavelength. Hemoglobin contributes to the absorbance peak by also absorbing light at this wavelength. The interference from hemoglobin can be corrected by measuring its absorbance peak at 410 nm. The contribution of hemoglobin to the 450 nm peak is equal to 5% of its absorbance at 410 nm. Therefore, the 5% of the absorbance at 410 nm is subtracted from the absorbance

at 450 nm to determine the corrected absorbance which is proportional to bilirubin concentration.

Alpha fetoprotein in amniotic fluid is measured by a sandwich type enzyme immunoassay, the same method used for maternal blood. AFP is a protein made by the fetal **liver**. It passes out of the fetus and enters both the amniotic fluid and the mother's blood. Screening for open neural tube defects, abnormal openings in the fetal head or **spinal cord**, or ventral wall defects, openings along the abdominal wall, can be performed by measuring AFP during the fifteenth to twentieth weeks of pregnancy. An unusually high level of serum AFP does not necessarily indicate a problem with **fetal development**, but is cause for some concern. A high AFP level in amniotic fluid will detect up to 98% of all openings on the fetal body that are not covered by skin. Further studies may be suggested if the AFP is high. Most initial AFP results are available within two to three days after amniocentesis.

Preparation

The usual precautions concerning sterility of the injection site and sterility of equipment and the hands of those who will come into contact with a woman must be taken during amniocentesis.

Counseling must be offered to a woman or couple to ensure that they fully understand the results of an amniocentesis test. Counseling should be offered prior to the procedure so that a woman or couple can understand the procedure and slight risk of miscarriage that is associated with amniocentesis.

Aftercare

Physical care after an amniocentesis procedure involves the site of needle insertion. It should be kept clean and dry. Covering the puncture site with a sterile bandage is usually sufficient.

Mental care after an amniocentesis may be more important than physical care. Many women or couples require emotional support and reassurance while they are waiting for test results. Those receiving abnormal results often require ongoing support while they weigh options and make decisions that are appropriate for them. Some may require long-term support as they adjust to the outcomes of their decisions.

Complications

Women who have had an amniocentesis often describe it as uncomfortable, involving some mild pressure or **pain** as the needle is inserted. Fewer women

KEY TERMS

Alpha fetoprotein—A protein found in amniotic fluid that is commonly used to screen for certain structural birth defects.

Amnion—A thin, transparent membrane that holds the fetus in the amniotic fluid. The amniotic sac is sometimes called the bag of waters.

Anesthetic—Drug used to temporarily cause loss of sensation in an area of the body. An anesthetic may either be general, associated with a loss of consciousness, or local, affecting one area only without loss of consciousness. Anesthetics are administered via inhalation, topical application or needle injection.

Aneuploid—A fetus with an abnormal number of chromosomes.

Chorion—The outer membrane of the amniotic sac. Chorionic villi develop from its outer surface early in pregnancy. The villi establish a physical connection with the wall of the uterus. The chorionic villi eventually develop into the placenta.

Chromosome—A linear thread of genetic material contained within every cell. Humans have 46 chromosomes arranged into 23 distinct pairs. Each parent contributes one set of chromosomes, or 23, to a child. Changes in the total number of chromosomes, the shape and size (structure) of a chromosome or the contents of a chromosome may lead to abnormalities in the amount of genetic material. These abnormalities often lead to abnormal physical and mental development.

Conceptus—The product of conception, or the union of a sperm and egg cell at fertilization.

Cystic fibrosis—An inherited disease characterized by repeated lung infections, functional abnormalities of the pancreas, and an elevated level of salt in sweat. Individuals with cystic fibrosis require long-term aggressive medical care. Survival into adulthood is common, in part due to advances in treatment. Death, however, is frequently caused by respiratory failure. Although cystic fibrosis is more common among Caucasians, it has been reported in individuals of other races.

Down syndrome—A genetic condition characterized by moderate to severe mental retardation, a characteristic facial appearance, and, in some indi-

viduals, abnormalities of some internal organs. Down syndrome is always caused by an extra copy of chromosome 21, thus there are three rather than the normal two. For this reason, Down syndrome is also known as trisomy 21.

Fetus—The term used to describe a developing human infant from approximately the third month of pregnancy until delivery. The term embryo is used prior to the third month.

Fibroid—A non-cancerous tumor of connective tissue. It is made up of elongated, threadlike structures, or fibers, which usually grow slowly and are contained within an irregular shape. Fibroids are firm in consistency but may become painful if they start to break down or apply pressure to areas within the body. They frequently occur in the uterus and are generally left alone unless growing rapidly or causing other problems. Surgery is needed to remove fibroids.

Sickle cell anemia—An hereditary form of anemia due to abnormal sickle-shaped red blood cells. As a result, the cells cannot efficiently carry oxygen to body tissues. Common clinical features of sickle cell anemia include severe pain in the joints and abdomen, swelling of the tops of hands and feet, and fever. Sickle cell anemia is frequently found among individuals with ancestors who lived in central Africa.

Tay-Sachs disease—An inherited biochemical disease caused by lack of a specific enzyme in the body. In classical Tay-Sachs disease, previously normal children become blind and mentally handicapped, develop seizures, and rapidly decline. Death often occurs between the ages of three to five years. Tay-Sachs disease is common among individuals of eastern European Jewish background but has been reported in other ethnic groups.

Trimester—A three-month period. Human pregnancies are normally divided into three trimesters: first (conception to week 12), second (week 13 to week 24), and third (week 25 until delivery).

Uterus—A muscular, hollow organ of the female reproductive tract. The uterus contains and nourishes an embryo or fetus from the time the fertilized egg is implanted until birth.

describe it as extremely painful. A local anesthetic may be used to numb the upper layer of the mother's skin prior to testing. This medicine has no effect on the fetus, but may help the mother feel more comfortable during the procedure. An experienced physician can, on average, perform amniocentesis in approximately one to two minutes.

Common complaints after amniocentesis include mild abdominal tenderness at the site of needle insertion or mild cramping. These usually go away within one to two days. More serious complications are significantly less common but include leakage of amniotic fluid, vaginal bleeding, or uterine **infection**. These complications are estimated to occur in less than 1% of pregnancies. In some women, complications after amniocentesis may lead to a miscarriage, or loss of the pregnancy. A woman's background risk of having a miscarriage, without amniocentesis, is approximately 2-3% in her second trimester. In experienced hands, the risk for an amniocentesis-related pregnancy loss is estimated to be an additional 0.25-0.50%, or roughly one in every 200-400 pregnancies.

Much attention is often paid to the physical side effects of amniocentesis. However, it is important to also emphasize some of the emotional side effects of amniocentesis. Many of these are also applicable to other forms of prenatal diagnosis.

The offer of prenatal testing is associated with increased **anxiety**. This appears to be true whether a woman knew prenatal testing would be offered to her during the pregnancy or if it comes about unexpectedly, as is usually the case following abnormal screening results. Women to whom genetic amniocentesis is presented must consider the perceived benefits of testing, such as the reassurance that comes when results are normal, and compare them to the possible risks. Examples of potential risks include not only the risk of a complication after testing but also the potential burden of knowing that she will have a child with a serious disability or chronic medical condition. The nature of the child's possible diagnosis is also important. For example, could it lead to an early death, be more subtle and cause few outward signs of a problem, or be somewhere in between? There are few treatments available to correct the hundreds of known genetic disorders. Couples may wish to consider whether or not they would consider a termination of the pregnancy if a serious abnormality were detected. The definition of serious is often a matter of personal opinion. A couple's value system and family history, including that of other pregnancies and their outcomes, all influence their decision regarding amniocentesis. Ideally, a woman and her partner will have discussed at least some of these issues with each other and with either the

woman's doctor or a genetic counselor prior to testing. The choice to have amniocentesis depends on many factors and should remain a personal decision.

Results

It is important to emphasize that normal results from tests performed on amniotic fluid do not necessarily guarantee the birth of a normal infant. Each couple in the general population faces a risk of roughly 3-4% of having a child with any type of congenital birth defect. Many of these will not be detected with tests performed on amniotic fluid samples obtained by amniocentesis. Babies with birth defects are often born into families with no history of genetic disorders.

Chromosome karyotyping is interpreted according to standardized nomenclature, International System of Cytogenetic Nomenclature (ISCN). The system describes the number of chromosomes, the sex chromosomes, and then any abnormalities seen in specific chromosomes using a numerical system to identify banding characteristics. Bands are numbered starting at the centromere. Standardized symbols and abbreviations describe the type of abnormality. For example, a + sign designates an extra chromosome and 47,XY,+21 designates a male with an extra chromosome 21. The designation 46,XX,t(3:5)(q21;p15.2) means that the subject is a female with a normal number of chromosomes. There is a translocation (exchange) between chromosomes three and five involving band 21 of the long arm of number three and band 15.2 of the short arm of chromosome five.

Amniotic fluid is normally clear or slightly turbid. The concentration of AFP is reported as multiples of the median (MOM). Normal values are dependent upon the sampling time. For example, the median AFP at 15 weeks is 16.3 micrograms per mL and at 20 weeks is 8.1 micrograms per mL. Bilirubin is also time-dependent normally decreasing during gestation. The concentration should be below 0.075 mg/dL at 20 weeks and below 0.025 mg/dL at 40 weeks (full term).

An L:S ratio of 2.0 or higher correlates with fetal lung maturity. Lecithin greater than 0.10 mg/dL also correlates with fetal lung maturity.

Health care team roles

Actual samples of amniotic fluid or placenta are obtained by persons with specialized training. These are usually obstetricians or gynecologists with additional training. Sonographers assist in amniocentesis. Specially trained nurses prepare women for amniocentesis. Cytogenetic technologists, CLSp(CG) perform cell culture, karyotyping, and DNA analysis of fetal cells.

Clinical laboratory scientists/medical technologists perform biochemical testing, and may also perform DNA and some molecular tests on fetal cells from the fluid. Pathologists with special training in genetics interpret results. Obstetricians or geneticists provide results to a woman or couple and discuss treatment options that may be available. Genetic counselors and other mental health professionals may provide additional support and counseling to a woman or couple after the results of amniocentesis have been returned.

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- American Association for Clinical Chemistry, 2101 L Street, NW - Suite 202, Washington, DC 20037-1558. (800) 892-1400 or (202) 857-0717. Fax: (202) 887-5093. www.aacc.org. info@aacc.org.
- American Board of Obstetrics and Gynecology, 2915 Vine Street Suite 300, Dallas TX. 75204. (214) 871-1619. Fax: (214) 871-1943. <<http://www.abog.org/>>. info@abog.org.
- American College of Obstetricians and Gynecologists, 409 12th St., S.W., PO Box 96920, Washington, D.C. 20090-6920. <<http://www.acog.org/>>.
- American Infertility Association, 666 Fifth Avenue, Suite 278, New York, NY 10103. (718) 621-5083. <<http://www.americaninfertility.org/>>. info@americaninfertility.org.
- American Society for Reproductive Medicine. 1209 Montgomery Highway, Birmingham, AL 35216-2809. (205) 978-5000. <<http://www.asrm.com>>.

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- Stanford University. <<http://www.stanford.edu/~holbrook/Amniocentesis.html>>.
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L. Fleming Fallon, Jr., MD, DrPH

Amphetamines see **Central nervous system stimulants**

Amylase and lipase tests

Definition

Amylase and lipase tests are performed to aid in the differential diagnosis of acute abdominal **pain**. Amylase and lipase are digestive enzymes made by the **pancreas**. An enzyme is a protein that accelerates a biochemical

KEY TERMS

Amylase—A digestive enzyme made primarily by the pancreas and salivary glands.

Enzyme—A substance made and used by the body to speed up specific chemical reactions which might otherwise not happen, or might happen only slowly.

Lipase—A digestive enzyme made primarily by the pancreas.

Pancreatitis—Inflammation of the pancreas.

reaction. Both enzymes are members of the hydrolase class, which means that they split a substrate by the addition of water. Amylase catalyzes the hydrolysis of starch forming maltose. The maltose can be converted to glucose by other enzymes. Lipase splits triglycerides, forming glycerol and fatty acids as the final product.

Purpose

Epigastric pain and abdominal tenderness associated with acute **appendicitis** is difficult to distinguish from acute **pancreatitis**. Serial measurements of amylase and lipase are used to exclude a diagnosis of acute pancreatitis when results are within normal limits. One or both enzymes may be increased in acute pancreatitis, but neither enzyme is specific. In addition to acute pancreatitis, amylase is increased mumps, some malignancies, ectopic **pregnancy**, alcoholic **liver** disease, peptic ulcers, intestinal obstruction, and renal failure. Lipase is increased in renal failure, intestinal obstruction and liver disease. Use of both enzymes increases diagnostic sensitivity and specificity to around 90%. Acute pancreatitis is highly likely when the plasma amylase is increased to more than twofold normal and lipase is increased more than fivefold normal. When plasma amylase is increased, but the lipase is normal, a nonpancreatic condition is almost always the cause. When amylase is increased more than twofold and lipase is increased but less than fivefold, renal failure, pancreatitis, intestinal obstruction, peptic ulcer disease, and acute pancreatitis are possible causes.

In acute pancreatitis, plasma amylase becomes elevated two to 12 hours after an episode of acute abdominal pain. Levels peak in 12-72 hours, usually reaching two to six times the upper limit of normal, then return to normal by four days. Amylase is a small protein and is excreted in urine in significant quantities. Urinary amylase rises in parallel with plasma amylase, but reaches higher levels and remains elevated for seven to 14 days.

Renal excretion of amylase is increased in pancreatitis, and the ratio of amylase to creatinine clearance is a more specific test for acute pancreatitis than is plasma amylase. Lipase in plasma becomes abnormal four to eight hours following an episode of acute pancreatitis, reaches a peak level two to 50 times normal in approximately one day, and remains elevated for seven to 10 days. Recently, serum and urine levels of trypsinogen-2 have been shown to be very sensitive and specific indicators of pancreatitis, but assays are not yet widely available.

Precautions

Blood for measurement of amylase and lipase is collected by venipuncture. The nurse or phlebotomist should follow standard precautions for the prevention of transmission of bloodborne pathogens. Amylase and lipase should not be used as screening tests for future pancreatic disease. Neither enzyme is likely to be elevated in chronic pancreatitis because enzyme production is decreased by chronic disease. Up to 1% of persons have increased plasma amylase owing to formation of a complex between amylase and immunoglobulins. This condition is termed macroamylasemia and it occurs more frequently in the older population. Plasma amylase is elevated above normal, but urinary amylase is low in this condition. The presence of natural amylase inhibitors in the diet may decrease plasma amylase activity. Drugs that may increase amylase include morphine, phenformin, ethanol, and contraceptives. Lipase may be increased by ethanol, codeine, and narcotics. Results are dependent upon the method used and normal values may vary significantly between laboratories.

Description

Amylase and lipase tests are usually performed on a blood sample, but amylase testing can also be performed on urine. Enzymes are usually measured by determining the rate of product formation under controlled pH and temperature. Measurements are reported as units of activity rather than in mass units. Reference methods for amylase and lipase are labor intensive and difficult to automate. There are several methods for measuring amylase and lipase each with its own advantages and disadvantages. A common method of measuring amylase is based upon the hydrolysis of a synthetic glucose polymer that is labeled at one end with p-nitrophenol. The amylase splits the substrate into various subunits of glucose. Subunits consisting of three glucose molecules are hydrolyzed by an enzyme in the reagent, alpha-glucosidase, forming glucose and p-nitrophenol. The activity of amylase is proportional to the rate of p-nitrophenol formation. This is determined by measuring the amount of light that the

reaction mixture absorbs at 405 nm over a fixed time interval. Lipase is often measured using a cascade of coupling enzyme reactions that yield a colored product. Lipase is incubated with a synthetic diglyceride substrate and splits it forming a monoglyceride and a fatty acid. The monoglyceride is split by an enzyme in the reagent, monoglyceride esterase, to yield glycerol. The glycerol is converted to glycerol-3-phosphate by the enzyme glycerol kinase which attaches a phosphate from adenosine triphosphate (ATP). The glycerol-3-phosphate is oxidized by another enzyme, glycerol phosphate oxidase (GPO), forming dihydroxyacetone phosphate and hydrogen peroxide. In the final step, peroxidase catalyzes the oxidation of a dye by the hydrogen peroxide forming a pink product. The rate of absorbance (color) increase at 500 nm is measured, and is proportional to lipase activity.

Preparation

No special preparation is necessary for a person undergoing an amylase or lipase test. Urinary amylase is frequently measured using a timed urine sample. The patient should be given a urine container with instructions for collecting the urine at home. The urine should be refrigerated until it is brought to the laboratory.

Aftercare

Discomfort or bruising may occur at the puncture site, or the person may feel dizzy or faint. To reduce bruising, pressure should be applied to the puncture site until the bleeding stops. Applying warm packs to the puncture site relieves discomfort.

Complications

Amylase and lipase tests are not associated with complications.

Results

The normal range will vary depending upon the method used. Results shown below are representative of the methods described above performed at 37 degrees C.

- Plasma amylase: 70-200 U/L.
- Plasma lipase: 7-58 U/L.
- Urine amylase: Less than 1200 U/L.
- Amylase creatinine clearance ratio: 1-4%.

Health care team roles

A physician orders and interprets tests for amylase and lipase. A nurse or phlebotomist usually collects

blood for amylase and lipase tests by venipuncture. A nurse educates the patient on the proper collection and storage of a urine sample, and may also take a drug history to identify medications which might interfere with the testing. Drug interference is usually caused by inducing the release of the enzyme from an organ or tissue. Amylase and lipase tests are performed by a clinical laboratory scientist, CLS(NCA)/ medical technologist, MT(ASCP) or clinical laboratory technician, CLT(NCA) or medical laboratory technician, MLT(ASCP).

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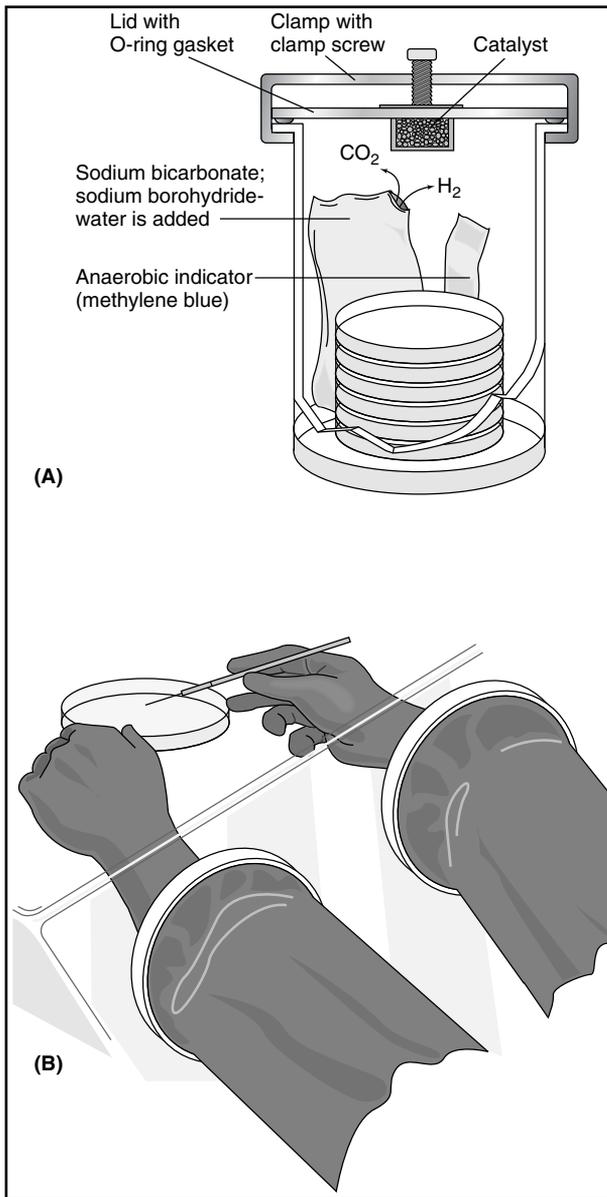
Anaerobic bacteria culture

Definition

An anaerobic **bacteria** culture is a method used to grow anaerobes from a clinical specimen. Obligate anaerobes are bacteria that can live only in the absence of oxygen. Obligate anaerobes are destroyed when exposed to the atmosphere for as briefly as 10 minutes. Some anaerobes are tolerant to small amounts of oxygen. Facultative anaerobes are those organisms that will grow with or without oxygen. The methods of obtaining specimens for anaerobic culture and the culturing procedure are performed to ensure that the organisms are protected from oxygen.

Purpose

Anaerobic bacterial cultures are performed to identify bacteria that grow only in the absence of oxygen and which may cause human **infection**. If overlooked or killed by exposure to oxygen, anaerobic infections result in serious consequences such as amputation, organ failure, sepsis, **meningitis**, and death. Culture is required to



Anaerobic culture equipment: (A) anaerobic jar with generating packet and indicator; (B) technologist working with anaerobic culture. (Delmar Publishers, Inc. Reproduced by permission.)

correctly identify anaerobic pathogens and institute effective antibiotic treatment.

Precautions

It is crucial that the health care provider obtain the sample for culture via **aseptic technique**. Anaerobes are commonly found on mucous membranes and other sites such as the vagina and oral cavity. Therefore, specimens likely to be contaminated with these organisms should not be submitted for culture (e.g., a throat or vaginal swab).

Some types of specimens should always be cultured for anaerobes if an infection is suspected. These include abscesses, bites, **blood**, cerebrospinal fluid and exudative body fluids, deep **wounds**, and necrotic tissues. The specimen must be protected from oxygen during collection and transport and must be transported to the laboratory immediately. The health care team member who performs the collection should follow **universal precautions** for the prevention of transmission of bloodborne pathogens.

Description

Anaerobes are normally found within certain areas of the body but result in serious infection when they have access to a normally sterile body fluid or deep tissue that is poorly oxygenated. Some anaerobes normally live in the crevices of the skin, in the nose, mouth, throat, intestine, and vagina. Injury to these tissues (i.e., cuts, puncture wounds, or trauma) especially at or adjacent to the mucus membranes allows anaerobes entry into otherwise sterile areas of the body and is the primary cause of anaerobic infection. A second source of anaerobic infection occurs from the introduction of spores into a normally sterile site. Spore producing anaerobes live in the soil and water and spores may be introduced via wounds especially punctures. Anaerobic infections are most likely to be found in persons who are immunosuppressed, those treated recently with broad-spectrum **antibiotics**, and persons who have a necrotic, discolored injury on or near a mucus membrane, especially if the site is foul-smelling.

Some specimens from which anaerobes are likely to be isolated are:

- blood
- bile
- bone marrow
- cerebrospinal fluid
- direct lung aspirate
- tissue biopsy from a normally sterile site
- fluid from a normally sterile site (like a joint)
- dental abscess
- abdominal or pelvic abscess
- knife, gunshot, or surgical wound
- severe burn

Some of the specimens that are not suitable for anaerobic cultures include:

- coughed throat discharge (sputum)
- rectal swab
- nasal or throat swab

- urethral swab
- voided urine

Specimen collection

The keys to effective anaerobic bacteria cultures include collecting a contamination-free specimen and protecting it from oxygen exposure. Anaerobic bacteria cultures should be obtained from an appropriate site without the health care professional contaminating the sample with bacteria from the adjacent skin, mucus membrane, or tissue. Swabs should be avoided when collecting specimens for anaerobic culture because cotton fibers may be detrimental to anaerobes. Abscesses or fluids can be aspirated using a sterile syringe that is then tightly capped to prevent entry of air. Tissue samples should be placed into a degassed bag and sealed, or into a gassed out screw top vial that may contain oxygen-free prereduced culture medium and tightly capped. The specimens should be plated as rapidly as possible onto culture media that has been prepared as prereduced anaerobically sterilized media (PRAS). Alternatively, media that contains a reducing agent such as dithiothreitol or palladium chloride and has been stored for one day in an anaerobic chamber can be used.

Culture

Broth and solid media should both be inoculated. The culture media should include anaerobic blood agar plates enriched with substances such as brain-heart infusion, yeast extract, amino acids, and **vitamin K**; a selective medium such as kanamycin-vancomycin (KV) blood agar or laked blood agar; and a broth such as **brain heart** infusion broth with thioglycolate or other reducing agent. The choice of media depends upon the type of specimen. Some commonly used media include prereduced peptone-yeast extract-glucose broth which is suitable for analysis of volatile products by gas chromatography; egg yolk agar for detection of lecithinase activity of *Clostridium spp.*; cycloserine-cefoxitin-fructose agar (CCFA) for isolation of *Clostridium difficile* from stool; and Bacteroides bile esculin agar for isolation of the *Bacteroides fragilis* group.

Cultures should be placed in an environment that is free of oxygen, at 35°C for at least 48 hours before the plates are examined for growth. In addition, blood agar plates should be cultured both aerobically and in 10% carbon dioxide. Comparison of these cultures to anaerobic cultures is needed to identify the oxygen tolerance of the organisms. An anaerobic glove box made of acrylic or plastic with sealed armholes and attached gloves is the most commonly used environment for anaerobic culture. The interior of the glove box or hood is supplied with a

mixture of 10% hydrogen, 10% carbon dioxide, and 80% nitrogen from compressed gases. Inoculation and transfers can be performed in the glove box without risk of oxygen exposure. The alternative to an anaerobic chamber is a jar such as the GasPak system. When using jars, several are needed to contain uninoculated media and subcultured plates (i.e., plates containing a colony transferred from the primary isolate). The GasPak system uses a disposable envelope containing citric acid, sodium bicarbonate, cobalt chloride, and sodium borohydride. When water is added these react to form hydrogen gas. A catalyst, palladium, located in the lid converts the hydrogen and oxygen in the jar to water. Silica gel or paper towels are used to absorb the water, and an indicator strip of methylene blue is used to indicate anaerobic conditions. Methylene blue will be oxidized when the atmosphere contains oxygen causing formation of a blue color.

Gram staining is performed on the specimen at the time of culture. While infections can be caused by aerobic or anaerobic bacteria or a mixture of both, some infections have a high probability of being caused by anaerobic bacteria. These infections include brain abscesses, lung abscesses, aspiration **pneumonia**, and dental infections. Anaerobic organisms can often be suspected because many anaerobes have characteristic microscopic morphology (appearance). For example, *Bacteroides spp.* are gram-negative rods that are pleomorphic (variable in size and shape) and exhibit irregular bipolar staining. *Fusobacterium spp.* are often pale gram-negative spindle-shaped rods having pointed ends. *Clostridium spp.* are large gram-positive rods that form spores. The location of the spore (central, subterminal, terminal, or absent) is a useful differential characteristic. The presence of growth, oxygen tolerance, and **Gram stain** results are sufficient to establish a diagnosis of an anaerobic infection and begin antibiotic treatment with a drug appropriate for most anaerobes such as clindamycin or vancomycin.

Gram-negative anaerobes and some of the infections they produce include the following genera:

- *Bacteroides* (the most commonly found anaerobes in cultures; intra-abdominal infections, rectal abscesses, soft tissue infections, **liver** infection)
- *Fusobacterium* (abscesses, wound infections, pulmonary and intracranial infections)
- *Porphyromonas* (aspiration pneumonia, periodontitis)
- *Prevotella* (intra-abdominal infections, soft tissue infections)

Gram-positive anaerobes include the following:

- *Actinomyces* (head, neck, pelvic infections; aspiration pneumonia)

KEY TERMS

Aerobic bacteria—Bacteria that can grow freely in oxygen-rich environments.

Aseptic—Free from living disease-causing organisms; sterile and without contamination.

Pathogen—An organism capable of causing disease.

Sepsis—The systemic inflammatory response due to an infectious organism circulating throughout the body. Sepsis can progress to severe sepsis and septic shock, where blood pressure drops (hypotension), the blood supply to tissues decreases, and organs fail.

Venipuncture—Puncture of a vein with a needle for the purpose of withdrawing a blood sample for analysis.

- *Bifidobacterium* (ear infections, abdominal infections)
- *Clostridium* (gas **gangrene**, **food poisoning**, tetanus, pseudomembranous colitis)
- *Peptostreptococcus* (oral, respiratory, and intra-abdominal infections)
- *Propionibacterium* (shunt infections)

Isolated organisms are always subcultured and the pure culture is tested in order to identify the organism. The identification of anaerobes is highly complex, and laboratories may use different identification systems. Partial identification is often the goal. For example, there are six species of the *Bacteroides* genus that may be identified as the *Bacteroides fragilis* group rather than identified individually. Organisms are identified by their colonial and microscopic morphology, growth on selective media, oxygen tolerance, and biochemical characteristics. These include sugar fermentation, bile solubility, esculin, starch, and gelatin hydrolysis, casein and gelatin digestion, catalase, lipase, lecithinase, and indole production, nitrate reduction, volatile fatty acids as determined by gas chromatography, and susceptibility to antibiotics. The antibiotic susceptibility profile is determined by the microtube broth dilution method. Many species of anaerobes are resistant to penicillin, and some are resistant to clindamycin and other commonly used antibiotics.

Preparation

The health care provider should take special care to collect a contamination-free specimen. All procedures

must be performed aseptically. The health care professional who collects the specimen should be prepared to take two samples, one for anaerobic culture and one for aerobic culture, since it is unknown whether the pathogen can grow with or without oxygen. In addition, health care professionals should document any antibiotics that patient is currently taking and any medical conditions that could influence growth of bacteria.

Aftercare

In the case of venipuncture for anaerobic blood cultures, direct pressure should be applied to the venipuncture site for several minutes or until the bleeding has stopped. An adhesive bandage may be applied, if appropriate. If swelling or bruising occurs, ice can be applied to the site. For collection of specimens other than blood, the patient and the collection site should be monitored for any complications after the aspiration, biopsy, etc.

Complications

Special care must be taken by the health care team obtaining, transporting, and preparing the specimen for anaerobic culture. Poor methodology may delay the identification of the bacterium, may allow the patient's condition to deteriorate, and may require the patient to provide more samples than would otherwise be required. Patients may experience bruising, discomfort, or swelling at the collection site when tissue, blood, or other fluids are obtained.

Results

Negative results will show no pathogenic growth in the sample. Positive results will show growth, the identification of each specific bacterium, and its antibiotic susceptibility profile.

Health care team roles

The physician orders the culture, and the physician, nurse, or physician assistant usually collects the specimen. A health care team member transports the specimen to the laboratory. The decision to perform anaerobic culture is determined by the type of specimen submitted to the laboratory. A clinical laboratory scientist/medical technologist performs the culture and Gram stain. The physician receives the culture report and selects the appropriate antibiotic if one is required.

Patient education

A health care team member should explain the specimen collection procedure to the patient. If the patient is

seriously ill, the team member should explain the procedure to the patient's family members. The patient and his or her family should understand that because bacteria need time to grow in the laboratory, several days may be required for bacterium identification.

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National Center for Infectious Disease, Centers for Disease Control and Prevention. 1600 Clifton Road NE, Atlanta, GA 30333. (800) 311-3435. <<http://www.cdc.gov>>.

Linda D. Jones, B.A., PBT (ASCP)

Analgesia, patient-controlled see **Patient-controlled analgesia**

Analgesics

Definition

Analgesics are medicines that relieve **pain**.

Purpose

Analgesics are those drugs whose primary purpose is pain relief. The primary classes of analgesics are the narcotics, including additional agents that are chemically based on the morphine molecule but have minimal abuse potential; **nonsteroidal anti-inflammatory drugs** (NSAIDs) including the salicylates; and acetaminophen. Other drugs, notably the tricyclic antidepressants and anti-epileptic agents such as gabapentin, have been used

to relieve pain, particularly neurologic pain, but are not routinely classified as analgesics. Analgesics provide symptomatic relief, but have no effect on causation, although clearly the NSAIDs, by virtue of their dual activity, may be beneficial in both regards.

Description

Pain has been classified as "productive" pain and "non-productive" pain. While this distinction has no physiologic meaning, it may serve as a guide to treatment. "Productive" pain has been described as a warning of injury, and so may be both an indication of need for treatment and a guide to diagnosis. "Non-productive" pain by definition serves no purpose either as a warning or diagnostic tool.

Although pain syndromes may be dissimilar, the common factor is a sensory pathway from the affected organ to the **brain**. Analgesics work at the level of the nerves, either by blocking the signal from the peripheral nervous system, or by distorting the interpretation by the **central nervous system**. Selection of an appropriate analgesic is based on consideration of the risk-benefit factors of each class of drugs, based on type of pain, severity of pain, and risk of adverse effects. Traditionally, pain has been divided into two classes, acute and chronic, although severity and projected patient survival are other factors that must be considered in drug selection.

Acute pain

Acute pain is self limiting in duration, and includes post-operative pain, pain of injury, and **childbirth**. Because pain of these types is expected to be short term, the long-term side effects of analgesic therapy may routinely be ignored. Thus, these patients may safely be treated with narcotic analgesics without concern for their addictive potential, or NSAIDs with only limited concern for their ulcerogenic risks. Drugs and doses should be adjusted based on observation of healing rate, switching patients from high to low doses, and from narcotic analgesics to non-narcotics when circumstances permit.

An important consideration of **pain management** in severe pain is that patients should not be subject to the return of pain. Analgesics should be dosed adequately to assure that the pain is at least tolerable, and frequently enough to avoid the **anxiety** that accompanies the anticipated return of pain. Analgesics should never be dosed on a "prn" (as needed) basis, but should be administered often enough to assure constant **blood** levels of analgesic. This applies to both the narcotic and non-narcotic analgesics.

Opioid analgesics			
Drug	Route of administration	Onset of action (min)	Duration of action (h)
Strong agonists			
Fentanyl (Sublimaze)	IM	7–15	1–2
	IV	1–2	0.5–1
Hydromorphone (Dilaudid)	Oral	30	4
	IM	15	4
	IV	10–15	2–3
	Sub-Q	15	4
Levorphanol (Levo-Dromoran)	Oral	10–60	4–5
	IM	—	4–5
	IV	—	4–5
	Sub-Q	—	4–5
Meperidine (Demerol)	Oral	15	2–4
	IM	10–15	2–4
	IV	1	2–4
	Sub-Q	10–15	2–4
Methadone (Dolophine)	Oral	30–60	4–6
	IM	10–20	4–5
	IV	—	3–4
	Oral	—	4–5
Morphine (many trade names)	IM	10–30	4–5
	IV	—	4–5
	Sub-Q	10–30	4–5
	Epidural	15–60	up to 24
Oxymorphone (Numorphan)	IM	10–15	3–6
	IV	5–10	3–4
	Sub-Q	10–20	3–6
	Rectal	15–30	3–6
Mild-to-moderate agonists			
Codiene (many trade names)	Oral	30–40	4
	Im	10–30	4
	Sub-Q	10–30	4
Hydrocodone (Hycodan)	Oral	10–30	4–6
Oxycodone (Percodan)	Oral	—	3–4
Propoxyphene (Darvon, Dolene)	Oral	15–60	4–6
Butorphanol (Stadol)	IM	10–30	3–4
	IV	2–3	2–4
Nalbuphine (Nubian)	IM	within 15	3–6
	IV	2–3	3–4
	Sub-Q	within 15	3–6
Pentazocine (Talwin)	Oral	15–30	3
	IM	15–20	2–3
	IV	2–3	2–3
	Sub-Q	15–20	2–3

IM= intramuscular; IV = intravenous; sub-Q = subcutaneous

SOURCE: Ciccone, C.D. *Pharmacology in Rehabilitation*. 2nd ed. Philadelphia: F.A. Davis Co., 1996.

Chronic pain

Chronic pain, pain lasting over three months and severe enough to impair function, is more difficult to treat, since the anticipated side effects of the analgesics are more difficult to manage. In the case of narcotic analgesics this means the addiction potential, as well as respiratory depression and constipation. For the NSAIDs, the risk of gastric ulcers may be dose limiting. While some classes of drugs, such as the narcotic agonist/antagonist drugs bupronorphine, nalbuphine and pentazocine, and the selective COX-2 inhibitors celecoxib and rofe-

coxib represent advances in reduction of adverse effects, they are still not fully suitable for long-term management of severe pain. Generally, chronic pain management requires a combination of drug therapy, life-style modification, and other treatment modalities.

Narcotic analgesics

The narcotic analgesics, also termed opioids, are all derived from opium. The class includes morphine, codeine, and a number of semi-synthetics including meperidine (Demerol), propoxyphen (Darvon), and others. The narcotic analgesics vary in potency, but all are effective in treatment of visceral pain when used in adequate doses. Adverse effects are dose related. Because these drugs are all addictive, they are controlled under federal and state laws. A variety of dosage forms are available, including oral solids, liquids, intravenous and intrathecal injections, and transcutaneous patches.

NSAIDs, non-steroidal anti-inflammatory drugs, are effective analgesics even at doses too low to have any anti-inflammatory effects. There are a number of chemical classes, but all have similar therapeutic effects and side effects. Most are appropriate only for oral administration; however ketorolac (Toradol) is appropriate for injection and may be used in moderate to severe pain for short periods.

Acetaminophen is a non-narcotic analgesic with no anti-inflammatory properties. It is appropriate for mild to moderate pain. Although the drug is well tolerated in normal doses, it may have significant toxicity at high doses. Because acetaminophen is largely free of side effects at therapeutic doses, it has been considered the first choice for mild pain, including that of **osteoarthritis**.

Recommended dosage

Appropriate dosage varies by drug, and should consider the type of pain, as well as other risks associated with patient age and condition. For example, narcotic analgesics should usually be avoided in patients with a history of substance abuse, but may be fully appropriate in patients with **cancer** pain. Similarly, because narcotics are more rapidly metabolized in patients who have used these drugs for a long period, higher than normal doses may be needed to provide adequate pain management. NSAIDs, although comparatively safe in adults, represent an increased risk of gastrointestinal bleeding in patients over the age of 60.

KEY TERMS

Acute pain—Pain that is usually temporary and results from something specific, such as a surgery, an injury, or an infection.

Analgesic—Medicine used to relieve pain.

Chronic pain—Pain that lasts more than three months and threatens to disrupt daily life.

Inflammation—Pain, redness, swelling, and heat that usually develop in response to injury or illness.

Osteoarthritis—Joint pain resulting from damage to the cartilage.

Precautions

Narcotic analgesics may be contraindicated in patients with respiratory depression. NSAIDs may be hazardous to patients with ulcers or an ulcer history. They should be used with care in patients with renal insufficiency or coagulation disorders. NSAIDs are contraindicated in patients allergic to aspirin.

Side effects

Review adverse effects of each drug individually. Drugs within a class may vary in their frequency and severity of adverse effects.

The primary adverse effects of the narcotic analgesics are addiction, constipation, and respiratory depression. Because narcotic analgesics stimulate the production of enzymes that cause the **metabolism** of these drugs, patients on narcotics for a prolonged period may require increasing doses. This is not the same thing as addiction, and is not a reason for withholding medication from patients in severe pain.

NSAIDs are ulcerogenic and may cause kidney problems. Gastrointestinal discomfort is common, although in some cases, these drugs may cause ulcers without the prior warning of gastrointestinal distress. Platelet aggregation problems may occur, although not to the same extent as if seen with aspirin.

Interactions

Interactions depend on the specific type of analgesic. See specific references.

Samuel Uretsky, PharmD

Anaphylaxis

Definition

Anaphylaxis is a rapidly progressing, life-threatening allergic reaction.

Description

Anaphylaxis is a type of allergic reaction, in which the **immune system** responds to otherwise harmless substances from the environment. Unlike other allergic reactions, however, anaphylaxis can result in death. Reaction may begin within minutes or even seconds of exposure, and rapidly progress to cause airway constriction, skin and intestinal irritation, and altered **heart** rhythms. In severe cases, it can result in complete airway obstruction, **shock**, and death.

In 2001, more cases of anaphylaxis have been reported, especially in reaction to latex and exotic food antigens. The increased use of latex gloves in hospitals, doctors' offices, dentist offices, and among forensic investigators has also increased exposure to latex allergens.

The broadening of the Western diet, with the incorporation of more exotic foods and increased food processing, also exposes more people to possible food allergens, and at earlier ages. Peanut oil, for example, is often used in fast-food restaurants, and sulfites are used in processed meats and seafood. There is still no labeling for trace amounts of foods or food additives. Unfortunately, problem food allergens can still be present in favorite foods, even if the label does not show it. In some cases, even a small amount can prove fatal in certain individuals.

Causes and symptoms

Causes

Like the majority of other allergic reactions, anaphylaxis is caused by the release of histamine and other chemicals from mast cells, which are a type of white **blood** cell found in large numbers in the tissues that regulate exchange with the environment: the airways, **digestive system**, and skin.

On their surfaces, mast cells display antibodies called immunoglobulin type E (IgE). These antibodies are designed to detect environmental substances to which the immune system is sensitive. Substances from a gen-

usually threatening source such as **bacteria** or **viruses** are called antigens. A substance that most people tolerate well, but to which others have an allergic response, is called an allergen. When IgE antibodies bind with allergens, they cause the mast cells to release histamine and other chemicals that spill out onto neighboring cells.

The interaction of these chemicals with receptors on the surface of **blood vessels** causes the vessels to leak fluid into surrounding tissues, resulting in fluid accumulation, redness, and swelling. On the smooth muscle cells of the airways and digestive system, they cause constriction. On nerve endings, they increase sensitivity and cause itching.

In anaphylaxis, the dramatic response is due both to extreme hypersensitivity to the allergen and its usually systemic distribution. Allergens are more likely to cause anaphylaxis if they are introduced directly into the circulatory system by injection. However, exposure by ingestion, inhalation, or skin contact can also cause anaphylaxis. In some cases, anaphylaxis may develop over time from less severe **allergies**.

Anaphylaxis most often results from allergens in foods, drugs, latex, and insect venom. Specific causes include, but are not limited to:

- fish, shellfish, and mollusks
- peanuts, tree nuts, and seeds
- eggs
- milk
- insulin in vegetables and processed foods
- stings of bees, wasps, and hornets
- preservatives, especially sulfites and parabens
- vaccines (e.g. flu, measles, rabies, chicken pox, and diphtheria-tetanus-pertussis) prepared with a gelatin base made from pork products
- antibiotics, including penicillin and its derivatives, cephalosporins, streptomycin, tetracycline, and sulphonamides
- gamma globulin and human serum albumin
- hormones like insulin, ACTH, and glucocorticoids
- anti-inflammatory drugs such as aspirin, ibuprofen, and other NSAIDs
- anti-venoms
- antiseptics such as mercurochrome
- allergy immunotherapy vaccines
- radiopaque dyes used in diagnostic studies (radiocontrast media)

- latex from exam gloves, catheters, tubing, condoms, etc.
- local anesthetics
- dyes (erythrosine and resorcinol, used in hair dyes)

Exposure to cold or **exercise** can also trigger anaphylaxis in some individuals.

Symptoms

Symptoms may include:

- flushing of face, head, or hands
- urticaria (hives)
- swelling and irritation of the tongue or mouth
- swelling of the sinuses
- difficulty breathing
- wheezing
- cramping, vomiting, or diarrhea
- anxiety or confusion
- strong, very rapid heartbeat (palpitations)
- drop in blood pressure
- chest pain
- loss of consciousness

Not all symptoms may be present, and some may be more severe than others. Symptoms usually occur immediately or within 20 minutes of exposure. On occasion, with food anaphylaxis, symptoms may not appear for several minutes or even hours. As a general guideline, the slower the onset of symptoms comes on, the less serious the episode. Symptoms may also reappear several hours later, sometimes in a more severe form.

Diagnosis

Anaphylaxis is diagnosed based on the rapid development of symptoms in response to a suspected allergen. Identification of the cause may be done with RAST testing, a blood test that identifies IgE reactions to specific allergens. Skin testing can also be done, but with care. Food challenges should be avoided.

Sometimes, the offending allergen is not readily apparent, and the diagnosis of anaphylaxis could be overlooked. Also, some of the symptoms resemble other conditions such as cardiac arrhythmia, **myocardial infarction**, **seizure disorder**, insulin reaction, and pulmonary embolism.

A detailed medical history taken of the patient before medical or surgical procedures may help in diagnosis if

symptoms manifest. Often, the only evidence of anaphylactic reaction is anecdotal or self-reported surveys.

Treatment

Emergency treatment of anaphylaxis involves injection of adrenaline (epinephrine), which constricts blood vessels and counteracts the effects of histamine. Oxygen may be given, as well as intravenous replacement fluids. **Antihistamines** may be used for skin rash, and aminophylline for bronchial constriction. If the upper airway is obstructed, the insertion of a breathing tube or **tracheotomy** tube may be needed.

Treatment should be administered immediately. Epinephrine injected directly into muscle tissue is quick and extremely effective. Intravenous injections require specific calculations regarding the dilution of adrenaline in order for it to be administered. Epinephrine inhalers are not as effective, as are short-acting b-agonist inhalers used by persons suffering from **asthma**. These can prove fatal because they delay effective treatment.

Self-administered epinephrine devices such as EpiPen and EpiE-Z are life-saving tools. Patients must be properly trained in their use and instructed to keep these devices updated and close at hand.

Patients should also be monitored for 24 hours after the symptoms have subsided. Symptoms have been known to return several hours later when the patient has returned home from the hospital.

Prognosis

The rapidity of symptom development is an indication of the likely severity of reaction: the faster symptoms develop, the more severe the ultimate reaction. Prompt emergency medical attention and close monitoring reduces the likelihood of death. Nonetheless, death is possible from severe anaphylaxis. For most people who receive rapid treatment, recovery is complete.

Health care team roles

All medical personnel should be trained to recognize the symptoms of anaphylaxis and to use the proper emergency procedures. Nurses and physicians assistants need to ask patients about their history of allergy when preparing them for a doctor's visit or before invasive procedures. Physicians, lab personnel, and nurses need to routinely ask whether a person is allergic to medications and latex. Inquiries about food allergies can be very helpful when preparing to administer vaccinations or medica-

KEY TERMS

Allergen—A substance that causes an allergic reaction.

Adrenocorticotrophic hormone (ACTH)—A hormone normally produced by the pituitary gland, sometimes taken as a treatment for arthritis and other disorders.

Antibody—An immune system protein that binds to a substance from the environment.

Histamine—A substance produced by the immune system in response to an allergen.

NSAIDs—Non-steroidal anti-inflammatory drugs, including aspirin and ibuprofen.

Tracheostomy tube—A tube that is inserted into an incision in the trachea (tracheotomy) to relieve upper airway obstruction.

tions. A patient's allergy history may have changed since the last doctor's visit. Even a small reaction like a rash on initial exposure to an allergen can be an indicator that a patient may have a more serious reaction on subsequent encounters with the agent.

In the case of latex allergy in the wake of a surgical procedure, medical personnel will need to strip the operating room or the procedure room of all latex items. Some patients are so sensitive to latex in any form that even inhaling a latex particle in the air could be life threatening.

Prevention

Avoidance of the allergic trigger is the only reliable method of preventing anaphylaxis. For insect allergies, this requires recognizing likely nest sites, wearing long sleeves, and using insect repellent. Preventing food allergies requires knowledge of the prepared foods or dishes in which the allergen is likely to occur, reading labels, and carefully questioning about ingredients when dining out. Use of a Medic-Alert tag detailing drug allergies is vital to prevent inadvertent administration during a medical emergency. In addition, patients with latex sensitivity need to avoid using latex products of all kinds and must notify medical and dental personnel of their latex allergy.

People prone to anaphylaxis should carry an Epi-pen or Ana-kit, which contains an adrenaline dose ready for injection. They also should be carefully trained in its use.

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American College of Allergy, Asthma, & Immunology. 85 West Algonquin Road, Suite 550, Arlington Heights, IL 60005. <<http://www.allergy.mcg.edu>>.

OTHER

Merck Manual On-line. <<http://www.merck.com/pubs/mmanual/>>.

Janie F. Franz

Anemias

Definition

Anemia is a condition characterized by abnormally low levels of healthy red **blood** cells or hemoglobin (the component of red blood cells that delivers oxygen to tissues throughout the body).

Description

The tissues of the human body need a regular supply of oxygen to stay healthy. Red blood cells, which contain hemoglobin that allows them to deliver oxygen throughout the body, live for only about 120 days. When they die, the **iron** they contain is returned to the bone marrow and used to create new red blood cells. Anemia develops when heavy bleeding causes significant iron loss or when something happens to slow down the production of red blood cells or to increase the rate at which they are destroyed.

Types of anemia

Anemia can be mild, moderate, or severe enough to lead to life-threatening complications. More than 400 different types of anemia have been identified. Many of them are rare.

IRON DEFICIENCY ANEMIA. Iron deficiency anemia is the most common form of anemia in the world. In the United States, iron deficiency anemia affects about 240,000 toddlers between one and two years of age and 3.3 million women of childbearing age. This condition is less common in older children and in adults over 50 and rarely occurs in teenage boys and young men.

The onset of iron deficiency anemia is gradual and, at first, there may be no symptoms. The deficiency begins when the body loses more iron than it derives from food. Because depleted iron stores cannot meet the body's red blood cell needs, fewer red blood cells develop. In this early stage of anemia, the red blood cells look normal, but they are reduced in number. Then the body tries to compensate for the iron deficiency by producing more red blood cells, which are characteristically smaller in size. Symptoms develop at this stage.

FOLIC ACID DEFICIENCY ANEMIA. Folic acid deficiency anemia is the most common type of megaloblastic anemia (in which red blood cells are bigger than normal). It is caused by a deficiency of folic acid, a vitamin that the body needs to produce normal cells.

Folic acid anemia is especially common in infants and teenagers. Although this condition usually results from a dietary deficiency, it is sometimes due to inability to absorb enough folic acid from such foods as:

- cheese
- eggs
- fish
- green vegetables
- meat
- milk
- mushrooms
- yeast

Smoking raises the risk of developing this condition by interfering with the absorption of **vitamin C**, which the body needs to absorb folic acid. Folic acid anemia can also be a complication of **pregnancy**, when a woman's body needs eight times as much folic acid.

VITAMIN B₁₂ DEFICIENCY ANEMIA. Less common in this country than folic acid anemia, **vitamin B₁₂** deficiency anemia is another type of megaloblastic anemia that develops when the body doesn't absorb enough of this

nutrient. Necessary for the creation of red blood cells, B₁₂ is found in meat and vegetables.

Large amounts of B₁₂ are stored in the body, so this condition may not become apparent until as much as four years after B₁₂ absorption stops or slows down. The resulting drop in red blood cell production can cause:

- loss of muscle control
- loss of sensation in the legs, hands, and feet
- soreness or burning of the tongue
- weight loss
- yellow-blue color blindness

The most common form of B₁₂ deficiency is pernicious anemia. Since most people who eat meat or eggs get enough B₁₂ in their diets, a deficiency of this vitamin usually means that the body is not absorbing it properly. This can occur among people who have had intestinal surgery or among those who do not produce adequate amounts of intrinsic factor, a chemical secreted by the **stomach** lining that combines with B₁₂ to help its absorption in the **small intestine**.

Pernicious anemia usually strikes between the ages of 50 and 60. Eating disorders or an unbalanced diet increases the risk of developing pernicious anemia. So do:

- diabetes mellitus
- **gastritis**, stomach **cancer**, or stomach surgery
- thyroid disease
- family history of pernicious anemia

VITAMIN C DEFICIENCY ANEMIA. A rare disorder that causes the bone marrow to manufacture abnormally small red blood cells, vitamin C deficiency anemia results from a severe, long-standing dietary deficiency.

HEMOLYTIC ANEMIA. Hemolytic anemia is a condition in which **infection** or antibodies destroy red blood cells more rapidly than bone marrow can replace them. Some people are born with the disease, while others acquire it later in life.

Hemolytic anemia can enlarge the spleen, accelerating the destruction of red blood cells (hemolysis). Other complications of hemolytic anemia include **pain**, **shock**, gallstones, and other serious health problems.

THALASSEMIAS. An inherited form of hemolytic anemia, thalassemia stems from the body's inability to manufacture as much normal hemoglobin as it needs. There are two categories of thalassemia, depending on which of the amino acid chains is affected. (Hemoglobin is composed of four chains of amino acids.) In alpha-thalassemia, there is an imbalance in the production of the alpha chain of amino acids; in beta-thalassemia, there is

an imbalance in the beta chain. Alpha-thalassemias most commonly affect blacks (25% have at least one gene); beta-thalassemias most commonly affect people of Mediterranean and Southeast Asian ancestry.

Characterized by production of red blood cells that are unusually small and fragile, thalassemia only affects people who inherit the gene for it from each parent (autosomal recessive inheritance).

AUTOIMMUNE HEMOLYTIC ANEMIAS. Warm antibody hemolytic anemia is the most common type of this disorder. This condition occurs when the body produces autoantibodies that coat red blood cells. The coated cells are destroyed by the spleen, **liver**, or bone marrow.

Warm antibody hemolytic anemia is more common in women than in men. About one-third of patients who have warm antibody hemolytic anemia also have lymphoma, leukemia, lupus, or connective tissue disease.

In cold antibody hemolytic anemia, the body attacks red blood cells at or below normal body temperature. The acute form of this condition frequently develops in people who have had **pneumonia**, mononucleosis, or other acute infections. It tends to be mild and short-lived, and disappears without treatment.

Chronic cold antibody hemolytic anemia is most common in women and most often affects those who are over 40 and who have arthritis. This condition usually lasts for a lifetime, generally causing few symptoms. However, exposure to cold temperatures can accelerate red blood cell destruction, causing fatigue, joint aches, and discoloration of the arms and hands.

SICKLE CELL ANEMIA. Sickle cell anemia is a chronic, incurable condition that causes the body to produce defective hemoglobin, which forces red blood cells to assume an abnormal crescent shape. Unlike normal oval cells, fragile sickle cells can't hold enough hemoglobin to nourish body tissues. The deformed shape makes it hard for sickle cells to pass through narrow **blood vessels**. When capillaries become obstructed, a life-threatening condition called sickle cell crisis is likely to occur.

Sickle cell anemia is hereditary. Its rate of incidence is highest among those of African descent, although it can occur in peoples around the world. A child who inherits the sickle cell gene from each parent will have the disease. A child who inherits the sickle cell gene from only one parent carries the sickle cell trait, but does not have the disease.

APLASTIC ANEMIA. Sometimes curable by bone marrow transplant, but potentially fatal, aplastic anemia is characterized by decreased production of red and white blood cells and platelets (disc-shaped cells that allow the

blood to clot). This disorder may be inherited or acquired as a result of recent severe illness, long-term exposure to industrial chemicals, and use of **anticancer drugs** and certain other medications.

SIDEROBLASTIC ANEMIA. Sideroblastic anemia results from an enzyme disorder in which the body has adequate iron but is unable to incorporate it into hemoglobin. In sideroblastic anemia, iron enters a developing red blood cell and builds up in mitochondria of the cell. This build-up of iron gives the cell nucleus a ringed appearance, and the cell is called a ringed sideroblast, the primary sign of sideroblastic anemia. Ringed sideroblasts develop poorly or not at all into mature red blood cells, and the red blood cells cannot properly transport oxygen to tissues throughout the body. X-linked sideroblastic anemia is the hereditary form of sideroblastic anemia, also known as iron overload anemia or sideroblastosis. Another, more common type of sideroblastic anemia is called acquired sideroblastic anemia, which can result from prolonged exposure to toxins or nutritional imbalances. Other causes may be inflammatory disease, cancerous conditions such as leukemia and lymphoma, kidney disorders causing uremia, endocrine disorders, or metabolic disorders.

ANEMIA OF CHRONIC DISEASE. Cancer, chronic infection or inflammation, and kidney and liver disease often cause mild or moderate anemia. Chronic liver failure generally produces the most severe symptoms.

Causes and symptoms

Anemia is caused by bleeding, decreased red blood cell production, or increased red blood cell destruction. Poor diet can contribute to vitamin deficiency and iron deficiency anemias in which fewer red blood cells are produced. Hereditary disorders and certain diseases can cause increased blood cell destruction. However, excessive bleeding is the most common cause of anemia, and the speed with which blood loss occurs has a significant effect on the severity of symptoms. Chronic blood loss is usually a consequence of:

- cancer
- gastrointestinal tumors
- diverticulosis
- polyposis
- heavy menstrual flow
- hemorrhoids
- nosebleeds
- stomach ulcers
- long-standing alcohol abuse

Acute blood loss is usually the result of:

- childbirth
- miscarriage of pregnancy
- injury
- a ruptured blood vessel
- surgery

When a large volume of blood is lost within a short time, **blood pressure** and the amount of oxygen in the body drop suddenly. **Heart failure** and death can follow.

Loss of even one-third of the body's blood volume in the space of several hours can be fatal. More gradual blood loss is less serious, because the body has time to create new red blood cells to replace those that have been lost.

Symptoms

Weakness, fatigue, and a run-down feeling may be signs of mild anemia. Skin that is pasty or sallow, or lack of color in the creases of the palm, gums, nail beds, or linings of the eyelids are other signs of anemia. Someone who is weak, tires easily, is often out of breath, and feels faint or dizzy may be severely anemic.

Other symptoms of anemia are:

- angina pectoris (chest pain, often accompanied by a choking sensation that provokes severe anxiety)
- cravings for ice, paint, or dirt (called pica)
- headache
- inability to concentrate, **memory** loss
- inflammation of the mouth (**stomatitis**) or tongue (glossitis)
- insomnia
- irregular heartbeat
- loss of appetite
- nails that are dry, brittle, or ridged
- rapid breathing
- sores in the mouth, throat, or rectum
- sweating
- swelling of the hands and feet
- thirst
- tinnitus (ringing in the ears)
- unexplained bleeding or bruising

In pernicious anemia, the tongue feels unusually slick. A patient with pernicious anemia may have problems with movement or balance, tingling in the hands and feet, confusion, depression, and memory loss.

Pernicious anemia can damage the **spinal cord**. A doctor should be notified whenever symptoms of this condition occur.

A doctor should also be notified if a patient who has been taking iron supplements develops **diarrhea**, cramps, or vomiting.

Diagnosis

Personal and family **health history** may suggest the presence of certain types of anemia. Laboratory tests that measure the percentage of red blood cells or the amount of hemoglobin in the blood are used to confirm diagnosis and determine which type of anemia is responsible for a patient's symptoms. X rays and examinations of bone marrow may be used to identify the source of bleeding.

Treatment

Anemia due to nutritional deficiencies can usually be treated at home with appropriate supplements, under a health professional's guidance. People with iron deficiency should take iron supplements. People with folic acid anemia should take oral folic acid replacements. Vitamin C deficiency anemia can be cured by the recommended daily allowance of vitamin C. People with pernicious anemia may be able to self-administer injections of vitamin B₁₂.

Surgery may be necessary to treat anemia caused by excessive loss of blood. Transfusions of red blood cells may be used to accelerate production of red blood cells in the body.

Medication or surgery may also be necessary to control heavy menstrual flow, repair a bleeding ulcer, or remove polyps (growths or nodules) from the bowels.

Patients with thalassemia usually do not require treatment. However, people with a severe form may require periodic hospitalization for blood transfusions or bone marrow transplantation.

Alternative therapies for iron deficiency anemia focus on adding iron-rich foods to the diet or on techniques to improve circulation and digestion. Herbal remedies to improve digestion include Gentian (*Gentiana lutea*), which is widely used in Europe to treat anemia and other nutritionally based disorders, as well as anise (*Pimpinella anisum*), caraway (*Carum carvi*), cumin (*Cuminum cyminum*), and licorice.

SICKLE CELL ANEMIA. Treatment for sickle cell anemia involves regular eye examinations, immunizations for pneumonia and infectious diseases, and prompt treatment for sickle cell crises and infections of any kind.

Psychotherapy or counseling may help patients deal with the emotional impact of this condition.

VITAMIN B₁₂ DEFICIENCY ANEMIA. A life-long regimen of B₁₂ shots is necessary to control symptoms of pernicious anemia. The patient may be advised to limit physical activity until treatment restores strength and balance.

APLASTIC ANEMIA. People who have aplastic anemia are especially susceptible to infection. Treatment for aplastic anemia may involve blood transfusions and bone marrow transplant to replace malfunctioning cells with healthy ones.

SIDEROBLASTIC ANEMIA. X-linked sideroblastic anemia often improves with pyridoxine (vitamin B₆) therapy. In cases of extreme anemia, whole red blood cell transfusion may be required.

If anemia is acquired, removal of the offending agent or treatment for the primary disorder may allow the anemia to disappear.

ANEMIA OF CHRONIC DISEASE. There is no specific treatment for anemia associated with chronic disease, but treating the underlying illness may alleviate this condition. This type of anemia rarely becomes severe. If it does, transfusions or hormone treatments to stimulate red blood cell production may be prescribed.

HEMOLYTIC ANEMIA. There is no specific treatment for cold-antibody hemolytic anemia. About one-third of patients with warm-antibody hemolytic anemia respond well to large doses of intravenous and oral **corticosteroids**, which are gradually discontinued as the patient's condition improves. Patients with this condition who don't respond to medical therapy must have the spleen surgically removed. This operation controls anemia in about half of the patients on whom it's performed. **Immune system** suppressants are prescribed for patients whose surgery is not successful.

Self-care

Anyone who has anemia caused by poor **nutrition** should modify his or her diet to include more **vitamins**, **minerals**, and iron. Vitamin C can stimulate iron absorption. The following foods are also good sources of iron:

- almonds
- broccoli
- dried beans
- dried fruits
- enriched breads and cereals
- lean red meat
- liver
- potatoes

KEY TERMS

Aplastic—Exhibiting incomplete or faulty development.

Diabetes mellitus—A disorder of carbohydrate metabolism brought on by a combination of hereditary and environmental factors.

Erythropoiesis—Erythropoiesis is the development of mature red blood cells (erythrocytes).

Hemoglobin—An iron-containing pigment of red blood cells composed of four amino acid chains (alpha, beta, gamma, delta) that delivers oxygen from the lungs to the tissues of the body.

Megaloblast—A large erythroblast (a red marrow cell that synthesizes hemoglobin).

Red blood cells—Yellowish, circular, biconcave disks found in the blood, which contain hemoglobin and carries oxygen. Also known as erythrocytes.

- poultry
- rice
- shellfish
- tomatoes

Because light and heat destroy folic acid, fruits and vegetables should be eaten raw, or cooked as little as possible.

Health care team roles

Often, anemia is not discovered until blood tests are run as part of a routine **physical examination**. Hemoglobin tests are commonly run by medical technologists or other laboratory professionals. Nurses and allied health professionals can play a critical role in the well-being and quality of life of patients at risk for anemia by understanding erythropoiesis, pathophysiology, nursing assessment (including laboratory data assessment), and nursing interventions related to anemia. In particular, nurses should be sure that patients are educated about their disease and about the treatment options available. In cases where anemia may be inherited, they may provide patients with information about **genetic testing**. They may also refer patients to professional genetic counselors.

Prognosis

Folic acid and iron deficiency anemias

It usually takes three to six weeks to correct folic acid or iron deficiency anemia. Patients should continue taking supplements for another six months to replenish iron reserves and should have periodic blood tests to make sure the bleeding has stopped and the anemia has not recurred.

Pernicious anemia

Although pernicious anemia is considered incurable, regular B₁₂ shots will alleviate symptoms and reverse complications. Some symptoms will disappear almost as soon as treatment begins.

Aplastic anemia

Aplastic anemia can sometimes be cured by bone marrow transplantation. If the condition is due to immunosuppressive drugs, symptoms may disappear after the drugs are discontinued.

Sickle cell anemia

Although sickle cell anemia cannot be cured, effective treatments enable patients with this disease to enjoy longer, more productive lives.

Thalassemia

People with mild thalassemia (alpha thalassemia trait or beta thalassemia minor) lead normal lives and do not require treatment. Those with severe thalassemia may require bone marrow transplantation. Genetic therapy is being investigated and may soon be available.

Hemolytic anemia

Acquired hemolytic anemia can generally be cured when the cause is removed.

Health care team roles

Anemia is often overlooked as a priority associated with quality patient care. Identifying the underlying causes of anemia in patients is critical to positive care outcomes and requires early assessment and intervention. The entire health care team plays a critical role in the well-being and quality of life of patients with anemia by understanding the disease and appropriate treatments, and by providing patients with any materials and education needed to understand the disease and its treatment.

Prevention

Inherited anemias cannot be prevented. **Genetic counseling** can help parents cope with questions and concerns about transmitting disease-causing genes to their children.

Avoiding excessive use of alcohol, eating a balanced diet that contains plenty of iron-rich foods, and taking a daily multivitamin can help prevent anemia.

Methods of preventing specific types of anemia include:

- Avoiding lengthy exposure to industrial chemicals and drugs known to cause aplastic anemia.
- Not taking medication that has triggered hemolytic anemia and not eating foods that have caused hemolysis (breakdown of red blood cells).
- Receiving regular B₁₂ shots to prevent pernicious anemia resulting from gastritis or stomach surgery.

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Aplastic Anemia & MDS International Foundation. P.O. Box 613, Annapolis, MD 21404-0613. (800) 747-2820 or (410) 867-0242. <<http://www.aplastic.org>>.

Leukemia & Lymphoma Society. 1311 Mamaroneck Ave., White Plains, NY 10605. (914) 949-5213. <<http://www.leukemia-lymphoma.org>>.

National Heart, Lung, Blood Institute Information Center. P.O. Box 30105, Bethesda, MD 20824-0105. (301) 592-8573. <<http://www.nhlbi.nih.gov>>.

National Organization for Rare Disorders. P.O. Box 8923, New Fairfield, CT 06812-8923, (203) 746-6518 or (800) 999-6673. <<http://www.rarediseases.org>>.

OTHER

Iron Disorders Institute. <<http://www.irondisorders.org>>.

National Center for Biotechnology Information.
<<http://www.ncbi.nlm.nih.gov>>.

Jennifer F. Wilson

Anencephaly *see* **Neural tube defect**

Anesthesia, general

Definition

General anesthesia is the induction of a balanced state of unconsciousness, accompanied by the absence of **pain** sensation and the **paralysis** of skeletal muscle over the entire body. It is induced through the administration of anesthetic drugs and is used during major and other invasive surgical procedures.

Purpose

General anesthesia is intended to bring about five distinct states during surgery:

- analgesia, or pain relief
- amnesia, or loss of **memory** of the procedure
- loss of consciousness
- motionlessness
- weakening of autonomic responses

Precautions

A complete medical history, including a history of **allergies** in family members, is an important precaution. Patients may have a potentially fatal allergic response to anesthesia known as malignant hyperthermia, even if there is no previous personal history of reaction.

General anesthetics should be administered only by board-certified medical professionals. Anesthesia providers consider many factors, including a patient's age, weight, allergies to medications, medical history, and general health when deciding which anesthetic or combination of anesthetics to use. The American Society of Anesthesiologists has compiled guidelines for classifying patients according to risk levels as follows:

- I: healthy patient
- II: patient with mild systemic disease without functional limitations
- III: patient with severe systemic disease with definite functional limitations

ANESTHETICS: HOW THEY WORK			
Type	Name(s)	Administered	Affect
General	Halothane, Enflurane Isoflurane, Ketamine, Nitrous Oxide, Thiopental	Intravenously, Inhalation	Produces total unconsciousness affecting the entire body
Regional	Mepivacaine, Chloroprocaine, Lidocaine	Intravenously	Temporarily interrupts transmission of nerve impulses (temperature, touch, pain) and motor functions in a large area to be treated; does not produce unconsciousness
Local	Procaine, Lidocaine, Tetracaine, Bupivacaine	Intravenously	Temporarily blocks transmission of nerve impulses and motor functions in a specific area; does not produce unconsciousness
Topical	Benzocaine, Lidocaine Dibucaine, Pramoxine, Butamben, Tetracaine	Dermal (Sprays, Drops, Ointments, Creams, Gels)	Temporarily blocks nerve endings in skin and mucous membranes; does not produce unconsciousness

(Illustration by Standley Publishing. Courtesy of Gale Group.)

- IV: patient with severe systemic disease that is life-threatening
- V: dying patient not expected to survive for 24 hours with or without an operation

Equipment for general anesthesia should be thoroughly checked before the operation; all items that might be needed, such as extra tubes or laryngoscope blades, should be available. Staff members should be knowledgeable about the problems that might arise with the specific anesthetic being used, and be able to recognize them and respond appropriately. General anesthetics cause a lowering of the **blood pressure** (hypotension), a hemodynamic response that requires close monitoring and special drugs to reverse it in emergency situations.

Description

General anesthetics may be gases or volatile liquids that evaporate as they are inhaled through a mask along with oxygen. Other general anesthetics are given intravenously. The amount of anesthesia produced by inhaling a general anesthetic can be adjusted rapidly, if necessary, by adjusting the anesthetic-to-oxygen ratio that is inhaled by the patient. The degree of anesthesia produced by an intravenously injected anesthetic cannot be changed as rapidly and must be reversed by administration of another drug.

The precise mechanism of general anesthesia is not yet fully understood. There are, however, several

hypotheses that have been advanced to explain why general anesthesia occurs. The first, the so-called Meyer-Overton theory, suggests that anesthesia occurs when a sufficient number of molecules of an inhalation anesthetic dissolve in the lipid cell membrane. The second theory maintains that protein receptors in the **central nervous system** are involved, in that inhalation anesthetics inhibit the enzyme activity of **proteins**. A third hypothesis, proposed by Pauling in 1961, suggests that anesthetic molecules interact with water molecules to form clathrates (hydrated microcrystals), which in turn inhibit receptor function.

Stages of anesthesia

There are four stages of general anesthesia that help providers to better predict the course of events, from anesthesia induction to emergence. Stage I begins with the induction of anesthesia and ends with the patient's loss of consciousness. The patient still feels pain in Stage I. Stage II, or REM stage, includes uninhibited and sometimes dangerous responses to stimuli, including vomiting and uncontrolled movement. This stage is typically shortened by administering a barbiturate, such as sodium pentothal, before the anesthetic agent. Stage III, or surgical anesthesia, is the stage in which the patient's pupillary gaze is central and the pupils are constricted. This is the target depth of surgical anesthesia. During this stage, the **skeletal muscles** relax, the patient's breathing becomes regular, and eye movements stop. Stage IV, or overdose, is

marked by hypotension or circulatory failure. Death may result if the patient cannot be revived quickly.

Types of anesthetic agents

There are two major types of anesthetics used for general anesthesia, inhalation and intravenous anesthetics. Inhalation anesthetics, which are sometimes called volatile anesthetics, are compounds that enter the body through the **lungs** and are carried by the **blood** to body tissues. Inhalation anesthetics are less often used alone in recent clinical practice; they are usually used together with intravenous anesthetics. A combination of inhalation and intravenous anesthetics, often with opioids added for pain relief and neuromuscular blockers for muscle paralysis, is called balanced anesthesia.

INHALATION ANESTHETICS. The following are the most commonly used inhalation anesthetics:

- Halothane causes unconsciousness but provides little pain relief; often administered with **analgesics**. It may be toxic to the **liver** in adults. Halothane, however, has a pleasant smell and is therefore often the anesthetic of choice when mask induction is used with children.
- Enflurane is less potent, but produces in a rapid onset of anesthesia and possibly a faster recovery. Enflurane is not used in patients with kidney failure.
- Isoflurane is not toxic to the liver but can induce irregular **heart** rhythms.
- Nitrous oxide (laughing gas) is used with such other drugs as thiopental to produce surgical anesthesia. It has the fastest induction and recovery time. It is regarded as the safest inhalation anesthetic because it does not slow respiration or blood flow to the **brain**.
- Sevoflurane works quickly and can be administered through a mask since it does not irritate the airway. On the other hand, one of the breakdown products of sevoflurane can cause renal damage.
- Desflurane, a second-generation version of isoflurane, is irritating to the airway and therefore cannot be used for mask (inhalation) inductions, especially not in children.

INTRAVENOUS ANESTHETICS. Commonly administered intravenous general anesthetics include ketamine, thiopental (a barbiturate), methohexital (Brevital), etomidate, and propofol (Diprivan). Ketamine produces a different set of reactions from other intravenous anesthetics. It resembles phencyclidine, which is a street drug that may cause hallucinations. Because patients who have been anesthetized with ketamine often have sensory illusions and vivid dreams during post-operative recovery, ketamine is not often given to adult patients. It



Monitoring a patient under general anesthesia is important so that his or her state of unconsciousness is maintained at a safe level. (M. English, MD/Custom Medical Stock Photo. Reproduced by permission.)

is, however, useful in anesthetizing children, patients in **shock**, and trauma casualties in war zones where anesthesia equipment may be difficult to obtain.

General anesthesia in dental procedures

The use of general anesthesia in dental and oral surgery patients differs from its use in major surgery because the patient's level of fear is usually a more important factor than the nature of the procedure. In 1985 an NIH Consensus Statement reported that high levels of preoperative **anxiety**, lengthy and complex procedures, and the need for a pain-free operative period may be indications for general anesthesia in healthy adults and in very young children. The NIH statement specified that at least three professionals are required when general anesthesia is used during dental procedures: one is the operating dentist; the second is a professional responsible for observing and monitoring the patient; the third person assists the operating dentist.

Although the United States allows general anesthesia for dental procedures to be administered outside hospitals provided that the facility has the appropriate equipment and emergency drugs, Scotland banned the use of general anesthesia outside hospitals in 2000, after a ten-year-old boy died during a procedure to have a tooth removed.

Preparation

Preparation for general anesthesia includes the taking of a complete medical history and the evaluation of all factors—especially a family history of allergic responses to anesthetics—that might influence the patient's response to specific anesthetic agents.

Patients should not eat or drink before general anesthesia because of the risk of regurgitating food and liquid or aspirating vomitus into the lungs.

Informed consent

Patients should be informed of the risks associated with general anesthesia as part of their **informed consent**. These risks include possible dental injuries from intubation as well as such serious complications as stroke, liver damage, or massive hemorrhage. If **local anesthesia** is an option for some procedures, the patient should be informed of this alternative. In all cases, patients should be given the opportunity to ask questions about the risks and benefits of the procedure requiring anesthesia as well as questions about the anesthesia itself.

Premedication

Depending on the patient's level of anxiety and the procedure to be performed, the patient may be premedicated. Most medications given before general anesthesia are either anxiolytics, usually benzodiazepines; or analgesics. Patients in severe pain prior to surgery may be given morphine or fentanyl. Anticholinergics (drugs that block impulses from the parasympathetic nervous system) may be given to patients with a known history of bronchospasm or heavy airway secretions.

Aftercare

The anesthetist and medical personnel provide supplemental oxygen and monitor patients for **vital signs** and monitor their airways. Vital signs include an EKG (unless the patient is hooked to a monitor), blood pressure, pulse rate, oxygen saturation, respiratory rate, and temperature. The staff also monitors the patient's level of consciousness as well as signs of excess bleeding from the incision.

Complications

Although the risk of serious complications from general anesthesia are low, they can include heart attack, stroke, brain damage, and death. The risk of complications depends in part on the patient's age, sex, weight, allergies, general health, and history of smoking, drinking alcohol, or drug use.

The overall risk of mortality from general anesthesia is difficult to evaluate as of 2001, because so many different factors are involved, ranging from the patient's overall health and the circumstances preceding surgery to the type of procedure and the skill of the physicians involved. The risk appears to be somewhere between 1:1,000 and 1:100,000, with infants younger than age one and patients older than 70 being at greater risk.

Awareness during surgery

One possible complication is the patient's "waking up" during the operation. It is estimated that about 30,000 patients per year in the United States "come to" during surgery. This development is in part the result of the widespread use of short-acting general anesthetics combined with blanket use of neuromuscular blockade. The patients are paralyzed with regard to motion, but otherwise "awake and aware." At present, special devices that measure brain wave activity are used to monitor the patient's state of consciousness. The bispectral index monitor was approved by the FDA in 1996 and the patient state analyzer in 1999.

Nausea and vomiting

Post-operative nausea and vomiting is a common problem during recovery from general anesthesia. In addition, patients may feel drowsy, weak, or tired for several days after the operation, a combination of symptoms sometimes called the "hangover effect." Fuzzy thinking, blurred **vision**, and coordination problems are also possible. For these reasons, anyone who has had general anesthesia should not drive, operate machinery, or perform other activities that could endanger themselves or others for at least 24 hours, or longer if necessary.

Anesthetic toxicity

Inhalation anesthetics are sometimes toxic to the liver, the kidney, or to blood cells. Halothane may cause hepatic necrosis or hepatitis. Sevoflurane may react with the carbon dioxide absorbents in anesthesia machines to form compound A, a haloalkene that is toxic to the **kidneys**. The danger to red blood cells comes from carbon monoxide formed by the breakdown products of inhalation anesthetics in the circuits of anesthesia machines.

Malignant hyperthermia

Malignant hyperthermia is a rare condition caused by an allergic response to a general anesthetic. The signs of malignant hyperthermia include rapid, irregular heart-beat; breathing problems; very high **fever**; and muscle tightness or spasms. These symptoms can occur following the administration of general anesthetics, especially halothane.

Results

General anesthesia is much safer today than it was in the past, thanks to faster-acting anesthetics; improved safety standards in the equipment used to deliver the drugs; and better devices to monitor breathing, heart rate, blood pressure, and brain activity during surgery. Unpleasant

side effects are also less common, in part because of recent developments in equipment that reduce the problems of anesthetizing patients with “difficult” airways. These developments include the laryngeal mask airway and the McCoy laryngoscope, which has a hinged tip on its blade that allows a better view of the patient’s larynx.

Health care team roles

Nurse anesthetists sometimes work with physician anesthesiologists in administering general anesthesia. Anesthesiologist assistants are other allied health professionals who assist anesthesiologists. Anesthesiologist assistants help in many areas, including preparation for the delivery of general anesthesia; performance of pre-treatment assessments; administration of maintenance and supportive drugs; **airway management**; and assistance with transferring the patient to the recovery room.

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American Academy of Anesthesiologist Assistants. PO Box 81362, Wellesley, MA 02481-0004. (800) 757-5858. <<http://www.anesthetist.org>>.

American Society of Anesthesiologists. 520 N. Northwest Highway, Park Ridge, IL 60068-2573. (847) 825-5586. <<http://www.asahq.org>>.

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KEY TERMS

Analgesia—Relief from pain.

Anticholinergics—Drugs that interfere with impulses from the parasympathetic nervous system. They may be given before general anesthesia to reduce airway secretions or the risk of bronchospasm.

Anxiolytics—Medications given to reduce anxiety; tranquilizers. Benzodiazepines are the anxiolytics most commonly used to premedicate patients before general anesthesia.

Balanced anesthesia—The use of a combination of inhalation and intravenous anesthetics, often with opioids for pain relief and neuromuscular blockers for muscle paralysis.

Clathrates—Substances in which a molecule from one compound fills a space within the crystal lattice of another compound. One theory of general anesthesia proposes that water molecules interact with anesthetic molecules to form clathrates that decrease receptor function.

Laryngoscope—An endoscope equipped for viewing a patient’s larynx through the mouth.

Malignant hyperthermia—A type of allergic reaction (probably with a genetic basis) that can occur during general anesthesia in which the patient experiences a high fever, the muscles become rigid, and the heart rate and blood pressure fluctuate.

Volatile anesthetics—Another name for inhalation anesthetics.

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Lisette Hilton

Anesthesia, local

Definition

Local or regional anesthesia involves the injection or application of an anesthetic drug to a specific area of the body. This is in contrast to **general anesthesia**, which provides anesthesia to the entire body and **brain**.

Purpose

Local anesthetics are used to prevent patients from feeling **pain** during medical, surgical, or dental procedures. Over-the-counter local anesthetics are also available to provide temporary relief from pain, irritation, and itching caused by various conditions, such as cold sores, canker sores, sore throats, sunburn, insect bites, poison ivy, and minor cuts and scratches.

Precautions

People who feel strongly that they do not want to be awake and alert during certain procedures may not be good candidates for local or regional anesthesia. However, other medications that have systemic effects may be given in addition to an anesthetic to relieve **anxiety** and help the patient relax.

Local anesthetics should be used only for the conditions for which they are intended. For example, a topical anesthetic meant to relieve sunburn pain should not be used on cold sores. Anyone who has had an unusual reaction to any local anesthetic in the past should check with a doctor before using any type of local anesthetic again. The doctor should also be told about any **allergies** to foods, dyes, preservatives, or other substances.

Older people may be more sensitive to the effects of local anesthetics, especially lidocaine. Children may also be especially sensitive to some local anesthetics, and certain types should not be used at all on young children. People caring for these groups need to be aware that they are at increased risk of more severe side effects. Packages should be followed carefully so that the recommended dosage is not exceeded. A doctor or pharmacist should be consulted about any concerns.

Regional anesthetics

Serious and possibly life-threatening side effects may occur when injectable or inhaled anesthetics are given to people who use street drugs. Doctors and nurses should inform patients about the dangers of mixing anesthetics with cocaine, **marijuana**, amphetamines, barbiturates, phencyclidine (PCP or angel dust), heroin, or other street drugs. Some anesthetic drugs may interact with other medicines. When this happens, the effects of one or both of the drugs may change, or the risk of side effects may be greater. In select cases, a **urinalysis** can help identify drug use.

Patients who have a personal or family history of malignant hyperthermia after receiving a general anesthetic must also be cautious when receiving regional or local anesthetics. Malignant hyperthermia is a serious reaction that involves a fast or irregular heartbeat, high

fever, breathing problems, and muscle spasms. All patients should be asked if they are aware of such a risk in their family before receiving any kind of anesthetic.

Although problems are rare, some side effects may occur when regional anesthetics are used during labor and delivery. Anesthetics can prolong labor and increase the risk of requiring a cesarean section. Doctors should discuss the risks and benefits associated with epidural or spinal anesthesia with pregnant patients.

Patients should not drive or operate machinery immediately following a procedure involving regional anesthesia because of the danger that numbness or weakness may cause impairment. Doctors and nurses should also warn patients who have had local anesthesia, especially when combined with drugs to make patients sleep or to reduce pain, about operating any type of machinery.

Injectable local anesthetics

Until the anesthetic wears off, patients should be careful not to inadvertently injure the numbed area. If the anesthetic was used in the mouth, patients should not eat or chew gum until feeling returns.

Topical anesthetics

Unless advised by a doctor, topical anesthetics should not be used on or near any part of the body with large sores, broken or scraped skin, severe injury, or **infection**. They should also not be used on large areas of skin. Some topical anesthetics contain alcohol and should not be used near an open flame or while smoking.

Patients should be careful not to get topical anesthetics in the eyes, nose, or mouth. If a spray-type anesthetic is to be used on the face, it can be applied with a cotton swab or sterile gauze pad. After using a topical anesthetic on a child, make sure the child does not get the medicine in his or her mouth or eyes.

Topical anesthetics are intended for the temporary relief of pain and itching. They should not be used for more than a few days at a time. Check with a doctor if:

- discomfort continues for more than seven days
- the problem gets worse
- the treated area becomes infected
- new signs of irritation, such as skin rash, burning, stinging, or swelling appear

Dental anesthetics

Dental anesthetics should not be used if certain kinds of infections are present. Check package directions or check with a dentist, pharmacist, or doctor if uncertain.

Dental anesthetics should be used only for temporary pain relief. Consult the dentist if problems such as toothache, mouth sores, or pain from dentures or braces continue or if signs of general illness, such as fever, rash, or vomiting develop.

Patients should not eat or chew gum while the mouth is numb from a dental anesthetic to avoid accidentally biting the tongue or the inside of the mouth. In addition, nothing should be eaten or drunk for one hour after applying a dental anesthetic to the back of the mouth or throat, because the medicine may interfere with swallowing and may cause choking. If normal feeling does not return to the mouth within a few hours after receiving a dental anesthetic or if it is difficult to open the mouth, the dentist should be consulted.

Ophthalmic anesthetics

When anesthetics are used in the eye, it is important not to rub or wipe the eye until the effect of the anesthetic has worn off and feeling has returned. Rubbing the eye while it is numb could cause injury.

Description

Medical procedures and situations that regularly make use of local or regional anesthesia include the following:

- biopsies, in which skin or tissue samples are taken for diagnostic procedures
- childbirth
- scar repair
- surgery on the face (including plastic surgery), skin, arms, hands, legs, and feet
- eye surgery
- surgery involving the urinary tract or reproductive organs

Surgery involving the chest or abdomen is usually performed under general anesthesia. **Laparoscopy** and hernia repair, however, may be performed under local or regional anesthesia.

Local and regional anesthesia have many advantages over general anesthesia. Most importantly, the risk of unusual and sometimes fatal reactions to general anesthesia is lessened. More minor but significant risks of general anesthesia include longer recovery time and the psychological discomfort of losing consciousness.

Regional anesthesia typically affects a larger area than local anesthesia. As a result, regional anesthesia is typically used for more involved or complicated proce-



A local anesthetic is administered to the foot prior to a minor operation to remove a verruca (plantar wart).

(Photograph by David Parker. Science Source/Photo Researchers. Reproduced by permission.)

dures. The duration of action of an anesthetic depends on the type and amount of anesthetic administered.

Regional anesthetics are injected. Local anesthesia involves the injection into the skin or application to the skin surface of an anesthetic directly where pain will occur. Local anesthesia can be divided into four groups: injectable, topical, dental (non-injectable), and regional blockade injection.

Local and regional anesthesia work by altering the flow of sodium molecules into nerve cells (**neurons**) through the cell membrane. The exact mechanism is not understood, since the drug apparently does not bind to any receptor on the cell surface and does not seem to affect the release of chemicals that transmit nerve impulses (neurotransmitters) from the nerve cells. Experts believe, however, that when the sodium molecules do not get into the neurons, nerve impulses are not generated and pain impulses are not transmitted to the brain.

KEY TERMS

Canker sore—A painful sore inside the mouth.

Cold sore—A small blister on the lips or face, caused by a virus. Also called a fever blister.

Epidural space—The space surrounding the spinal fluid sac.

Malignant hyperthermia—A type of reaction (probably with a genetic basis) that can occur during general anesthesia in which the patient experiences a high fever, the muscles become rigid, and the heart rate and blood pressure fluctuate.

Subarachnoid space—The space surrounding the spinal cord that is filled with cerebrospinal fluid.

Topical—Not ingested; applied to the outside of the body, for example to the skin, eye, or mouth.

Regional anesthesia

Types of regional anesthesia include:

- Spinal anesthesia, which involves the injection of a small amount of local anesthetic into the cerebrospinal fluid surrounding the **spinal cord** (the subarachnoid space). A drop in **blood pressure** is a common but easily treated side effect.
- Epidural anesthesia, which involves the injection of a large volume of local anesthetic into the space surrounding the spinal fluid sac (the epidural space), not directly into the spinal fluid. Pain relief occurs more slowly but is less likely to produce a drop in **blood pressure**. The block can be maintained for long periods, even for days if necessary.
- Nerve blockades, which involve the injection of an anesthetic into the area around a sensory or motor nerve that supplies a particular region of the body, preventing the nerve from carrying nerve impulses to and from the brain.

Local and regional anesthetics may be administered with other drugs to enhance their action. Examples include vasoconstrictors such as epinephrine (adrenaline) to decrease bleeding, or sodium bicarbonate to lower acidity, which may make a drug work faster. In addition, medications may be administered to help a patient remain calm and more comfortable or to make them sleepy.

Local anesthesia

INJECTABLE LOCAL ANESTHETICS. Injectable local anesthetics provide pain relief for some part of the body

during surgery, dental procedures or other medical procedures. They are given only by a trained health care professional and only in a doctor's office or a hospital. Some commonly used injectable local anesthetics are lidocaine (Xylocaine), bupivacaine (Marcaine), and mepivacaine (Carbocaine).

TOPICAL ANESTHETICS. Topical anesthetics, such as benzocaine, lidocaine (in smaller quantities or doses), dibucaine and tetracaine, relieve pain and itching by blocking the sensory nerve endings in the skin. They are ingredients in a variety of nonprescription products that are applied to the skin to relieve the discomfort of sunburn, insect bites or stings, poison ivy, and minor cuts, scratches, and **burns**. These products are sold as creams, ointments, sprays, lotions, and gels.

Topical dental anesthetics are intended for pain relief in the mouth or throat. They may be used to relieve throat pain, teething pain, painful canker sores, toothaches, or discomfort from dentures, braces or bridgework. Some dental anesthetics are available only with a doctor's prescription. Others may be purchased over the counter, including products such as Num-Zit, Orajel, Chloraseptic lozenges, and Xylocaine.

Ophthalmic anesthetics are designed for use in the eye. Lidocaine and tetracaine are used to numb the eye before certain eye examinations. Eye doctors may also use these medicines before measuring eye pressure or removing stitches or foreign objects from the eye. These drugs are to be given only by a trained health care professional.

The recommended dosage of a topical anesthetic depends on the type of local anesthetic and the purpose for which it is being used. When using a nonprescription local anesthetic, follow the directions on the package. Questions concerning how to use a product should be referred to a doctor, dentist or pharmacist.

Aftercare

Most patients can return home immediately after a local anesthetic, but some patients might require limited observation. The degree of aftercare needed depends on where the anesthetic was given, how much was given, and other individual circumstances. Patients who have had their eyes numbed should wear a patch after surgery or treatment until the full feeling of the eye area has returned. If the throat was anesthetized, the patient cannot drink until the gag reflex returns. If a major extremity was anesthetized, one may have to wait until function returns before the patient goes home. Some local anesthetics can cause cardiac arrhythmias and therefore require monitoring for a time with an EKG. Patients who

have had regional anesthesia or larger amounts of local anesthesia usually recover in a post-anesthesia care unit before being discharged. There, medical personnel watch for immediate postoperative problems. These patients need to be driven home after discharge.

Complications

Side effects of regional or local anesthetics vary depending on the type of anesthetic used and the way it is administered. Any unusual symptoms following the use of an anesthetic requires the immediate attention of a doctor.

Paralysis after a regional anesthetic such as an epidural, spinal or ganglionic blockade is extremely rare, but can occur. Paralysis reportedly occurs even less frequently than deaths due to general anesthesia.

There is also a small risk of developing a severe headache called a spinal headache following a spinal or epidural block. This headache is severe when the patient is upright, even when only elevated 30 degrees, and is hardly felt when the patient lies down. It is treated by increasing fluids to help clear the anesthetic and enhance the flow of spinal fluid.

Finally, blood clots or **abscess** can form at the site where an anesthetic is injected. Although they can usually be treated, antibiotic resistance is becoming increasingly common. Such infections must be regarded as potentially dangerous, particularly if they develop at the site of a spinal injection.

A physician should be notified immediately if any of the following occur:

- symptoms of an allergic reaction, such as **hives** (urticaria), which are itchy swellings on the skin, or swelling in the mouth or throat
- severe headache
- blurred or double **vision** or photophobia (sensitivity to light)
- dizziness or lightheadedness
- drowsiness
- confusion
- an irregular, too slow, or rapid heartbeat
- anxiety, excitement, nervousness, or restlessness
- convulsions (seizures)
- feeling hot, cold, or numb anywhere other than the anesthetized area
- ringing or buzzing in the ears
- shivering or trembling

- sweating
- pale skin
- breathing problems
- unusual weakness or tiredness

Results

Local and regional anesthetics help to make many conditions and procedures more comfortable and tolerable for patients.

Health care team roles

A **registered nurse** often can administer local anesthesia. For other types, including spinal and epidural anesthesia and ganglionic blockades, a health care team may include a certified registered **nurse anesthetist** (CRNA) working independently or with an anesthesiologist. Anesthesiologist assistants are other allied health professionals who assist anesthesiologists. They may prepare for the delivery of anesthesia; perform pre-treatment assessments; insert catheters; administer maintenance and supportive drugs; manage patient airways; make anesthetic adjustments; and assist with the patient transition to the recovery room.

Resources

ORGANIZATIONS

Nettina, Sandra. *Lippincott Manual of Nursing Practice*, 7th edition. Philadelphia: Lippincott, 2001, pp. 115-117.

ORGANIZATIONS

American Academy of Anesthesiologist Assistants. PO Box 81362, Wellesley, MA 02481-0004. (800) 757-5858. <<http://www.anesthetist.org>>.

American Society of Anesthesiologists. 520 N. Northwest Highway, Park Ridge, IL 60068-2573. (847) 825-5586. <<http://www.asahq.org>>.

OTHER

Interview with Harvey Plosker, MD. The Pain Center. 501 Glades Road, Boca Raton, FL 33431.

Lisette Hilton

Angiography

Definition

Angiography is the x-ray (radiographic) study of the **blood vessels**. An angiogram uses a radiopaque substance, or contrast medium, to make the **blood** vessels

visible under x ray. The key ingredient in most radiographic contrast media is iodine. Arteriography is a type of radiographic examination that involves the study of the arteries.

Purpose

Angiography is used to detect abnormalities, including narrowing (stenosis) or blockages in the blood vessels (called occlusions) throughout the circulatory system and in some organs. The procedure is commonly used to identify atherosclerosis; to diagnose **heart** disease; to evaluate kidney function and detect kidney cysts or tumors; to map renal anatomy in transplant donors; to detect an aneurysm (an abnormal bulge of an artery that can rupture leading to hemorrhage), tumor, blood clot, or arteriovenous malformations (abnormal tangles of arteries and veins) in the **brain**; and to diagnose problems with the retina of the eye. It is also used to provide surgeons with an accurate vascular “map” of the heart prior to open-heart surgery, or of the brain prior to neurosurgery. Angiography may be used after penetrating trauma, like a gunshot or knife wound, to detect blood vessel injury; it may be used to check the position of shunts and stents placed by physicians into blood vessels.

Precautions

Patients with kidney disease or injury may suffer further kidney damage from the contrast media used for angiography. Patients who have blood clotting problems, have a known allergy to contrast media, or are allergic to iodine, may also not be suitable candidates for an angiography procedure. Newer types of contrast media classified as non-ionic are less toxic and cause fewer side effects than traditional ionic agents do. Because x rays carry risks of ionizing radiation exposure to the fetus, pregnant women are also advised to avoid this procedure.

Description

Angiography requires the injection of a contrast medium that makes the blood vessels visible to x ray. The contrast medium is injected through a procedure known as arterial puncture. The puncture is usually made in the groin area, armpit, inside elbow, or neck. The site is cleaned with an antiseptic agent and injected with a local anesthetic. First, a small incision is made in the skin to help the needle pass. A needle containing a solid inner core called a stylet is inserted through the incision and into the artery. When the radiologist has punctured the artery with the needle, the stylet is removed and replaced with another long wire called a guide wire. It is normal

for blood to spurt out of the needle before the guide wire is inserted.

The guide wire is fed through the outer needle into the artery and to the area that requires angiographic study. A **fluoroscope** displays a view of the patient’s vascular system and is used to direct the guide wire to the correct location. Once it is in position, the needle is removed, and a catheter is threaded over the length of the guide wire until it reaches the area of study. The guide wire is removed, and the catheter is left in place in preparation for the injection of the contrast medium.

Depending on the type of angiographic procedure being performed, the contrast medium is either injected by hand with a syringe or is mechanically injected with an automatic injector connected to the catheter. An automatic injector is used frequently because it is able to deliver a large volume of contrast medium very quickly to the angiographic site. Usually a small test injection is made to confirm that the catheter is in the correct position. The patient is told that the injection will start, and is instructed to remain very still. The injection causes some mild to moderate discomfort. Possible side effects or reactions include headache, dizziness, irregular heart-beat, nausea, warmth, burning sensation, and chest **pain**, but they usually last only momentarily. To view the area of study from different angles or perspectives, the patient may be asked to change positions several times, and subsequent contrast medium injections may be administered. During any injection, the patient or the imaging equipment may move.

Throughout the injection procedure, radiographs (x-ray pictures) and/or fluoroscopic images will be obtained. Because of the high pressure of arterial blood flow, the contrast medium will dissipate through the patient’s system quickly and become diluted, so images must be obtained in rapid succession. One or more automatic film changers may be used to capture the required radiographic images. In many imaging departments, angiographic images are captured digitally obviating the need for film changers. The ability to capture digital images also makes it possible to manipulate the information electronically allowing for a procedure known as digital subtraction angiography (DSA). Since every image captured is comprised of tiny picture elements called pixels, computers can be used to manipulate the information in ways that enhance diagnostic information. One common approach is to electronically remove or (subtract) bony structures which otherwise would be superimposed over the vessels being studied, hence the name digital subtraction angiography.

Once the x rays are complete, the catheter is slowly and carefully removed from the patient. Manual pressure

is applied to the site with a sandbag or other weight for 10-20 minutes to allow for clotting to take place and the arterial puncture to reseal itself. A pressure bandage is then applied.

Most angiograms follow the general procedures outlined above, but vary slightly depending on the area of the vascular system being studied. A variety of common angiographic procedures are outlined below:

Cerebral angiography

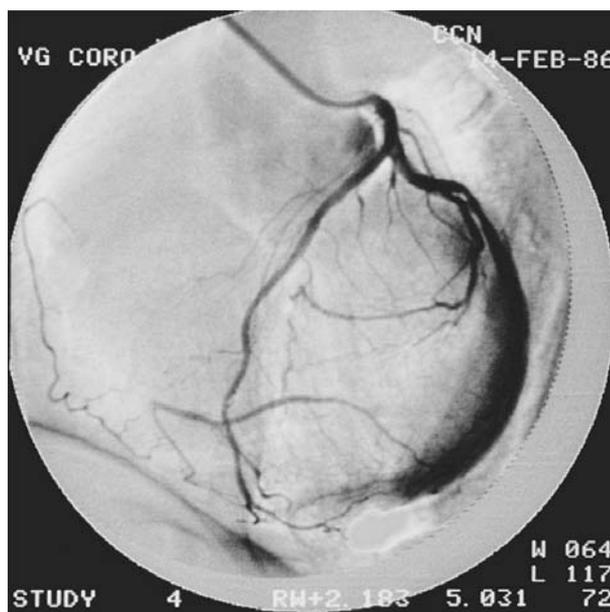
Cerebral angiography is used to detect aneurysms, stenosis, blood clots, and other vascular irregularities in the brain. The catheter is inserted into the femoral or carotid artery and the injected contrast medium travels through the blood vessels in the brain. Patients frequently experience headache, warmth, or a burning sensation in the head or neck during the injection portion of the procedure. A cerebral angiogram takes two to four hours to complete.

Coronary angiography

Coronary angiography is administered by a cardiologist with training in radiology or, occasionally, by a radiologist. The arterial puncture is typically made in the femoral artery, and the cardiologist uses a guide wire and catheter to perform a contrast injection and x-ray series on the coronary arteries. The catheter may also be placed in the left ventricle to examine the mitral and aortic valves of the heart. If the cardiologist requires a view of the right ventricle of the heart or of the tricuspid or pulmonary valves, the catheter will be inserted through a large vein and guided into the right ventricle. The catheter also serves the purpose of monitoring blood pressures in these different locations inside the heart. The angiographic procedure takes several hours, depending on the complexity of the procedure.

Pulmonary angiography

Pulmonary, or lung, angiography is performed to evaluate blood circulation to the **lungs**. It is also considered the most accurate diagnostic test for detecting a pulmonary embolism. The procedure differs from cerebral and coronary angiography in that the guide wire and catheter are inserted into a vein instead of an artery, and are guided up through the chambers of the heart and into the pulmonary artery. Throughout the procedure, the patient's **vital signs** are monitored to ensure that the catheter doesn't cause arrhythmias, or irregular heartbeats. The contrast medium is then injected into the pulmonary artery where it circulates through the lungs' capillaries. The test typically takes up to 90 minutes and carries more risk than other angiography procedures.



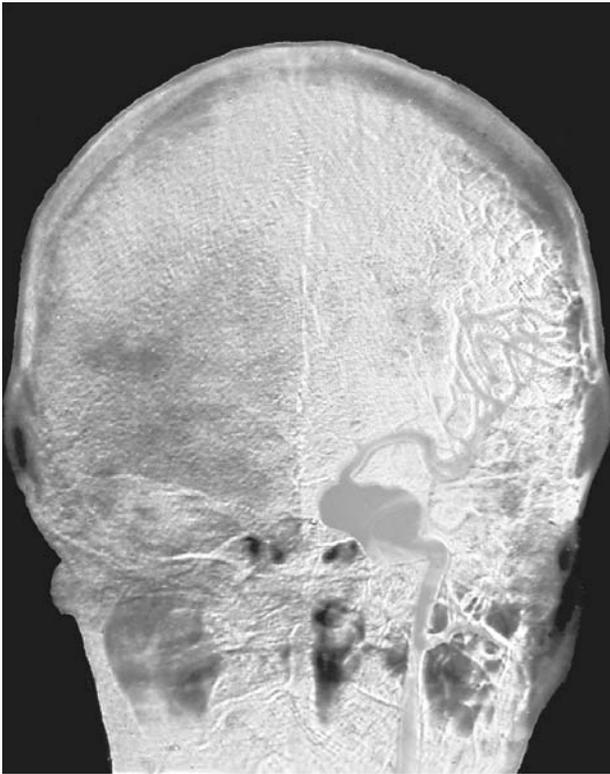
An angiogram of a coronary artery. (Phototake NYC. Reproduced by permission.)

Kidney (renal) angiography

Patients with chronic renal disease or injury can suffer further damage to their **kidneys** from the contrast medium used in a renal angiogram, yet they often require the test to evaluate kidney function. These patients should be well-hydrated with an intravenous saline drip before the procedure, and may benefit from available medications (e.g., dopamine) that help to protect the kidney from further injury associated with contrast agents. During a renal angiogram, the guide wire and catheter are inserted into the femoral artery in the groin area and advanced through the abdominal aorta, the main artery in the abdomen, and into the renal arteries. The procedure takes approximately one hour.

Fluorescein angiography

Fluorescein angiography is used to diagnose retinal problems and circulatory disorders. It is typically conducted as an outpatient procedure. The patient's pupils are dilated with eye drops and he or she rests the chin and forehead against a bracing apparatus to keep it still. Sodium fluorescein dye is then injected with a syringe into a vein in the patient's arm. The dye will travel through the patient's body and into the blood vessels of the eye. The procedure does not require x rays. Instead, a rapid series of close-up photographs of the patient's eyes are taken, one set immediately after the dye is injected, and a second set approximately 20 minutes later once the dye has moved through the patient's vascular system. The entire procedure takes up to one hour.



X ray showing brain aneurism (to the right of the midline).
(CNRI/National Audubon Society Collection/Photo
Researchers, Inc. Reproduced by permission.)

Celiac and mesenteric angiography

Celiac and mesenteric angiography involves radiographic exploration of the celiac and mesenteric arteries, arterial branches of the abdominal aorta that supply blood to the abdomen and **digestive system**. The test is commonly used to detect aneurysm, thrombosis, and signs of ischemia in the celiac and mesenteric arteries, and to locate the source of gastrointestinal bleeding. It is also used in the diagnosis of a number of conditions, including portal **hypertension**, and cirrhosis. The procedure can take up to three hours, depending on the number of blood vessels studied.

Splenoportography

A splenoportograph is a variation of an angiogram that involves the injection of contrast medium directly into the spleen to view the splenic and portal veins. It is used to diagnose blockages in the splenic vein and portal vein thrombosis and to assess the strength and location of the vascular system prior to **liver** transplantation.

Most angiographic procedures are typically paid for by major medical insurance. Patients should check

with their individual insurance plans to determine their coverage.

Computerized tomographic angiography (CTA), a new technique, is used in the evaluation of patients with intracranial aneurysms. CTA is particularly useful in delineating the relationship of vascular lesions with bony anatomy close to the **skull** base. While such lesions can be demonstrated with standard angiography, it often requires studying several projections of the two dimensional films rendered with standard angiography. CTA is ideal for more anatomically complex skull base lesions because it clearly demonstrates the exact relationship of the bony anatomy with the vascular pathology. This is not possible using standard angiographic techniques. Once the information has been captured a workstation is used to process and reconstruct images. The approach yields shaded surface displays of the actual vascular anatomy which are three dimensional and clearly show the relationship of the bony anatomy with the vascular pathology.

Angiography can also be performed using MRI (**magnetic resonance imaging**) scanners. The technique is called MRA (magnetic resonance angiography). A contrast medium is not usually used, but may be used in some body applications. The active ingredient in the contrast medium used for MRA is one of the rare earth elements, gadolinium. The contrast agent is injected into an arm vein, and images are acquired with careful attention being paid to the timing of the injection and selection of MRI specific imaging parameters. Once the information has been captured, a workstation is used to process and reconstruct the images. The post processing capabilities associated with CTA and MRA yield three dimensional representations of the vascular pathology being studied and can also be used to either enhance or subtract adjacent anatomical structures.

Preparation

Patients undergoing an angiogram are advised to stop eating and drinking eight hours prior to the procedure. They must remove all jewelry before the procedure and change into a hospital gown. If the arterial puncture is to be made in the armpit or groin area, shaving may be required. A sedative may be administered to relax the patient for the procedure. An IV line will also be inserted into a vein in the patient's arm before the procedure begins in case medication or blood products are required during the angiogram, or in case complications arise.

Prior to the angiographic procedure, patients will be briefed on the details of the test, the benefits and risks, and the possible complications involved, and asked to sign an **informed consent** form.

KEY TERMS

Arteriosclerosis—A chronic condition characterized by thickening and hardening of the arteries and the build-up of plaque on the arterial walls. Arteriosclerosis can slow or impair blood circulation.

Carotid artery—An artery located in the neck.

Catheter—A long, thin, flexible tube used in angiography to inject contrast material into the arteries.

Cirrhosis—A condition characterized by the destruction of healthy liver tissue. A cirrhotic liver is scarred and cannot break down the proteins in the bloodstream. Cirrhosis is associated with portal hypertension.

Embolism—A blood clot, air bubble, or clot of foreign material that travels and blocks the flow of blood in an artery. When blood supply to a tissue or organ is blocked by an embolism, infarction, or death of the tissue the artery feeds, occurs. Without immediate and appropriate treatment, an embolism can be fatal.

Femoral artery—An artery located in the groin area that is the most frequently accessed site for arterial puncture in angiography.

Fluorescein dye—An orange dye used to illuminate

the blood vessels of the retina in fluorescein angiography.

Fluoroscope—An imaging device which displays “moving x-rays” of the body. Fluoroscopy allows the radiologist to visualize the guide wire and catheter he is moving through the patient’s artery.

Guide wire—A wire that is inserted into an artery to guide a catheter to a certain location in the body.

Ischemia—A lack of normal blood supply to a organ or body part because of blockages or constriction of the blood vessels.

Necrosis—Cellular or tissue death; skin necrosis may be caused by multiple, consecutive doses of radiation from fluoroscopic or x-ray procedures.

Plaque—Fatty material that is deposited on the inside of the arterial wall.

Portal hypertension—A condition caused by cirrhosis of the liver. It is characterized by impaired or reversed blood flow from the portal vein to the liver, an enlarged spleen, and dilated veins in the esophagus and stomach.

Portal vein thrombosis—The development of a blood clot in the vein that brings blood into the liver. Untreated portal vein thrombosis causes portal hypertension.

Aftercare

Because life-threatening internal bleeding is a possible complication of an arterial puncture, an overnight stay in the hospital is sometimes recommended following an angiographic procedure, particularly with cerebral and coronary angiography. If the procedure is performed on an outpatient basis, the patient is typically kept under close observation for a period of at six to 12 hours before being released. If the arterial puncture was performed in the femoral artery, the patient will be instructed to keep his leg straight and relatively immobile during the observation period. The patient’s **blood pressure** and vital signs will be monitored and the puncture site observed closely. Pain medication may be prescribed if the patient is experiencing discomfort from the puncture, and a cold pack is often applied to the site to reduce swelling. It is normal for the puncture site to be sore and bruised for several weeks. The patient may also develop a hematoma, a hard mass created by the blood vessels broken during the procedure. Hematomas should be watched

carefully, as they may indicate continued bleeding of the arterial puncture site.

Angiography patients are also advised to enjoy two to three days of rest after the procedure in order to avoid placing any undue stress on the arterial puncture site. Patients who experience continued bleeding or abnormal swelling of the puncture site, sudden dizziness, or chest pain in the days following an angiographic procedure should seek medical attention immediately.

Patients undergoing a fluorescein angiography should not drive or expose their eyes to direct sunlight for 12 hours following the procedure.

Risks

Because angiography involves puncturing an artery, internal bleeding or hemorrhage are possible complications of the test. As with any invasive procedure, **infection** of the puncture site or bloodstream is also a risk, but this is rare.

A stroke or heart attack may be triggered by an angiogram if blood clots or plaque on the inside of the arterial wall are dislodged by the catheter and form a blockage in the blood vessels or artery. The heart may also become irritated by the movement of the catheter through its chambers during pulmonary and coronary angiographic procedures, and arrhythmias may develop.

Patients who develop an allergic reaction to the contrast medium used in angiography may experience a variety of symptoms, including swelling, difficulty breathing, **heart failure**, or a sudden drop in blood pressure. If the patient is aware of the allergy before the test is administered, certain medications can be administered at that time to counteract the reaction.

Angiography involves minor exposure to radiation through the x rays and fluoroscopic guidance used in the procedure. Unless the patient is pregnant, or multiple radiological or fluoroscopic studies are required, the small dose of radiation incurred during a single procedure poses little risk. However, multiple studies requiring fluoroscopic exposure that are conducted in a short time period have been known to cause skin necrosis in some individuals. This risk can be minimized by careful monitoring and documentation of cumulative radiation doses administered to these patients, particularly in those who have therapeutic procedures performed along with the diagnostic angiography.

Results

The results of an angiogram or arteriogram depend on the artery or organ system being examined. Generally, test results should display a normal and unimpeded flow of blood through the vascular system. Fluorescein angiography should result in no leakage of fluorescein dye through the retinal blood vessels.

Abnormal results of an angiogram may display a restricted blood vessel or arterial blood flow (ischemia) or an irregular placement or location of blood vessels. The results of an angiogram vary widely by the type of procedure performed, and should be interpreted by and explained to the patient, by a trained radiologist.

Health care team roles

Angiography is usually performed in a hospital-based imaging department by a trained radiologist and assisting technologist or nurse. Coronary angiography is performed by a cardiologist. It takes place in an angiographic suite, and for most types of angiograms, the patient's vital signs are monitored throughout the procedure.

Resources

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Radiological Society of North America CMEJ *Renal MR Angiography*. <<http://ej.rsna.org/ej3/0091-98.fin/main-right.html>>.

Stephen John Hage, AAAS, RT(R), FAHRA

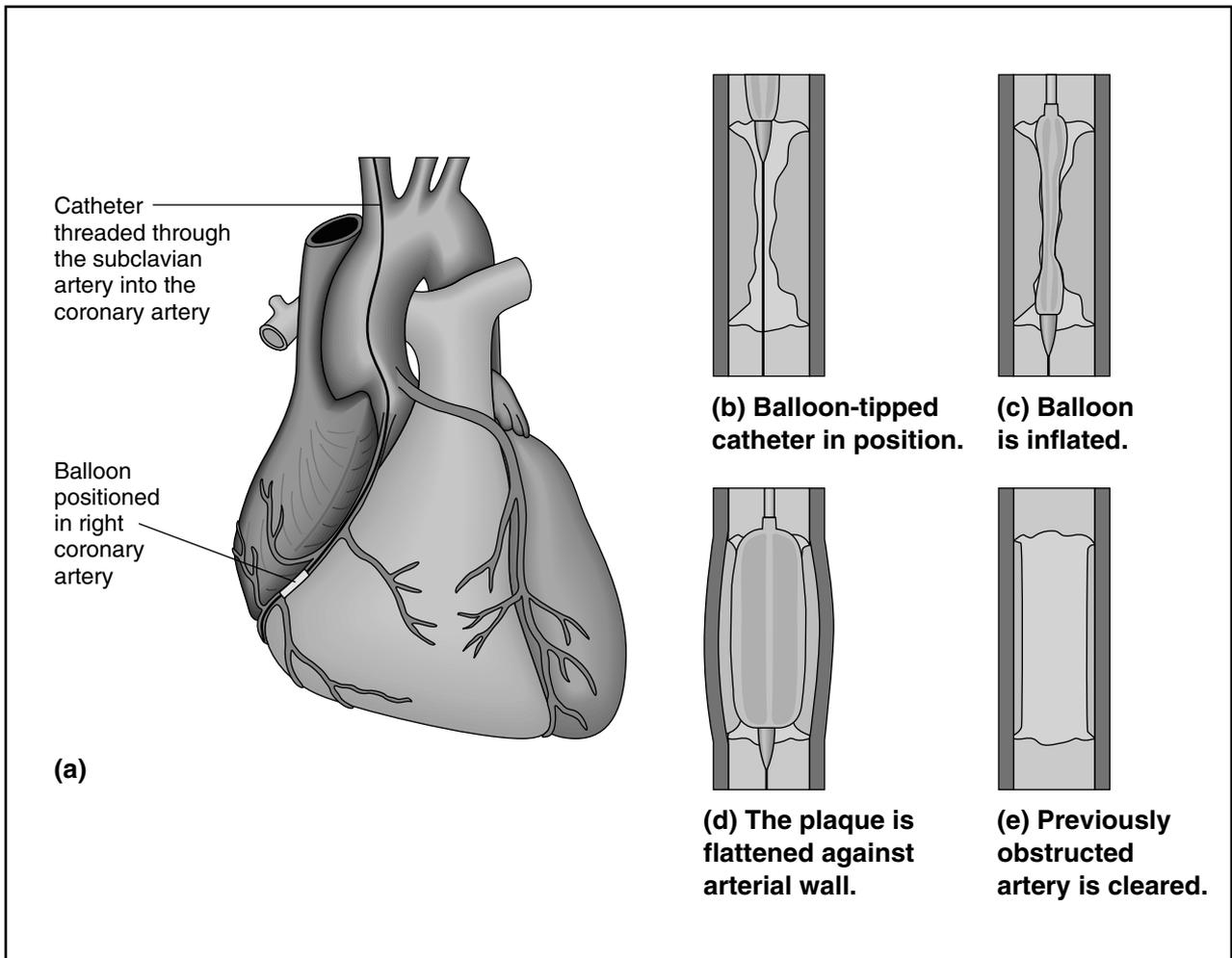
Angioplasty

Definition

Angioplasty is a term describing a procedure used to widen vessels narrowed by stenoses or occlusions. There are various types of these procedures and their names are associated with the type of vessel entry and equipment used. For example, percutaneous transluminal angioplasty (PTA) describes entry through the skin (percutaneous) and navigates to the area of the vessel of interest through the same vessel or one that communicates with it (transluminal). In the case of a procedure involving the coronary arteries, the point of entry could be the femoral artery in the groin and the catheter/guidewire system is passed through the aorta to the **heart** and the origin of the coronary arteries at the base of the aorta just outside the aortic valve.

Purpose

In individuals with an occlusive vascular disease such as atherosclerosis, **blood** flow is impaired to an organ (such as the heart) or to a distal (away from the central portion of the body) body part (such as the lower leg) by the narrowing of the vessel's lumen due to fatty deposits or **calcium** accumulation. This narrowing may occur in any vessel but may occur anywhere. Once the vessel has been widened, adequate blood flow is restored.



Procedure for coronary balloon angioplasty. (Delmar Publishers, Inc. Reproduced by permission.)

The vessel may narrow again over time at the same location and the procedure may then be repeated.

Precautions

Angioplasty procedures are performed on hospital inpatients in facilities for proper monitoring and recovery. If the procedure is to be performed in a coronary artery, the patient's care is likely to be provided by specially trained physicians, nurses, and vascular specialists. Typically, patients are given anticoagulants prior to the procedure to assist in the prevention of thromboses (blood clots). Administration of anticoagulants, however, may impede the sealing of the vascular entry point. The procedure is performed using fluoroscopic guidance and contrast media. Since the decision to perform angioplasty may have been made following a diagnostic angiogram, the patient's sensitivity to iodinated contrast media is likely to be known. The procedure may then require the use of non-ionic contrast agents.

Description

Angioplasty was originally performed by dilating the vessel with the introduction of larger and larger stiff catheters through the narrowed space. Complications of this procedure caused researchers to develop means of widening the vessel using a minimally sized device. Today, catheters contain balloons that are inflated to widen the vessel and stents (devices comprised of a mesh of wire that resembles a "Chinese finger puzzle") to provide structural support for the vessel. Lasers may be used to assist in the break up of the fat or calcium plaque. Catheters may also be equipped with spinning wires or drill tips to clean out the plaque.

Angioplasty may be performed while the patient is sedated or anesthetized, depending on the vessels involved. If a percutaneous transluminal coronary angioplasty (PTCA) is to be performed, the patient is kept awake to report on discomfort and to cough if required.

KEY TERMS

Cardiac catheterization—A procedure to pass a catheter to the heart and its vessels for the purpose of diagnosing coronary artery disease, assessing injury or disease of the aorta, or evaluating cardiac function.

Contrast medium—A substance injected into the body to facilitate the radiographic imaging of internal structures.

EKG—Electrocardiogram, used to study and record the electrical activity of the heart.

Embolus—A gas or air bubble, bit of tissue, blood clot, or foreign object that circulates in the bloodstream until it lodges in a vessel.

Fluoroscopy—A radiologic technique that creates x-ray images of internal body structures for immediate projection on a fluorescent screen.

Hematoma—A collection of blood trapped in the tissues of the skin or in an organ.

Occlusion—A blockage in a vessel.

Plaque—In atherosclerosis, a swollen area in the lining of an artery formed by fatty deposits.

Stenosis—Narrowing or constriction of an opening or passageway.

PTCA procedures are performed in **cardiac catheterization** labs with sophisticated monitoring devices. If angioplasty is performed in the radiology department's angiographic suite, the patient may be sedated for the procedure and a nurse monitors the patient's **vital signs** during the procedure. If performed by a vascular surgeon, the angioplasty procedure is performed in an operating room or specially designed vascular procedure suite.

The site of the introduction of the angioplasty equipment is prepared as a sterile surgical site. Although many procedures are performed by puncturing the vessel through skin, many procedures are also performed by surgically exposing the site of entry. Direct view of the vessel's puncture site aids in monitoring damage to the vessel or excessive bleeding at the site. Once the vessel is punctured and the guidewire is introduced, fluoroscopy is used to monitor small injections of contrast media used to visualize the path through the vessel. If the fluoroscopy system has a feature called "roadmap," the amount of contrast media injected is greater in order to define the full route the guidewire will take. The fluoroscopy system then superimposes subsequent images over the roadmap

while the vessel is traversed, that is, the physician moves the guidewire along the map to the destination.

Having reached the area of stenosis, the physician inflates the balloon on the catheter that has been passed along the guidewire. Balloons are inflated in size and duration depending on the size and location of the vessel. In some cases, a stent may also be used. The vessel may be widened before, during, or after the deployment of the stent. Procedures for deploying stents are dependent on the type of stent used. In cases where the vessel is tortuous (twisted) or at intersections of vessels, the use of a graph may be necessary to provide structural strength to the vessel. Stents, graphs, and balloon dilation may all be used together or separately. Sometimes radiation is used with stents.

The procedure is verified using fluoroscopy and contrast media to produce an angiogram or by using intravascular ultrasound or both. All equipment is withdrawn from the vessel and the puncture site is repaired.

Complications

During the procedure there is a danger of puncturing the vessel with the guidewire. This is a very small risk. Patients must be monitored for hematoma or hemorrhage at the puncture site. There is also a small risk of heart attack, emboli, and, although unlikely, death. Hospitalization varies in length with the patient's overall condition, any complications, and the availability of **home care**.

Health care team roles

Physicians often have specially trained assistants for vascular procedures. These assistants may be nurses, surgical techs, or radiographers. In cardiac catheterization labs, the team also includes a member specially trained in monitoring EKG equipment and vital signs. Angioplasty is a fluoroscopy-guided procedure so a radiographer trained in vascular imaging is also required. Either a nurse, **nurse anesthetist**, or anesthesiologist will administer sedation or anesthesia for the procedure.

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Antacids

Definition

Antacids are medicines that neutralize **stomach** acid.

Purpose

Antacids are used to relieve acid indigestion, upset stomach, sour stomach, and heartburn. Additional components of some formulations include dimethicone, to reduce gas pains (flatulence) and alginic acid, which, in combination with antacids, may help manage GERD (gastroesophageal reflux disease). Antacids should not be confused with gastric acid inhibitors, such as the H-2 receptor blockers (cimetidine, ranitide, and others) or the proton pump inhibitors (lansoprazole, omeprazole, and others). Although all three classes of drugs act to reduce the levels of gastric acid, their mechanisms are different,

and this affects the appropriate use of the drug. Antacids have a rapid onset and short duration of action, and are most appropriate for rapid relief of gastric discomfort for a short period of time.

Antacids may be divided into two classes: those that work by chemical neutralization of gastric acid, most notably sodium bicarbonate; and those that act by adsorption of the acid (non-absorbable antacids), such as **calcium** and magnesium salts.

The chemical antacids show the most rapid onset of action, but may cause “acid rebound,” a condition in which the gastric acid returns in greater concentration after the drug effect has stopped. Also, since these antacids may contain high concentrations of sodium, they may be inappropriate in patients with **hypertension**.

Calcium and magnesium salts act by adsorption of the acid, and are less prone to the rebound effect, but may have other significant disadvantages. These antacids are particularly prone to **drug interactions**, and patients taking other medications must often avoid simultaneous administration of the medications. These antacids are more effective in liquid formulations than in tablet or capsule form, and so may be inconvenient for routine dosing.

The non-absorbable antacids may have additional uses beyond control of hyperacidity. Calcium salts may be used as diet supplements in prevention of **osteoporosis**. Aluminum carbonate is useful for binding phosphate, and has been effective in treatment and control of hyperphosphatemia or for use with a low phosphate diet to prevent formation of phosphate urinary stones. This application is particularly valuable in patients with chronic renal failure. Antacids with aluminum and magnesium hydroxides or aluminum hydroxide alone effectively prevent significant **stress** ulcer bleeding in post-operative patients or those with severe **burns**.

Recommended dosage

The dose depends on the type of antacid. Consult specific references.

When using antacids in chewable tablet form, chew the tablet well before swallowing. Drink a glass of water after taking chewable aluminum hydroxide. Lozenges should be allowed to dissolve completely in the mouth. Liquid antacids should be shaken well before using.

Precautions

Antacids should be avoided if any signs of **appendicitis** or inflamed bowel are present. These include

KEY TERMS

Acid indigestion—Indigestion that results from too much acid in the stomach.

Chronic—A word used to describe a long-lasting condition. Chronic conditions often develop gradually and involve slow changes.

Heartburn—A burning sensation, usually in the center of the chest, near the breastbone.

Indigestion—A feeling of discomfort or illness that results from the inability to properly digest food.

Inflamed bowel—Irritation of the intestinal tract.

Inflammation—Pain, redness, swelling, and heat that usually develop in response to injury or illness.

Pregnancy safety categories—A system for reporting the known safety issues of drugs for use during pregnancy. The ratings range from A, proven safe by well controlled studies, to X, proven harmful.

cramping, **pain**, and soreness in the lower abdomen, bloating, and nausea and vomiting.

Antacids may affect the results of some medical tests, such as those that measure how much acid the stomach produces. Health care providers and patients should keep this in mind when scheduling a medical test.

Antacids that contain magnesium may cause **diarrhea**. Other types of antacids may cause constipation.

Antacids containing sodium bicarbonate should not be taken when the stomach is uncomfortably full from eating or drinking.

Antacids should not be given to children under six years of age.

Antacids that contain calcium or sodium bicarbonate may cause side effects, such as dizziness, nausea, and vomiting, in people who consume large amounts of calcium (from dairy products or calcium supplements). In some cases, this can lead to permanent kidney damage. Before combining antacids with extra calcium, check with a physician.

Some antacids contain large amounts of sodium, particularly sodium bicarbonate (baking soda). Anyone who is on a low-sodium diet should check the list of ingredients or check with a physician or pharmacist before taking an antacid product.

Excessive use of antacids may cause or increase the severity of kidney problems. Calcium based antacids may lead to renal stone formation.

ALLERGIES. **Allergies** to antacids are extremely rare, however the inactive ingredients in some formulations may include dyes or other products with allergic potential.

PREGNANCY. Antacids are not classified under the **pregnancy** safety categories A, B, C, D, and X. Occasional use of antacids in small amounts during pregnancy is considered safe. However, pregnant women should check with their physicians before using antacids or any other medicines. Pregnant women who are consuming extra calcium should be aware that using antacids that contain sodium bicarbonate or calcium can lead to serious side effects.

BREASTFEEDING. Some antacids may pass into breast milk. However, no evidence exists that the ingestion of antacids through breast milk causes problems for nursing babies whose mothers use antacids occasionally.

DRUG INTERACTIONS. Antacids have multiple drug interactions, usually due to inhibition of absorption of other medications. In rare cases, the absorbable antacids may alter the pH of the stomach contents or urine sufficiently to alter drug absorption or excretion. Consult specific references.

Side effects

Side effects are very rare when antacids are taken as directed. They are more likely when the medicine is taken in large doses or over a long time. Minor side effects include a chalky taste, mild constipation or diarrhea, thirst, stomach cramps, and whitish or speckled stools. These symptoms do not need medical attention unless they do not go away or they interfere with normal activities.

Other uncommon side effects may occur. Anyone who has unusual symptoms after taking antacids should get in touch with his or her health care provider.

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Antepartum testing

Definition

Antepartum testing involves the use of **electronic fetal monitoring** (EFM) or ultrasound (US) to assess fetal well-being as determined by the fetal **heart** rate

(FHR) and other characteristics during the antepartum period (the period spanning conception and labor).

Purpose

Antepartum testing can start as early as 24 weeks but usually after 32 weeks of **pregnancy** depending on the status of the mother. It provides a means for the physician and pregnant woman to identify fetal well-being and be alert to any changes that may necessitate additional testing or interventions. The results of testing reflect the functioning of the placenta and its ability to adequately supply **blood** and, therefore, oxygen to the fetus. The testing is done for pregnancies at risk for maternal and/or fetal complications.

Some of these risks include:

- gestational (insulin requiring) diabetes
- intrauterine growth restriction
- chronic **hypertension** or pregnancy induced hypertension
- too little or too much amniotic fluid (oligohydramnios and polyhydramnios, respectively)
- history of unexplained stillbirth
- autoimmune diseases, including systemic lupus erythematosus
- multiple gestation
- placental abnormalities, i.e. partial abruption (a portion of the placenta pulls away from the wall of the uterus) or **placenta previa** (the placenta is covering the cervix and subsequent bleeding occurs)

Antepartum testing is used in low-risk pregnancies to evaluate decreased fetal activity, a lag in fundal height (the height of the fundus, measured from pubic symphysis to the highest point in the midline at the top of the uterus), and a postdate pregnancy. A normal pregnancy is 40 weeks and testing should begin at 41 weeks to assess the status of the placenta, which may be no longer capable of meeting the baby's needs. This can be indicated by the FHR pattern, amniotic fluid status, and fetal movement patterns.

Precautions

Clinicians should only prescribe these tests if they are ready to intervene when faced with ominous data. A fetus is considered viable at 24 weeks, as that is the minimum gestational age for sufficient lung development. There are no significant risks to the mother or the fetus from the nonstress test (NST) or the biophysical profile (BPP). Ultrasound waves utilized for the BPP are painless and safe because this method employs no harmful

radiation. There is no evidence that sound waves cause any harm to the mother or the baby.

Description

The spectrum of fetal assessment includes fetal movement (FM) counting, nonstress test (NST), contraction **stress test** (CST), oxytocin contraction **stress test** (OCT), biophysical profile (BPP), Doppler flow studies, **amniocentesis**, and cordocentesis. Fetal movement can be determined on a daily basis by the pregnant woman who should be instructed to monitor fetal movement between tests by selecting a consistent time of day and documenting how long it takes to feel 10 fetal movements. She should call her health care provider if there are fewer than 10 movements in 10 hours, or if there are no movements in any 10-hour period. She should also be instructed to report significant decreases in fetal activity from the baby's normal pattern. This daily monitoring of FM by the mother is the least expensive and easiest of all antepartum tests to perform.

The nonstress test (NST) is performed with an electronic fetal monitoring (EFM) that traces the fetal heart rate (FHR) and the presence of any contractions on a monitor. The mother reclines with a slight tilt and the EFM is applied to her abdomen by two straps. The NST indirectly provides information about fetal status by the observation of FHR accelerations with fetal movement. If a fetus is not receiving adequate oxygen from the placenta, the FHR will not accelerate, but if the oxygen supply is sufficient, accelerations will be observed. If it is difficult to obtain fetal movements, a vibroacoustic stimulator (VAS) may be used to provide a loud noise that will awaken the fetus and produce the desired results. The minimum amount of time required for an NST is 20 minutes, but, depending upon the conditions, it may take 60–90 minutes to obtain definitive results.

The contraction stress test (CST) is like the NST except the FHR is evaluated in response to contractions as well as for accelerations. A CST requires the presence of three uterine contractions (UCs) within a 10-minute period lasting at least 40 seconds and of moderate intensity. During a contraction, the blood flow to the baby is temporarily restricted, which provides a form of “stress” to the baby. The baby's response to this stressor reveals significant information regarding the oxygen stores available. If contractions are not present, oxytocin can be given to produce contractions or nipple stimulation may be utilized to produce contractions through the release of natural oxytocin.

The biophysical profile (BPP) is done by an ultrasound exam over a 30-minute period and the examiner looks for fetal movement, fetal tone, breathing move-

KEY TERMS

Acceleration—An increase in the fetal heart rate that can indicate normal placental blood flow to the fetus.

Amniocentesis—A procedure by which amniotic fluid is obtained for biochemical determinations, i.e. fetal lung maturity, genetic studies.

Amniotic fluid—The liquid that surrounds the baby within the amniotic sac. It is composed mostly of fetal urine, thus, a decreased amount can indicate inadequate placental blood flow to the fetus.

Cordocentesis—A method of obtaining a fetal blood sample from the umbilical cord, also called percutaneous umbilical blood sampling (PUBS).

Deceleration—A decrease in the fetal heart rate that can indicate inadequate placental blood flow to the fetus.

Doppler flow studies—A procedure for measuring blood flow that is helpful in determining abnormalities.

Oxytocin—A natural hormone that produces uterine contractions.

Ultrasound—A procedure in which high-frequency sound waves are used to create an image of a baby. It can be used alone or with other antepartum testing.

Vibroacoustic stimulation—An artificial larynx that produces a loud noise to stimulate the fetus to wake up. It should not be used more than three times in a testing period.

ments (which the mother can perceive as hiccups), and amniotic fluid volume. A score of 0 or 2 points is assigned to each observation with the NST also adding 2 points for a total possible score of 10 points. The modified BPP includes an NST and the determination of the amniotic fluid index by ultrasound, which relates to the amount of fluid present. A physician performs the Doppler flow studies, amniocentesis, and cordocentesis. The majority of health insurance companies do cover a portion, if not all, of the tests' costs.

Preparation

The health care provider gives a complete explanation to the pregnant woman about the test, what to expect, how long the test may take, what it means, and why it is

being done. It frequently helps if the pregnant woman has eaten prior to undergoing the test.

Aftercare

If the test results are acceptable, the pregnant woman is instructed to continue following her current medical regimen and return for additional testing on the dates prescribed. For NSTs/CSTs, the time period between tests should be no longer three to four days under high-risk conditions. Ultrasounds should be rescheduled as the need dictates per the physician.

Complications

There are no complications per se from the tests themselves with the exception of unfavorable test results or supine (lying horizontally on the back) hypotension secondary to a pregnant woman lying on her back for an ultrasound with resultant vena cava (one of two large veins that return blood from peripheral circulation to the heart) compression.

Results

Usually, a report of normal results for NSTs provides reassurance that the fetus is healthy and should remain so for three to four days, at which time repeat testing will be necessary. A normal NST means the FHR accelerated at least 15 beats above the baseline FHR for 15 seconds within a 20-minute period of time. A non-reactive NST is one that fails to meet this criterion within an 80–90 minute period of time. For an extremely preterm fetus, a normal NST refers to reactive for gestational age or the FHR accelerated 10 beats above the baseline for 10 seconds over a 20–30 minute period. Typically, the **central nervous system** is not completely mature until approximately 32 weeks gestational age and this report takes that into consideration. It is important to remember that a normal result does not guarantee that no problems are present. Although very rare in occurrence, false normal results can be observed.

The CST results are reported as a reactive/negative, suspicious, or positive or non-reactive/negative, suspicious, or positive. The reactive/nonreactive part of the test report refers to the presence or absence of accelerations and the negative part refers to no decelerations being present with UCs. Suspicious and positive refer to the presence of decelerations with UCs. This result requires further evaluation, i.e. prolonged EFM monitoring or a BPP. A normal BPP report is 8-10 points. Six points is suspicious and requires either a CST or a repeat BPP within 24 hours. A total of 4 points is not reassuring and requires immediate evaluation by prolonged EFM.

All results are given to the primary physician who must then make a decision as to the appropriate course of action. Abnormal CST results usually indicate the baby is not receiving sufficient oxygen and may not be able to withstand the stress of labor and vaginal delivery. If this is the case, a cesarean section may be performed. The final outcome depends on the mother's individual circumstances, i.e. severe pregnancy induced hypertension may require immediate delivery via cesarean section, and an extra large fetus of a diabetic mother may require the same. In some cases, medications may be given to the mother for her condition, and to speed up the lung maturity of the baby. If the mother's cervix is favorable for induction, labor may be induced.

Health care team roles

The physician is the head of a health team of interdisciplinary members and determines the medical regimen necessary for the pregnant woman, depending on whether the pregnancy is normal or high-risk. Nurses schedule the tests and provide the woman with the necessary information regarding the tests. Nurses must perform any tests that they conduct correctly, interpret them appropriately, and provide the necessary follow-up or interventions. They may utilize this time period with the woman for teaching, answering questions, and offering emotional support. The ultrasonographer performs the BPP and reports the results directly to the physician.

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ORGANIZATIONS

- National Perinatal Association. 3500 East Fletcher Avenue, Suite 205, Tampa, FL 33613-4712. (888) 971-3295.

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Antianxiety drugs

Definition

Antianxiety drugs are medicines that calm and relax people with excessive **anxiety**, nervousness, or tension, or for short term control of social phobia disorder or specific phobia disorder.

Purpose

Antianxiety agents, or anxiolytics, may be used to treat mild transient bouts of anxiety as well as more pronounced episodes of social phobia and specific phobia. Clinically significant anxiety is marked by several symptoms. The patient experiences marked or persistent fear of one or more social or performance situations in which he or she is exposed to unfamiliar people or possible scrutiny by others, and may react in a humiliating or embarrassing way. The exposure to the feared situation produces an anxiety attack. Fear of these episodes of anxiety leads to avoidance behavior, which impairs normal social functioning, including working or attending classes. The patient is aware that these fears are unjustified.

Description

In psychiatric practice, treatment of anxiety has largely turned from traditional antianxiety agents, anxiolytics, to antidepressant therapies. In current use, the benzodiazepines, the best known class of anxiolytics, have been largely supplanted by serotonin-specific reuptake inhibitors (SSRIs, citalopram, fluoxetine, fluvoxamine, and others) which have a milder side effect profile and less risk of dependency. However, traditional anxiolytics remain useful for patients who need a rapid onset of action, or whose frequency of exposure to anxiety provoking stimuli is low enough to eliminate the need for continued treatment. While SSRIs may require three to five weeks to show any effects, and must be taken continuously, benzodiazepines may produce a response within 30 minutes, and may be dosed on an as-needed basis.

The intermediate action benzodiazepines, alprazolam (Xanax), and lorazepam (Ativan) are the appropriate choice for treatment of mild anxiety and social phobia. Diazepam (Valium) is still widely used for anxiety, but its active metabolite, desmethyldiazepam, which has a long half-life, may make this a poorer choice than other drugs in its class. Note that there is considerable variation between individuals in **metabolism** of benzodiazepines, so patient response may not be predictable. As a class, benzodiazepines are used not only as anxiolytics, but also as sedatives, **muscle relaxants**, and in treatment of

ANTIANSXIETY DRUGS	
<i>Brand Name (Generic Name)</i>	<i>Possible Common Side Effects Include:</i>
Atarax (hydroxyzine hydrochloride)	Drowsiness, dry mouth
Ativan (lorazepam)	Dizziness, excessive calm, weakness
BuSpar, Buspirone (buspirone hydrochloride)	Dry mouth, dizziness, headache, fatigue, nausea
Centrax (prazepam)	Decreased coordination, dizziness, drowsiness, fatigue, weakness
Librium, Libritabs (chlordiazepoxide)	Constipation, drowsiness, nausea, swelling
Miltown, Equanil (meprobamate)	Diarrhea, bruising, fever, headache, nausea, rash, slurred speech
Serax (oxazepam)	Dizziness, fainting, headache, liver problems, decreased coordination, nausea, swelling, vertigo
Stelazine (trifluoperazine hydrochloride)	Abnormal glucose in urine, allergic reactions, blurred vision, constipation, eye spasms, fluid retention and swelling
Tranxene, Tranxene-SD (clorazepate dipotassium)	Drowsiness
Valium (diazepam)	Decreased coordination, drowsiness, light-headedness

(Illustration by Standley Publishing. Courtesy of Gale Group.)

epilepsy and **alcoholism**. The distinctions between these uses are largely determined by onset and duration of action, and route of administration.

Buspirone (BuSpar), which is not chemically related to other classes of **central nervous system** drugs, is also a traditional anxiolytic, although it is now considered either a third line or adjunctive agent for use after trials of SSRIs and benzodiazepines. It is appropriate for use in patients who have either failed trials of other treatments, or who should not receive benzodiazepines because of a history of substance abuse problems. Buspirone, in common with antidepressants, requires a two to three week period before there is clinical evidence of improvement, and must be continuously dosed to maintain its effects.

Benzodiazepines are controlled drugs under federal law. Buspirone is not a controlled substance and has no established abuse potential.

Recommended dosage

Benzodiazepines should be administered 30 to 60 minutes before exposure to the anticipated **stress**. Dosage should be individualized to minimize sedation. The normal dose of alprazolam is 0.25–0.5 mg. The usual dose of lorazepam is 2–3 mg. Doses may be repeated if necessary.

Buspirone is initially dosed at 5 mg t.i.d. (3 times a day.) Increase the dosage 5 mg/day, at intervals of two to three days, as needed. Do not exceed 60 mg/day. Two to three weeks may be required before a satisfactory response is seen.

Precautions

Benzodiazepines should not be used in patients with psychosis, acute narrow angle **glaucoma**, or **liver** disease. The drugs can act as respiratory depressants and should be avoided in patients with respiratory conditions. Benzodiazepines are potentially addictive and should not be administered to patients with substance abuse disorders. Because benzodiazepines are sedative, they should be avoided in patients who must remain alert. Their use for periods over four months has not been documented. These drugs should not be used during the second and third trimester of **pregnancy**, although use during the first trimester appears to be safe. They should not be taken while breastfeeding. Consult specialized references for use in children.

Buspirone is metabolized by the liver and excreted by the kidney, and should be used with care in patients with hepatic or renal disease. The drug is classified as schedule B during pregnancy, but should not be taken

KEY TERMS

Anxiety—Worry or tension in response to real or imagined stress, danger, or dreaded situations. Physical reactions, such as fast pulse, sweating, trembling, fatigue, and weakness may accompany anxiety.

Epilepsy—A brain disorder with symptoms that include seizures.

Panic disorder—An disorder in which people have sudden and intense attacks of anxiety in certain situations. Symptoms such as shortness of breath, sweating, dizziness, chest pain, and extreme fear often accompany the attacks.

Phobia—An intense, abnormal, or illogical fear of something specific, such as heights or open spaces.

Pregnancy category B—Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies.

Pregnancy category C—No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data.

Seizure—A sudden attack, spasm, or convulsion.

during breastfeeding. Its use in children under the age of 18 years has not been studied.

Drug interactions

The metabolism of alprazolam may be increased by: cimetidine, oral contraceptives, disulfiram, fluoxetine, isoniazid, ketoconazole, metoprolol, propoxyphene, propranolol and valproic acid. The absorption of all benzodiazepines is inhibited by concomitant use of **antacids**. Benzodiazepines may increase **blood** levels of digoxin, and reduce the efficacy of levodopa. Other **drug interactions** have been reported.

Buspirone levels will be increased by concomitant use of erythromycin, itraconazole, and nefazadone. Doses should be adjusted based on clinical response. Use of buspirone at the same time as mono-amine oxidase inhibitors (MAOIs, phenelzine, tranylcypromine) may cause severe **blood pressure** elevations. Use of buspirone with MAOIs should be avoided.



Valium is an antianxiety drug. (Photograph by Van Bucher. Photo Researchers, Inc. Reproduced by permission.)

Side effects

The most common side effects of benzodiazepines are secondary to their CNS effects and include sedation and sleepiness; depression; lethargy; apathy; fatigue; hypoactivity; lightheadedness; **memory** impairment; disorientation; anterograde amnesia; restlessness; confusion; crying or sobbing; delirium; headache; slurred speech; aphonia; **dysarthria**; stupor; seizures; **coma**; **syncope**; rigidity; tremor; dystonia; vertigo; dizziness; euphoria; nervousness; irritability; difficulty in concentration; agitation; inability to perform complex mental functions; akathisia; hemiparesis; hypotonia; unsteadiness; ataxia; incoordination; weakness; vivid dreams; psychomotor retardation; “glassy-eyed” appearance; extrapyramidal symptoms; paradoxical reactions. Other reactions include changes in **heart** rate and blood pressure, changes in bowel function, severe skin rash and changes in genitourinary function. Other adverse effects have been reported.

Buspirone has a low incidence of side effects. Dizziness and drowsiness are the most commonly reported adverse effects. Other CNS effects include dream disturbances; depersonalization, dysphoria, noise intolerance, euphoria, akathisia, fearfulness, loss of interest, disassociative reaction, hallucinations, suicidal ideation, seizures; feelings of claustrophobia, cold intolerance, stupor and slurred speech, psychosis. Rarely, heart problems, including congestive **heart failure** and **myocardial infarction**, have been reported. Other adverse effects have been reported.

Samuel Uretsky, PharmD

Antibiotics

Definition

Antibiotics may be informally defined as the subgroup of anti-infectives that are derived from bacterial sources and are used to treat bacterial infections. Other classes of drugs, most notably the sulfonamides, may be effective antibacterials. Similarly, some antibiotics may have secondary uses, such as the use of demeclocycline (Declomycin, a tetracycline derivative) to treat the syndrome of inappropriate antidiuretic hormone (SIADH) secretion. Other antibiotics may be useful in treating protozoal infections.

Purpose

Antibiotics are used for treatment or prevention of bacterial **infection**.

Description

Although there are several classification schemes for antibiotics, based on bacterial spectrum (broad versus narrow) or route of administration (injectable versus oral versus topical), or type of activity (bactericidal vs. bacteriostatic), the most useful is based on chemical structure. Antibiotics within a structural class will generally show similar patterns of effectiveness, toxicity, and allergic potential.

Penicillins

The penicillins are the oldest class of antibiotics, and have a common chemical structure which they share with the cephalosporins. The two groups are classed as the beta-lactam antibiotics, and are generally bacteriocidal—that is, they kill **bacteria** rather than inhibiting growth. The penicillins can be further subdivided. The natural penicillins are based on the original penicillin G structure; penicillinase-resistant penicillins, notably methicillin and oxacillin, are active even in the presence of the bacterial enzyme that inactivates most natural penicillins. Aminopenicillins such as ampicillin and amoxicillin have an extended spectrum of action compared with the natural penicillins; extended spectrum penicillins are effective against a wider range of bacteria. These generally include coverage for *Pseudomonas aeruginosa* and may provide the penicillin in combination with a penicillinase inhibitor.

Cephalosporins

Cephalosporins and the closely related cephamycins and carbapenems, like the penicillins, contain a beta-lactam chemical structure. Consequently, there are patterns

of cross-resistance and cross-allergenicity among the drugs in these classes. The “cepha” drugs are among the most diverse classes of antibiotics, and are themselves subgrouped into 1st, 2nd and 3rd generations. Each generation has a broader spectrum of activity than the one before. In addition, ceftiofex, a cephamycin, is highly active against anaerobic bacteria, which offers utility in treatment of abdominal infections. The 3rd generation drugs, cefotaxime, ceftizoxime, ceftriaxone and others, cross the blood-brain barrier and may be used to treat **meningitis** and encephalitis. Cephalosporins are the usually preferred agents for surgical prophylaxis.

Fluoroquinolones

The fluoroquinolones are synthetic antibacterial agents, and not derived from bacteria. They are included here because they can be readily interchanged with traditional antibiotics. An earlier, related class of antibacterial agents, the quinolones, were not well absorbed, and could be used only to treat urinary tract infections. The fluoroquinolones, which are based on the older group, are broad-spectrum bacteriocidal drugs that are chemically unrelated to the penicillins or the cephalosporins. They are well distributed into bone tissue, and so well absorbed that in general they are as effective by the oral route as by intravenous infusion.

Tetracyclines

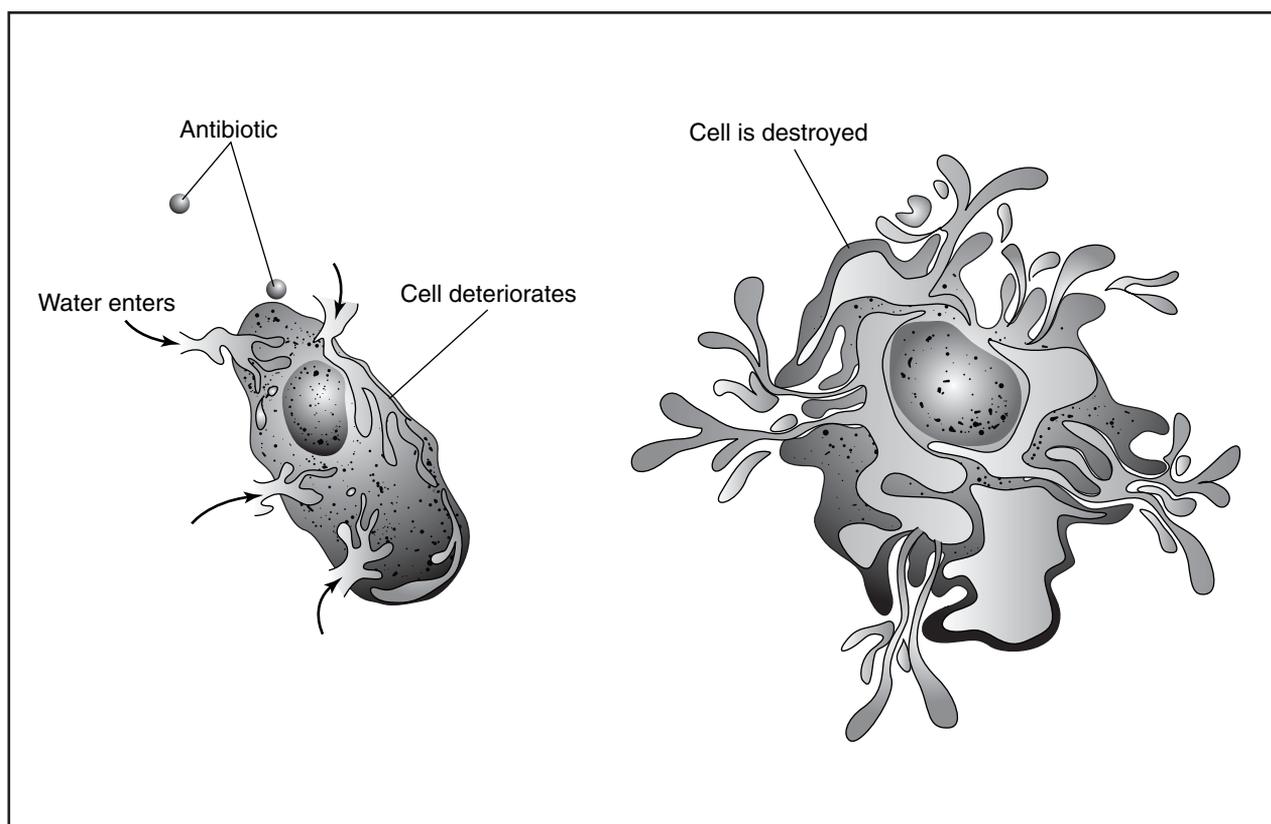
Tetracyclines got their name because they share a chemical structure which has four rings. They are derived from a species of *Streptomyces* bacteria. Broad-spectrum bacteriostatic agents, the tetracyclines may be effective against a wide variety of microorganisms, including rickettsia and amebic parasites.

Macrolides

The macrolide antibiotics are derived from *Streptomyces* bacteria, and got their name because they all have a macrocyclic lactone chemical structure. Erythromycin, the prototype of this class, has a spectrum and use similar to penicillin. Newer members of the group, azithromycin and clarithromycin, are particularly useful for their high level of lung penetration. Clarithromycin has been widely used to treat *Helicobacter pylori* infections, the cause of **stomach** ulcers.

Others

Other classes of antibiotics include the aminoglycosides, which are particularly useful for their effectiveness in treating *Pseudomonas aeruginosa* infections; the lincosamides, clindamycin and lincomycin, which are highly active against anaerobic pathogens. There are



Different antibiotics destroy bacteria in different ways. Some short-circuit the processes by which bacteria receive energy. Others disturb the structure of the bacterial cell wall, as shown in the illustration above. Still others interfere with the production of essential proteins. (Illustration by Electronic Illustrators Group.)

other, individual drugs which may have utility in specific infections.

Recommended dosage

Dosage varies with drug, route of administration, pathogen, site of infection, and severity. Additional considerations include renal function, age of patient, and other factors. Consult manufacturers' recommendations for dose and route.

Side effects

All antibiotics cause risk of overgrowth by non-susceptible bacteria. Manufacturers list other major hazards by class; however, the health care provider should review each drug individually to assess the degree of risk. Generally, breastfeeding is not recommended while taking antibiotics because of risk of alteration to infant's intestinal flora, and risk of masking infection in the infant. Excessive or inappropriate use may promote growth of resistant pathogens.

Penicillins: Hypersensitivity may be common, and cross allergenicity with cephalosporins has been reported. Penicillins are classed as category B during **pregnancy**.

Cephalosporins: Several cephalosporins and related compounds have been associated with seizures. Cefmetazole, cefoperazone, cefotetan and ceftriaxone may be associated with a fall in prothrombin activity and coagulation abnormalities. Pseudomembranous colitis has been reported with cephalosporins and other broad spectrum antibiotics. Some drugs in this class may cause renal toxicity. Pregnancy category B.

Fluroquinolones: Lomefloxacin has been associated with increased photosensitivity. All drugs in this class have been associated with convulsions. Pregnancy category C.

Tetracyclines: Demeclocycline may cause increased photosensitivity. Minocycline may cause dizziness. Do not use tetracyclines in children under the age of eight, and specifically avoid during periods of tooth development. Oral tetracyclines bind to anions such as **calcium** and **iron**. Although doxycycline and minocycline may be taken with meals, patients must be advised to take other

KEY TERMS

Bacteria—Tiny, one-celled forms of life that cause many diseases and infections.

Inflammation—Pain, redness, swelling, and heat that usually develop in response to injury or illness.

Meningitis—Inflammation of tissues that surround the brain and spinal cord.

Microorganism—An organism that is too small to be seen with the naked eye.

Organism—A single, independent unit of life, such as a bacterium, a plant or an animal.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

tetracycline antibiotics on an empty stomach, and not to take the drugs with milk or other calcium-rich foods. Expired tetracycline should never be administered. Pregnancy category D. Use during pregnancy may cause alterations in bone development.

Macrolides: Erythromycin may aggravate the weakness of patients with myasthenia gravis. Azithromycin has, rarely, been associated with allergic reactions, including angioedema, **anaphylaxis**, and dermatologic reactions, including Stevens-Johnson syndrome and toxic epidermal necrolysis. Oral erythromycin may be highly irritating to the stomach and when given by injection may cause severe phlebitis. These drugs should be used with caution in patients with **liver** dysfunction. Pregnancy category B: Azithromycin, erythromycin. Pregnancy category C: Clarithromycin, dirithromycin, troleandomycin.

Aminoglycosides: This class of drugs causes kidney and ototoxicity. These problems can occur even with normal doses. Dosing should be based on renal function, with periodic testing of both kidney function and **hearing**. Pregnancy category D.

Interactions

Consult specialized references.

Recommended usage

To minimize risk of adverse reactions and development of resistant strains of bacteria, antibiotics should be restricted to use in cases where there is either known or a reasonable presumption of bacterial infection. The use of antibiotics in viral infections is to be avoided. Avoid use of fluoroquinolones for trivial infections.

In severe infections, presumptive therapy with a broad-spectrum antibiotic such as a third generation cephalosporin may be appropriate. Treatment should be changed to a narrow spectrum agent as soon as the pathogen has been identified. After 48 hours of treatment, if there is clinical improvement, an oral antibiotic should be considered.

When the pathogen is known or suspected to be *Pseudomonas*, use a suitable beta-lactam drug in combination with an aminoglycoside. Do not rely on a single agent for treatment of *Pseudomonas*. When the patient has renal insufficiency, consider azactam in place of the aminoglycoside.

In treatment of children with antibiotic suspensions, caregivers should be instructed in use of oral syringes or measuring teaspoons. Household teaspoons are not standardized and will give unreliable doses.

Resources

PERIODICALS

- Braffman-Miller, Judith. "Beware the Rise of Antibiotic-Resistant Microbes." *USA Today (Magazine)* 125 (March 1997): 56.
- "Consumer Alert: Antibiotic Resistance Is Growing!" *People's Medical Society Newsletter* 16 (August 1997): 1.
- Swartz, Morton N. "The Path of Least Resistance." *Harvard Health Letter* 20 (April 1995): 6.

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Antibody screening see **Type and screen**

Anticancer drugs

Definition

Anticancer, or antineoplastic, drugs are used to treat malignancies, cancerous growths. Drug therapy may be

used alone, or in combination with other treatments such as surgery or radiation therapy.

Purpose

Anticancer drugs are used to control the growth of cancerous cells. **Cancer** is commonly defined as the uncontrolled growth of cells, with loss of differentiation and commonly, with metastasis, spread of the cancer to other tissues and organs. Cancers are malignant growths. In contrast, benign growths remain encapsulated and grow within a well-defined area. Although benign tumors may be fatal if untreated, due to pressure on essential organs, as in the case of a benign **brain tumor**, surgery or radiation are the preferred methods of treating growths which have a well defined location. Drug therapy is used when the tumor has spread, or may spread, to all areas of the body.

Description

Several classes of drugs may be used in cancer treatment, depending on the nature of the organ involved. For example, breast cancers are commonly stimulated by estrogens, and may be treated with drugs which inactive the sex hormones. Similarly, **prostate cancer** may be treated with drugs that inactivate androgens, the male sex hormone. However, the majority of antineoplastic drugs act by interfering with cell growth. Since cancerous cells grow more rapidly than other cells, the drugs target those cells which are in the process of reproducing themselves. As a result, antineoplastic drugs will commonly affect not only the cancerous cells, but others cells that commonly reproduce quickly, including hair follicles, ovaries and testis, and the blood-forming organs.

Newer approaches to antineoplastic drug therapy have taken different approaches, including angiogenesis—the inhibition of formation of **blood vessels** feeding the tumor and contributing to tumor growth. Although these approaches hold promise, they are not yet in common use.

Antineoplastic drugs may be divided into two classes: cycle specific and non-cycle specific. Cycle specific drugs act only at specific points of the cell's duplication cycle, such as anaphase or metaphase, while non-cycle specific drugs may act at any point in the cell cycle. In order to gain maximum effect, antineoplastic drugs are commonly used in combinations.

Precautions

Because antineoplastic agents do not target specific cell types, they have a number of common adverse side

effects. Hair loss is common due to the effects on hair follicles, and anemia, **immune system** impairment, and clotting problems are caused by destruction of the **blood** forming organs, leading to reduction in the number of red cells, white cells, and platelets. Because of the frequency and severity of these side effects, it is common to administer **chemotherapy** in cycles, allowing time for recovery from the drug effects before administering the next dose. Doses are often calculated, not on the basis of weight, but rather based on blood counts, in order to avoid dangerous levels of anemia (red cell depletion), neutropenia (white cell deficiency), or thrombocytopenia (platelet deficiency).

Nausea and vomiting are among the most common adverse effects of cancer chemotherapy, and in some cases may be severe enough to cause dose reduction or discontinuation of treatment. The health professional has many responsibilities in dealing with patients undergoing chemotherapy. The patient must be well informed of the risks and benefits of chemotherapy, and must be emotionally prepared for the side effects. These may be permanent, and younger patients should be aware of the high risk of sterility after chemotherapy.

The patient must also know which side effects should be reported to the practitioner, since many adverse effects do not appear until several days after a dose of chemotherapy. When chemotherapy is self-administered, the patient must be familiar with proper use of the drugs, including dose scheduling and avoidance of drug-drug and food-drug interactions.

Appropriate steps should be taken to minimize side effects. These may include administration of anti-nauseant medications to reduce nausea and vomiting, maintaining fluid levels to reduce drug toxicity, particularly to the **kidneys**, or application of a scalp tourniquet to reduce blood flow to the scalp and minimize hair loss due to drug therapy.

Patients receiving chemotherapy are also at risk of infections due to reduced white blood counts. While prophylactic **antibiotics** may be useful, the health care professional should also be sure to use standard precautions, including gowns and gloves when appropriate. Patients should be alerted to avoid risks of viral contamination, and live virus immunizations are contraindicated until the patient has fully recovered from the effects of chemotherapy. Similarly, the patient should avoid contact with other people who have recently had live virus immunizations.

Other precautions which should be emphasized are the risks to pregnant or nursing women. Because antineoplastic drugs are commonly harmful to the fetus, women of childbearing potential should be cautioned to

ANTI CANCER DRUGS		
Generic (Brand Name)	Clinical Uses	Common Side Effects To Drug
Altretamine (Hexalen)	Treatment of advanced ovarian cancer	Bone marrow depression, nausea and vomiting
Asparaginase (Elspar)	Commonly used in combination with other drugs; refractory acute lymphocytic leukemia	Liver, kidney, pancreas, CNS abnormalities,
Bleomycin (Blenoxane)	Lymphomas, Hodgkin's disease, testicular cancer	Hair loss, stomatitis, pulmonary toxicity, hyperpigmentation of skin
Busulfan (Myleran)	Chronic granulocytic leukemia	Bone marrow depression, pulmonary toxicity
Carboplatin (Paraplatin)	Palliation of ovarian cancer	Bone marrow depression, nausea and vomiting
Carmustine	Hodgkin's disease, brain tumors, multiple myeloma, malignant melanoma	Bone marrow depression, nausea and vomiting, toxic damage to liver
Chlorambucil (Leukeran)	Chronic lymphocytic leukemia, non-Hodgkin's lymphomas, breast and ovarian cancer	Bone marrow depression, excess uric acid in blood
Cisplatin (Platinol)	Treatment of bladder, ovarian, uterine, testicular, head and neck cancers	Renal toxicity and ototoxicity
Cladribine (Leustatin)	Hairy cell leukemia	Bone marrow depression, nausea and vomiting, fever
Cyclophosphamide (Cytoxan)	Hodgkin's disease, non-Hodgkin's lymphomas, neuroblastoma. Often used with other drugs for breast, ovarian, and lung cancers; acute lymphoblastic leukemia in children; multiple myeloma	Bone marrow depression, hair loss, nausea and vomiting, inflammation of the bladder
Cytarabine (Cytosar-U)	Leukemias occurring in adults and children	Bone marrow depression, nausea and vomiting, diarrhea, stomatitis
Dacarbazine (DTIC-Dome)	Hodgkin's disease, malignant melanoma	Bone marrow depression, nausea and vomiting
Diethylstilbestrol (DES) (Stilbestrol)	Breast cancer in post-menopausal women, prostate cancer	Hair loss, nausea and vomiting, edema, excess calcium in blood; feminizing effects in men
Ethinyl estradiol (Estinyl)	Advanced breast cancer in post-menopausal women, prostate cancer	Excess calcium in blood, anorexia, edema, nausea and vomiting; feminizing effects in men
Etoposide (VePesid)	Acute leukemias, lymphomas, testicular cancer	Bone marrow depression, nausea and vomiting, hair loss

(Illustration by Standley Publishing. Courtesy of Gale Group.)

ANTI CANCER DRUGS (continued)		
Generic (Brand Name)	Clinical Uses	Common Side Effects To Drug
Floxuridine (FUDR)	Cancers of the liver, pancreas, GI and biliary tract, head and neck tumors	See Cytarabine
Fludarabine (Fludara)	Chronic lymphocytic leukemia	Bone marrow depression, nausea and vomiting, fever
Fluorouracil (5-FU) (Adrucil)	Breast, colon, pancreatic cancer, cancer of the rectum and stomach	See Cytarabine
Flutamide (Eulexin)	Advanced prostate cancer	Nausea and vomiting, hot flashes, diarrhea, impotence, decreased libido, gynecomastia
Goserelin (Zoladex)	Advanced prostate cancer	Pain in bones
Hydroxyurea (Hydrea)	Chronic granulocytic leukemia, malignant melanoma	Bone marrow depression, gastrointestinal irritation
Idarubicin (Idamycin)	Used in combination with other antileukemic drugs, acute myelogenous leukemia	See Doxorubicin
Ifosfamide (Ifex)	Germ cell testicular cancer	Bone marrow depression, nausea and vomiting, inflammation of the bladder
Leuprolide (Lupron)	Advanced prostate cancer	See Goserelin
Levamisole (Ergamisol)	Used in conjunction with Fluorouracil to treat colon cancer	Diarrhea, dermatitis, nausea and vomiting
Lomustine	Brain tumors, Hodgkin's disease	Bone marrow depression, nausea and vomiting, toxic damage to liver
Mechlorethamine (Mustargen)	Lung cancer, Hodgkin's disease and non-Hodgkin's lymphomas	Bone marrow depression, nausea and vomiting
Medroxyprogesterone (Depo-Provera)	Advanced uterine cancer	May cause edema
Megestrol (Megace)	Advanced uterine cancer, breast cancer	Masculinizing effects
Melphalan (Alkeran)	Multiple myeloma	Bone marrow depression, nausea and vomiting
Mercaptopurine (Purinethol)	Acute and chronic leukemias	Bone marrow depression, nausea, excess uric acid in blood
Methotrexate (Mexate)	Acute lymphoblastic leukemias in children, bone cancer, choriocarcinoma of the testes	Bone marrow depression, diarrhea, nausea, stomatitis

(Illustration by Standley Publishing. Courtesy of Gale Group.)

ANTI CANCER DRUGS (continued)		
Generic (Brand Name)	Clinical Uses	Common Side Effects To Drug
Mitomycin (Mutamycin)	Bladder, breast, colon, lung, pancreas, rectum cancers, head and neck cancer, malignant melanoma	Bone marrow depression, nausea and vomiting, diarrhea, stomatitis, possible tissue damage
Mitotane (Lysodren)	Cancer of the adrenal cortex (inoperable)	Damage to adrenal cortex, nausea, anorexia
Mitoxantrone (Novantrone)	Acute nonlymphocytic leukemia	Cardiac arrhythmias, labored breathing, nausea and vomiting, diarrhea, fever, congestive heart failure
Paclitaxel (Taxol)	Advanced ovarian cancer	Bone marrow depression, hair loss, nausea and vomiting, hypotension, allergic reactions, slow heart action, muscle and joint pain
Pentastatin (Nipent)	Hairy cell leukemia unresponsive to alpha-interferon	Bone marrow depression, fever, skin rash, liver damage, nausea and vomiting
Pipobroman (Vercyte)	Chronic granulocytic leukemia	Bone marrow depression
Plicamycin (Mithracin)	Testicular tumors	Toxicity/damage to bone marrow, kidneys, and liver
Prednisone (Meticorten)	Used in adjunct therapy for palliation of symptoms in lymphomas, acute leukemia, Hodgkin's disease	May be toxic to all body systems
Procarbazine (Matulane)	Hodgkin's disease	Bone marrow depression, nausea and vomiting
Streptozocin (Zanosar)	Islet cell carcinoma of pancreas	Nausea and vomiting, toxicity to kidneys
Tamoxifen (Nolvadex)	Advanced breast cancer in post menopausal	Nausea and vomiting, ocular toxicity, hot flashes
Teniposide (Vumon)	Acute lymphocytic leukemia in children	See Etoposide
Vinblastine (Velban)	Breast cancer, Hodgkin's disease, metastatic testicular cancer	Bone marrow depression, neurotoxicity
Vincristine (Oncovin)	Acute leukemia, Hodgkin's disease, lymphomas	Constipation, neurotoxicity, possible tissue necrosis

(Illustration by Standley Publishing. Courtesy of Gale Group.)

use two effective methods of birth control while receiving cancer chemotherapy. This also applies if the woman's male partner is receiving chemotherapy. Breastfeeding should be avoided while the mother is being treated.

Before prescribing or administering anticancer drugs, health care providers should inquire whether the patient has any of the following conditions:

- chickenpox or recent exposure to someone with chickenpox
- shingles (herpes zoster)
- mouth sores
- current or past seizures
- head injury
- nerve or muscle disease
- hearing problems
- infection of any kind
- gout
- colitis
- intestine blockage
- stomach ulcer
- kidney stones
- kidney disease
- liver disease
- current or past alcohol abuse
- immune system disease
- **cataracts** or other eye problems
- high cholesterol

Other precautions

The anticancer drug methotrexate has additional precautions. Patients should be given advice on the effects of sun exposure and the use of alcohol and **pain** relievers.

Side effects

Tamoxifen

The anticancer drug tamoxifen (Nolvadex) increases the risk of cancer of the uterus in some women. It also causes cataracts and other eye problems. Women taking this drug may have hot flashes, menstrual changes, genital itching, vaginal discharge, and weight gain. Men who take tamoxifen may lose interest in sex or become impotent. Health care providers should keep in close contact with patients to assess the individual risks associated with taking this powerful drug.

Other anticancer drugs

These side effects are not common, but could be a sign of a serious problem. Health care providers should immediately be consulted if any of the following occur:

- black, tarry, or bloody stools
- blood in the urine
- diarrhea
- fever or chills
- cough or hoarseness
- wheezing or shortness of breath
- sores in the mouth or on the lips
- unusual bleeding or bruising
- swelling of the face
- red “pinpoint” spots on the skin
- redness, pain, or swelling at the place on the body where an injectable anticancer drug is given
- pain in the side or lower back
- problems urinating or painful urination
- dizziness or faintness
- fast or irregular heartbeat

Other side effects do not need immediate care, but should have medical attention. They are:

- joint pain
- skin rash
- hearing problems or ringing in the ears
- numbness or tingling in the fingers or toes
- trouble walking or balance problems
- swelling of the feet or lower legs
- unusual tiredness or weakness
- loss of **taste**
- seizures
- dizziness
- confusion
- agitation
- headache
- dark urine
- yellow eyes or skin
- flushing of the face

In addition, there are other possible side effects that do not need medical attention unless they persist or interfere with normal activities. These include changes in

KEY TERMS

Cataract—Clouding of the lens of the eye, leading to poor vision or blindness.

Impotent—Unable to achieve or maintain an erection of the penis.

menstrual period, itchy skin, nausea and vomiting, and loss of appetite.

Other rare side effects may occur. Anyone who has unusual symptoms after taking anticancer drugs should contact the physician who prescribed the medication.

Interactions

Anticancer drugs may interact with a number of other medicines. When this happens, the effects of one or both of the drugs may change or the risk of side effects may be greater. The health care provider should be aware of all other prescription or non-prescription (over-the-counter) medicines a patient is taking. The primary care provider should also be told if the patient has been treated with radiation or has taken other anticancer drugs.

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Anticholinergic drugs see **Antiparkinson drugs**

Antidepressant drugs

Definition

Antidepressant drugs are medicines that relieve symptoms of **depressive disorders**.

Purpose

Depressive disorders may be either unipolar (depression alone) or bipolar (depression alternating with periods of extreme excitation). The formal diagnosis requires a cluster of symptoms lasting at least two weeks. These symptoms include, but are not limited to mood changes, insomnia or hypersomnia, and diminished interest in daily activities. The symptoms are not caused by any medical condition, drug side effect, or adverse life event. The condition is severe enough to cause clinically signif-

icant distress or impairment in social, occupational, or other important areas of functioning.

Secondary depression, depression caused by unfavorable life events, is normally self limiting, and may be best treated with cognitive/behavioral therapy rather than drugs.

Description

Antidepressant agents act by increasing the levels of excitatory neurotransmitters. The main types of antidepressant drugs in use today are:

- tricyclic antidepressants, such as amitriptyline (Elavil), imipramine (Tofranil), nortriptyline (Pamelor)
- selective serotonin reuptake inhibitors (SSRIs or serotonin boosters), such as fluoxetine (Prozac), paroxetine (Paxil), and sertraline (Zoloft)
- monoamine oxidase inhibitors (MAO inhibitors), such as phenelzine (Nardil), and tranylcypromine (Parnate)
- tetracyclic compounds and atypical antidepressants that do not fall into any of the above categories

Selective serotonin reuptake inhibitors maintain levels of the excitatory neurohormone serotonin in the **brain**. They do not alter levels of norepinephrine. These have become the drugs of choice for a variety of psychiatric disorders, primarily because of their low incidence of severe side effects as compared with other drugs in this therapeutic class. SSRIs show similar actions and side effect profiles, but may vary in duration of action.

Tricyclic compounds, identified by their chemical structure containing three carbon rings, are an older class of antidepressants. Although generally effective, they have a high incidence of anticholinergic effects, notably dry mouth and dry eyes, which can cause discomfort. They also cause cardiac arrhythmias. Because tricyclics act on both serotonin and norepinephrine, they may have some value in treatment of patients who fail to respond to SSRIs. Drugs in this class are often available at low prices, which may be significant when cost is a major factor in treatment. They have also been found useful in control of some neurologic **pain** syndromes.

Tricyclic antidepressants are similar, but may vary in severity of side effects, most notably the degree of sedation and the extent of the anticholinergic effects.

Tetracyclic compounds and atypical antidepressants are chemically distinct from both the major groups and each other. Although maprotilene (no brand name, marketed in generic form only) and mirtazepine (Remeron) are similar in chemical structures, they differ in their balance of activity on serotonin and norepinephrine levels.

ANTIDEPRESSANT DRUGS	
<i>Brand Name (Generic Name)</i>	<i>Possible Common Side Effects Include:</i>
Desyrel (trazodone hydrochloride)	Allergic skin reactions, blurred vision, decreased appetite, fluid retention, headache
Effexor (venlafaxine hydrochloride)	Diarrhea, dizziness, gas, headache, insomnia, rash, vomiting
Elavil (amitriptyline hydrochloride)	Constipation, dizziness, high blood pressure, fever, nausea, rash, weight gain or loss
Nardil (phenelzine sulfate)	Dry mouth, fatigue, headache, muscle spasms, tremors
Norpramin (desipramine hydrochloride)	Blurred vision, cramps, hallucinations, hair loss, vomiting
Pamelor (nortriptyline hydrochloride)	Diarrhea, fatigue, headache, decreased coordination
Paxil (paroxetine hydrochloride)	Cold symptoms, drowsiness, nervousness, stomach pain
Prozac (fluoxetine hydrochloride)	Bronchitis, drowsiness, fatigue, nausea, tremors
Sinequan (doxepin hydrochloride)	Bruising, constipation, fluid retention, itching, increased heartbeat
Surmontil (trimipramine maleate)	Disorientation, flushing, headache, nausea, vomiting
Tofranil (imipramine hydrochloride)	Bleeding sores, fever, hives, decreased coordination
Travil	Asthma, diarrhea, dizziness, fatigue, seizures
Wellbutrin (bupropion hydrochloride)	Agitation, dry mouth, headache, nausea, rash
Zoloft (sertraline)	Diarrhea, fainting, gas, headache, nervousness

(Illustration by Standley Publishing. Courtesy of Gale Group.)

Monoamine oxidase inhibitors (phenelzine [Nardil], tranylcypromine [Parnate]) have largely been supplanted in therapy because of their high risk of severe adverse effects, most notably severe **hypertension**. They act by inhibiting the enzyme monoamine oxidase, which is responsible for the **metabolism** of the stimulatory neurohormones norepinephrine, epinephrine, dopamine, and serotonin. The MAOIs are normally reserved for patients who are resistant to safer drugs. Two drugs, eldepryl (Carbex, used in treatment of **Parkinson's disease**) and the herb, St. John's wort, have some action against monoamine oxidase B, and have shown some value as anti-depressants. They do not share the same risks as the non-selective MAO inhibitors.

All antidepressant agents, regardless of their structure, have a slow onset of action, typically three to five weeks. Although adverse effects may be seen as early as the first dose, significant therapeutic improvement is

always delayed. Similarly, the effects of antidepressants will continue for a similar length of time after the drugs have been discontinued.

Recommended dosage

Dose varies with the specific drug and patient. Consult specialized references.

Precautions

Antidepressants have many significant cautions and adverse effects. Although a few are listed here, specific references should be consulted for more complete information.

SSRIs. The most common side effect of SSRIs is excitation and insomnia. Excitation has been reported in over 20% of patients, and insomnia in 33%. Significant weight loss has been frequently reported, but most com-

KEY TERMS

Cognitive behavioral therapy—A type of psychotherapy in which people learn to recognize and change negative and self-defeating patterns of thinking and behavior.

Depression—A mental condition in which people feel extremely sad and lose interest in life. People with depression may also have sleep problems and loss of appetite and may have trouble concentrating and carrying out everyday activities.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

monly in patients who are already underweight. SSRIs may cause some sedation, and patients should be cautioned not to perform tasks requiring alertness until they have evaluated the effects of these drugs. SSRIs are **pregnancy** category C drugs. Most SSRIs are excreted in breast milk, and there have been anecdotal reports of somnolence in infants whose mothers were taking SSRIs while breastfeeding.

Tricyclic antidepressants. Amoxepine (not marketed by brand, generic available), although a tricyclic antidepressant rather than a neuroleptic (major tranquilizer), displays some of the more serious effects of the neuroleptics, including tardive dyskinesias (drug induced involuntary movements) and neuroleptic malignant syndrome, a potentially fatal syndrome whose symptoms include high **fever**, altered mental status, irregular pulse or **blood pressure**, and changes in **heart** rate. These adverse effects have not been reported with other tricyclic antidepressants.

The most common adverse effects of tricyclic antidepressants are sedation and the anticholinergic effects, such as dry mouth, dry eyes, and difficult urination. Alterations in heartbeat are also common, and may progress to congestive **heart failure**, stroke, and sudden death.

Tricyclic antidepressants are in pregnancy categories C or D, although there have been no formal studies of the drugs on **fetal development**. There are no studies of effects on newborns, but some anecdotal reports of malformations have resulted from animal studies. The drugs are excreted in breast milk.

Monoamine oxidase inhibitors. The greatest risk associated with these drugs is a hypertensive crisis which may be fatal and most often occurs when the drugs are taken with interacting foods or drugs. More common adverse reactions may include low **blood** pressure and slowing of heartbeat. Sedation and gastrointestinal disturbances are also common. MAOIs are in pregnancy category C. Safety in breast feeding has not been established.

Tetracyclines and atypicals. Because these drugs are individual, there are no group patterns of adverse reactions. Consult specific references.

Interactions

The antidepressants have many **drug interactions**, some severe. Although a few are listed here, specific references should be consulted for more complete information.

SSRIs should not be administered with MAOIs. Allow a wash-out period of about four weeks before switching from one class of drugs to the other. Allow five weeks if switching from fluoxetine (Prozac) to an MAOI.

MAOIs have many interactions; however the best known are those with foods containing the amino acid tyramine. These include aged cheese, chianti wine, and many others. Patients and providers should review the MAOI diet restrictions before using or prescribing these drugs. Because of the severity of MAOI interactions, all additions to the patient's drug regimen should be reviewed with care.

Tricyclic compounds have many interactions, and specialized references should be consulted. Specifically avoid other drugs with anticholinergic effects. Tricyclics should not be taken with the **antibiotics** grepafloxacin and sparfloxacin, since the combination may cause serious heart arrhythmias.

Tricyclic compounds should not be taken with the gastric acid inhibitor cimetidine (Tagamet), since this increases the blood levels of the tricyclic compound. Other acid inhibiting drugs do not share this interaction.

SSRIs interact with a number of other drugs which act on the **central nervous system**. Use care in combining these drugs with major or minor tranquilizers, or with anti-epileptic agents such as phenytoin (Dilantin) or carbamazepine (Tegretol).

Resources

PERIODICALS

Johnson, Lois. "Daylight for Depression." *Total Health* 16 (December 1994): 14.

Sacra, Cheryl. "The New Cure-alls: Mood Lifters May Offer Handfuls Of Hope for More Than Just Depression." *Health* 22 (September 1990): 36.

"Treatment of Depression: Drugs Alone Are Not Enough." *HealthFacts* 20 (February 1995): 189.

Samuel Uretsky, PharmD

Antidiabetic drugs

Definition

Antidiabetic drugs are medicines that help control **blood** sugar levels in people with **diabetes mellitus** (sugar diabetes).

Purpose

Diabetes may be divided into type I and type II, formerly termed juvenile onset or insulin-dependent, and maturity onset or non insulin-dependent. Type I is caused by a deficiency of insulin production, while type II is characterized by insulin resistance.

Treatment of type I diabetes is limited to insulin replacement, while type II diabetes is treatable by a number of therapeutic approaches. Many cases of insulin resistance are asymptomatic due to normal increases in insulin secretion, and others may be controlled by diet and **exercise**. Drug therapy may be directed towards increasing insulin secretion, increasing insulin sensitivity, or increasing insulin penetration of the cells.

Description

Antidiabetic drugs may be subdivided into six groups: insulin, sulfonyleureas, alpha-glucosidase inhibitors, biguanides, meglitinides, and thiazolidinediones.

Insulin (Humulin, Novolin) is the hormone responsible for glucose utilization. It is effective in both types of diabetes, since, even in insulin resistance, some sensitivity remains and the condition can be treated with larger doses of insulin. Most insulins are now produced by recombinant DNA techniques, and are chemically identical to natural human insulin. Isophane insulin suspension, insulin **zinc** suspension, and other formulations are intended to extend the duration of action of insulin, and permit glucose control over longer periods of time.

ANTIDIABETIC DRUGS

<i>Brand Name (Generic Name)</i>	<i>Possible Common Side Effects Include:</i>
Diabinese (chlorpropamide)	Diarrhea, nausea, loss of appetite
Glucotrol (glipizide)	Dizziness, fatigue, headache, nervousness
*Insulin	Mild allergic reactions, decreased blood pressure, rash, shortness of breath
Micronase (glyburide)	Nausea, heartburn, bloating
Orinase (tolbutamide)	Nausea, heartburn, bloating
*Insulin is the generic name for several brands which may be animal-based, human-based, or synthetic.	

(Illustration by Standley Publishing. Courtesy of Gale Group.)

Sulfonylureas (chlorpropamide [Diabinese], tolazamide [Tolinase], glipizide [Glucotrol], and others) act by increasing insulin release from the beta cells of the pancreas. Glimpiride (Amaryl), a member of this class, appears to have a useful secondary action in increasing insulin sensitivity in peripheral cells.

Alpha-glucosidase inhibitors (acarbose [Precose], miglitol [Glyset]) do not enhance insulin secretion. Rather, they inhibit the conversion of disaccharides and complex **carbohydrates** to glucose. This mechanism does not prevent conversion, but only delays it, reducing the peak blood glucose levels. Alpha-glucosidase inhibitors are useful for either monotherapy or in combination therapy with sulfonylureas or other hypoglycemic agents.

Metformin (Glucophage) is the only available member of the biguanide class. Metformin decreases hepatic glucose production, decreases intestinal absorption of glucose and increases peripheral glucose uptake and utilization. Metformin may be used as monotherapy, or in combination therapy with a sulfonylurea.

There are two members of the meglitinide class: repaglinide (Prandin) and nateglitinide (Starlix). The mechanism of action of the meglitinides is to stimulate insulin production. This activity is both dose dependent and dependent on the presence of glucose, so that the drugs have reduced effectiveness in the presence of low blood glucose levels. The meglitinides may be used alone, or in combination with metformin. The manufacturer

KEY TERMS

Blood sugar—The concentration of glucose in the blood.

Glucose—A simple sugar that serves as the body's main source of energy.

Hormone—A substance that is produced in one part of the body, then travels through the bloodstream to another part of the body where it has its effect.

Metabolism—All the physical and chemical changes that occur in cells to allow growth and maintain body functions. These include processes that break down substances to yield energy and processes that build up other substances necessary for life.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

Salicylates—A group of drugs that includes aspirin and related compounds. Salicylates are used to relieve pain, reduce inflammation, and lower fever.

Seizure—A sudden attack, spasm, or convulsion.

warns that nateglitinide should not be used in combination with other drugs which enhance insulin secretion.

Rosiglitazone (Avandia) and pioglitazone (Actos) and the members of the thiazolidinedione class. They act by both reducing glucose production in the **liver**, and increasing insulin dependent glucose uptake in muscle cells. They do not increase insulin production. These drugs may be used in combination with metoformin or a sulfonylurea.

Recommended dosage

Dosage must be highly individualized for all antidiabetic agents and is based on blood glucose levels which must be taken regularly. Review specific literature.

Precautions

The greatest short term risk of insulin is hypoglycemia, which may be the result of either a direct **overdose** or an imbalance between insulin injection and level of exercise and diet. This may also occur in the presence of other conditions which reduce the glucose load, such as illness with vomiting and **diarrhea**. Treatment is with glucose in the form of glucose tablets or liquid, although severe cases may require intravenous therapy. Allergic reactions and skin reactions may also occur. Insulin is classified as category **B** in **pregnancy**, and is considered the drug of choice for glucose control during pregnancy. Insulin glargine (Lantus), an insulin analog which is suitable for once-daily dosing, is classified as category **C**, because there have been reported changes in the hearts of newborns in animal studies of this drug. The reports are essentially anecdotal, and no cause and effect relationship has been determined. Insulin is not recommended during breast feeding because either low or high doses of insulin may inhibit milk production. Insulin administered orally is destroyed in the GI tract, and represents no risk to the newborn.

All sulfonylurea drugs may cause hypoglycemia. Most patients become resistant to these drugs over time, and may require either dose adjustments or a switch to insulin. The list of adverse reactions is extensive, and includes **central nervous system** problems and skin reactions, among others. Hematologic reactions, although rare, may be severe and include aplastic anemia and hemolytic anemia. The administration of oral hypoglycemic drugs has been associated with increased cardiovascular mortality as compared with treatment with diet alone or diet plus insulin. The sulfonylureas are classified as category **C** during pregnancy, based on animal studies, although glyburide has not shown any harm to the fetus and is classified as category **B**. Because there may be significant alterations in blood glucose levels during pregnancy, it is recommended that patients be switch to insulin. These drugs have not been fully studied during breast feeding, but it is recommended that because their presence in breast milk might cause hypoglycemia in the newborn, breast feeding be avoided while taking sulfonylureas.

Alpha-glucosidase inhibitors are generally well tolerated, and do not cause hypoglycemia. The most common adverse effects are gastrointestinal problems, including flatulence, diarrhea, and abdominal **pain**. These drugs are classified as category **B** in pregnancy. Although there is no evidence that the drugs are harmful to the fetus, it is important that rigid blood glucose control be maintained during pregnancy, and pregnant women should be switched to insulin. Alpha-glucosidase inhibitors may be excreted in

small amounts in breast milk, and it is recommended that the drugs not be administered to nursing mothers.

Metformin causes gastrointestinal reactions in about a third of patients. A rare, but very serious, reaction to metformin is lactic acidosis, which is fatal in about 50% of cases. Lactic acidosis occurs in patients with multiple medical problems, including renal insufficiency. The risk may be reduced with careful renal monitoring, and careful dose adjustments to metformin. Metformin is category B during pregnancy. There have been no carefully controlled studies of the drug during pregnancy, but there is no evidence of fetal harm from animal studies. It is important that rigid blood glucose control be maintained during pregnancy, and pregnant women should be switched to insulin. Animal studies show that metformin is excreted in milk. It is recommended that metformin not be administered to nursing mothers.

Meglitinides are generally well tolerated, with an adverse event profile similar to placebo. The drugs are classified as category C during pregnancy, based on fetal abnormalities in rabbits given about 40 times the normal human dose. It is important that rigid blood glucose control be maintained during pregnancy, and pregnant women should be switched to insulin. It is not known whether the meglitinides are excreted in human milk, but it is recommended that these drugs not be given to nursing mothers.

Thiazolidinediones are generally well tolerated, however they are structurally related to an earlier drug, troglitazone, which was associated with liver function problems. It is strongly recommended that all patients treated with pioglitazone or rosiglitazone have regular liver function monitoring. The drugs are classified as pregnancy category C, based on evidence of inhibition of fetal growth in rats given more than four times the normal human dose. It is important that rigid blood glucose control be maintained during pregnancy, and pregnant women should be switched to insulin. It is not known whether the thiazolidinediones are excreted in human milk, however they have been identified in the milk of lactating rats. It is recommended that these drugs not be administered to nursing mothers.

Interactions

The sulfonylureas have a particularly long list of **drug interactions**, several of which may be severe. Review specific literature for these drugs.

The actions of oral hypoglycemic agents may be strengthened by highly protein bound drugs, including NSAIDs, salicylates, sulfonamides, chloramphenicol, coumarins, probenecid, MAOIs, and beta blockers.

Review the specific literature of each drug for possible drug-drug or food-drug interactions.

Resources

PERIODICALS

Hingley, Audrey. "Diabetes Demands a Trial of Treatments." *FDA Consumer*, 31 (May-June 1997): 33.

ORGANIZATIONS

American Diabetes Association. ADA National Service Center, 1660 Duke Street, Alexandria, VA 22314. 800-232-3472. <<http://www.diabetes.org>>.

National Diabetes Information Clearinghouse. 1 Information Way, Bethesda, MD 20892-3560. 301-654-3327. ndic@info.niddk.nih.gov.

OTHER

National Institute of Diabetes and Digestive and Kidney Diseases. <<http://www.niddk.nih.gov>>.

Samuel Uretsky, PharmD

Antidiuretic hormone (ADH) test *see*
Pituitary hormone tests

Antifungal drugs, topical

Definition

Topical antifungal drugs are medicines applied to the skin to treat skin infections caused by a fungus.

Purpose

Dermatologic fungal infections are usually described by their location on the body: tinea pedis (**infection** of the foot), tinea unguium (infection of the nails), tinea capitis (infection of the scalp). Three types of fungus are involved in most skin infections: *Trichophyton*, *Epidermophyton*, and *Microsporum*. Mild infections are usually susceptible to topical therapy, however severe or resistant infections may require systemic treatment.

Description

There are a large number of drugs currently available in topical form for fungal infections. Other than the imidazoles, (miconazole [Micatin, Miconazole], clotrimazole [Lotrimin], econazole [Spectazole], ketoconazole [Nizoral], oxiconazole [Oxistat], sulconazole [Exelderm]) and the allylamine derivatives (butenafine [Mentax], naftifine [Naftin], terbinafine [Lamisil]), the drugs in this therapeutic class are chemically distinct from each other. All drugs when applied topically have a good margin of safety, and most show a high degree of effectiveness. There are no studies comparing drugs on which to base a recommendation for drugs of choice. Although some of

KEY TERMS

Cream—A spreadable substance, similar to an ointment, but not as thick. Creams may be more appropriate than ointments for application to exposed skin areas such as the face and hands.

Ointment—A thick, spreadable substance that contains medicine and is meant to be used on the skin, or if a vaginal preparation, in the vagina.

Ophthalmic—Pertaining to the eye.

Otic—Pertaining to the ear.

Topical—A term used to describe medicine that has effects only in a specific area, not throughout the body, particularly medicine that is put directly on the skin.

the topical antifungals are available over-the-counter, they may be as effective as prescription drugs for this purpose.

Traditional antifungal drugs such as undecylinic acid (Cruex, Desenex) and gentian violet (also known as crystal violet) remain available, but have a lower cure rate (complete eradication of fungus) than the newer agents and are not recommended. Tolnaftate (Tinactin) has a lower cure rate than the newer drugs, but may be used prophylactically to prevent infection.

Recommended dosage

All drugs are applied topically. Consult individual product information for specific application recommendations.

As with all topical products, selection of the dosage form may be as important as proper drug selection. Consider factors such as presence or absence of hair on the affected area, and type of skin to which the medication is to be applied. Thin liquids may be preferable for application to hairy areas, creams for the hands and face, and ointments may be preferable for the trunk and legs. Other dosage forms available include shampoos and sprays. Ciclopirox and triacetin are available in formulations for topical treatment of nail fungus as well as skin infections (ciclopirox as Penlac Nail Lacquer and triacetin as Ony-Clear Nail).

Most topical antifungal drugs require four weeks of treatment. Infections in some areas, particularly the spaces between toes, may take up to six weeks for cure.

Precautions

Most topical antifungal agents are well tolerated. The most common adverse effects are localized irritation caused by the vehicle or its components. This may include redness, itch, and a burning sensation. Some direct allergic reactions are possible.

Topical antifungal drugs should only be applied in accordance with labeled uses. They are not intended for ophthalmic (eye) or otic (ear) use. Application to mucous membranes should be limited to appropriate formulations.

The antifungal drugs have not been evaluated for safety in **pregnancy** and **lactation** on topical application under the pregnancy risk category system. Although systemic absorption is probably low, review specific references. Gentian violet is labeled with a warning against use in pregnancy.

Interactions

Topical antifungal drugs have no recognized drug-drug or food-drug interactions.

Samuel Uretsky, PharmD

Antiglobulin tests

Definition

Antiglobulin (Coombs') tests are **blood** tests that identify the causes of immune-mediated anemia or hemolysis. Antiglobulin tests utilize an antibody to human immunoglobulin in order to detect antibody coated (sensitized) cells. In addition to being a medical test that is ordered by a physician, the antiglobulin test is a procedure employed in various blood banking and immunology methods in order to detect immune complex formation. This test is also the basis for some blood typing tests.

Purpose

Antiglobulin tests are used to detect antibodies in serum or attached to cells. The test is ordered as a medical laboratory test to aid in the differential diagnosis of anemia. Anemia refers to blood with abnormally low oxygen-carrying capacity. The hemoglobin in red blood cells carries oxygen. Anemia may be caused by low numbers of red blood cells or a low level of functional hemoglobin. One of the many causes of anemia is destruction of red blood cells, a process called hemolysis (*hemo*

means blood and *lysis* means disintegration). Any anemia caused by a shortened red blood cell survival in the circulation is called a hemolytic anemia. The causes of hemolytic anemia include **septic shock**, mechanical trauma, intrinsic red blood cell membrane defects or biochemical (enzyme) defects that make the cells more fragile, and antibody induced destruction. The antiglobulin test identifies red blood cells coated (sensitized) by antibody, and therefore, hemolytic anemia caused by immune mediated destruction. The test also identifies red blood cells coated by complement. Complement is a series of **proteins** that attach to the cell following the reaction of some types of antibodies with antigens on the cell surface. Complement components undergo changes after attachment to the red cells that damage the membrane and serve as binding sites for phagocytes that remove the red cells from the blood as they pass through the spleen and **liver**.

Immune-mediated hemolytic anemia can result from a transfusion reaction in which antibodies formed by the recipient attach to and destroy the donor's red blood cells, or it can result from the production of antibodies that attach to the surface of the person's own red cells (autoimmune hemolytic anemia).

Autoimmunity is the cause of many systemic collagen-vascular diseases, including rheumatoid arthritis and systemic lupus erythematosus, and several organ-specific diseases such as type I **diabetes mellitus** and chronic lymphocytic thyroiditis (hypothyroidism). Some persons with systemic autoimmune disease produce autoantibodies to their red cells, and the antiglobulin test is used to identify these antibodies. In addition, the antiglobulin test may be employed to detect the antibodies responsible for the destruction of the target tissue in autoimmune diseases.

Causes of immune-mediated hemolytic anemia include:

- drugs such as penicillin, methyldopa (lowers **blood pressure**), and quinidine (treats **heart** rhythm disturbances)
- cancers of the lymph system, including Hodgkin's disease and lymphomas
- some viral infections
- collagen-vascular diseases
- incompatible blood transfusions
- Rh incompatibility between a mother and fetus (hemolytic disease of the newborn)

In some cases, the cause of an autoimmune hemolytic anemia cannot be identified.

Precautions

A blood sample collected by venipuncture is used for antiglobulin tests. The nurse or phlebotomist collecting the specimen should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. It is recommended that samples for the direct antiglobulin test be collected in EDTA. This chelates **calcium**, preventing the attachment of complement components to red cells during storage. Refrigeration of blood specimens that have cold agglutinins may cause a false positive test. The blood should be stored at room temperature until separation of red cells and serum or plasma.

Description

There are two forms of the antiglobulin (Coombs') test. A direct antiglobulin (Coombs') test (DAT) detects antibody bound *in vivo* to either antigen(s) or complement components on the red cell surface. The test uses a broad spectrum reagent containing antibodies that bind to human immunoglobulin and C3. Such antibodies can be made by immunizing rabbits, burros, or goats with purified human immunoglobulin or complement proteins or by gene fusion technology (hybridomas) that produces a malignant clone of antibody secreting cells containing the genes needed to make the desired antibody. Reagents typically have reactivity to human IgG (the most common class of antibody), complement components C3b and C3d, and immunoglobulin light chains to permit detection of other immunoglobulin classes (IgA and IgM). A 2-3% suspension of the cells is made using saline. The blood cells are washed three times with isotonic saline to remove the immunoglobulins and other proteins not bound to the red cells. After washing the antiglobulin (AHG) reagent is added to the cell button. The cells are suspended in the reagent and the mixture is centrifuged. The cells are resuspended and examined for visible clumping (agglutination). If the red blood cells are coated with either antibody or complement they will clump, and the button will break up into small pieces instead of resuspending in the saline. If no agglutination is observed, a drop of antibody-coated red cells is added to the mixture and it is centrifuged again and examined. The presence of agglutination verifies that the antiglobulin reagent is present and had not been neutralized by improper washing. In addition, monospecific anti-human immunoglobulins may be used to distinguish between antibody and complement binding and to identify the class of antibody that has attached to the red blood cells. The direct antiglobulin tests can be used to detect autoantibodies that have attached to other types of cells. For example, the DAT test is often used to identify the autoimmune form of a kidney disease called

KEY TERMS

Anemia—Reduced oxygen-carrying capacity of the blood, due to too little hemoglobin or too few red blood cells.

Antibody—A protein made by the immune system, that is directed against antigens, and used as a weapon against foreign invaders in the body.

Antigen—The chemical that stimulates an immune response.

Collagen-vascular disease—Various diseases inflaming and destroying connective tissue.

Hematologist—Physician who specializes in diseases of the blood.

Hemoglobin—The red pigment in blood that carries oxygen.

Hemolysis—Breaking apart red blood cells.

Rh—A blood typing group, like the ABO system. When a mother is Rh negative and her baby is Rh positive, she may develop antibodies to the baby's blood that will cause it to hemolyze.

glomerulonephritis. The anti-human immunoglobulin is conjugated to a fluorescent dye. This is added to a thin-section of the renal tissue on a **microscope** slide. The slide is washed to remove unbound antibody and then examined under a fluorescent microscope. Fluorescence of the tissue indicates a positive test for antibody-coated cells.

The second type of antiglobulin test is called the indirect antiglobulin test. This procedure is used to demonstrate the presence of specific antibodies in the serum or plasma. It is also used to detect blood group antigens of several blood group systems including the Kell, Kidd, and Duffy systems, to detect incomplete (nonagglutinating) antibodies that have attached to donor red blood cells in the compatibility test (cross-match), and to investigate the cause of a transfusion reaction. Many antibodies are able to attach to the corresponding antigens on red blood cells, but do not cause agglutination because the size of the antibodies is too small to cross link antigens on adjacent cells. These antibodies can be detected in plasma or serum by the indirect antiglobulin test. This test is performed in the same way as the direct test except that the red blood cells must be incubated with the patient's serum or plasma before washing and adding the AHG reagent. For example, in order to screen for antibodies that might be present in the

serum of a person needing a blood transfusion, the serum is incubated with reagent red blood cells. Two or three different reagents are used each consisting of a standardized suspension of group O red cells obtained from various donors so that a broad spectrum of different blood group antigens is represented. Group O red cells are used because they lack A or B antigens that would cause agglutination with anti-A or anti-B antibodies that occur naturally in persons lacking the respective antigen. Following incubation, the red cells are washed to remove unbound proteins (antibodies) and the AHG is added. The cell suspension is centrifuged and examined for agglutination as described above. The presence of agglutination indicates that at least one antibody against the reagent cells are present. The indirect antiglobulin test using a fluorescent-labeled antihuman globulin is also used to identify antibodies produced against DNA and other cellular components by persons with various autoimmune diseases.

Preparation

No preparation is needed for this test. Prior to performing the venipuncture, the nurse or other health care professional should document any medications the patient is currently taking, since many medications have been implicated in autoimmune hemolytic anemia.

Aftercare

The patient may feel discomfort when blood is drawn from a vein. Bruising may occur at the puncture site or the person may feel dizzy or faint. Pressure should be applied to the puncture site until the bleeding stops to reduce bruising. Warm packs can also be placed over the puncture site to relieve discomfort.

Complications

The most common complication is a bruise at the site of the puncture or excessive bleeding. The patient can apply moist warm compresses if there is any discomfort.

Results

Antiglobulin tests are reported as negative or positive. If the direct antiglobulin test is positive, an elution study may be performed to identify the specificity of the antibody. In addition, the indirect antiglobulin test may be performed to determine if there is unattached circulating antibody. If the indirect antiglobulin test is positive, serial dilutions may be performed to quantify the concentration of antibody. The antibody titre is defined as the highest dilution of the serum that gives a positive test

result. If the antiglobulin tests are negative, the anemia is unlikely to be immune-mediated, and the physician will have to search elsewhere for a cause.

Health care team roles

A physician will order the tests, and will interpret the results. The blood specimen is drawn by a nurse or phlebotomist, and transported to the laboratory. AHG tests are performed by clinical laboratory scientists/medical technologists. If a direct AHG test is performed on tissue, the specimen is processed by a histologic technician and the tissue is examined under the microscope by a pathologist. The pathologist writes an interpretative report of the microscopic finding.

Resources

BOOKS

American Association of Blood Banks. *Technical Manual*, 13th ed., Bethesda, MD: American Association of Blood Banks, 1999.

American Society of Clinical Pathologists. *Practical Diagnosis of Hematologic Disorders*, 3rd ed., edited by Carl Kjeldsberg, et al. Chicago, IL: ASCP Press, 2000.

Henry, John B. *Clinical Diagnosis and Management by Laboratory Methods*, 20th ed. Philadelphia, PA: W. B. Saunders, 2001.

Rosse, Wendell and H. Franklin Bunn. "Hemolytic Anemias and Acute Blood Loss." In *Harrison's Principles of Internal Medicine*, edited by Kurt Isselbacher, et al. New York: McGraw-Hill, 1998.

Mark A. Best

Antihistamines

Definition

Antihistamines are drugs that block the action of histamine (a compound released in allergic inflammatory reactions) at the H₁ receptor sites, responsible for immediate hypersensitivity reactions such as sneezing and itching. Members of this class of drugs may also be used for their side effects, including sedation and antiemesis (prevention of nausea and vomiting).

Purpose

Antihistamines provide their primary action by blocking histamine H₁ at the receptor site. They have no effect on rate of histamine release, nor do they inactivate histamine. By inhibiting the activity of histamine, they

can reduce capillary fragility, which produces the erythema, or redness, associated with allergic reactions. They will also reduce histamine-induced secretions, including excessive tears and salivation. Additional effects vary with the individual drug used. Several of the older drugs, called first-generation antihistamines, bind non-selectively to H₁ receptors in the **central nervous system** as well as to peripheral receptors, and can produce sedation, inhibition of nausea and vomiting, and reduction of motion sickness. The second-generation antihistamines bind only to peripheral H₁ receptors, and reduce allergic response with little or no sedation.

The first-generation antihistamines may be divided into several chemical classes. The side effect profile, which also determines the uses of the drugs, will vary by chemical class. The alkylamines include brompheniramine (Dimetapp) and chlorpheniramine (Chlor-Trimeton). These agents cause relatively little sedation, and are used primarily for treatment of allergic reactions. Promethazine (Phenergan), in contrast, is a phenothiazine, chemically related to the major tranquilizers, and while it is used for treatment of **allergies**, may also be used as a sedative, to relieve **anxiety** prior to surgery, as an anti-nauseant, and for control of motion sickness. Diphenhydramine (Benadryl) is chemically an ethanolamine, and in addition to its role in reducing allergic reactions, may be used as a nighttime sedative, for control of drug-induced parkinsonism, and, in liquid form, for control of coughs. Consult more detailed references for further information.

The second generation antihistamines have no central action, and are used only for treatment of allergic reactions. These are divided into two chemical classes. Cetirizine (Zyrtec) is a piperazine derivative, and has a slight sedative effect. Loratidine (Claritin) and fexofenadine (Allegra) are members of the piperadine class and are essentially non-sedating.

Recommended dosage

Dosage varies with drug, patient, and intended use. Consult more detailed references for further information.

When used for control of allergic reactions, antihistamines should be taken on a regular schedule, rather than on an as-needed basis, since they have no effect on histamine itself, nor on histamine already bound to the receptor site.

Efficacy is highly variable from patient to patient. If an antihistamine fails to provide adequate relief, switch to a drug from a different chemical class. Individual drugs may be effective in no more than 40% of patients, and provide 50% relief of allergic symptoms.

ANTIHISTAMINES	
<i>Brand Name (Generic Name)</i>	<i>Possible Common Side Effects Include:</i>
*Atarax (hydroxyzine hydrochloride)	Drowsiness, dry mouth
Benadryl (diphenhydramine hydrochloride)	Dizziness, sleepiness, upset stomach, decreased coordination
Hismanal (astemizole)	Drowsiness, dry mouth, fatigue, weight gain
PBZ-SR (tripelennamine hydrochloride)	Dizziness, drowsiness, dry mouth and throat, chest congestion, decreased coordination, upset stomach
Periactin (cyproheptadine hydrochloride)	Chest congestion, dizziness, fluttery heartbeat, loss of appetite, hives, sleepiness, vision problems
Phenergan (promethazine hydrochloride)	Changes in blood pressure, dizziness, blurred vision, nausea, rash
Polaramine (dexchlorpheniramine maleate)	Drowsiness
Seldane, Seldane-D (terfenadine)	Upset stomach, nausea, drowsiness, headache, fatigue
Tavist (clemastine fumarate)	Decreased coordination, dizziness, upset stomach
Trinalin Repetabs (azatadine maleate, pseudoephedrine sulfate)	Abdominal cramps, chest pain, dry mouth, headache
*Also used in the treatment of anxiety	

(Illustration by Standley Publishing. Courtesy of Gale Group.)

Side effects

The frequency and severity of adverse effects will vary between drugs. Not all adverse reactions will apply to every member of this class.

Central nervous system reactions include drowsiness, sedation, dizziness, faintness, disturbed coordination, lassitude, confusion, restlessness, excitation, tremor, seizures, headache, insomnia, euphoria, blurred **vision**, hallucinations, disorientation, disturbing dreams/nightmares, schizophrenic-like reactions, weakness, vertigo, hysteria, nerve **pain**, and convulsions. Overdoses may cause involuntary movements. Other problems have been reported.

Gastrointestinal problems include increased appetite, decreased appetite, nausea, vomiting, **diarrhea**, and constipation.

Hematologic reactions are rare, but may be severe. These include anemia, or breakdown of red **blood** cells; reduced platelets; reduced white cells; and bone marrow failure.

A large number of additional reactions have been reported. Not all apply to every drug, and some reactions may not be drug related. Some of the other adverse effects are chest tightness; wheezing; nasal stuffiness; dry mouth, nose and throat; **sore throat**; respiratory depression; sneezing; and a burning sensation in the nose.

When taking antihistamines during **pregnancy**, Chlorpheniramine (Chlor-Trimeton), dexchlorpheniramine (Polaramine), diphenhydramine (Benadryl), brompheniramine (Dimetapp), cetirizine (Zyrtec), cyproheptadine (Periactin), clemastine (Tavist), azatadine (Optimine), and loratadine (Claritin) are all listed as category B. Azelastine (Astelin), hydroxyzine (Atarax), and promethazine (Phenergan) are category C.

Regardless of chemical class of the drug, it is recommended that mothers not breast feed while taking antihistamines.

Contraindications

The following are absolute or relative contraindications to use of antihistamines. The significance of the contraindication will vary with the drug and dose.

KEY TERMS

Allergen—A substance that causes an allergy.

Anaphylaxis—A sudden, life-threatening allergic reaction.

Hallucination—A false or distorted perception of objects, sounds, or events that seems real. Hallucinations usually result from drugs or mental disorders.

Histamine—A chemical released from cells in the immune system as part of an allergic reaction.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

- glaucoma
- hyperthyroidism (overactive thyroid)
- high **blood pressure**
- enlarged prostate
- heart disease
- ulcers or other **stomach** problems
- stomach or intestinal blockage
- liver disease
- kidney disease
- bladder obstruction
- diabetes

Interactions

Drug interactions will vary with the chemical class of antihistamine. In general, antihistamines will increase the effects of other sedatives, including alcohol.

Monoamine oxidase inhibitor antidepressants (phenelzine [Nardil], tranylcypromine [Parnate]) may prolong and increase the effects of some antihistamines. When used with promethazine (Phenergan) this may cause reduced blood pressure and involuntary movements.

Resources

ORGANIZATIONS

Allergy and Asthma Network. 3554 Chain Bridge Road, Suite 200. 800-878-4403.

American Academy of Allergy and Immunology. 611 East Wells Street, Milwaukee, WI 53202. 800-822-2762.

Asthma and Allergy Foundation of America. 1125 15th Street NW, Suite 502, Washington, DC 20005. 800-727-8462.

Samuel Uretsky, PharmD

Antihypertensive drugs

Definition

Antihypertensive drugs are medicines that help lower **blood pressure**.

Purpose

The overall class of antihypertensive agents lowers **blood pressure**, although the mechanisms of action vary greatly. Within this therapeutic class, there are several subgroups. There are a very large number of drugs used to control **hypertension**, and the drugs listed below are representatives, but not the only members of their classes.

The **calcium** channel blocking agents, also called slow channel blockers or calcium antagonists, inhibit the movement of ionic calcium across the cell membrane. This reduces the force of contraction of muscles of the **heart** and arteries. Although the calcium channel blockers are treated as a group, there are four different chemical classes, leading to significant variations in the activity of individual drugs. Nifedipine (Adalat, Procardia) has the greatest effect on the **blood vessels**, while verapamil (Calan, Isoptin) and diltiazem (Cardizem) have a greater effect on the heart muscle itself.

Peripheral vasodilators such as hydralazine (Apresoline), isoxuprine (Vasodilan), and minoxidil (Loniten) act by relaxing blood vessels.

There are several groups of drugs which act by reducing adrenergic nerve stimulation, the excitatory nerve stimulation that causes contraction of the muscles in the arteries, veins, and heart. These drugs include the beta-adrenergic blockers and alpha/beta adrenergic blockers. There are also non-specific adrenergic blocking agents.

Beta-adrenergic blocking agents include propranolol (Inderal), atenolol (Tenormin), and pindolol (Visken). Propranolol acts on the beta-adrenergic receptors any-

ANTIHYPERTENSIVE DRUGS	
Brand Name (Generic Name)	Possible Common Side Effects Include:
Accupril (quinapril hydrochloride)	Headache, dizziness
Aldactazide	Diarrhea, fever, headache, decreased coordination
Aldactone (spironolactone)	Cramps, drowsiness, stomach disorders
Aldomet (methyldopa)	Fluid retention, headache, weak feeling
Altace (ramipril)	Headache, cough
Calan, Calan SR (verapamil hydrochloride)	Constipation, fatigue, decreased blood pressure
Capoten (captopril)	Decreased sense of taste, decreased blood pressure itching, rash
Capozide	Decreased sense of taste, decreased blood pressure, itching, rash
Cardene (nicardipine hydrochloride)	Dizziness, headache, indigestion and nausea, increased heartbeat
Cardizem (diltiazem hydrochloride)	Dizziness, fluid retention, headache, nausea, skin rash
Cardura (doxazosin mesylate)	Dizziness, fatigue, drowsiness, headache
Catapres	Dry mouth, drowsiness, dizziness, constipation
Corgard (nadolol)	Behaviorial changes, dizziness, decreased heartbeat, tiredness
Corzide	Dizziness, decreased heartbeat, fatigue, cold hands and feet
Diuril (chlorothiazide)	Cramps, constipation or diarrhea, dizziness, fever, increased glucose level in urine
Dyazide	Blurred vision, muscle and abdominal pain, fatigue
DynaCirc (isradipine)	Chest pain, fluid retention, headache, fatigue
HydroDIURIL (hydrochlorothiazide)	Upset stomach, headache, cramps, loss of appetite
Hygroton (chlorthalidone)	Anemia, constipation or diarrhea, cramps, itching
Hytrin (terazosin hydrochloride)	Dizziness, labored breathing, nausea, swelling
Inderal (propranolol hydrochloride)	Constipation or diarrhea, tingling sensation, nausea and vomiting
Inderide	Blurred vision, cramps, fatigue, loss of appetite
Lasix (furosemide)	Back and muscle pain, indigestion, nausea
Lopressor (metoprolol tartrate)	Diarrhea, itching/rash, tiredness
Lotensin (benazepril hydrochloride)	Nausea, dizziness, fatigue, headache

(Illustration by Standley Publishing. Courtesy of Gale Group.)

ANTIHYPERTENSIVE DRUGS (continued)	
Brand Name (Generic Name)	Possible Common Side Effects Include:
Alozol (indapamide)	Anxiety, headache, loss of energy, muscle cramps
Maxzide	Cramps, labored breathing, drowsiness, irritated stomach
Minipress (prazosin hydrochloride)	Headache, nausea, weakness, dizziness
Moduretic	Diarrhea, fatigue, itching, loss of appetite
Monopril (fosinopril sodium)	Nausea and vomiting, headache, cough
Normodyne (labetalol hydrochloride)	Fatigue, nausea, stuffy nose
Norvasc (amlodipine besylate)	Fluid retention, fatigue, dizziness, headache
Plendil (felodipine)	Pain in back, chest, muscles, joints, and abdomen, itching, dry mouth, respiratory problems
Procardia, Procardia X (nifedipine)	Swelling, constipation, decreased blood pressure, nausea, fatigue
Sectral (acebutolol hydrochloride)	Constipation or diarrhea, gas, chest and joint pain
Ser-Ap-Es	Blurred vision, cramps, muscle pain, dizziness
Tenex (guanfacine hydrochloride)	Headache, constipation, dry mouth, weakness
Tenoretic	Decreased heartbeat, fatigue, nausea
Tenormin (atenolol)	Nausea, fatigue, dizziness
Veseretic	Diarrhea, muscle cramps, rash
Vasotec (enalapril maleate)	Chest pain, blurred vision, constipation or diarrhea, hives, nausea
Visken (pindolol)	Muscle cramps, labored breathing, nausea, fluid retention
Wytensin (guanabenz acetate)	Headache, drowsiness, dizziness
Zaroxolyn (metolazone)	Constipation or diarrhea, chest pain, spasms, nausea
Zestoretic (lisinopril hydrochlorothiazide)	Fatigue, headache, dizziness
Zestril (lisinopril)	Labored breathing, abdominal and chest pain, nausea, decreased blood pressure

(Illustration by Standley Publishing. Courtesy of Gale Group.)

where in the body, and has been used as a treatment for emotional **anxiety** and rapid heart beat. Atenolol and acebutolol (Sectral) act specifically on the nerves of the heart and circulation.

There are two alpha/beta adrenergic blockers, labetalol (Normodyne, Trandate) and carvedilol (Coreg). These work similarly to the beta blockers.

Angiotensin-converting enzyme inhibitors (ACE inhibitors) act by inhibiting the production of angiotensin II, a substance that both induces constriction of blood vessels and retention of sodium, which leads to water retention and increased blood volume. There are 10 ACE inhibitors currently marketed in the United States, including captopril (Capoten), benazepril (Lotensin),

KEY TERMS

Adrenergic—Activated by adrenalin (norepinephrine), loosely applied to the sympathetic nervous system responses.

Angioedema—An allergic skin disease characterized by patches of circumscribed swelling involving the skin and its subcutaneous layers, the mucous membranes, and sometimes the viscera—called also angioneurotic edema, giant urticaria, Quincke's disease, or Quincke's edema.

Arteries—Blood vessels that carry blood away from the heart to the cells, tissues, and organs of the body.

Laryngospasm—Spasmodic closure of the larynx.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

Sympathetic nervous system—The part of the autonomic nervous system that is concerned especially with preparing the body to react to situations of stress or emergency; it contains chiefly adrenergic fibers and tends to depress secretion, decrease the tone and contractility of smooth muscle, and increase heart rate.

enalapril (Vasotec), and quinapril (Acupril). The primary difference between these drugs is their onset and duration of action.

The ACE II inhibitors, losartan (Cozaar), candesartan (Atacand), irbesartan (Avapro), telmisartan (Micardis), valsartan (Diovan) and eprosartan (Teveten) directly inhibit the effects of ACE II rather than blocking its production. Their actions are similar to the ACE inhibitors, but they appear to have a more favorable side effect and safety profile.

In addition to these drugs, other classes of drugs have been used to lower blood pressure, most notably the thiazide diuretics. There are 12 thiazide diuretics marketed in the United States, including hydrochlorothiazide

(Hydrodiuril, Esidrex), indapamide (Lozol), polythiazide (Renese), and hydroflumethiazide (Diucardin). The drugs in this class appear to lower blood pressure through several mechanisms. By promoting sodium loss they lower blood volume. At the same time, the pressure of the walls of blood vessels, the peripheral vascular resistance, is lowered. Thiazide diuretics are commonly used as the first choice for reduction of mild hypertension, and may be used in combination with other antihypertensive drugs.

Recommended dosage

Recommended dosage varies with patient, drug, severity of hypertension, and whether the drug is being used alone or in combination with other drugs. Consult specialized references for further information.

Precautions

Because of the large number of classes and individual drugs in this group, consult specialized references for complete information.

Peripheral vasodilators may cause dizziness and orthostatic hypotension—a rapid lowering of blood pressure when the patient stands up in the morning. Patients taking these drugs must be instructed to rise from bed slowly. **Pregnancy** risk factors for this group are generally category C. Hydralazine has been shown to cause cleft palate in animal studies, but there is no human data available. Breastfeeding is not recommended.

ACE inhibitors are generally well tolerated, but may rarely cause dangerous reactions including laryngospasm and angioedema. Persistent cough is a common side effect. ACE inhibitors should not be used in pregnancy. When used in pregnancy during the second and third trimesters, ACE inhibitors can cause injury to and even death in the developing fetus. When pregnancy is detected, discontinue the ACE inhibitor as soon as possible. Breastfeeding is not recommended.

ACE II inhibitors are generally well tolerated and do not cause cough. Pregnancy risk factor is category C during the first trimester and category D during the second and third trimesters. Drugs that act directly on the renin-angiotensin system can cause fetal and neonatal morbidity and death when administered to pregnant women. Several dozen cases have been reported in patients who were taking ACE inhibitors. When pregnancy is detected, discontinue ACE inhibitors as soon as possible. Breastfeeding is not recommended.

Thiazide diuretics commonly cause potassium depletion. Patients should have potassium supplementation either through diet, or potassium supplements. Pregnancy risk factor is category B (chlorothiazide, chlorthalidone, hydrochlorothiazide, indapamide, metolazone) or category C (bendroflumethiazide, benzthiazide, hydroflumethiazide, methyclothiazide, trichlormethiazide). Routine use during normal pregnancy is inappropriate. Thiazides are found in breast milk. Breastfeeding is not recommended.

Beta blockers may cause a large number of adverse reactions including dangerous heart rate abnormalities. Pregnancy risk factor is category B (acebutolol, pindolol, sotalol) or category C (atenolol, labetalol, esmolol, metoprolol, nadolol, timolol, propranolol, penbutolol, carteolol, bisoprolol). Breastfeeding is not recommended.

Interactions

Consult specific references for food and drug interactions.

Samuel Uretsky, PharmD

Antimitochondrial antibody test see
Autoimmune disease tests

Antinuclear antibody test see **Autoimmune disease tests**

Antiparkinson drugs

Definition

Antiparkinson drugs are medicines that relieve the symptoms of **Parkinson's disease** and other forms of parkinsonism.

Purpose

Antiparkinson drugs are used to treat symptoms of parkinsonism, a group of disorders that share four main symptoms: tremor or trembling in the hands, arms, legs, jaw, and face; stiffness or rigidity of the arms, legs, and trunk; slowness of movement (bradykinesia); and poor balance and coordination. Parkinson's disease is the most common form of parkinsonism and is seen more frequently with advancing age. Other forms of the disorder may result from viral infections, environmental toxins, **carbon monoxide poisoning**, and the effects of treatment with **antipsychotic drugs**.

ANTIPARKINSON DRUGS

<i>Brand Name (Generic Name)</i>	<i>Possible Common Side Effects Include:</i>
Artane (trihexyphenidyl hydrochloride)	Dry mouth, nervousness, blurred vision, nausea
Benadryl (diphenhydramine hydrochloride)	Dizziness, sleepiness, upset stomach, decreased coordination
Cogentin (benztropine mesylate)	Constipation, dry mouth, nausea and vomiting, rash
Eldepryl (selegiline hydrochloride)	Abdominal and back pain, drowsiness, decreased coordination
Parlodel (bromocriptine mesylate)	Constipation, decreased blood pressure, abdominal cramps
Sinemet CR	Involuntary body movements, confusion, nausea, hallucinations

(Illustration by Standley Publishing. Courtesy of Gale Group.)

The immediate cause of Parkinson's disease or parkinsonian-like syndrome is the lack of the neurotransmitter dopamine in the **brain**. Drug therapy may take several forms, including replacement of dopamine, inhibition of dopamine **metabolism** to increase the effects of the dopamine already present, or sensitization of dopamine receptors. Drugs may be used singly or in combination.

Description

Levodopa (Larodopa) is the mainstay of Parkinson's treatment. The drug crosses the blood-brain barrier, and is converted to dopamine. The drug may be administered alone, or in combination with carbidopa (Lodosyn) which inhibits the enzyme responsible for the destruction of levodopa. The limitation of levodopa or levodopa-carbidopa therapy is that after approximately two years of treatment, the drugs cease to work reliably. This has been termed the "on-off phenomenon." Additional treatment strategies have been developed to retard the progression of parkinsonism, or to find alternative approaches to treatment.

Anticholinergic drugs reduce some of the symptoms of parkinsonism, and reduce the reuptake of dopamine, thereby sustaining the activity of the natural neurohormone. They may be effective in all stages of

KEY TERMS

Anorexia—Lack or loss of appetite.

Anticholinergic—An agent that blocks the parasympathetic nerves and their actions.

Bradykinesia—Extremely slow movement.

Bruxism—Compulsive grinding or clenching of the teeth, especially at night.

Carbon monoxide—A colorless, odorless, highly poisonous gas.

Central nervous system—The brain, spinal cord and nerves throughout the body.

Chronic—A word used to describe a long-lasting condition. Chronic conditions often develop gradually and involve slow changes.

Hallucination—A false or distorted perception of objects, sounds, or events that seems real. Hallucinations usually result from drugs or mental disorders.

Heat stroke—A severe condition caused by prolonged exposure to high heat. Heat stroke interferes with the body's temperature regulating abilities and can lead to collapse and coma.

Parkinsonism—A group of conditions that all have these typical symptoms in common: tremor, rigidity, slow movement, and poor balance and coordination.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

Seizure—A sudden attack, spasm, or convulsion.

Spasm—Sudden, involuntary tensing of a muscle or a group of muscles.

Tremor—Shakiness or trembling.

the disease. All drugs with anticholinergic properties, the naturally occurring belladonna alkaloids (atropine, scopolamine, hyoscyamine), some **antihistamines** with anticholinergic properties, and synthetics such as benzotropin (Cogentin), procyclidine (Kemadrin) and biperiden (Akineton) are members of this group. Although the anticholinergic drugs have only limited activity against Parkinson's disease, they are useful in the early stages, and may be adjuncts to levodopa as the disease progresses.

Amantadine (Symmetrel), was developed for prevention of **influenza virus infection**, but has anti-Parkinsonian properties. Its mechanism of action is not known.

Bromocriptine (Parlodel) is a prolactin inhibitor, which is used for a variety of indications including amenorrhea/galactorrhea, female **infertility**, and acromegaly. It appears to work by direct stimulation of the dopamine receptors. Bromocriptine is used as a late adjunct to levodopa therapy, and may permit reduction in levodopa dosage. Pergolide (Permax) is similar to bromocriptine, but has not been studied as extensively in Parkinson's disease.

Entacapone (Comtan) appears to act by maintaining levels of dopamine through enzyme inhibition. It is used as an adjunct to levodopa as the patient is beginning to experience the on-off effect. Tolcapone (Tasmar) is a similar agent, but has demonstrated the potential for inducing severe **liver** failure. As such, tolcapone is reserved for cases where all other adjunctive therapies have failed or are contraindicated.

Selegeline (Carbex, Eldepryl) is a selective monoamine oxidase B (MAO-B) inhibitor, however its mechanism of action in Parkinsonism is unclear, since other drugs with MAO-B inhibition have failed to show similar anti-parkinsonian effects. Selegeline is used primarily as an adjunct to levodopa, although some studies have indicated that the drug may be useful in the early stages of Parkinsonism, and may delay the progression of the disease.

Pramipexole (Mirapex) and ropinirole (Requip) are believed to act by direct stimulation of the dopamine receptors in the brain. They may be used alone in early Parkinson's disease, or as adjuncts to levodopa in advanced stages.

Recommended dosage

Dosages of anti-parkinsonian medications must be highly individualized. All doses must be carefully titrated. Consult specific references.

Precautions

There are a large number of drugs and drug classes used to treat Parkinson's disease, and individual references should be consulted. The most common side effects are associated with the **central nervous system**, and include dizziness, lightheadedness, mood changes and hallucinations. Gastrointestinal problems, including nausea and vomiting, are also common.

The anticholinergics have a large number of adverse effects, all related to their primary mode of activity. Their cardiovascular effects include tachycardia, palpitations, hypotension, postural hypotension, and mild bradycardia. They may also cause a wide range of central nervous system effects, including disorientation, confusion, **memory** loss, hallucinations, psychoses, agitation, nervousness, delusions, delirium, paranoia, euphoria, excitement, lightheadedness, dizziness, headache, listlessness, depression, drowsiness, weakness, and giddiness. Dry mouth, dry eyes and gastrointestinal distress are common problems. Sedation has been reported with some drugs in this group, but this may be beneficial in patients who suffer from insomnia. **Pregnancy** risk factor is C. Because anticholinergic drugs may inhibit milk production, their use during breastfeeding is not recommended. Patients should be warned that anticholinergic medications will inhibit perspiration, and so **exercise** during periods of high temperature should be avoided.

Levodopa has a large number of adverse effects. Anorexia, loss of appetite, occurs in roughly half the patients using this drug. Symptoms of gastrointestinal upset, such as nausea and vomiting, have been reported in 80% of cases. Other reported effects include increased hand tremor, headache, dizziness, numbness, weakness and faintness, **bruxism**, confusion, insomnia, nightmares, hallucinations and delusions, agitation and **anxiety**, malaise, fatigue, and euphoria. Levodopa has not been listed under the pregnancy risk factor schedules, but should be used with caution. Breastfeeding is not recommended.

Amantadine is generally well tolerated, but may cause dizziness and nausea. It is classified as pregnancy schedule C. Since amantadine is excreted in breast milk, breastfeeding while taking amantadine is not recommended.

Pergolide and bromocriptine have been generally well tolerated. Orthostatic hypotension is a common

problem, and patients must be instructed to risk slowly from bed. This problem can be minimized by low initial doses with small dose increments. Hallucinations may be a problem. Bromocriptine has not been evaluated for pregnancy risk, while pergolide is category B. Since both drugs may inhibit **lactation**, breastfeeding while taking these drugs is not recommended.

Pramipexole and ropinirole cause orthostatic hypotension, hallucinations and dizziness. The two drugs are in pregnancy category C. In animals, ropinirole has been shown to have adverse effects on embryo-fetal development, including teratogenic effects, decreased fetal body weight, increased fetal death and digital malformation. Because these drugs inhibit prolactin secretion, they should not be taken while breastfeeding.

Interactions

All anti-parkinsonian regimens should be carefully reviewed for possible **drug interactions**. Note that combination therapy with anti-parkinsonian drugs is, in itself, use of additive and potentiating interactions between drugs, and so careful dose adjustment is needed whenever a drug is added or withdrawn.

Resources

ORGANIZATIONS

American Parkinson Disease Association. 60 Bay Street, Suite 401, Staten Island, NY 10301. (800) 223-2732.

National Institute of Neurological Disorders and Stroke. P.O. Box 5801, Bethesda, MD 20824. (800) 352-9424.

National Parkinson Foundation, Inc. 1501 N.W. 9th Avenue, Miami, FL 33136-1494. (800) 327-4545.

Samuel Uretsky, PharmD

Antiphospholipid antibody test see
Autoimmune disease tests

Antipsychotic drugs

Definition

Antipsychotic drugs are a class of medicines used to treat psychosis and other mental and emotional conditions.

Purpose

Psychosis is defined as "a serious mental disorder (as **schizophrenia**) characterized by defective or lost contact with reality often with hallucinations or delu-

KEY TERMS

Agranulocytosis—An acute condition marked by severe depression of the bone marrow, which produces white blood cells, and by prostration, chills, swollen neck, and sore throat sometimes with local ulceration. Also called agranulocytic angina or granulocytopenia.

Anticholinergic—Blocking the action of the neurohormone acetylcholine. The most obvious effects include dry mouth and dry eyes.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies, or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies, or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

sions.” Psychosis is an end-stage condition arising from a variety of possible causes. Anti-psychotic drugs control the symptoms of psychosis, and in many cases are effective in controlling the symptoms of other disorders that may lead to psychosis, including bipolar mood disorder (formerly termed manic-depressive), in which the patient cycles from severe depression to feelings of extreme excitation. This class of drugs is primarily composed of the major tranquilizers; however, lithium carbonate, a drug that is largely specific to bipolar mood disorder, is commonly classified among the antipsychotic agents.

Description

The antipsychotic agents may be divided by chemical class. The phenothiazines are the oldest group, and include chlorpromazine (Thorazine), mesoridazine (Serentil), prochlorperazine (Compazine), and thioridazine (Mellaril). These drugs are essentially similar in action and adverse effects. They may also be used as anti-emetics, although prochlorperazine is the drug most often used for this indication.

The phenylbutylpiperadines are haloperidol (Haldol) and pimozide (Orap). They find primary use in control of Tourette’s syndrome. Haloperidol has been extremely useful in controlling aggressive behavior.

The debenzapine derivatives, clozapine (Clozaril), loxapine (Loxitane), olanzapine (Zyprexa) and quetiapine (Seroquel), have been effective in controlling psychotic symptoms that have not been responsive to other classes of drugs.

The benzisoxidil group is composed of resperidone (Resperidal) and ziprasidone (Geodon). Resperidone has been found useful for controlling bipolar mood disorder, while ziprasidone is used primarily as second-line treatment for schizophrenia.

In addition to these drugs, the class of antipsychotic agents includes lithium carbonate (Eskalith, Lithonate), which is used for control of bipolar mood disorder, and thiothixene (Navane), which is used in the treatment of psychosis.

Recommended dosage

Dose varies with the drug, condition being treated, and patient response. See specific references.

Precautions

Neuroleptic malignant syndrome (NMS) is a rare, idiosyncratic combination of extra-pyramidal symptoms (EPS), hyperthermia, and autonomic disturbance. Onset may be hours to months after drug initiation, but once started, proceeds rapidly over 24 to 72 hours. It is most commonly associated with haloperidol, long-acting fluphenazine, but has occurred with thiothixene, thioridazine, and clozapine, and may occur with other agents. NMS is potentially fatal, and requires intensive symptomatic treatment and immediate discontinuation of neuroleptic treatment. There is no established treatment. Most patients who develop NMS will have the same problem if the drug is restarted.

Tardive dyskinesia (TD) is a syndrome of involuntary movements that may appear in patients treated with neuroleptic drugs. Although prevalence of TD appears highest among the elderly, especially women, it is impossible to predict which patients are likely to develop the syndrome. Both the risk of developing TD and the likelihood that it will become irreversible are increased with higher doses and longer periods of treatment. The syndrome can develop after short treatment periods at low doses. Anticholinergic agents may worsen these effects. Clozapine has occasionally been useful in controlling the TD caused by other antipsychotic drugs.

Agranulocytosis has been associated with clozapine. This is a potentially fatal reaction, but can be prevented with careful monitoring of the white **blood** count. There are no well-established risk factors for developing agranulocytosis, and so all patients treated with this drug must

ANTIPSYCHOTIC DRUGS	
Brand Name (Generic Name)	Possible Common Side Effects Include:
Clozaril (clozapine)	Seizures, agranulocytosis, dizziness, increased blood pressure
Compazine (prochlorperazine)	Involuntary muscle spasms, dizziness, jitteriness, puckering of the mouth
Haldol (haloperidol)	Involuntary muscle spasms, blurred vision, dehydration, headache, puckering of the mouth
Mellaril (thioridazine)	Involuntary muscle spasms, constipation and diarrhea, sensitivity to light
Navane (thiothixene)	Involuntary muscle spasms, dry mouth, rash, hives
Risperdal (risperidone)	Involuntary muscle spasms, abdominal and chest pain, fever, headache
Stelazine (trifluoperazine hydrochloride)	Involuntary muscle spasms, drowsiness, fatigue
Thorazine (chlorpromazine)	Involuntary muscle spasms, labored breathing, fever, puckering of the mouth
Triavil	Involuntary muscle spasms, disorientation, excitability, lightheadedness

(Illustration by Standley Publishing. Courtesy of Gale Group.)

follow the clozapine Patient Management System. For more information, call 1-800-448-5938.

Anticholinergic effects, particularly dry mouth, have been reported with all of the phenothiazines, and can be severe enough to cause patients to discontinue their medication.

Photosensitization is a common reaction to chlorpromazine. Patients must be instructed to use precautions when exposed to sunlight.

Lithium carbonate commonly causes increased frequency of urination.

Antipsychotic drugs are **pregnancy** category C. (Clozapine is category B.) The drugs in this class appear to be generally safe for occasional use at low doses during pregnancy, but should be avoided near time of delivery. Although the drugs do not appear to be teratogenic, when used near term, they may cross the placenta and have adverse effects on the newborn infant, including causing involuntary movements. There is no information about safety in breastfeeding.

As a class, the antipsychotic drugs have a large number of potential side effects, many of them serious. Specific references should be consulted.

Drug interactions

Because the phenothiazines have anticholinergic effects, they should not be used in combination with other drugs that may have similar effects.

Because the drugs in this group may cause hypotension, or low **blood pressure**, they should be used with extreme care in combination with blood pressure-lowering drugs.

The antipsychotic drugs have a large number of **drug interactions**. Consult specific references.

Samuel D. Uretsky, PharmD

Antiretroviral drugs

Definition

Antiretroviral drugs inhibit the reproduction of retroviruses—viruses composed of RNA rather than DNA. The best known of this group is HIV, human **immunodeficiency** virus, the causative agent of **AIDS**.

Purpose

Antiretroviral agents are virustatic agents which block steps in the replication of the virus. The drugs are not curative; however continued use of drugs, particularly in multi-drug regimens, significantly slows disease progression.

Description

There are three main types of antiretroviral drugs, although only two steps in the viral replications process are blocked. Nucleoside analogs, or nucleoside reverse transcriptase inhibitors (NRTIs), such as didanosine (ddI, Videx), lamivudine (3TC, Epivir), stavudine (d4T, Zerit), zalcitabine (ddC, Hivid), and zidovudine (AZT, Retrovir), act by inhibiting the enzyme reverse transcriptase. Because a retrovirus is composed of RNA, the virus must make a DNA strand in order to replicate itself. Reverse transcriptase is an enzyme that is essential to making the DNA copy. The nucleoside reverse transcriptase inhibitors are incorporated into the DNA strand. This is a faulty DNA molecule which is incapable of reproducing.

The non-nucleoside reverse transcriptase inhibitors (NNRTIs), such as delavirdine (Rescriptor), loviride, and nevirapine (Viramune) act by binding directly to the reverse transcriptase molecule, inhibiting its activity.

Protease inhibitors, such as indinavir (Crixivan), nelfinavir (Viracept), ritonavir (Norvir), and saquinavir (Invirase) act on the enzyme protease, which is essential for the virus to break down the **proteins** in infected cells. Without this essential step, the virus produces immature copies of itself, which are non-infectious.

Because HIV mutates readily, the virus can develop resistance to single drug therapy. However, treatment with drug combinations appears to produce a durable response. Proper treatment appears to slow the progression of HIV infections and reduce the frequency of opportunistic infections.

Recommended dosage

Doses must be individualized based on the patient, and use of interacting drugs. The optimum combinations of antiretroviral drugs have not been determined, nor is there agreement on the stage of **infection** at which to start treatment.

Precautions

Although the antiretroviral drugs fall into three groups, each drug has a unique pattern of adverse effects and **drug interactions**. Since the drugs are used in vari-

KEY TERMS

Antiviral drugs—Medicines that cure or control virus infections.

Bioavailability—A measure of the amount of drug that is actually absorbed from a given dose.

Immune system—The body's natural defenses against disease and infection.

Inflammation—Pain, redness, swelling, and heat that usually develop in response to injury or illness.

Insomnia—A sleep disorder characterized by inability to either fall asleep or to stay asleep.

Mutates—Undergoes a spontaneous change in the make-up of genes or chromosomes.

Pancreas—A gland located beneath the stomach. The pancreas produces juices that help break down food and secretes insulin that helps the body use sugar for energy.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

Retrovirus—A virus composed of ribonucleic acid (RNA) instead of deoxynucleic acid (DNA).

Virus—A tiny, disease-causing particle that can reproduce only in living cells.

ous combinations, the frequency and severity of adverse effects will vary with the combination. Although most drug combinations show a higher rate of adverse events than single drug therapy, some patterns are not predictable. For example, indinavir has been reported to cause insomnia in 3% of patients, however, when used in combination with zidovudine, only 1.5% of patients complained of sleep difficulties.

The most severe adverse effects associated with the protease inhibitors are renal and hepatic toxicity. Patients have also reported a syndrome of abdominal distention and increased body odor, which may be socially limiting.

Hemophilic patients have reported increased bleeding tendencies while taking protease inhibitors. The drugs are **pregnancy** category B. There have been no controlled studies of safety in pregnancy. HIV-infected mothers are advised not to breast feed in order to prevent transmission of the virus to the newborn.

The nucleoside reverse transcriptase inhibitors have significant levels of toxicity. Lactic acidosis in the absence of hypoxemia and severe hepatomegaly with steatosis have been reported with zidovudine and zalcitabine, and are potentially fatal. Rare cases of hepatic failure, considered possibly related to underlying hepatitis B and zalcitabine monotherapy, have been reported.

Abacavir has been associated with fatal hypersensitivity reactions. Didanosine has been associated with severe **pancreatitis**. Nucleoside reverse transcriptase inhibitors are pregnancy category C. There is limited information regarding safety during pregnancy. Zidovudine has been used during pregnancy to reduce the risk of HIV infection to the infant. HIV-infected mothers are advised not to breastfeed in order to prevent transmission of the virus to the newborn.

Efavirenz has been associated with a high frequency of skin rash, 27% in adults and 40% in children. Nevirapine has been associated with severe **liver** damage and skin reactions. All of the non-nucleoside reverse transcriptase inhibitors are pregnancy category C, based on animal studies.

Because of the high risk of viral resistance development, antiretroviral agents should be used in combination. If one drug in the group must be discontinued, it is recommended that all antiretroviral therapy be discontinued until a multi-drug regimen can be resumed. The non-nucleoside reverse transcriptase inhibitors particularly should not be used alone.

Interactions

Because of the high frequency of drug interactions associated with AIDS therapy, specialized references should be consulted.

Saquinavir is marketed in both hard and soft gelatin capsules. Because saquinavir in the hard gelatin capsule formulation (Invirase) has poor bioavailability, it is recommended that this formulation only be used in combination with other drugs which interact to raise saquinavir **blood** levels. Saquinavir soft gelatin capsules (Fortovase) are the preferred dosage form of this drug.

Resources

PERIODICALS

Lipsky, James J. "Antiretroviral Drugs for AIDS." *The Lancet* 348 (September 21, 1996): 800.

Williams, Ann B. "New Horizons: Antiretroviral Therapy in 1997." *Journal of the Association of Nurses in AIDS Care* 8 (July-August 1997): 26.

ORGANIZATIONS

Project Inform. 205 13th Street, #2001, San Francisco, CA 94103. (415) 558-8669. <<http://www.projinf.org>>.

OTHER

AIDS Clinical Trials Information Service website and telephone information line. Sponsored by Centers for Disease Control and Prevention, Food and Drug Administration, National Institute of Allergy and Infectious Diseases, and National Library of Medicine. 800-TRIALS-A (800-874-2572). <<http://actis.org>>.

HIV/AIDS Treatment Information Service website and telephone information line. Sponsored by Agency for Health Care Policy and Research, Centers for Disease Control and Prevention, Health Resources and Services Administration, Indian Health Service, National Institutes of Health, and Substance Abuse and Mental Health Services Administration. 800-HIV-0440 (800-448-0440). <<http://www.hivatis.org>>.

Project Inform National HIV/AIDS Treatment Hotline. 800-822-7422.

Samuel Uretsky, PharmD

Antiseptics

Definition

An antiseptic is a substance which inhibits the growth and development of microorganisms. For practical purposes, antiseptics are routinely thought of as topical agents, for application to skin, mucous membranes, and inanimate objects, although a formal definition includes agents which are used internally, such as the urinary tract antiseptics.

Purpose

Antiseptics are a diverse class of drugs which are applied to skin surfaces or mucous membranes for their anti-infective effects. This may be either bacteriocidal or bacteriostatic. Their uses include cleansing of skin and wound surfaces after injury, preparation of skin surfaces prior to injections or surgical procedures, and routine disinfection of the oral cavity as part of a program of **oral**



Hands shown applying ointment to baby's lower back.
(Field Mark Publications. Reproduced by permission.)

hygiene. Antiseptics are also used for disinfection of inanimate objects, including instruments and furniture surfaces.

Commonly used antiseptics for skin cleaning include benzalkonium chloride, chlorhexidine, hexachlorophene, iodine compounds, mercury compounds, alcohol, and hydrogen peroxide. Other agents which have been used for this purpose, but have largely been supplanted by more effective or safer agents, include boric acid and volatile oils such as methyl salicylate (oil of wintergreen).

Chlorhexidine shows a high margin of safety when applied to mucous membranes, and has been used in oral rinses and preoperative total body washes.

Benzalkonium chloride and hexachlorophene are used primarily as hand scrubs or face washes. Benzalkonium may also find application as a disinfecting agent for instruments, and in low concentration as a preservative for drugs including ophthalmic solutions. Benzalkonium chloride is inactivated by organic compounds, including soap, and must not be applied to areas that have not been fully rinsed.

Iodine compounds include tincture of iodine and povidone iodine compounds. Iodine compounds have the broadest spectrum of all topical anti-infectives, with action against **bacteria, fungi, viruses**, spores, protozoa, and yeasts. Iodine tincture is highly effective, but its alcoholic component is drying and extremely irritating when applied to abraded (scraped or rubbed) skin. Povidone iodine, an organic compound, is less irritating and less toxic, but not as effective. Povidone iodine has been used for hand scrubs and disinfection of surgical sites. Aqueous solutions of iodine have also been used as antiseptic agents, but are less effective than alcoholic solutions and less convenient to use than the povidone iodine compounds.

Hydrogen peroxide acts through the liberation of oxygen gas. Although the antibacterial activity of hydrogen peroxide is relatively weak, the liberation of oxygen bubbles produces an effervescent action, which may be useful for wound cleansing through removal of tissue debris. The activity of hydrogen peroxide may be reduced by the presence of **blood** and pus. The appropriate concentration of hydrogen peroxide for antiseptic use is 3%, although higher concentrations are available.

Thimerosal (Mersol) is a mercury compound with activity against bacteria and yeasts. Prolonged use may result in mercury toxicity.

Recommended dosage

Dosage varies with product and intended use. Consult individualized references.

Precautions

Precautions vary with individual product and use. Consult individualized references.

Hypersensitivity reactions should be considered with organic compounds such as chlorhexidine, benzalkonium and hexachlorophene.

Skin dryness and irritation should be considered with all products, but particularly with those containing alcohol.

Systemic toxicity may result from ingestion of iodine containing compounds or mercury compounds.

Most antiseptics have not been rated according to **pregnancy** category under the pregnancy risk factor system. Hexachlorophene is schedule C during pregnancy, and should not be used on newborns due to risk of systemic absorption with potential **central nervous system** (CNS) effects, including convulsions. Avoid application of hexachlorophene to open **wounds**, mucous membranes, or areas of thin skin, such as the genitalia, since this may promote systemic absorption.

Chlorhexidine should not be instilled into the ear. There is one anecdotal report of deafness following use of chlorhexidine in a patient with a perforated eardrum. Safety in pregnancy and breastfeeding have not been reported, however there is one anecdotal report of an infant developing slowed heartbeat apparently related to maternal use of chlorhexidine.

Iodine compounds should be used sparingly during pregnancy and **lactation** due to risk of infant absorption of iodine with alterations in thyroid function.

KEY TERMS

Antibiotic—A medicine used to treat infections.

Bacteria—Tiny, one-celled forms of life that cause many diseases and infections.

Mucous membrane—The moist lining of a body cavity or structure, such as the mouth or nose.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

Residue—Traces that remain after most of the rest of the material is gone.

Interactions

Antiseptics are not known to interact with any other medicines. However, they should not be used together with any other topical cream, solution, or ointment.

Resources

PERIODICALS

Farley, Dixie. "Help for Cuts, Scrapes and Burns." *FDA Consumer* (May 1996):12.

Samuel Uretsky, PharmD

Antithrombin III test see **Hypercoagulability tests; Thrombosis risk tests**

Antilucer drugs

Definition

Antilucer drugs are a class of drugs, exclusive of the antibacterial agents, used to treat ulcers in the **stomach** and the upper part of the **small intestine**.

Purpose

Recurrent gastric and duodenal ulcers are caused by *Helicobacter pylori* infections, and are treated with com-

bination treatments that incorporate antibiotic therapy with gastric acid suppression. Additionally, bismuth compounds have been used. The primary class of drugs used for gastric acid suppression are the proton pump inhibitors, omeprazole, lansoprazole, pantoprazole and rabeprazole. The H₂ receptor blocking agents, cimetidine, famotidine, nizatidine, and ranitidine have been used for this purpose, but are now more widely used for maintenance therapy after treatment with the proton pump inhibitors. Sucralfate, which acts by forming a protective coating over the ulcerate lesion, is also used in ulcer treatment and may be appropriate for patients in whom other classes of drugs are not indicated, or those whose gastric ulcers are caused by non-steroidal anti-inflammatory drugs (NSAIDs) rather than *H. pylori* infections.

Description

The proton pump inhibitors block the secretion of gastric acid by the gastric parietal cells. The extent of inhibition of acid secretion is dose related. In some cases, gastric acid secretion is completely blocked for over 24 hours on a single dose. In addition to their role in treatment of gastric ulcers, the proton pump inhibitors are used to treat syndromes of excessive acid secretion (Zollinger-Ellison Syndrome) and gastroesophageal reflux disease (GERD).

Histamine H₂ receptor blockers stop the action of histamine on the gastric parietal cells, inhibiting the secretion of gastric acid. These drugs are less effective than the proton pump inhibitors, but may achieve a 75–79% reduction in acid secretion. Higher rates of acid inhibition may be achieved when the drug is administered by the intravenous route. The H₂ receptor blockers may also be used to treat heartburn and hypersecretory syndromes. When given before surgery, the H₂ receptor blockers are useful in prevention of aspiration **pneumonia**.

Sucralfate (Carafate), a substituted sugar molecule with no nutritional value, does not inhibit gastric acid, but rather, reacts with existing stomach acid to form a thick coating that covers the surface of an ulcer, protecting the open area from further damage. A secondary effect is to act as an inhibitor of the digestive enzyme pepsin. Sucralfate does not bind to the normal stomach lining. The drug has been used for prevention of **stress** ulcers, the type seen in patients exposed to physical stress such as **burns** and surgery. It has no systemic effects.

ANTIULCER DRUGS	
Brand Name (Generic Name)	Possible Common Side Effects Include:
Axid (nizatidine)	Diarrhea, headache, nausea and vomiting, sore throat
Carafate (sucralfate)	Constipation, insomnia, hives, upset stomach, vomiting
Cytotec (misoprostol)	Cramps, diarrhea, nausea, gas, headache, menstrual disorders (including heavy bleeding and severe cramping)
Pepcid (famotidine)	Constipation or diarrhea, dizziness, fatigue, fever
Prilosec (omeprazole)	Nausea and vomiting, headache, diarrhea, abdominal pain
Tagamet (cimetidine)	Headache, breast development in men, depression and disorientation
Zantac (ranitidine hydrochloride)	Headache, constipation or diarrhea, joint pain

(Illustration by Standley Publishing. Courtesy of Gale Group.)

Recommended dosage

The doses of the proton pump inhibitors and H₂ receptor blockers vary depending on the drug and condition being treated. Consult individual references.

The dose of sucralfate for acute ulcer therapy is 1 gram four times a day. After the ulcer has healed, maintenance treatment may continue at 1 gram two times daily.

Precautions

The proton pump inhibitors are generally well tolerated, and the most common adverse effects are **diarrhea**, itching, skin rash, dizziness, and headache. Muscle aches and a higher than normal rate of respiratory infections are among the other adverse reactions reported. Omeprazole is classed as **pregnancy category C** due to an increased rate of fetal deaths in animal studies. The other drugs in this group are pregnancy category B. It is not known if these drugs are excreted in human milk, but because of reported adverse effects to infants in animal studies, it is recommended that proton pump inhibitors not be used by nursing mothers.

The H₂ receptor blockers vary widely in their adverse effects. Although they are generally well tolerated, cimetidine may cause confusion in elderly patients, and has an antiandrogenic effect that may cause **sexual dysfunction** in males. Famotidine has been reported to cause headache in 4.7% of patients. Nizatidine is pregnancy category C, the others are schedule B. It is advisable that mothers not take H₂ receptor blockers while nursing.

Sucralfate is well tolerated. It is poorly absorbed, and its most common side effect is constipation in 2% of patients. Diarrhea, nausea, vomiting, gastric discomfort, indigestion, flatulence, dry mouth, rash, pruritus (itching), back **pain**, headache, dizziness, sleepiness, and vertigo have been reported, as well as rare allergic responses. Because sucralfate releases small amounts of aluminum into the system, it should be used with caution in patients with renal insufficiency. Sucralfate is category B in pregnancy. There is no information available about its safety in breastfeeding.

Interactions

Proton pump inhibitors may increase the pH of the stomach. This will inactivate some antifungal drugs that require an acid medium for effectiveness, notable itraconazole and ketoconazole.

H₂ receptor blocking agents have a large number of **drug interactions**. Consult individualized references.

Sucralfate should not be used with aluminum containing **antacids**, because of the risk of increased aluminum absorption. Sucralfate may inhibit absorption and reduce **blood** levels of anticoagulants, digoxin, quinine, ketoconazole, quinolones, and phenytoin.

Resources

ORGANIZATIONS

Digestive Disease National Coalition. 507 Capitol Court NE, Suite 200, Washington, DC 20003. (202) 544-7497.

KEY TERMS

Antibiotic—Medicine used to treat infections.

Enzyme—A type of protein, produced in the body, that brings about or speeds up chemical reactions.

Gastrointestinal tract—The stomach, small intestine and large intestine.

Hypersecretory—Excessive production of a bodily secretion. The most common hypersecretory syndrome of the stomach is Zollinger-Ellison Syndrome, a syndrome consisting of fulminating intractable peptic ulcers, gastric hypersecretion and hyperacidity, and the occurrence of gastrinomas of the pancreatic cells of the islets of Langerhans.

Inflammation—Pain, redness, swelling, and heat that usually develop in response to injury or illness.

Mucous—Thick fluid produced by the moist membranes that line many body cavities and structures.

Nonsteroidal anti-inflammatory drug (NSAID)—A type of medicine used to relieve pain, swelling, and other symptoms of inflammation, such as ibuprofen or ketoprofen.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

National Digestive Diseases Information Clearinghouse. 2
Information Way, Bethesda, MD 20892-3570.
nddic@erie.com.
<<http://www.niddk.nih.gov/Brochures/NDDIC.htm>>.

OTHER

Duodenal Ulcer Fact sheet. Johns Hopkins Health Information
Adult Health Advisor. Available at
<<http://csi.intelihealth.com>>.

National Institute of Diabetes and Digestive and Kidney
Diseases. <<http://www.niddk.nih.gov>>.

PharmInfoNet's Digestive Disease Center
<<http://pharminfo.com/disease.gastro.html>>.

Stomach and Duodenal Ulcers Fact sheet. National Institute of
Diabetes and Digestive and Kidney Diseases, January
1995 (NIH Publication No. 95-38).

Stomach Ulcer (Gastric Ulcer) Fact sheet. Johns Hopkins
Health Information Adult Health Advisor.
<<http://csi.intelihealth.com>>.

Samuel Uretsky, PharmD

Antiviral drugs

Definition

Antiviral drugs are medicines that cure or control virus infections.

Purpose

Antivirals are used to treat infections caused by **viruses**. Unlike antibacterial drugs, which may cover a wide range of pathogens, antiviral agents tend to be narrow in spectrum, and have limited efficacy.

Description

Exclusive of the antiretroviral agents used in HIV (**AIDS**) therapy, there are currently only 11 antiviral drugs available, covering four types of virus. Acyclovir (Zovirax), famciclovir (Famvir), and valacyclovir (Valtrex) are effective against herpesvirus, including herpes zoster and herpes genitalis. They may also be of value in either conditions caused by herpes, such as chickenpox and shingles. These drugs are not curative, but may reduce the **pain** of a herpes outbreak and shorten the period of viral shedding.

Amantadine (Symmetrel), oseltamivir (Tamiflu), rimantidine (Flumadine), and zanamivir (Relenza) are useful in treatment of **influenza** virus. Amantadine, rimantidine, and oseltamivir may be administered throughout the flu season as preventatives for patients who cannot take influenza virus vaccine.

Cidofovir (Vistide), foscarnet (Foscavir), and ganciclovir (Cytovene) have been beneficial in treatment of cytomegalovirus in immunosuppressed patients, primarily HIV-positive patients and transplant recipients. Ribavirin (Virazole) is used to treat respiratory syncytial virus. In combination with interferons, ribavirin has shown some efficacy against hepatitis C, and there have been anecdotal reports of utility against other types of viral infections.

KEY TERMS

Asthenia—Muscle weakness.

Cytomegalovirus (CMV)—A type of virus that attacks and enlarges certain cells in the body. The virus also causes a disease in infants.

Herpes simplex—A virus that causes sores on the lips (cold sores) or on the genitals (genital herpes).

HIV—Acronym for human immunodeficiency virus, the virus that causes AIDS.

Parkinsonism—A group of conditions that all have these typical symptoms in common: tremor, rigidity, slow movement, and poor balance and coordination.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies, or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies, or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

Prophylactic—Guarding from or preventing the spread or occurrence of disease or infection.

Retrovirus—A group of viruses that contain RNA and the enzyme reverse transcriptase. Many viruses in this family cause tumors. The virus that causes AIDS is a retrovirus.

Shingles—An disease caused by an infection with the Herpes zoster virus, the same virus that causes chickenpox. Symptoms of shingles include pain and blisters along one nerve, usually on the face, chest, stomach, or back.

Virus—A tiny, disease-causing structure that can reproduce only in living cells and causes a variety of infectious diseases.

As a class, the antivirals are not curative, and must be used either prophylactically or early in the development of an **infection**. Their mechanism of action is typically to inactivate the enzymes needed for viral replication. This will reduce the rate of viral growth, but will not inactivate the virus already present. Antiviral therapy must normally be initiated within 48 hours of the onset of an

infection to provide any benefit. Drugs used for influenza may be used throughout the influenza season in high risk patients, or within 48 hours of exposure to a known carrier. Antiherpetic agents should be used at the first signs of an outbreak. Anti-cytomegaloviral drugs must routinely be used as part of a program of secondary prophylaxis (maintenance therapy following an initial response) in order to prevent reinfection in immunocompromised patients.

Recommended dosage

Dosage varies with the drug, patient age and condition, route of administration, and other factors. See specific references.

Precautions

Ganciclovir is available in intravenous injection, oral capsules, and intraocular inserts. The capsules should be reserved for prophylactic use in organ transplant patients, or for HIV infected patients who cannot be treated with the intravenous drug. The toxicity profile of this drug when administered systemically includes granulocytopenia, anemia, and thrombocytopenia. The drug is in **pregnancy** category C, but has caused significant fetal abnormalities in animal studies, including cleft palate and organ defects. Breastfeeding is not recommended.

Cidofovir causes renal toxicity in 53% of patients. Patients should be well hydrated, and renal function should be checked regularly. Other common adverse effects are nausea and vomiting in 65% of patients, asthenia in 46% and headache and **diarrhea**, both reported in 27% of cases. The drug is category C in pregnancy, due to fetal abnormalities in animal studies. Breastfeeding is not recommended.

Foscarnet is used in treatment of immunocompromised patients with cytomegalovirus infections and in acyclovir-resistant herpes simplex virus. The primary hazard is renal toxicity. Alterations in electrolyte levels may cause seizures. Foscarnet is category C during pregnancy. The drug has caused skeletal abnormalities in developing fetuses. It is not known whether foscarnet is excreted in breast milk, however the drug does appear in breast milk in animal studies.

Valaciclovir is metabolized to acyclovir, so that the hazards of the two drugs are very similar. They are generally well tolerated, but nausea and headache are common adverse effects. They are both pregnancy category B. Although there have been no reports of fetal abnormalities attributable to either drug, the small number of reported cases makes it impossible to draw conclusions regarding safety in pregnancy. Acyclovir is found in

breast milk, but no adverse effects have been reported in the newborn. Famciclovir is similar in actions and adverse effects.

Ribavirin is used by aerosol for treatment of hospitalized infants and young children with severe lower respiratory tract infections due to respiratory syncytial virus (RSV). When administered orally, the drug has been used in adults to treat other viral diseases including acute and chronic hepatitis, herpes genitalis, measles, and Lassa fever, however there is relatively little information about these uses. In rare cases, initiation of ribavirin therapy has led to deterioration of respiratory function in infants. Careful monitoring is essential for safe use.

The anti-influenza drugs are generally well tolerated. Amantadine, which is also used for treatment of parkinsonism, may show more frequent CNS effects, including sedation and dizziness. Rapid discontinuation of amantadine may cause an increase in parkinsonian symptoms in patients using the drug for that purpose. All are schedule C for pregnancy. In animal studies, they have caused fetal malformations in doses several times higher than the normal human dose. Use caution in breastfeeding.

Interactions

Consult specific references for information on **drug interactions**.

Use particular caution in HIV-positive patients, since these patients are commonly on multi-drug regimens with a high frequency of interactions. Ganciclovir should not be used with other drugs which cause hematologic toxicity, and cidofovir should not be used with other drugs that may cause kidney damage.

Resources

PERIODICALS

Gray, Mary Ann. "Antiviral Medications." *Orthopaedic Nursing* 15 (November-December 1996): 82.

Samuel D. Uretsky, PharmD

Anxiety

Definition

Anxiety is a multisystem response to a perceived threat or danger. It reflects a combination of biochemical changes in the body, the patient's personal history and **memory**, and the social situation at hand. Human anxiety

involves an ability to use memory and imagination and to move backward and forward in time; a large portion of human anxiety is produced by anticipation of future events. Without a sense of personal continuity over time, people would not have the "raw materials" of anxiety.

It is important to distinguish between anxiety as a feeling or experience, and an anxiety disorder as a psychiatric diagnosis. A person may feel anxious without having an anxiety disorder.

Short-term anxiety can be considered within the range of normal human experience. It is only when anxiety presents with great intensity or long duration that it is classified as a pathological state. Particular manifestations of anxiety, such as a flashback experience, the development of a phobia, or the sudden onset of a panic attack, are suggestive of a serious anxiety problem.

Description

Although anxiety is something that everyone experiences from time to time, it is difficult to describe concretely because it has so many different potential causes and degrees of intensity. Doctors sometimes categorize anxiety as either an emotion or an affect, depending on whether it is being described by the person having it (emotion) or by an outside observer (affect). The word "emotion" is generally used for the biochemical changes and feeling state that underlie a person's internal sense of anxiety. The term "affect" is used to describe the person's emotional state from an observer's perspective. If a doctor says that a patient has an anxious affect, he or she means that the patient appears outwardly nervous or anxious, or responds to others in an anxious manner.

Although anxiety is related to fear, it is not the same thing. Fear is a direct, focused response to a specific event or object, and the person is consciously aware of it. Anxiety, on the other hand, is often vague and unfocused. In this form it is called free-floating anxiety. Sometimes anxiety being experienced in the present may stem from an event or person that produced **pain** and fear in the past, but the anxious individual is not consciously aware of the original source of the feeling. It is anxiety's aspect of remoteness that makes it hard for people to compare their experiences of it. Whereas most people will be fearful in physically dangerous situations, and can agree that fear is an appropriate response in the presence of danger, anxiety is often triggered by objects or events that are unique and specific to an individual. An individual might be anxious because of a unique meaning or memory being stimulated by present circumstances, not because of some immediate danger. Another individual looking at the anxious person from the outside may be truly puzzled as to the reason for the person's anxiety.

Generalized anxiety disorder (GAD) is the common name for a clinically confirmed diagnosis of anxiety. GAD is defined as a state in which an individual has significant worry, fear, and anxiety for a majority of the time for a period of at least six months. The anxiety present in such an individual must produce at least three significant somatic symptoms, such as impaired concentration, sleep disturbance, muscle tension, irritability, increased fatigue, or restlessness.

GAD has been estimated to occur in 4% to 7% of the population at any given time in the United States. Females are about twice as likely as males to develop GAD. Nearly one-third of cases of GAD present before 11 years of age. Half of all cases have onset before 18 years of age.

Causes and symptoms

Anxiety can have a number of different causes. It is a multidimensional response to stimuli in the person's environment, or a response to an internal stimulus (for example, a hypochondriac's reaction to a **stomach** rumbling) resulting from a combination of general biological and individual psychological processes.

Physical

In some cases, anxiety is produced by physical responses to **stress**, or by certain disease processes or medications.

THE AUTONOMIC NERVOUS SYSTEM (ANS). The nervous system is "hard-wired" to respond to dangers or threats. These responses are not subject to conscious control and are the same in humans as in lower animals. They represent an evolutionary adaptation to the animal predators and other dangers with which all animals, including primitive humans, had to cope. The most familiar reaction of this type is the so-called "fight-or-flight" reaction. This is the human organism's automatic response to a life-threatening situation, a state of physiological and emotional hyperarousal marked by high muscle tension and strong feelings of fear or anger. When people have a fight-or-flight reaction, the level of stress hormones in their **blood** rises. They become more alert and attentive, their eyes dilate, their heartbeat increases, their breathing rate increases, and their digestion slows down, allowing more energy to be available to the muscles.

This emergency reaction is regulated by a part of the nervous system called the **autonomic nervous system**, or ANS. The ANS is controlled by the hypothalamus, a specialized part of the brainstem that is among a group of structures called the limbic system. The limbic system controls human emotions through its connections to

glands and muscles; it also connects to the ANS and "higher" **brain** centers, such as parts of the cerebral cortex. One problem with this arrangement is that the limbic system cannot tell the difference between a realistic physical threat and an anxiety-producing thought or idea. The hypothalamus may trigger the release of stress hormones by the **pituitary gland**, even when there is no external and objective danger. A second problem is caused by the biochemical side effects of too many "false alarms" in the ANS. When a person responds to a real danger, his or her body gets rid of the stress hormones by running away or by fighting. In modern life, however, people often have fight-or-flight reactions in situations in which they can neither run away nor lash out physically. As a result, their bodies have to absorb all the biochemical changes of hyperarousal rather than release them. These biochemical changes can produce anxious feelings, as well as muscle tension and other physical symptoms associated with anxiety. They may even produce permanent changes in the brain, if the process occurs repeatedly. Moreover, chronic physical disorders, such as **coronary artery disease**, may be worsened by anxiety, as chronic hyperarousal puts undue stress on the **heart**, stomach, and other organs.

Other theorists attribute some drug addiction to the desire to relieve symptoms of anxiety. Most addictions, they argue, originate in the use of mood-altering substances or behaviors to "medicate" anxious feelings.

DISEASES AND DISORDERS. Anxiety can be a symptom of certain medical conditions. Some of these diseases are disorders of the **endocrine system**, such as Cushing's syndrome (overproduction of cortisol by the adrenal cortex), and include over- or underactivity of the **thyroid gland**. Other medical conditions that can produce anxiety include **respiratory distress syndrome**, mitral valve prolapse, porphyria, and chest pain caused by inadequate blood supply to the heart (angina pectoris).

MEDICATIONS AND SUBSTANCE USE. Numerous medications may cause anxiety-like symptoms as a side effect. They include birth control pills; some thyroid or **asthma** drugs; some psychotropic agents; occasionally, local anesthetics; **corticosteroids**; **antihypertensive drugs**; and **nonsteroidal anti-inflammatory drugs** (such as flurbiprofen and ibuprofen).

Although people do not usually think of **caffeine** as a drug, it can cause anxiety-like symptoms when consumed in sufficient quantity. Patients who consume caffeine-rich foods and beverages, such as chocolate, cocoa, coffee, tea, or carbonated soft drinks (especially cola beverages) can sometimes lower their anxiety symptoms simply by reducing their intake of these substances.

Withdrawal from certain prescription drugs, primarily beta blockers and corticosteroids, can cause anxiety. Withdrawal from drugs of abuse, including LSD, cocaine, alcohol, and opiates, can also cause anxiety.

Learned associations

Some aspects of anxiety appear to be unavoidable byproducts of the human developmental process. Humans are unique among animals in that they spend an unusually long period of early life in a relatively helpless condition, and a sense of helplessness can lead to anxiety. The extended period of human dependency on adults means that people may remember, and learn to anticipate, frightening or upsetting experiences long before they are capable enough to feel a sense of mastery over their environment. In addition, the fact that anxiety disorders often run in families indicates that children can learn unhealthy attitudes and behaviors from parents. Also, recurrent disorders in families may indicate that there is a genetic or inherited component in some anxiety disorders. For example, there has been found to be a higher rate of anxiety disorders (panic) in identical twins than in fraternal twins.

CHILDHOOD DEVELOPMENT AND ANXIETY. Researchers in early childhood development regard anxiety in adult life as a residue of childhood memories of dependency. Humans learn during the first year of life that they are not self-sufficient and that their basic survival depends on the care of others. It is thought that this early experience of helplessness underlies the most common anxieties of adult life, including fear of powerlessness and fear of being unloved. Thus, adults can be made anxious by symbolic threats to their sense of competence and/or significant relationships, even though they are no longer helpless children.

SYMBOLIZATION. The psychoanalytic model gives considerable weight to the symbolic aspect of human anxiety; examples include phobic disorders, obsessions, compulsions, and other forms of anxiety that are highly individualized. The length of the human maturation process allows many opportunities for children and adolescents to connect their experiences with certain objects or events that can bring back feelings in later life. For example, a person who was frightened as a child by a tall man wearing glasses may feel panicky years later by something that reminds him of that person without consciously knowing why.

PHOBIAS. Phobias are a special type of anxiety reaction in which the person's anxiety is concentrated on a specific object or situation that the person then tries to avoid. In most cases, the person's fear is out of proportion to its "cause." Prior to the *Diagnostic and Statistical*

Manual of Mental Disorders, 4th edition (*DSM-IV*), currently the model text for diagnostic criteria, these specific phobias were called simple phobias. It is estimated that 10%-11% of the population will develop a phobia in the course of their lives. Some phobias, such as agoraphobia (fear of open spaces), claustrophobia (fear of small or confined spaces), and social phobia, are shared by large numbers of people. Others are less common or unique to the patient.

Social and environmental stressors

Anxiety often has a social dimension because humans are social creatures. People frequently report feelings of high anxiety when they anticipate—and therefore fear—the loss of social approval or love. Social phobia is a specific anxiety disorder that is marked by high levels of anxiety or fear of embarrassment in social situations.

Another social stressor is prejudice. People who belong to groups that are targets of bias are at higher risk for developing anxiety disorders. Some experts assert, for example, that the higher rates of phobias and panic disorders among women reflect their greater social and economic vulnerability.

Some controversial studies indicate that the increase in violent or upsetting pictures and stories in news reports and entertainment may raise the anxiety level of many people. Stress and anxiety management programs often suggest that patients cut down their exposure to upsetting stimuli.

Anxiety may also be caused by environmental or occupational factors. People who must live or work around sudden or loud noises, bright or flashing lights, chemical vapors, or similar nuisances that they cannot avoid or control, may develop heightened anxiety levels.

Existential anxiety

Another factor that shapes human experiences of anxiety is knowledge of personal mortality. Humans are the only animals that appear to be aware of their limited life span. Some researchers think that awareness of death influences experiences of anxiety from the time that a person is old enough to understand death.

Symptoms of anxiety

In order to understand the diagnosis and treatment of anxiety, it is helpful to have a basic understanding of its symptoms.

SOMATIC. The somatic or physical symptoms of anxiety include headaches, dizziness or lightheadedness, nausea and/or vomiting, **diarrhea**, gastrointestinal prob-

lems, tingling, pale complexion, sweating, numbness, difficulty breathing or sleeping, and sensations of tightness in the chest, neck, shoulders, or hands. These symptoms are produced by the hormonal, muscular, and cardiovascular reactions involved in the fight-or-flight reaction.

BEHAVIORAL. Behavioral symptoms of anxiety include pacing, trembling, general restlessness, hyperventilation, pressured speech, hand wringing, or finger tapping.

COGNITIVE. Cognitive symptoms of anxiety include recurrent or obsessive thoughts, feelings of doom, morbid or fear-inducing thoughts or ideas, and confusion or inability to concentrate.

EMOTIONAL. Feeling states associated with anxiety include tension or nervousness, feeling “hyper” or “keyed up,” and feelings of unreality, panic, or terror.

DEFENSE MECHANISMS. In psychoanalytic theory, the symptoms of anxiety in humans may arise from or activate a number of unconscious defense mechanisms. Because of these defenses, it is possible for a person to be anxious without being consciously aware of it or appearing anxious to others. These psychological defenses include:

- **Repression.** The person pushes anxious thoughts or ideas out of conscious awareness.
- **Displacement.** Anxiety from one source is attached to a different object or event. Phobias are an example of the mechanism of displacement in psychoanalytic theory.
- **Rationalization.** The person justifies the anxious feelings by saying that any normal person would feel anxious in their situation.
- **Somatization.** The anxiety emerges in the form of physical complaints and illnesses, such as recurrent headaches, stomach upsets, or muscle and joint pain.
- **Delusion formation.** The person converts anxious feelings into conspiracy theories or similar ideas without reality testing. Delusion formation can involve groups as well as individuals.

Diagnosis

The diagnosis of anxiety is difficult and complex because of the variety of causes and the highly personalized and individualized nature of its symptom formation. When a doctor examines an anxious patient, he or she will first rule out physical conditions and diseases that have anxiety as a symptom. Apart from these exclusions, the **physical examination** is usually inconclusive. Some anxious patients may have their **blood pressure** or pulse rate affected by anxiety, or may look pale or perspire heavily, but others may appear physically normal. The

doctor will then take the patient’s medication, dietary, and occupational history to determine if they are taking prescription drugs that may cause anxiety; if they are abusing alcohol or mood-altering drugs; if they are consuming large amounts of caffeine; or if their workplace is noisy or dangerous. In most cases, patient history is the most important source of diagnostic information. The doctor may administer a brief psychological test to help evaluate the intensity of the patient’s anxiety and some of its features. Some tests that are often performed include the Hamilton Anxiety Scale and the Anxiety Disorders Interview Schedule (ADIS). Many doctors will check a number of chemical factors in the blood, such as the level of thyroid hormone and blood sugar.

The diagnosis of GAD is made when a person experiences anxiety coupled with physical symptoms that exists a majority of the time over a six-month period. The following conditions must be ruled out to confirm the GAD diagnosis:

- cardiovascular disease
- pulmonary disease
- myasthenia gravis
- alcohol and substance abuse

Treatment

Not all patients with anxiety require treatment, but for more severe cases, treatment is recommended. Because anxiety often has more than one cause and is experienced in highly individual ways, its treatment usually requires more than one type of therapy. In addition, there is no way to predict how patients will respond to a specific drug or therapy. Sometimes, the doctor will need to try different medications or methods of treatment before finding the best combination for the particular patient. It usually takes about six to eight weeks for a doctor to evaluate the effectiveness of a treatment regimen.

Medications

Medications are often prescribed to relieve the physical and psychological symptoms of anxiety. Most agents work by counteracting the biochemical and muscular changes involved in the fight-or-flight reaction. Some work directly on the chemicals in the brain that are thought to cause the anxiety.

ANXIOLYTICS. Most anxiolytic drugs (sometimes called tranquilizers) are either benzodiazepines or barbiturates. Barbiturates, once commonly used, are now rarely involved in clinical practice. Barbiturates work by slowing down the transmission of nerve impulses from

the brain to other parts of the body. They include such drugs as phenobarbital (Luminal) and pentobarbital (Nembutal). Benzodiazepines work by relaxing the **skeletal muscles** and calming the limbic system. They include such drugs as chlordiazepoxide (Librium) and diazepam (Valium). Both barbiturates and benzodiazepines are potentially habit-forming and may cause withdrawal symptoms, but benzodiazepines are far less likely than barbiturates to cause physical dependency. Benzodiazepines are associated with a high rate of anxiety relapse if use is discontinued. Both drugs also increase the effects of alcohol and should never be taken in combination with it. Longer-acting benzodiazepines, such as flurazepam and diazepam, should generally not be used in the elderly.

Two other types of anxiolytic medications include meprobamate (Equanil), which is now rarely used, and buspirone (BuSpar), a new type of anxiolytic that appears to work by increasing the efficiency of the body's own emotion-regulating brain chemicals. Buspirone has several advantages over other anxiolytics. It is not known to cause dependency, does not interact with alcohol, and does not affect the patient's ability to drive or operate machinery. Buspirone is also associated with a lower rate of relapse when use is discontinued. Buspirone is also far less likely to lead to tolerance over time than the benzodiazepines, so it is effective for a much longer period of time. However, buspirone is not effective against certain types of anxiety, such as panic disorder.

ANTIDEPRESSANTS AND BETA-BLOCKERS. For some anxiety disorders such as obsessive-compulsive disorder and panic-type anxiety, selective serotonin reuptake inhibitors (SSRIs), such as Prozac and Paxil, are the treatment of choice. SSRIs are most commonly used to treat depression. Because anxiety often coexists with symptoms of depression, many doctors prescribe antidepressant medications for anxious/depressed patients. While SSRIs are more common, antidepressants, including tricyclic antidepressants such as imipramine (Tofranil) or monoamine oxidase inhibitors (MAO inhibitors) such as phenelzine (Nardil), are prescribed. The tricyclic antidepressants are also somewhat effective in relieving insomnia in many patients.

Beta-blockers are medications that work by blocking the body's reaction to the stress hormones that are released during the fight-or-flight reaction. These include drugs like propranolol (Inderal) or atenolol (Tenormin). Beta-blockers are sometimes given to patients with post-traumatic anxiety symptoms. More commonly, the beta-blockers are given to patients with a mild form of social phobic anxiety, such as fear of public speaking.

Psychotherapy

Most patients with anxiety will be given some form of **psychotherapy** along with medication. Many patients benefit from insight-oriented therapies, which are designed to help them uncover unconscious conflicts and defense mechanisms in order to understand how their symptoms developed. Patients who are extremely anxious may benefit from supportive psychotherapy, which aims at symptom reduction rather than personality restructuring.

Two newer approaches that work well with anxious patients are cognitive-behavioral therapy (CBT) and **relaxation** training. In CBT, the patient is taught to identify the thoughts and situations that stimulate his or her anxiety, and to view them more realistically. In the behavioral part of the program, the patient is exposed to the anxiety-provoking object, situation, or internal stimulus (like a rapid heartbeat) in gradual stages until he or she is desensitized to it. Relaxation training, which is sometimes called anxiety management training, includes breathing exercises and similar techniques intended to help the patient prevent hyperventilation and relieve the muscle tension associated with the fight-or-flight reaction. Both CBT and relaxation training can be used in group therapy as well as individual treatment. In addition to CBT, support groups are often helpful to anxious patients because they provide a social network and lessen the embarrassment that often accompanies anxiety symptoms. Biofeedback training is also used in an approach similar to relaxation training.

Psychosurgery

Surgery on the brain is very rarely recommended for patients with anxiety; however, some patients with severe cases of obsessive-compulsive disorder (OCD) have been helped by an operation on a part of the brain that is involved in OCD. Normally, this operation is attempted after all other treatments have failed.

Alternative treatment

Alternative treatments for anxiety cover a variety of approaches. **Meditation** and mindfulness training are thought to be beneficial to patients with phobias and panic disorders. **Hydrotherapy** and aromatherapy can be useful to some anxious patients by promoting general relaxation of the nervous system. **Yoga**, aikido, tai chi, and **dance therapy** can help patients work with the physical, as well as the emotional, tensions that either promote anxiety or are created by the anxiety.

Prognosis

The prognosis for resolution of anxiety depends on the specific disorder and a wide variety of factors, includ-

KEY TERMS

Affect—An observed emotional expression or response. In some situations, anxiety would be considered an inappropriate affect.

Anxiolytic—A type of medication that helps to relieve anxiety.

Autonomic nervous system (ANS)—The part of the nervous system that supplies nerve endings in the blood vessels, heart, intestines, glands, and smooth muscles, and governs their involuntary functioning. The autonomic nervous system is responsible for the biochemical changes involved in experiences of anxiety.

Endocrine gland—A ductless gland, such as the pituitary, thyroid, or adrenal gland, that secretes its products directly into the blood or lymph.

Free-floating anxiety—Anxiety that lacks a definite focus or content.

Hyperarousal—A state or condition of muscular and emotional tension produced by hormones released during the fight-or-flight reaction.

Hypothalamus—A portion of the brain that regulates the autonomic nervous system, the release of hormones from the pituitary gland, sleep cycles, and body temperature.

Limbic system—A group of structures in the brain that includes the hypothalamus, amygdala, and hippocampus. The limbic system plays an important part in regulation of human moods and emotions. Many psychiatric disorders are related to malfunctioning of the limbic system.

Phobia—In psychoanalytic theory, a psychological defense against anxiety in which the patient displaces anxious feelings onto an external object, activity, or situation.

ing the patient's age, sex, general health, living situation, belief system, social support network, and responses to different anxiolytic medications and forms of therapy. Success rates using pharmacologic therapy in patients with acute anxiety is between 50% and 70%. Success rates using antidepressants in patients with chronic or generalized anxiety are lower. Anxiety disorders typically involve a complex interaction of psychologic and physiologic factors. They are not easy to treat and do not disappear with great ease. Medications, behavioral techniques, and psychotherapy can be successful to varying degrees. The best outcomes occur when the anxiety-

panic-phobia-depression cycle that is commonly found in these patients is disrupted. Anxiety should be viewed as a chronic condition that may involve an occasional increase in the severity of symptoms.

Health care team roles

Allied health personnel may be involved in the diagnosis and treatment of persons with anxiety at a variety of stages. Nurses will likely be involved in the initial interview of patients who present with anxiety. Psychological technicians may help conduct a more in-depth interview. Radiologic technicians play an important role in the process by conducting tests that help rule out conditions such as cardiovascular disease, hyperthyroidism, and myasthenia gravis. Nurse practitioners and physician assistants will often make the diagnosis of anxiety.

Pharmacists play a large role in the proper treatment of patients with anxiety because they dispense the drugs that are so important in the therapy of these patients. They also provide essential information on how to properly use these drugs to achieve peak effectiveness. Technicians may also be involved if the patient receives biofeedback, relaxation training, or cognitive-behavioral therapy.

Prevention

Humans have significant control over thoughts, and, therefore, may learn ways of preventing anxiety by changing irrational ideas and beliefs. Humans also have some power over anxiety arising from social and environmental conditions. Other forms of anxiety, however, are built into the human organism and its life cycle, and cannot be prevented or eliminated. Some cognitive-behavioral techniques may be effective in preventing more serious anxiety when applied at an early stage.

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Anxiolytics see **Antianxiety drugs**

Apgar testing

Definition

Apgar testing is the assessment of the neonate rating color, **heart** rate, stimulus response, muscle tone, and respirations on a scale of zero to two, for a maximum possible score of 10. It is performed twice, first at one minute and then again at five minutes after birth.

Purpose

Apgar scoring was originally developed in the 1950s by the anesthesiologist Virginia Apgar to assist practitioners attending a birth in deciding whether or not a newborn was in need of resuscitation. Using a scoring method fosters consistency and standardization among different practitioners.

Precautions

When the neonate needs immediate intervention or resuscitation, time is not taken away from these actions in order to perform the test. The interventions (such as suctioning to remove mucus and thereby improve breathing) are begun, while simultaneously noting the scoring of the five specific areas.

Description

The five areas are scored as follows:

- Appearance, or color: 2 if the skin is pink all over; 1 for acrocyanosis, where the trunk and head are pink, but the arms and legs are blue; and 0 if the whole body is blue. Newborns with naturally darker skin color will not be pink. However, pallor is still noticeable, especially in the soles and palms. Color is related to the neonate's ability to oxygenate its body and extremities, and is dependent on heart rate and respirations. A perfectly healthy newborn will often receive a score of 9 because of some blueness in the hands and feet.
- Pulse (heart rate): 2 for a pulse of 100+ beats per minute (bpm); 1 for a pulse below 100 bpm; 0 for no pulse. Heart rate is assessed by listening with a **stethoscope** to the newborn's heart and counting the number of beats.
- Grimace, or reflex irritability: 2 if the neonate coughs, sneezes, or vigorously cries in response to a stimulus (such as the use of nasal suctioning, stroking the back to assess for spinal abnormalities, or having the foot tapped); 1 for a slight cry or grimace in response to the stimulus; 0 for no response.

KEY TERMS

Acrocyanosis—A slight cyanosis, or blueness of the hands and feet of the neonate is considered normal. This impaired ability to fully oxygenate the extremities is due to an immature circulatory system which is still in flux.

Amniotic fluid—The protective bag of fluid that surrounds the fetus while growing in the uterus.

Neonate—A term referring to the newborn infant, from birth until one month of age.

Neonatologist—A physician who specializes in problems of newborn infants.

Pallor—Extreme paleness in the color of the skin.

- Activity, or muscle tone: 2 for vigorous movements of arms and legs; 1 for some movement; 0 for no movement, limpness.
- Respirations: 2 for visible breathing and crying; 1 for slow, weak, irregular breathing; 0 for apnea, or no breathing. A crying newborn can adequately oxygenate its **lungs**. Respirations are best assessed by watching the rise and fall of the neonate's abdomen, as infants are diaphragmatic breathers.

The combined first letters in these five areas spell Apgar.

Preparation

No preparation is needed to perform the test. However, while being born the neonate may receive nasal and oral suctioning to remove mucus and amniotic fluid. This may be done when the head of the newborn is safely out, while the mother rests before she continues to push.

Aftercare

Since the test is primarily observational in nature, no aftercare is needed. However, the test may flag the need for immediate intervention or prolonged observation.

Complications

There are no complications from the test itself, just the possible complications if intervention is required but not initiated.

Results

The maximum possible score is 10, the minimum is zero. It is rare to receive a true 10, as some acrocyanosis

APGAR SCORING SYSTEM			
Factor	0 points	1 point	2 points
Heart rate	No heartbeat	Under 100 beats per minute	Over 100 beats per minute
Respiration	Not breathing	Irregular, with weak cry	Regular with strong cry
Muscle tone	Limp, no movement	Limited movement of the limbs	Active movement of the limbs
Color	Completely blue, pale	Pink body with blue hands and feet	All pink
Reflexes	No response to being poked in the nose	Grimace when poked	Cry, cough, or sneeze when poked

(Illustration by Standley Publishing. Courtesy of Gale Group.)

in the neonate is considered normal, and therefore not a cause for concern. Most infants score between 7 and 10. These infants are expected to have an excellent outcome. A score of 4, 5, or 6 requires immediate intervention, usually in the form of oxygen and respiratory assistance, or perhaps just suctioning if breathing has been obstructed by mucus. While suctioning is being done, a source of oxygen may be placed near, but not over the newborn's nose and mouth. This form of oxygen is referred to as blow-by. A score in the 4-6 range indicates that the neonate is having some difficulty adapting to extrauterine life. This may be due to medications given to the mother during a difficult labor, or at the very end of labor, when these medications have an exaggerated effect on the neonate. With a score of 0-3 the neonate is unresponsive, apneic, pale, limp and may not have a pulse. Interventions to resuscitate will begin immediately. The test is repeated at 5 minutes after birth and both scores are documented. Should the resuscitation effort continue into the five minute time period, interventions will not stop in order to perform the test. The one-minute score indicates the need for intervention at birth. It addresses survival and prevention of birth-related complications resulting from inadequate oxygen supply. Poor oxygenation may be due to inadequate neurological and/or chemical control of respiration. The five-minute score appears to have a more predictive value for morbidity and normal development, although research studies on this are inconsistent in their conclusions.

A February 2001 study published in the *New England Journal of Medicine* investigated whether Apgar scoring continues to be relevant. Researchers concluded that "The Apgar scoring system remains as rele-

vant for the prediction of neonatal survival today as it was almost 50 years ago."

Health care team roles

In an uncomplicated delivery, the attending labor and delivery nurse, the obstetrician, or the midwife usually performs the test. If a problem birth has been anticipated, there may be a nurse from the neonatal intensive care unit or a neonatologist in attendance at the birth. One or all of these individuals may make a mental score and provide input regarding their observations, if there appears to be a discrepancy in the score to be noted on the official delivery and nursery forms.

The first question asked by new parents after the birth of their child is usually "Is s/he all right?" Reassuring the parents is an important nursing role. Explaining to new parents what is being done to their newborn keeps them informed, without interfering with the nurse's actions. The brief time spent suctioning and stimulating the neonate to take its first breath can seem like an eternity to the waiting parent, especially for the first-time parent for whom all this is a new experience. The ability to attend to the neonate's needs while simultaneously addressing the parents' needs becomes smoother as the nurse gains experience.

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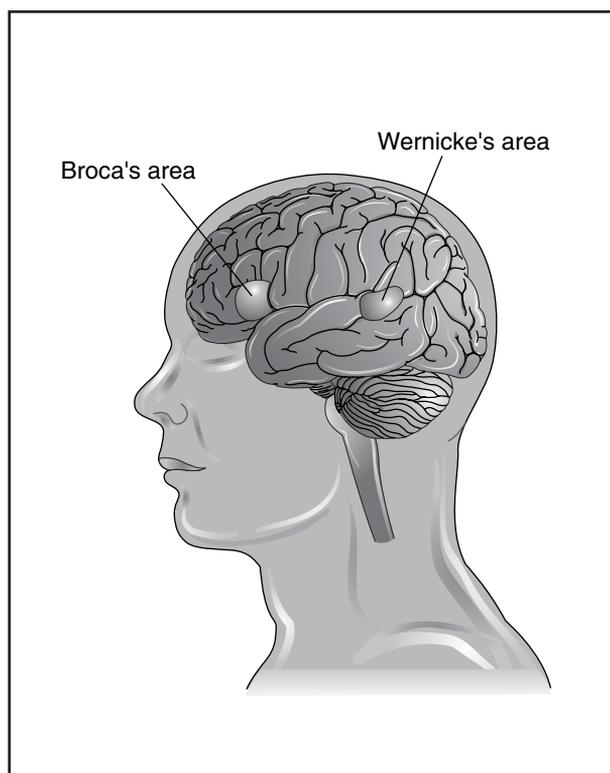
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Aphasia

Definition

Aphasia is an impairment of spoken language understanding and expression associated with **brain** damage.

Description

Neurologic etiologies that affect the left cerebral cortex can lead to aphasia (sometimes termed dysphasia). Aphasia is a language disturbance affecting the use of words and sentences; it is not simply difficulty with speech articulation. Aphasia is usually accompanied by difficulties with reading (dyslexia/alexia) and writing (dysgraphia/agraphia) and may also co-occur with speech articulation difficulties (**apraxia** of speech and **dysarthria**). Though more common in adults, aphasia can arise in children who incur brain damage or who fail to develop language abilities related to left hemisphere neurologic dysfunction, sometimes termed developmental dysphasia.

Causes and symptoms

Stroke leads to approximately 80,000 new cases of aphasia each year. Tumor, **dementia**, trauma, anoxic events (lack of oxygen), and infections affecting the left cerebral hemisphere also may lead to aphasia.

Broca's aphasia results from damage to the frontal lobe of the language-dominant area of the brain. Individuals with Broca's aphasia may become mute or may be able to use single-word statements or full sentences, although it may require great effort. **Wernicke's aphasia** is caused by damage to the temporal lobe of the language-dominant area of the brain. People with this condition speak in long, uninterrupted sentences, but the words used are often unnecessary and unintelligible. (Illustration by Electronic Illustrators Group.)

Approximately one million people in the United States live with aphasia.

The symptoms of aphasia vary depending upon the portion of the brain that is damaged. Fluency of verbal expression in aphasia refers to the ease with which individuals initiate and fill time with words, form grammatical and melodious sentences, and articulate speech sounds. Disruption of any one of these characteristics associated with damage anterior to the left Rolandic/central sulcus parts of the brain can lead to nonfluency. Comprehension of messages can be disrupted, especially with damage affecting the left superior temporal gyrus. Repetition of spoken messages can be impaired, particularly with damage surrounding the left Sylvian/lateral fissure. The patterns of preserved or impaired abilities in fluency, comprehension, and repetition lead to different syndromes of aphasia (for example, Broca's aphasia: nonfluent, impaired repetition, relatively spared compre-

KEY TERMS

Anomia—Difficulty thinking of a specific word to express an idea; word retrieval impairment.

Apraxia of speech—Difficulty selecting and sequencing movements to pronounce speech sounds in the absence of weakness or uncoordination.

Compensatory—Treatments focused on circumventing language impairments by using alternative methods to communicate.

Comprehension—Ability to understand language messages.

Dysarthria—Speech impairment due to impaired motor (for example, weakness, uncoordination) or sensory function.

Dysgraphia—Impaired writing abilities.

Dyslexia—Impaired reading abilities.

Fluency—Ease with which an individual forms complete, correct, rhythmic sentences.

Neologism—Nonsense words misspoken for an intended word (for example, sparndle for fork).

Paraphasia—Mis-selection of a word that may relate to the intended word in meaning or sound.

Repetition—Ability to imitate words and sentences exactly as presented.

Restorative—Treatments focused on regaining normal language abilities.

hension; Wernicke's aphasia: fluent, impaired repetition and comprehension). Anomia, or difficulty thinking of specific words (for example, knife), can occur across syndromes of aphasia. Instead, individuals may provide a description (it's for cutting), a paraphasia related by meaning (fork) or sound (night or nipe), a meaningless word or neologism (sparn), or no response.

Diagnosis

Following a clinical neurological examination, patients with aphasia are referred to speech-language pathologists or neuropsychologists trained in the administration of standardized language assessments to identify the patterns of aphasia. Most aphasia assessments include subtests to evaluate fluency, comprehension, repetition, and word retrieval (for example, Boston Diagnostic Aphasia Examination). Other tests allow assessment of specific symptoms of aphasia (for exam-

ple, word retrieval: Boston Naming Test; reading: Reading Comprehension Battery for Aphasia). Assessment of aphasia, which occurs in acute through chronic stages of the disorder, takes one to three hours to complete. Trained professionals are reimbursed for assessment and treatment of aphasia at the rate consistent with **Medicare** allowances.

Treatment

Patients with aphasia participate in speech-language treatment to alleviate its consequences for communication. A number of studies have indicated the efficacy of behavioral treatments for aphasia. Some treatment methods use drills and practice with language activities to restore skills or to engage other neural regions to mediate language abilities. In other treatments, clinicians teach patients to compensate for the symptoms of aphasia using alternative modalities to communicate including writing, gesture, musical abilities, pointing boards, or speech-generation devices. Speech-language pathologists also provide consultation to patients and family members on strategies to improve communication. Pharmacologic treatments for aphasia (for example, bromocriptine, amphetamines) primarily are experimental in nature and are not used in standard clinical practice.

Prognosis

The prognosis for recovery of aphasia relates to a number of medical, neurological, behavioral, and psychosocial factors. Positive indicators include acute neurologic conditions (for example, stroke) over degenerative conditions, hemorrhagic over ischemic stroke, unilateral left hemisphere lesion sparing subcortical white matter, onset within the past six to 12 months, and mild form of aphasia at onset. Psychosocial factors such as age, gender, intelligence, emotional state, and family support may also contribute to recovery to a lesser degree. The majority of individuals demonstrate some language recovery; fewer completely regain their previous language levels.

Health care team roles

Nursing and medical staff providing medical care for individuals with aphasia implement strategies recommended by speech-language pathologists to foster communication with patients. Nursing staff monitors changes in patient communication status, often noting the need for referral to speech-language pathology services. In performing their unique roles to assist neurological recovery, the rehabilitation team (for example, physical therapist,

occupational therapist, psychiatrist, social worker), implement strategies to maximize communication skills.

Prevention

Avoiding the neurologic event that causes aphasia is the only way to prevent its occurrence. For example, since strokes are a leading cause of aphasia, reducing the chances of having a stroke by not smoking cigarettes also reduces the chances of developing aphasia.

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National Aphasia Association. 156 Fifth Avenue, Suite 707, New York, NY, 10010. <<http://www.aphasia.org>>.

National Institute of Deafness and other Communicative Disorders: Health Information: aphasia. National Institutes of Health, 31 Center Drive, MSC 2320, Bethesda, MD, 20892-2320. <http://www.nidcd.nih.gov/health/pubs_vsl/aphasia.htm>.

Anastasia Marie Raymer, Ph.D.

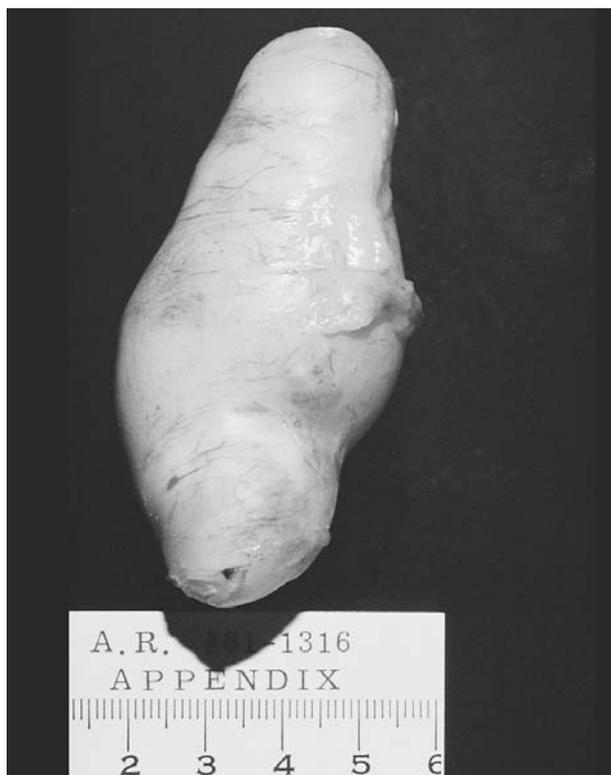
Apoprotein A test see **Lipoproteins test**

Apoprotein B100 test see **Lipoproteins test**

Appendicitis

Definition

Appendicitis is an inflammation of the appendix, which is the worm-shaped pouch attached to the cecum, the beginning of the **large intestine**. The appendix has no known function in the body, but it can become diseased and inflamed. Appendicitis is a medical emergency. If it is left untreated, the appendix may rupture and cause a potentially fatal **infection**.



An extracted appendix. (Photograph by Lester V. Bergman, Corbis Images. Reproduced by permission.)

Description

Appendicitis is the most common abdominal emergency in children and young adults. One person in 15 develops appendicitis in his or her lifetime. The incidence is highest among males aged 10–14 and females aged 15–19. More males than females develop appendicitis between **puberty** and age 25. It is rare among the elderly and in children under the age of two.

The hallmark symptom of appendicitis is increasingly severe abdominal **pain**. The pain of appendicitis begins in the center of the abdomen and becomes concentrated in the lower right quadrant of the abdomen. Since many different conditions can cause abdominal pain, an accurate diagnosis of appendicitis can be difficult. A timely diagnosis is important, however, because a delay can result in perforation, or rupture, of the appendix. When this happens, infected contents of the appendix spill into the abdomen, potentially causing a serious infection of the abdomen called peritonitis.

Other conditions can have similar symptoms, especially in women. These include pelvic inflammatory disease, ruptured ovarian follicles, ruptured ovarian cysts, tubal pregnancies, and endometriosis. Various forms of **stomach** upset and bowel inflammation may also mimic appendicitis.

KEY TERMS

Appendectomy—Surgical removal of the appendix.

Appendix—The worm-shaped pouch attached to the cecum, the beginning of the large intestine.

Laparotomy—A surgical incision into the abdomen, made between the ribs and the pelvis, that offers surgeons a view inside the abdominal cavity.

Peritonitis—Inflammation of the peritoneum, membranes lining the abdominal pelvic wall.

Ulceration—An abnormal change in tissue accompanied by the death of cells.

The treatment for acute (sudden, severe) appendicitis is an appendectomy, surgery to remove the appendix. Because of the potential for a life-threatening ruptured appendix, persons suspected of having appendicitis are often taken to surgery before the diagnosis is certain.

Causes and symptoms

The causes of appendicitis are not well understood, but it is believed to occur as a result of one or more of these factors: an obstruction within the appendix, the development of an ulceration within the appendix, and the invasion of **bacteria**.

Under these conditions, bacteria may multiply within the appendix. The appendix may become swollen and filled with pus and may eventually rupture. Signs of rupture include the presence of symptoms for more than 24 hours, a **fever**, a high white **blood** cell count, and a fast **heart** rate. Very rarely, the inflammation and symptoms of appendicitis may disappear but recur again later.

The distinguishing symptom of appendicitis is pain beginning around or above the navel. The pain, which may be severe or only achy and uncomfortable, eventually moves into the right lower corner of the abdomen. There, it becomes more steady and more severe, and often increases with movement or coughing. The abdomen often becomes rigid and tender to the touch. Increasing rigidity and tenderness indicates an increased likelihood of perforation and peritonitis.

Loss of appetite is very common. Nausea and vomiting may occur in about half of the cases, and occasionally there may be constipation or **diarrhea**. The temperature may be normal or slightly elevated. The presence of a fever may indicate that the appendix has ruptured.

Diagnosis

A careful examination is the best way to diagnose appendicitis. It is often difficult, even for experienced physicians, to distinguish the symptoms of appendicitis from those of other abdominal disorders. A physician should ask questions such as where the pain is centered, whether the pain has shifted, and where the pain began. The physician should press on the abdomen to judge the location of the pain and the degree of tenderness.

The typical sequence of symptoms is present in about 50% of cases. In the other half of cases, less typical patterns may be seen, especially in pregnant women, older people, and infants. In pregnant women, appendicitis is easily masked by the frequent occurrence of mild abdominal pain and nausea from other causes. Elderly people may feel less pain and tenderness than most individuals, thereby delaying diagnosis and treatment, and leading to rupture in 30% of cases. Infants and young children often have diarrhea, vomiting, and fever in addition to pain.

While laboratory tests cannot establish the diagnosis, an increased white cell count may point to appendicitis. **Urinalysis** may help to rule out a urinary tract infection that can mimic appendicitis.

Persons with a diagnosis of appendicitis are usually taken immediately to surgery, where a laparotomy (surgical exploration of the abdomen) is done to confirm the diagnosis. In cases with a questionable diagnosis, other tests such as a computed tomography (CT) scan may be performed to avoid unnecessary surgery. An ultrasound examination of the abdomen may help to identify an inflamed appendix or other condition that would explain the symptoms. Abdominal x rays are not of much value, except when an appendix has ruptured.

Often, the diagnosis is not certain until an operation is completed. To avoid a ruptured appendix, surgery may be recommended without delay if the symptoms point clearly to appendicitis. If the symptoms are not clear, surgery may be postponed until they progress enough to confirm a diagnosis.

When appendicitis is strongly suspected in a woman of child-bearing age, a diagnostic **laparoscopy** is sometimes recommended to be sure that a gynecological problem such as a ruptured ovarian cyst is not causing the pain. In this procedure, a lighted viewing tube is inserted into the abdomen through a small incision around the navel.

A normal appendix is discovered in about 10–20% of patients who undergo laparotomy for suspected appendicitis. Sometimes the surgeon will remove a normal appendix as a safeguard against appendicitis in the future.

During the surgery, another specific cause for the pain and symptoms of appendicitis is found for about 30% of these patients.

Treatment

The treatment for appendicitis is an immediate appendectomy, which is done by opening the abdomen in the standard open appendectomy technique, or through laparoscopy. In laparoscopy, a smaller incision is made beside the navel. Both methods can successfully accomplish the removal of an appendix. It is not certain that laparoscopy holds any advantage over open appendectomy. When an appendix has ruptured, patients undergoing a laparoscopic appendectomy may have to be switched to the open appendectomy procedure for successful management of the rupture. If a ruptured appendix is left untreated, the condition is fatal.

Prognosis

Appendicitis is usually treated successfully by appendectomy. Unless there are complications, people usually recover without further problems. The mortality rate in cases without complications is less than 0.1%. When an appendix has ruptured, or a severe infection has developed, the likelihood for complications is higher, with slower recovery, or death from disease. There are higher rates of perforation and mortality among children and elderly persons.

Health care team roles

A physician, physician assistant, or nurse practitioner usually makes an initial diagnosis of appendicitis based on history, physical findings, and laboratory results. A laboratory technician may provide a test that confirms a diagnosis. A surgeon removes an appendix. Nurses assist by collecting data from the patient and family, monitoring **vital signs** and status of pain, and providing **patient education** about the diagnosis, surgery, and recovery.

Prevention

Appendicitis is probably not preventable, although there is some indication that a diet high in green vegetables and tomatoes may help prevent appendicitis.

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American College of Surgeons. 633 North St. Clair Street, Chicago, IL 60611. (312) 202-5000. (312) 202-5001. <<http://www.facs.org>>. postmaster@facs.org.

OTHER

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L. Fleming Fallon, Jr., M.D., Dr.P.H.

Apraxia

Definition

Apraxia is an impairment in the use of learned skilled movements (e.g., limb movements; speech) that occurs most often with damage affecting the left hemisphere of the **brain**.

KEY TERMS

Aphasia—Impairment of spoken language understanding and expression associated with damage affecting the left hemisphere of the brain.

Apraxia of speech—Difficulty selecting and sequencing movements to pronounce speech sounds in the absence of weakness or incoordination.

Apraxic agraphia—Difficulty selecting and sequencing movements necessary for legible writing.

Buccofacial apraxia—Impaired ability to perform learned, skilled facial (nonspeech) movements.

Dysarthria—Speech impairment due to impaired motor (e.g., weakness, incoordination) or sensory function.

Dysgraphia—Impaired writing and spelling abilities.

Dyslexia—Impaired reading abilities.

Limb apraxia—Impaired ability to perform learned, skilled limb movements.

Description

Apraxia is a general term for a disturbance of learned, skilled movements that cannot be attributed to sensory loss, weakness, or other cognitive impairments. To gain a processing advantage or skill each time a person attempts to enact complex, skilled movements of the limbs, mouth, and face, individuals develop memories that allow for smooth and efficient movements. The left hemisphere of the brain is integral to the ability to perform learned, skilled movements. Neurologic etiologies that affect the left cerebral cortex can lead to apraxia. Apraxia may be observed for different types of learned skilled movements leading to limb apraxia, apraxia of speech, buccofacial apraxia, and apraxic agraphia. Apraxia often is accompanied by other impairments of left hemisphere function including **aphasia**, **dyslexia**, **dysarthria**, and **dysgraphia**. Although more common in adults, apraxia can arise in children who incur brain damage or who fail to develop abilities due to left hemisphere neurologic dysfunction, sometimes termed developmental dyspraxia.

Causes and symptoms

Stroke affecting the left cerebral hemisphere is one leading cause of apraxia. Other neurologic conditions

that affect the left hemisphere, such as tumor, **dementia**, trauma, anoxic events, and infections, may lead to apraxia. Little data exist to document the number of cases of apraxia; however, it is known that apraxia is less common than aphasia following left hemisphere damage. Although the term apraxia has been applied to other disordered movements, such as eyelid opening or dressing, it more appropriately subsumes movements related to learned skilled movements.

The patterns of apraxia vary depending upon which portion of the left cerebral hemisphere is affected:

- Limb apraxia refers to difficulty activating patterns of muscle movements when using tools and implements (e.g., unsafe use of knife or razor) and producing common pantomimes (e.g., ok, come here, drink, comb).
- Buccofacial apraxia leads to difficulty with skilled oral movements (e.g., whistle, blow out a candle).
- Apraxia of speech leads to difficulty activating the complex array of movements necessary for accurate pronunciation of sounds in words. Individuals suffering from speech apraxia struggle to utter words, mispronouncing and simplifying the sounds of speech. Some are rendered mute when the disorder is severe.
- Apraxic agraphia is impaired ability to select and sequence the series of strokes necessary for legible writing. An individual affected this way may know how to spell but cannot write.

Diagnosis

Following a clinical neurological examination, patients with apraxia are referred to rehabilitation specialists (e.g., speech-language pathologists, occupational therapists, physical therapists) trained in the examination of apraxia using standardized testing batteries for speech and limb apraxia. Specialized training is often required to recognize the error patterns in apraxia and to distinguish it from other abnormalities that may disrupt the ability to perform movements including weakness, sensory loss, or language impairments. Assessment of apraxia, which occurs in acute through chronic stages of the disorder, takes one to three hours to complete. Although some individuals may recover from apraxia, others may demonstrate chronic, significant impairments of learned skilled movements that affect communication and functioning in activities of daily living.

Treatment

Patients with apraxia may participate in rehabilitation to alleviate its consequences for communication or for safe performance of activities of daily living. A num-

ber of small group or case studies have demonstrated that behavioral treatments provided by rehabilitation professionals can be effective for improving skilled movements of the limbs or speech. Some treatment methods use drills and practice with speech or limb movements to restore skills or to engage other neural regions to mediate skilled movements. In other treatments, clinicians teach patients to compensate for the symptoms of apraxia using alternative communication modalities or methods to complete daily living activities. Patients with apraxia participate in speech-language treatment to alleviate its consequences for communication.

Prognosis

Less is known about the prognosis for recovery of apraxia than is known about other left-hemisphere cognitive disorders such as aphasia. Positive indicators may include:

- acute neurologic conditions (e.g. stroke) over degenerative conditions
- hemorrhagic over ischemic stroke
- unilateral left-hemisphere lesion
- onset within the past six to 12 months
- mild form of apraxia at onset

Health care team roles

Nursing and medical rehabilitation staff providing care for individuals with apraxia may need to implement strategies recommended by rehabilitation professionals. This will help foster communication with patients with apraxia of speech, and ensure patient safety in the hospital environment for individuals with limb apraxia. Individuals with severe limb apraxia may require close supervision when using tools and implements in daily living activities (e.g., grooming or eating).

Prevention

The way to prevent apraxia is to prevent the neurologic event that causes apraxia.

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- Childhood Apraxia of Speech Association. 123 Eisele Rd., Cheswick, PA, 15024. <<http://apraxia-kids.org>>.
- National Aphasia Association. 156 Fifth Ave., Ste. 707, New York, NY, 10010. <<http://www.aphasia.org>>.

Anastasia Marie Raymer, Ph.D.

Art therapy

Definition

Art therapy, sometimes called creative arts therapy or expressive arts therapy, encourages people to express and understand emotions through artistic expression and through the creative process.

Origins

Humans have expressed themselves with symbols throughout history. Masks, ritual pottery, costumes, other objects used in rituals, cave drawings, Egyptian hieroglyphics, and Celtic art and symbols are all visual records of self-expression and communication through art. Art has also been associated spiritual power, and artistic forms such as the Hindu and Buddhist mandala and Native American sand painting are considered powerful healing tools.

In the late nineteenth century, French psychiatrists Ambrose Tardieu and Paul-Max Simon both published studies on the similar characteristics of and symbolism in the artwork of the mentally ill. Tardieu and Simon viewed art therapy as an effective diagnostic tool to identify specific types of mental illness or traumatic events. Later, psychologists would use this diagnostic aspect to develop psychological drawing tests (the Draw-A-Man test, the Draw-A-Person Questionnaire [DAP.Q]) and projective personality tests involving visual symbol recognition (e.g., the Rorschach Inkblot Test, the Thematic Apperception Test [TAT], and the Holtzman Inkblot Test [HIT]).

The growing popularity of milieu therapies at psychiatric institutions in the twentieth century was an important factor in the development of art therapy in the United States. Milieu therapies (or environmental therapy) focus on putting the patient in a controlled therapeutic social setting that provides the patient with opportuni-



Art therapist with students. (Photograph by Peter Berndt. Custom Medical Stock Photo, Inc. Reproduced by permission.)

ties to gain self-confidence and interact with peers in a positive way. Activities that encourage self-discovery and empowerment such as art, music, dance, and writing are important components of this approach.

Educator and therapist Margaret Naumburg was a follower of both Freud and Jung and incorporated art into **psychotherapy** as a means for her patients to visualize and recognize the unconscious. She founded the Walden School in 1915, where she used students' artworks in psychological counseling. She published extensively on the subject and taught seminars on the technique at New York University in the 1950s. Today, she is considered the founder of art therapy in the United States.

In the 1930s, Karl, William, and Charles Menninger introduced an art therapy program at their Kansas-based psychiatric hospital, the Menninger Clinic. The Menninger Clinic employed a number of artists in residence in the following years, and the facility was also considered a leader in the art therapy movement through the 1950s and 60s. Other noted art therapy pioneers who emerged in the 50s and 60s include Edith Kramer, Hanna Yaxa Kwiatkowska (National Institute of Mental Health), and Janie Rhyne.

Benefits

Art therapy provides the client-artist with critical insight into emotions, thoughts, and feelings. Key benefits of the art therapy process include:

- **Self-discovery.** At its most successful, art therapy triggers an emotional catharsis.
- **Personal fulfillment.** The creation of a tangible reward can build confidence and nurture feelings of self-worth. Personal fulfillment comes from both the creative and the analytical components of the artistic process.
- **Empowerment.** Art therapy can help people visually express emotions and fears that they cannot express through conventional means, and can give them some sense of control over these feelings.
- **Relaxation and stress relief.** Chronic stress can be harmful to both mind and body. Stress can weaken and damage the **immune system**, can cause insomnia and depression, and can trigger circulatory problems (like high **blood pressure** and irregular heartbeats). When used alone or in combination with other relaxation techniques such as guided imagery, art therapy can effectively relieve stress.
- **Symptom relief and physical rehabilitation.** Art therapy can also help patients cope with **pain**. This therapy can promote physiological healing when patients identify and work through anger, resentment, and other emotional stressors. It is often prescribed to accompany pain control therapy for chronically and terminally ill patients.

Description

Art therapy, sometimes called expressive art or art psychology, encourages self-discovery and emotional growth. It is a two-part process, involving both the creation of art and the discovery of its meaning. Rooted in Freud and Jung's theories of the subconscious and unconscious, art therapy is based on the assumption that visual symbols and images are the most accessible and natural form of communication to the human experience. Patients are encouraged to visualize, and then create, the thoughts and emotions that they cannot talk about. The resulting artwork is then reviewed and its meaning interpreted by the patient.

The "analysis" of the artwork produced in art therapy typically allows patients to gain some level of insight into their feelings and lets them to work through these issues in a constructive manner. Art therapy is typically practiced with individual, group, or family psychotherapy (talk therapy). While a therapist may provide critical guidance for these activities, a key feature of effective art

therapy is that the patient/artist, not the therapist, directs the interpretation of the artwork.

Art therapy can be a particularly useful treatment tool for children, who frequently have limited language skills. By drawing or using other visual means to express troublesome feelings, younger patients can begin to address these issues, even if they cannot identify or label these emotions with words. Art therapy is also valuable for adolescents and adults who are unable or unwilling to talk about thoughts and feelings.

Beyond its use in mental health treatment, art therapy is also used with traditional medicine to treat organic diseases and conditions. The connection between mental and physical health is well documented, and art therapy can promote healing by relieving stress and allowing the patient to develop coping skills.

Art therapy has traditionally centered on visual mediums, like paintings, sculptures, and drawings. Some mental healthcare providers have now broadened the definition to include music, film, dance, writing, and other types of artistic expression.

Art therapy is often one part of a psychiatric inpatient or outpatient treatment program, and can take place in individual or group therapy sessions. Group art therapy sessions often take place in hospital, clinic, shelter, and community program settings. These group therapy sessions can have the added benefits of positive social interaction, empathy, and support from peers. The client-artist can learn that others have similar concerns and issues.

Preparations

Before starting art therapy, the therapist may have an introductory session with the client-artist to discuss art therapy techniques and give the client the opportunity to ask questions about the process. The client-artist's comfort with the artistic process is critical to successful art therapy.

The therapist ensures that appropriate materials and space are available for the client-artist, as well as an adequate amount of time for the session. If the individual artist is exploring art as therapy without the guidance of a trained therapist, adequate materials, space, and time are still important factors in a successful creative experience.

The supplies used in art therapy are limited only by the artist's (and/or therapist's) imagination. Some of the materials often used include paper, canvas, poster board, assorted paints, inks, markers, pencils, charcoals, chalks, fabrics, string, adhesives, clay, wood, glazes, wire, bendable metals, and natural items (like shells, leaves, etc.). Providing artists with a variety of materials in assorted

colors and textures can enhance their interest in the process and may result in a richer, more diverse exploration of their emotions in the resulting artwork. Appropriate tools such as scissors, brushes, erasers, easels, supply trays, glue guns, smocks or aprons, and cleaning materials are also essential.

An appropriate workspace should be available for the creation of art. Ideally, this should be a bright, quiet, comfortable place, with large tables, counters, or other suitable surfaces. The space can be as simple as a kitchen or office table, or as fancy as a specialized artist's studio.

The artist should have adequate time to become comfortable with and explore the creative process. This is especially true for people who do not consider themselves "artists" and may be uncomfortable with the concept. If performed in a therapy group or one-on-one session, the art therapist should be available to answer general questions about materials and/or the creative process. However, the therapist should be careful not to influence the creation or interpretation of the work.

Precautions

Art materials and techniques should match the age and ability of the client. People with impairments, such as traumatic **brain** injury or an organic neurological condition, may have difficulties with the self-discovery portion of the art therapy process depending on their level of functioning. However, they may still benefit from art therapy through the sensory stimulation it provides and the pleasure they get from artistic creation.

While art is accessible to all (with or without a therapist to guide the process), it may be difficult to tap the full potential of the interpretive part of art therapy without a therapist to guide the process. When art therapy is chosen as a therapeutic tool to cope with a physical condition, it should be treated as a supplemental therapy and not as a substitute for conventional medical treatments.

Research and general acceptance

A wide body of literature supports the use of art therapy in a mental health capacity. And as the mind-body connection between psychological well-being and physical health is further documented by studies in the field, art therapy gains greater acceptance by mainstream medicine as a therapeutic technique for organic illness.

Training and certification

Both undergraduate and graduate art therapy programs are offered at many accredited universities across the United States. Typical art therapy programs combine

KEY TERMS

Catharsis—Therapeutic discharge of emotional tension by recalling past events.

Mandala—A design, usually circular, that appears in religion and art. In Buddhism and Hinduism, the mandala has religious ritual purposes and serves as a yantra (a geometric emblem or instrument of contemplation).

Organic illness—A physically, biologically based illness.

courses in art and psychology. The majority of these programs meets or exceeds standards set by the American Art Therapy Association (AATA).

The Art Therapy Credentials Board (ATCB), a voluntary organization, grants the designation ATR (Art Therapist Registered) to professionals who have completed an approved master's level program of study in art therapy (as described by the AATA) and have accumulated at least 1,000 hours of additional supervised clinical experience. Board certification is also available through the ATCB for art therapists who have met the ATR requirements and have passed a certification exam (ATR-BC). Art therapists with the ATR-BC designation must complete continuing education credits to maintain their certification.

Registration and/or certification is a recognition of professional expertise, not a legal qualification or requirement to practice. Professional licensing requirements for art therapists vary by state. However, if the therapy is intended as a companion treatment to psychological counseling or other mental health treatment, state licensing requirements typically apply. Where licensing is a prerequisite to practice, a combination of education and clinical experience, a written test, and continuing education are required to maintain the license.

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ORGANIZATIONS

American Art Therapy Association. 1202 Allanson Rd., Mundelein, IL 60060-3808. 888-290-0878 or 847-949-6064. Fax: 847-566-4580. E-mail: arttherapy@ntr.net <<http://www.arttherapy.org>>.

Paula Ford-Martin

Arterial blood gas analysis see **Blood gas analysis**

Arteriography see **Angiography**

Arthritis see **Osteoarthritis**

Arthrocentesis see **Joint fluid analysis**

Arthrography

Definition

Arthrography is the radiologic examination of soft tissue structures in the joints following an injection of a contrast agent with or without air. The structures demonstrated are the menisci, ligaments, tendons, articular cartilage, and bursae.

Purpose

The most commonly studied joints are the knee and shoulder, but this procedure may also be done on the hip, wrist, elbow, ankle and temporomandibular joints. Arthrography of the knee or a knee arthrogram is the most frequently performed arthrographic procedure; it is requested for patients with persistent **pain**, decrease in range of motion, or locking of the knee. Arthrography of the shoulder may be used to demonstrate partial or complete tears of the rotator cuff. A hip arthrogram is often used to detect a loose hip prosthesis or a congenital abnormality. Arthrography of the temporomandibular joints is ordered to detect abnormalities of the articular disk due to trauma or loosening of the ligaments. In many cases, however, an MRI may be obtained instead of an arthrogram.

Precautions

Patients who are or may be pregnant should not have this procedure unless the benefits of the findings outweigh the risk of radiation exposure. Patients who are known to be allergic to iodine should discuss this complication with their physician. Routine x rays of the

affected joint must be taken before starting an arthrogram to ensure that there is no fracture or dislocation.

Description

The patient is asked to change into a hospital gown for a hip, knee, or shoulder arthrogram. Since arthrography is done in a sterile field to prevent **infection**, the x-ray technologist must be trained to work with the radiologist under sterile conditions. All needles, syringes, contrast material, local anesthetic, extension tubing, and cleansing solutions are prepared in advance by the x-ray technologist depending on the part to be examined.

Routine x rays of the affected joint are done by the x-ray technologist if no recent x-rays have been taken. The films are reviewed by the radiologist to ensure that there is no fracture or dislocation in the joint.

The radiologist begins the procedure by cleansing the skin of the affected joint and applying a sterile drape. The x-ray technologist places all the required needles and syringes onto the sterile tray using proper sterile technique and assists the radiologist by drawing up the anesthetic and contrast material into the various syringes.

Once the area of skin over the joint has been numbed with a local anesthetic, the radiologist will place the needle into the joint, using x-ray images to guide placement. Additional fluid in the joint may be aspirated and sent for analysis, particularly if a joint infection is suspected. A small test injection of the contrast medium is done to confirm accurate needle placement. The contrast medium is then injected either with or without air depending on the area under investigation. The needle is removed and a small self-adhesive dressing is applied. The joint is then manipulated to properly distribute the contrast medium over the entire joint space.

Before the contrast medium can be absorbed by the joint itself, several films will be taken by the radiologist. The patient will be asked to move the joint into a series of positions, keeping still between positioning. During a knee arthrogram, the knee is manually stressed by the radiologist to open the joint space. Patients may experience some tingling or discomfort during the procedure. These are normal reactions, caused by the contrast material and air inside the joint as well as the manual positioning of the painful joint.

Following fluoroscopic tracking of the contrast medium, standard x rays of the area are taken by the x-ray technologist. An overexposed lateral x ray of the knee flexed at 90 degrees is usually done in addition to the routine AP (anteroposterior) internal and external oblique x rays in order to visualize the cruciate ligaments. An axillary view of the shoulder is usually

requested as well as an AP (anteroposterior) view of the shoulder with the arm rotated internally and externally. The procedure is usually completed within 30 minutes.

Preparation

It is important to alert the physician to any known sensitivity to local anesthetics or iodine prior to an arthrogram. Routine x rays of the affected joint should be taken before starting the arthrogram to make sure there is no fracture or dislocation, and to verify the diameter of the joint space before the needle is inserted. A small section of the knee may be shaved before starting the arthrogram.

Aftercare

The affected joint should be rested for approximately 12 hours following the procedure. Swelling may occur and can be treated with an application of ice or cold packs. A mild pain reliever may also be necessary to lessen discomfort for the first 12 hours. Noises in the joint such as cracking or clicking are normal for a few hours following an arthrogram. These noises are the result of the extra liquid (contrast) and air in the joint.

Complications

Some patients may have allergic reactions to iodine, ranging from mild nausea or a rash to severe cardiac and respiratory problems. Since the contrast material is injected directly into a joint, however, rather than the venous circulation, allergic reactions are rare. Facilities licensed to perform contrast examinations should meet requirements for emergency equipment, supplies and staff training in order to handle a possible severe reaction. Non-ionic contrast material is also available in most radiology departments.

Arthrographic studies should not be done on patients with a known joint infection, bleeding problems, or severe active arthritis.

Results

A normal arthrogram demonstrates a normal joint space with no damage to the articular cartilage, tendons, ligaments or bursae. Partial or incomplete tears of the rotator cuff are better demonstrated using MRI imaging.

Abnormal results of an arthrogram may indicate partial or complete tears of the rotator cuff, demonstrated as a leakage of contrast material out of the joint and into the bursa. In a knee arthrogram, meniscal tears are demonstrated as well as problems with the ligaments or evidence of a popliteal cyst, commonly referred to as a Baker's cyst. A Baker's cyst is demonstrated on the radi-

KEY TERMS

Aspirate—To remove fluids by suction, often through a needle.

Bursa—A closed space between two moving surfaces containing a small amount of lubricating fluid to reduce friction in the joint.

Contrast (agent, medium)—A substance injected into the body that outlines certain structures that would otherwise be hard to see on the radiograph (film).

Fluoroscope—An under-table x-ray tube used to visualize structures in real time on a television screen.

Fossa—An anatomical cavity or hollow.

Meniscus—A wedge of cartilage that separates the articulating bones in certain joints.

Popliteal—Pertaining to the area at the back of the knee.

Rotator cuff—A group of muscles lying outside the shoulder joint that allow the joint to move in many directions.

X ray—A form of electromagnetic radiation with shorter wavelengths than normal light. X-rays can penetrate most structures.

ographs as an extension of fluid into the popliteal fossa located behind the knee. Dislocations of the hip are visible as well as a loose hip prosthesis. Joint space narrowing and arthritis are also visualized on an arthrogram.

Health care team roles

Since a reaction to an iodine-based contrast medium is always a risk in arthrography, the x-ray technologist must be familiar with emergency procedures in place to deal with a cardiac arrest. The x-ray technologist works closely with the radiologist during this procedure and must be familiar with sterile techniques in order to prevent infection.

Patient education

The radiography technologist explains the procedure to the patient and inquires about any known **allergies** and the possibility of **pregnancy**. Since many patients are nervous about an injection directly into the joint, the x-ray technologist must assure the patient that the area will be numbed in advance with a local anesthetic. During a

knee arthrogram the radiologist manually positions the patient, so the patient must be encouraged to relax the knee completely. All radiography technologists must be certified and registered with the A.S.R.T. and are required to obtain continued education credits to maintain their credentials.

Following the arthrogram, the patient is also instructed to put ice on the affected joint and to take a mild pain reliever if necessary.

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American College of Radiology. 1891 Preston White Drive. Reston, VA 22091. (800) ACR-LINE. <<http://www.acr.org>>.

The Arthritis Foundation. 1330 West Peachtree Street. Atlanta, GA 30309. (800) 283-7800. <<http://www.arthritis.org>>.

Lorraine K. Ehresman

Arthroscopy

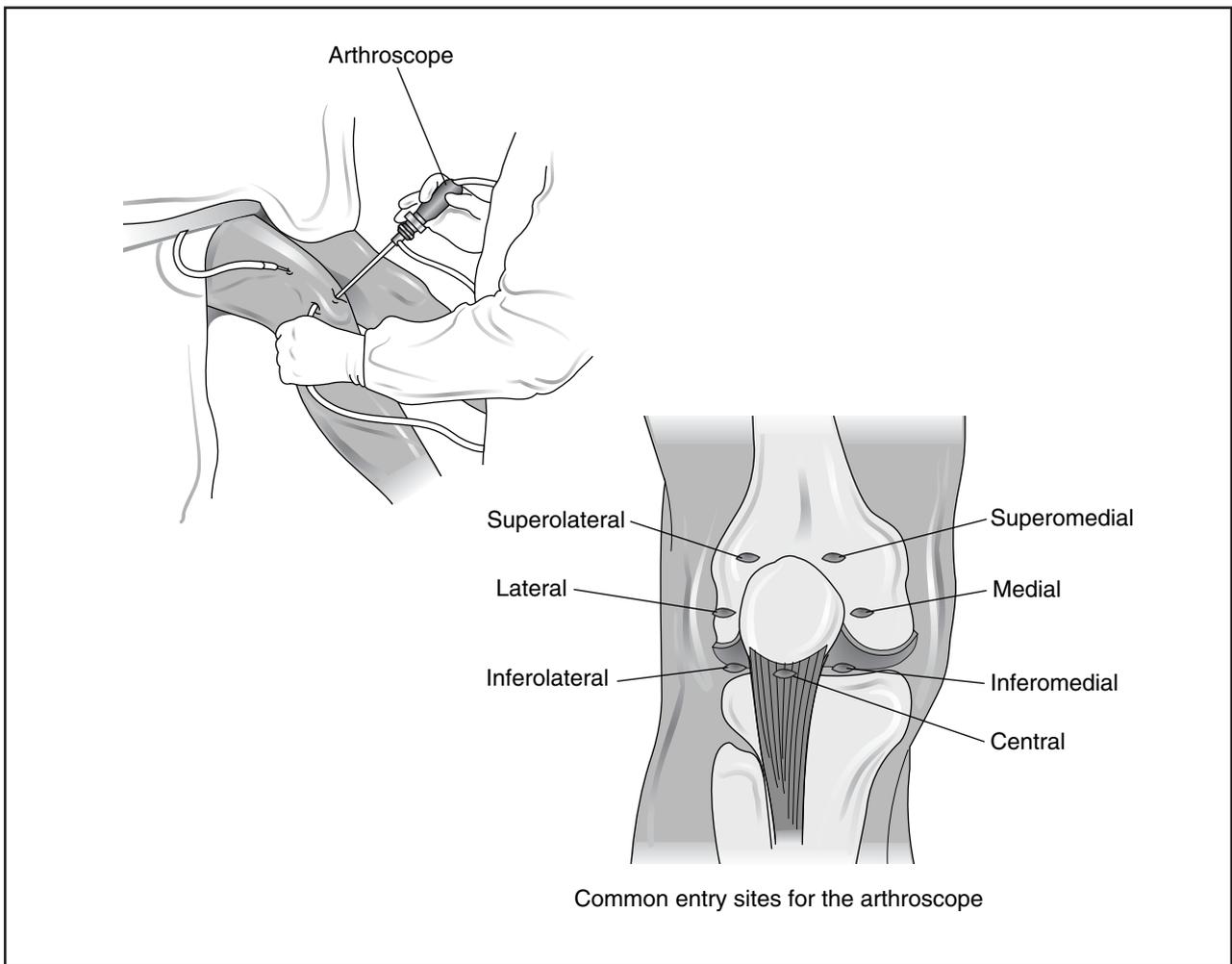
Definition

Arthroscopy is the examination of a joint, specifically, the inside structures. The procedure is performed by inserting a specifically designed illuminated device, called an arthroscope, into the joint through a small incision. Arthroscopy may be used to diagnose, as well as treat, conditions. When a repair is performed, the procedure is called arthroscopic surgery.

Purpose

Arthroscopy is used primarily by physicians who specialize in treating disorders of the bones and related structures (orthopedics) to help diagnose joint problems. Once described as essential for those who primarily care for athletic injuries, arthroscopy is now a technique commonly used by orthopedic surgeons for the treatment of patients of all ages. The six joints most frequently examined are:

- knee



Arthroscopy is primarily used to help diagnose joint problems. This procedure, most commonly associated with knee and shoulder problems, allows accurate examination and diagnosis of damaged joint ligaments, surfaces, and other related joint structures. The illustration above indicates the most common entry sites, or portals, in knee arthroscopy. (Illustration by Electronic Illustrators Group.)

- shoulder
- elbow
- ankle
- hip
- wrist

A joint is a complex system. Within a joint, ligaments attach bones to other bones, tendons attach muscles to bones, cartilage lines and helps protect the ends of bones, and a special fluid (synovial fluid) cushions and lubricates the structures. Direct visualization of the joint allows the doctor to see exactly which structures are damaged. Arthroscopy also permits earlier diagnosis of many types of joint problems, including those that had been difficult to detect in previous years.

Precautions

Arthroscopy is contraindicated for patients with ankylosis, due to the stiffness of the joint involved. Arthroscopy is also contraindicated in patients with an existing local **infection**, due to the potential for sepsis. Because of inflammation after the use of contrast dye, arthroscopy is contraindicated in patients who have recently undergone an arthrogram. Most arthroscopic procedures are performed as same-day surgery and do not require hospital admission. A few hours following the procedure, the patient is allowed to return home, although usually someone else must drive. Depending on the type of anesthesia used, the patient may need to remain NPO (nil per os, nothing by mouth) for several hours prior to the arthroscopy. Before the procedure, the anesthesiologist will ask if the patient has any known

KEY TERMS

Ankylosis—A stiff or fixed joint due to disease or surgery.

Hemarthrosis—A condition of blood within a joint.

Pulmonary embolus—Blockage of an artery of the lung by foreign matter such as fat, tumor, tissue, or a clot originating from a vein.

Sepsis—A toxic condition resulting from the spreading of bacteria due to infection.

Synovial fluid—A naturally occurring fluid that lubricates the joints.

Thrombophlebitis—Inflammation of a vein with the formation of a thrombus or clot.

Tourniquet—Something used to stop the flow of blood by pressure applied with an encircling device, such as a bandage twisted with a stick to apply pressure.

allergies to local or general anesthetics. Airway obstruction is always possible in any patient who receives a **general anesthesia**. Because of this, oxygen, suction, and monitoring equipment must be available. Cardiac status should be monitored in the event that any abnormalities arise during the procedure.

Description

The arthroscope is an instrument used to directly examine the joint. It contains magnifying lenses and glass-coated fibers that send concentrated light into the joint. A camera attached to the arthroscope allows the surgeon to view a clear image of the joint. This image is then transferred to a monitor. By attaching the arthroscope to a monitor, the surgeon is able to view the interior of the joint. This video technology is also important for documentation of the arthroscopic procedure. For example, if the surgeon decides after the arthroscopic examination that a conventional approach to surgically expose or “open” the joint (arthrotomy) must be used, a good photographic record will be useful when the surgeon returns to execute the final surgical plan.

The procedure requires the surgeon to make several small incisions (portals) through the skin’s surface into the joint. Through one or two of the portals, the pencil-sized instruments that contain a lens and lighting system to magnify and illuminate the joint structures are inserted. The joint is inflated with a sterile saline solution to

expand the joint for viewing. Often, following a recent traumatic injury to a joint, the synovial fluid may be cloudy, making interior viewing of the joint difficult. Therefore, a constant flow of the saline solution may be necessary. In other cases, a tourniquet may be applied in order to distend the joint, rather than use an infusion. The arthroscope is placed through one of the portals to view and evaluate the condition of the joint.

Preparation

The patient should be kept NPO after midnight the day of the procedure. Follow facility procedure for shaving the skin area around the joint, if needed.

Before the arthroscopy, the surgeon completes a thorough medical history and evaluation, which may reveal other disorders of the joint or body parts. Anatomical models and pictures are useful aids to explain to the patient the proposed arthroscopy and what the surgeon may be looking at specifically.

Proper draping of the body part is important to prevent contamination from instruments used in arthroscopy. Draping packs used in arthroscopy usually include disposable paper gowns and drapes with adhesive backing.

General or **local anesthesia** may be used during arthroscopy. Local anesthesia is preferred because it reduces the risk of lung and **heart** complications. The local anesthetic may be injected in small amounts in multiple locations in skin and joint tissues in a process called infiltration. In other cases, the anesthetic is injected into the **spinal cord** or a main nerve supplying the area. This process is called a “block,” as it blocks all sensation below the main trunk of the nerve. For example, a femoral block anesthetizes the leg from the thigh down. Most patients are comfortable once the skin, muscles, and other tissues around the joint are numbed by the anesthetic; however, some patients may be given a sedative if they express **anxiety** about the procedure. It is important for the patient to remain still during the arthroscopic examination.

General anesthesia may be used if the procedure is unusually complicated or painful, or extensive surgery is planned. For example, people who have relatively “tight” joints may be candidates for general anesthesia because the procedure may take longer and cause more discomfort.

Aftercare

The portals are closed by small tape strips or sutures and covered with sterile dressings and a pressure bandage. The patient spends a short amount of time in the recovery room after arthroscopy. Most patients can go

home after about an hour in the recovery room. A routine arthroscopy may take from 30 minutes to two hours.

Following the surgical procedure, the patient needs to be aware of the signs of infection, which include redness, warmth, excessive **pain**, and swelling. The risk of infection increases if the incisions become wet too early following surgery. Patients can cover the joint with plastic (for example, a plastic bag) while showering after arthroscopy. If a knee arthroscopy was performed, the patient should be instructed to elevate the knee while sitting, and to avoid twisting the joint. Ice may be applied to relieve pain and swelling.

The use of crutches is common after arthroscopy of the knee or hip, with progression to independent walking on an “as tolerated” basis by the patient. Generally, a rehabilitation program, supervised by a physical therapist, follows shortly after the arthroscopy to help the patient regain mobility and strength of the affected joint and limb.

Alternative procedures

Alternatives to arthroscopy depend upon the condition, and have limitations. X rays only examine bones, they will not show ligaments or torn cartilages. **Magnetic resonance imaging** (MRI) will reveal ligaments and cartilages but does not treat the condition. If a torn cartilage were discovered with MRI, an arthroscopy would be performed to correct the problem. Lateral ligament reconstruction for the treatment of ankle injuries is preferred over arthroscopy.

Complications

The incidence of complications is low compared to the number of arthroscopic procedures performed every year. Possible complications include infection, swelling, damage to the tissues in the joint, thrombophlebitis (**blood** clots in the leg veins), hemarthrosis (leakage of blood into the joint), pulmonary embolus (blood clots that move to the lung), and injury to the nerves around the joint. Low molecular weight heparin has been found to achieve effective prophylaxis for arthroscopy.

Results

Arthroscopy may show normal ligaments, menisci, and articular surfaces. Findings that require further treatment include spur formation, torn meniscus, and torn ligaments. Another finding that may require further treatment include adhesive capsulitis. In this condition, the joint capsule that naturally forms around the joint becomes thickened, forming adhesions, which results in

a stiff and less mobile joint. This problem may be corrected by manipulation and mobilization of the joint with the patient placed under general anesthesia.

Arthroscopic examination is often followed by arthroscopic surgery performed to repair the problem with appropriate arthroscopic tools. The optimal result is decreased pain, increased joint mobility, and improved quality of the patient’s activities of daily living (ADL).

Health care team roles

Arthroscopy is usually performed on an outpatient basis by a physician, but surgical repair may require hospitalization. In addition to providing assistance during the procedure, nurses monitor **vital signs** in the recovery room, including **blood pressure**, pulse, and respiration. They may also monitor circulation and sensation in the area that has been examined and/or operated on. Following arthroscopic surgery, a physical therapist guides the patient in rehabilitation to ensure that the patient regains full functioning in the targeted joint.

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ORGANIZATIONS

- American Academy of Orthopaedic Surgeons. 6300 North River Road Rosemont, Illinois 60018-4262 (800) 346-AAOS <<http://www.aaos.org>>.
- National Association of Orthopaedic Nurses, National Office. Box 56, Pitman, NJ 08071 (856) 256-2310 <<http://naon.inurse.com>>.

Maggie Boleyn, RN, BSN

Artificial insemination see **Fertility treatments**

Ascending contrast phlebography *see* **Phlebography**

Phlebography

Ascites fluid collection *see* **Paracentesis**

Ascorbic acid *see* **Vitamin C**

Aseptic technique

Definition

Aseptic technique is a set of specific practices and procedures performed under carefully controlled conditions with the goal of minimizing contamination by pathogens.

Purpose

Aseptic technique is employed to maximize and maintain asepsis, the absence of pathogenic organisms in the clinical setting. The goal of aseptic technique is to protect the patient from **infection**.

Description

All patients are potentially vulnerable to infection. Certain situations further increase vulnerability, such as disturbance of the body's natural defenses, such as occurs with extensive **burns** or an immune disorder. Typical situations that call for aseptic measures include surgery and the insertion of intravenous lines, urinary catheters, and drains.

The concept of asepsis can be applied in any clinical setting. Pathogens may introduce infection to the patient through contact with the environment, personnel, or equipment. The environment contains potential hazards that may spread pathogens through movement, touch, or proximity. Interventions such as controlling air flow by restricting traffic in the operating room, isolating a patient to protect airborne contamination, or using low-particle generating garb help to minimize environmental hazards.

A second element requiring careful attention is equipment or supplies. Medical equipment can be sterilized by chemical treatment, radiation, gas, or heat. Personnel can take steps to ensure sterility by assessing that sterile packages are dry and intact and checking sterility indicators such as dates or colored tape that changes color when sterile.

Besides overall attention to the clinical environment and equipment, clinicians need to be attentive to their own practices and those of their peers in order to avoid inadvertent contamination.

A key difference between the operating room and other clinical environments is that the operating area has high standards of sterility at all times, while most other settings are not designed to meet such standards. However, the principles of aseptic technique can be applied in other clinical settings. The application of aseptic technique in such settings is termed "medical asepsis" or "clean technique" rather than "surgical asepsis" or "sterile technique" required in the operating room.

Aseptic technique is most strictly applied in the operating room because of the direct and often extensive disruption of skin and underlying tissue. Aseptic technique helps to prevent or minimize postoperative infection. The patient is prepared or prepped by shaving hair from the surgical site, cleansing with a disinfectant such as iodine, and applying sterile drapes.

In all clinical settings, handwashing is an important step in asepsis. In general settings, hands are to be washed when visibly soiled, before and after contact with the patient, after contact with other potential sources of microorganisms, before invasive procedures, and after removal of gloves. Patients and visitors should also be encouraged to wash their hands. Proper handwashing for most clinical settings involves removal of jewelry, avoidance of clothing contact with the sink, and a minimum of 10-15 seconds scrubbing hands with soap, warm water, and vigorous friction.

A surgical scrub requires use of a long-acting, powerful, antimicrobial soap, careful scrubbing of the fingernails, and a longer period of time for scrubbing. Institutional policy usually designates an acceptable minimum length of time required. Thorough drying is essential, as moist surfaces invite the presence of pathogens. Contact after handwashing with the faucet or other potential contaminants should be avoided. The faucet can be turned off with a dry paper towel, or, in many cases, through use of foot pedals. Despite this careful scrub, bare hands are always considered potential sources of infection. An important principle of aseptic technique is that fluid (a potential mode of pathogen transmission) flows in the direction of gravity. With this in mind, hands are held below elbows during the surgical scrub and above elbows following the surgical scrub.

Sterile surgical clothing or protective devices such as gloves, face masks, goggles, and transparent eye/face shields serve as a barrier against microorganisms and are donned to maintain asepsis in the operating room. This practice includes covering facial hair, tucking hair out of sight, and removing jewelry or other dangling objects that may harbor unwanted organisms. This garb must be donned with deliberate care to avoid touching external, sterile surfaces with nonsterile objects including the skin.

This ensures that potentially contaminated items such as hands and clothing remain behind protective barriers, thus prohibiting inadvertent entry of microorganisms into sterile areas. Personnel assist the surgeon to don gloves and garb and arrange equipment to minimize the risk of contamination.

Donning sterile gloves requires specific technique so that the outer glove is not touched by the hand. A large cuff exposing the inner glove is created so that the glove may be grasped during donning. It is essential to avoid touching nonsterile items once sterile gloves are applied; the hands may be kept interlaced to avoid inadvertent contamination. Any break in the glove or touching the glove to a nonsterile surface requires immediate removal and application of new gloves.

Asepsis in the operating room or for other invasive procedures is also maintained by creating sterile surgical fields with drapes. Sterile drapes are sterilized linens placed on the patient or around the field to delineate sterile areas. Drapes or wrapped kits of equipment are opened in such a way that the contents do not touch nonsterile items or surfaces. Aspects of this method include opening the furthest areas of a package first, avoiding leaning over the contents, and preventing opened flaps from falling back onto contents.

Other principles that are applied to maintain asepsis include:

- All items in a sterile field must be sterile.
- Sterile packages or fields are opened or created as close as possible to time of actual use.
- Moist areas are not considered sterile.
- Contaminated items must be removed immediately from the sterile field.
- Only areas that can be seen by the clinician are considered sterile, i.e., the back of the clinician is not sterile.
- Gowns are considered sterile only in the front, from chest to waist and from the hands to slightly above the elbow.
- Tables are considered sterile only at or above the level of the table.
- Nonsterile items should not cross above a sterile field.
- There should be no talking, laughing, coughing, or sneezing across a sterile field.
- Personnel with colds should avoid working while ill or apply a double mask.
- Edges of sterile areas or fields (generally the outer inch) are not considered sterile.
- When in doubt about sterility, discard the potentially contaminated item and begin again.



Proper removal of used gloves. (Delmar Publishers, Inc. Reproduced by permission.)

- A safe space or margin of safety is maintained between sterile and nonsterile objects and areas.
- When pouring fluids, only the lip and inner cap of the pouring container is considered sterile. The pouring container should not touch the receiving container, and splashing should be avoided.
- Tears in barriers are considered breaks in sterility.

In the operating room, staff have assignments so that those who have undergone surgical scrub and donning of sterile garb are positioned closer to the patient. Other “unscrubbed” staff members are assigned to the perimeter and remain on hand to obtain supplies, acquire assistance, and facilitate communication with outside personnel. Unscrubbed personnel may relay equipment to scrubbed personnel only in a way that preserves the sterile field. For example, an unscrubbed nurse may open a package of forceps in sterile fashion so that he or she never touches the sterilized inside portion, the scrubbed staff or the sterile field. The uncontaminated item may either be picked up by a scrubbed staff member or carefully placed on to the sterile field.

Asepsis in the operating room is maintained by allowing only scrubbed personnel into the sterile field and checking all equipment and packaging for breaks in sterility, such as expired sterilization date, moisture, or torn wrappings. Clinicians observe aseptic technique by strictly avoiding practices that may introduce microorganisms. Arms of scrubbed staff are to remain within the field at all times, and reaching below the level of the patient or turning away from the sterile field are considered breaches in asepsis.

Clinical areas outside of the operating room generally do not allow for the same strict level of asepsis.



Surgeons scrubbing their hands and arms before surgery.

(Photograph by Doug Martin. Science Source/Photo Researchers. Reproduced by permission.)

However, avoiding potential infection remains the goal in every clinical setting. Observation of medical aseptic practices will help to avoid nosocomial infections, or those acquired in the hospital. General habits that help to preserve a clean medical environment include:

- Safe removal of hazardous waste, i.e., prompt disposal of contaminated needles or blood-soaked bandages to containers reserved for such purposes.
- Prompt removal of wet or soiled dressings.
- Prevention of accumulation of bodily fluid drainage, i.e., regular checks and emptying of receptacles such as surgical drains or nasogastric suction containers.
- Avoidance of backward drainage flow toward patient, i.e., keeping drainage tubing below patient level at all times.
- Immediate clean-up of soiled or moist areas.
- Labeling of all fluid containers with date, time, and timely disposal per institutional policy.
- Maintaining seals on all fluids when not in use.

These general practices are important for keeping the environment as free of microorganisms as possible. In addition, specific situations outside of the operating room require a strict application of aseptic technique. Some of these situations include:

- wound care
- drain removal and drain care
- intravascular procedures
- vaginal exams during labor
- insertion of urinary catheters
- respiratory suction

For example, a surgical dressing change at the bedside, though in a much less controlled environment than

the operating room, will still involve thorough hand-washing, use of gloves and other protective garb, creation of a sterile field, opening and introducing packages and fluids in such a way as to avoid contamination, and constant avoidance of contact with nonsterile items.

The isolation unit is another clinical setting that requires a high level of attention to aseptic technique. Isolation is the use of physical separation and strict aseptic technique for a patient who either has a contagious disease or is immunocompromised. For the patient with a contagious disease, the goal of isolation is to prevent the spread of infection to others. In the case of respiratory infections (i.e., **tuberculosis**), the isolation room is especially designed with a negative pressure system that prevents airborne flow of pathogens outside the room. The severely immunocompromised patient is placed in reverse isolation, where the goal is to avoid introducing any microorganisms to the patient. In these cases, attention to aseptic technique is especially important to avoid spread of infection in the hospital or injury to the patient unprotected by sufficient immune defenses. Entry and exit from the isolation unit involves careful handwashing, use of protective barriers like gowns and gloves, and care not to introduce or remove potentially contaminated items. Institutions supply specific guidelines that direct practices for different types of isolation, i.e., respiratory versus body fluid isolation precautions.

Preparation

Novice and less-experienced clinicians require thorough training and supervision in the principles and practices of aseptic technique. Maintaining asepsis requires practice and vigilance.

Health care team roles

In a multidisciplinary setting, one role of the nurse or other allied health professional is to assist the doctor in caring for the patient while maintaining asepsis, i.e., by supplying equipment to the surgeon in a sterile fashion. Nursing staff independently practice aseptic techniques in many day-to-day procedures, such as urinary catheter insertion, dressing changes, and respiratory suction. Even personnel experienced with aseptic technique must constantly monitor their own movements and practices, those of others, and the status of the overall field to prevent inadvertent breaks in sterile or clean technique. It is expected that personnel will alert other staff when the field or objects are potentially contaminated. Health care workers can also promote asepsis by evaluating, creating, and periodically updating policies and procedures that relate to this principle.

KEY TERMS

Contamination—A breach in the preservation of a clean or sterile object or environment

Host—A living organism that harbors or potentially harbors infection.

Immunocompromised—Lacking or deficient in defenses provided by the immune system, usually due to disease state or a side effect of treatment.

Invasive—Involving entry into the body.

Nosocomial—Occurring in the hospital or clinical setting.

Pathogen—A disease-causing organism.

Resistant organisms—Organisms that are difficult to eradicate with antibiotics.

Sterile—Completely free of pathogens.

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Katherine Hauswirth, APRN

Aspirin see **Nonsteroidal anti-inflammatory drugs**

Assisted suicide see **Euthanasia**

Assistive listening devices see **Hearing aids**

Asthma

Definition

Asthma is a chronic inflammatory disease of the airways in which periods of relatively free breathing are

punctuated by episodes in which breathing becomes difficult. During an attack, inflammation causes the airways to fill with mucus secretions and become obstructed. Asthmatics cough, gasp for air, wheeze, gag, and feel choking sensations as they struggle to breathe. Obstruction to airflow usually responds to a wide range of treatments.

Depending on the type of asthma, attacks may be triggered by environmental factors such as cold temperatures, air pollution, smoke, pollen, dust, mildew, mold, and animal hair or dander. **Exercise**, allergic reactions, respiratory infections, and emotional **stress** may also trigger attacks. Like other chronic diseases, asthma can be controlled, but not cured.

According to the American Lung Association, in 1998 there were 26 million Americans asthmatics, 10.6 of whom had had an attack during the past year. About a third of all asthmatics are children under 18. Since asthma is often undiagnosed, these statistics probably underestimate the true prevalence of the disease.

Description

The **lungs** of asthmatics are hypersensitive to stimuli that do not affect healthy lungs. Many patients with asthma react to allergens such as pollen, dust mites, or animal dander, but colds, **viruses**, and environmental irritants such as dust and pollution can also be triggers.

During an asthma attack, cells in the bronchial walls called mast cells release chemicals that force the bronchial muscle to contract in spasms. These chemicals, which include histamine, acetylcholine, and a group of substances called leukotrienes, also bring white **blood** cells into the area, which is a key part of the inflammatory response. This process also stimulates mucus formation. The entire process creates bronchoconstriction, making it difficult for the asthmatic person to breathe.

Asthma usually begins in childhood or adolescence, but it also may first appear in adulthood. While the symptoms may be similar, certain important aspects of asthma are different in children and adults.

Child-onset asthma

When asthma begins in childhood, it often does so in an atopic child, one who is genetically predisposed to become sensitized to allergens in the environment. Atopy is present in at least one-third and as many as half of the general population. When these children are exposed to dust mites, animal **proteins**, **fungi**, or other potential allergens, they produce a type of antibody intended to engulf and destroy the foreign materials. This sensitizes the airway cells to particular allergens. Further exposure can lead rapidly to an asthmatic response.



This patient is using a nebulizer for breathing treatment in the emergency room. (Photograph by Larry Mulvehill. Science Source/Photo Researchers. Reproduced by permission.)

Adult-onset asthma

Allergies may also play a role in adult-onset asthma, which can start at any age and in a wide variety of situations. Adults may begin to react to allergens such as pollen, dust mites, and pet dander; they may find themselves allergic to aspirin and other drugs; and can even trigger an asthma attack with exercise. Another major cause of adult asthma is occupational exposure (and sensitization) to animal products, certain forms of plastic, wood dust, or metals. In addition, many people have such conditions as sinusitis or nasal polyps that also make them prone to asthma attacks.

Causes and symptoms

In most cases, asthma is caused by inhaling an allergen that sets off the biochemical chain reaction, causing the tissue changes that lead to airway inflammation, bronchoconstriction, and wheezing. Since avoiding, or at least minimizing, exposure is the most effective way to treat asthma, it is vital to identify which allergen or irritant is causing symptoms in each patient. Once asthma is present, symptoms can be triggered or made worse if the patient also has rhinitis (a cold or cold-like symptoms

caused by allergies), sinusitis (inflammation or **infection** of the sinuses), or a viral infection of the respiratory tract (such as **influenza**). Gastroesophageal reflux disease (GERD), commonly referred to as acid reflux or heartburn, can also make asthma worse. Some asthmatics are free of symptoms most of the time but may occasionally be short of breath. Others spend their days (and nights) coughing and wheezing, until properly treated.

Allergens and irritants most likely to cause asthma attacks are: smoke, animal dander, dust mites, fungi and molds, cockroach allergens, pollen, and industrial chemicals, fumes, or pollution. In addition, there are three conditions that can also provoke attacks in certain asthmatic patients: inhaling cold air, breathing hard during exercise, and stress or a high **anxiety** level.

During moderate to severe asthma attacks wheezing may be obvious, but mild attacks can be confirmed by listening to the patient's chest with a **stethoscope**. Wheezing is often loudest during exhalation, when the patient tries to expel air through narrowed airways. Besides wheezing and shortness of breath, the patient may also cough and report a feeling of tightness in the chest. Children may experience itching on their back or

neck. Crying or even laughing may bring on an attack. Severe episodes often occur when patients contract viral respiratory tract infections or are exposed to heavy loads of an allergen or irritant. Asthma attacks may last only a few minutes or can persist for hours or even days (a condition called status asthmaticus).

Shortness of breath may cause a patient to become very anxious, sit upright, lean forward, and use the accessory muscles of respiration to help breathe. The patient may be able to say only a few words at a time before stopping to take a breath. Confusion and a bluish tint to the skin indicate that the patient's oxygen supply is very low and emergency treatment is needed. If a severe attack lasts for some time, air sacs in the lung may rupture, trapping air within the chest. This makes it even harder to breathe in enough air. Fortunately, even patients with the most severe attacks usually recover completely.

Diagnosis

Physical examination

Apart from listening to the patient's chest, the examiner should look for maximum chest expansion while taking in air. Hunched shoulders and contracting neck muscles are other signs of narrowed airways. Nasal polyps or increased amounts of nasal secretions are often noted in asthmatic patients. Skin problems like atopic dermatitis or eczema indicate that the patient has allergic problems. A family history of asthma or allergies can be a valuable indicator. The diagnosis may be strongly suggested when typical symptoms and signs are present.

Spirometry and chest x ray

Spirometry can confirm a diagnosis of asthma by measuring lung function: how much air the lungs can hold and how much they can expel. Asthma patients typically have normal lung volumes with diminished flow rates. Repeating the test after the patient inhales a bronchodilator will show whether the airway narrowing is reversible, a finding that distinguishes asthma from other obstructive diseases like **emphysema**.

Often patients use a related instrument, called a peak flow meter, to monitor asthma severity at home. Because this device measures the strength with which air is exhaled, it can detect narrowed airways at the earliest stage, before an attack becomes full blown. This allows the patient to take the appropriate medication and diminish or avoid the episode.

Determining what triggers asthma attacks can be difficult. Skin testing may be helpful, although an allergic skin response does not necessarily mean that the allergen being tested is causing the asthma. Once a specific aller-

gen is suspected, a blood test can be run to check for IgE antibodies, since the **immune system** always produces an antibody in response to an allergen. This will show if the patient is sensitive to a particular allergen. If the diagnosis is still in doubt, the patient can inhale a suspect allergen while using a spirometer to detect airway narrowing, a test called "allergen challenge." Spirometry may also be repeated after a bout of exercise to confirm or refute the diagnosis of exercise-induced asthma. A **chest x ray** may help to rule out other pulmonary disorders, or confirm findings particular to asthma.

Treatment

Patients should be examined periodically and have their pulmonary function measured by spirometry to ensure that treatment goals are being maintained. The goal is to prevent troublesome symptoms, maintain lung function as close to normal as possible, and allow patients to pursue their normal activities, including those requiring exertion. The best drug therapy is that which controls asthmatic symptoms while causing few or no side-effects.

Drugs

METHYDXANTHINES. The chief methylxanthine is theophylline. It may exert some anti-inflammatory effect, and is especially helpful in controlling nighttime asthma. When, for some reason, a patient cannot use an inhaler to maintain long-term control, sustained-release oral theophylline is a good alternative. The blood levels of the drug must be measured periodically, as too high a dose can cause an abnormal **heart** rhythm or convulsions.

BETA-RECEPTOR AGONISTS. These bronchodilators, such as albuterol, are the best choice for relieving sudden attacks of asthma and for preventing attacks triggered by exercise because they relax the smooth muscles in the lungs. This prevents bronchospasm but doesn't help the swelling that often accompanies an asthma attack. These drugs are effective within about 30 minutes, and are maximally effective for three or four hours. They may be taken by mouth, inhaled, or injected, although the oral forms often produce such side effects as jitters and sleeplessness.

STEROIDS. Steroids and **corticosteroids** block inflammation and are extremely effective in relieving asthma symptoms. When taken by inhalation for a long period, they reduce the airways' sensitivity to allergens, and asthma attacks become less frequent. This is the strongest medicine for asthma, and can control even severe cases over the long term. Oral or intravenous steroids taken over long periods, however, can cause numerous side effects, including gastric bleeding, loss of

calcium from bones, **cataracts**, and diabetes. Patients on long-term steroid therapy may also have problems with wound healing and weight gain, and may develop mental problems as well. In children, growth may be slowed. Besides being inhaled, steroids may be taken by mouth or injected to control severe asthma rapidly.

LEUKOTRIENE MODIFIERS. Leukotriene modifiers, such as montelukast (Singulair), zileuton (Zyflo), and zafirlukast (Accolate) are drugs that work by counteracting leukotrienes, substances released by white blood cells in the lungs that constrict air passages and promote mucus secretion. They may reduce the need for short-acting inhalers, and may replace inhaled steroid treatment for patients with mild forms of asthma. Leukotriene modifiers may also help asthma patients recover from severe attacks more quickly, and can even help alleviate the allergic rhinitis that often accompanies allergies.

OTHER DRUGS AND TREATMENTS. Cromolyn sodium (Intal) and nedocromil (Tilade) are anti-inflammatory agents that stabilize the airways and help prevent the swelling and inflammation that trigger asthma attacks. They can also prevent flareups when given before exercise or when exposure to an allergen cannot be avoided. Like most asthma medication, these drugs must be taken regularly even if there are no symptoms, and require weeks or months of use before they reach their optimum effectiveness.

Anti-cholinergic drugs, such as ipratropium bromide (Atrovent), are useful in controlling severe attacks when added to an inhaled beta-receptor agonist. They help widen the airways and suppress mucus production. The effects of anti-cholinergics usually last longer than beta-agonists, and are often given in combination with bronchodilators to improve breathing.

If a patient's asthma is caused by an allergen that cannot be avoided and has become difficult to control through drug therapy alone, immunotherapy (allergy shots) may be beneficial. In this treatment, increasing amounts of the allergen are injected over a period of three to five years, so the body can build up an effective **immune response**. There is a risk that this treatment may itself trigger an asthma attack or even **anaphylaxis**. Immunotherapy has been used since the early twentieth century to treat allergies and hayfever. New studies have indicated that it also reduces asthma symptoms caused by exposure to such allergens as dust mites, ragweed pollen, and cats.

Managing asthmatic attacks

A severe asthma attack can be a medical emergency and should be treated as quickly as possible. It is most important for a patient suffering an acute attack to be

given oxygen. Rarely, it may be necessary to use a mechanical ventilator to help the patient breathe. Under a doctor's care, a beta-receptor agonist is inhaled repeatedly or continuously. If the patient does not respond promptly and completely, a steroid is given. An additional course of steroid therapy, given after the attack is over, will make a recurrence less likely.

Once asthma has been controlled for several weeks or months, the dose may be gradually tapered. The last drug added to the regimen should be the first to be reduced. Patients should be evaluated every one to six months, depending on the frequency of attacks.

Long-term treatment

Long-term asthma treatment is based on inhaled medications that are a combination of beta-receptor agonists and steroids. The drugs are delivered to the lungs via special inhalers that meter each dose. While this regimen is usually quite successful in diminishing or preventing attacks, all patients should be taught how to monitor their symptoms so they will know when an attack is starting. Those with moderate or severe asthma can use a peak flow meter to determine if inflammation is increasing.

Asthmatics should also have a written action plan to follow if symptoms suddenly worsen, including how to adjust their medication and when to seek medical care. When deciding whether a patient should be hospitalized, the past history of acute attacks, severity of symptoms, current medication, and whether good support is available at home all must be taken into account.

Referral to an asthma specialist should be considered if:

- There has been a life-threatening asthma attack or severe, persistent asthma.
- Treatment for three to six months has been ineffective.
- Another condition, such as nasal polyps or chronic lung disease, is complicating asthma.
- Special tests, such as allergy skin testing or an allergen challenge are needed.
- Intensive steroid therapy has been necessary.

Special populations

INFANTS AND YOUNG CHILDREN. It is especially important to monitor the course of asthma in young patients so that treatment may be diminished or increased as necessary. The health care provider should write out an asthma treatment plan for the child's school. Although asthmatic children often need medication at school to control acute symptoms or to prevent exercise-induced attacks, proper management usually enables a child to

take part in physical activities. Only as a last resort should activities be limited.

OLDER ADULTS. Side effects from beta-receptor agonist drugs (including rapid heart rate and tremor) may be more common in older patients. These patients may benefit from receiving an anti-cholinergic drug along with the beta-receptor agonist. If theophylline is given, the dose should be carefully monitored, as older patients may be less able to metabolize this drug. Asthma in older patients may also be complicated by other obstructive lung diseases such as chronic bronchitis or emphysema. It is important to know the extent the symptoms caused by the asthma. A two- to three-week course of steroids can help determine which symptoms are attributable to asthma.

Prognosis

Once the best drug or combination of drugs is found, most patients with asthma respond well and are able to lead relatively normal lives. More than half of affected children stop having attacks by the time they reach twenty-one. Many others have less frequent and less severe attacks as they grow older. In either case ongoing treatment to prevent attacks and urgent measures to control them if they occur are equally important. A small minority of patients will have progressive difficulties breathing. These patients are at risk for **respiratory failure** and must receive intensive treatment.

Health care team roles

Diagnosis and effective asthma management involve cooperation and collaboration between the patient, family, and an interdisciplinary team of health care professionals. These include the patient's primary health care provider, allergy and immunology specialists, nurses, laboratory technologists, respiratory therapists, pharmacists, pharmacy assistants, and health educators are involved in helping patients and families gain an understanding of how to manage this chronic disease.

Patient education

Nurses, respiratory therapists, and health educators teach patients and families how to prevent, recognize, and manage asthma attacks, including the distinction between mild episodes and those requiring immediate medical attention. They can also train them in stress management techniques that reduce anxiety to help them gain control of this chronic condition.

USING AN INHALER. Perhaps most importantly, these professionals show patients the proper technique for using inhalers and other medications, and stress the importance of compliance. Using a respiratory inhaler properly is a

KEY TERMS

Allergen—A foreign substance, such as mites in dust or animal dander which, when inhaled, causes the airways to narrow and produces asthma symptoms.

Allergen challenge—“Provocation” testing in which a patient is exposed to a suspected allergen under controlled conditions.

Atopy—An allergy (probably hereditary) that makes people react immediately to allergens they encounter. Atopic individuals are more likely to develop allergic reactions of any type, including the inflammation and airway narrowing typical of asthma.

Hypersensitivity—The state where even a tiny amount of allergen can cause the airways to constrict and bring on an asthmatic attack.

Spirometry—A test using an instrument called a spirometer that shows how well an asthmatic is breathing, the severity of the asthma, and how well it is responding to treatment.

critical skill in asthma management and it's vitally important that patients be instructed in its proper use:

- Remove the inhaler's cap.
- Holding the inhaler upright, shake it thoroughly for several seconds.
- Exhale as much air as possible, while tilting the head back slightly.
- Hold the inhaler in the position required by the manufacturer. Some should be held an inch or two away from the mouth, others should be placed directly in the mouth.
- Press the inhaler to dispense the medication.
- Inhale slowly and deeply *through the mouth only* for several seconds.
- Hold the breath for at least 10 seconds; this allows the medication to penetrate into the lungs. Take only one breath for each puff.
- Exhale.
- Wait a minute or so between puffs. This delay allows the second dose to get even farther into the airways.

Successful use of metered-dose inhalers requires a close degree of coordination between dispensing the drug and inhaling it. Because this is usually difficult for young

children, they are often told to attach “spacers” to their inhalers. These are chambers into which the drug is sprayed before it is inhaled, allowing the medication to be ingested in one or more breaths. For the tiniest patients, masks are attached to the spacers. Many doctors recommend spacers for adult patients as well, since they decrease the chances of using the inhaler improperly, and increase the amount of medication that reaches the lungs. During a severe asthma attack, when patients may not have the ability to inhale a full dose, spacers can literally save lives by allowing patients in distress to take their medication in shorter breaths. Spacers are also usually attached to corticosteroid inhalers.

When using powder inhalers (Rotacaps), patients should close their lips around the inhaler’s mouthpiece and inhale quickly. After using a corticosteroid inhaler patients should gargle or rinse their mouths with water to avoid thrush, an overgrowth of yeast in the mouth.

Pharmacists and pharmacy assistants may offer additional instruction about medication use and reiterate the importance of adhering to prescribed treatment.

Prevention

Minimizing exposure to allergens

There are a number of ways patients can reduce exposure to allergens and irritants that provoke asthmatic attacks, or to avoid them altogether:

- If the patient is sensitive to the family pet, remove the animal or at least keep it out of the bedroom. Keep the pet away from carpets and upholstered furniture. Remove all feathers.
- To reduce exposure to dust mites, remove wall-to-wall carpeting, keep the humidity down, and use special pillow and mattress covers. Wash bedding in hot water once a week.
- Reduce the number of stuffed toys, and wash them each week in hot water as well.
- Eliminate cockroaches using poison, traps, or boric acid rather than chemical pesticides.
- Keep indoor air clean by vacuuming carpets once or twice a week (with the patient absent), avoid using humidifiers, and use air conditioning during warm weather so windows can remain closed.
- Avoid exposure to tobacco smoke.
- Do not exercise outside when air pollution levels are high.
- To reduce occupational exposure, wear a mask when working with or around irritants. Some patients may find it necessary to find work in a safer environment.

Resources

BOOKS

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ORGANIZATIONS

Asthma and Allergy Foundation of America. 1125 15th St. NW, Suite 502, Washington, DC 20005. 800-7ASTHMA. <<http://www.housecall.com/sponsors/nhc/1966vha/aafa.html>>.

National Asthma Education Program. 4733 Bethesda Ave., Suite 350, Bethesda, MD 20814. 301-495-4484.

National Jewish Medical and Research Center. 1400 Jackson St., Denver, CO 80206. 800-222-LUNG.

OTHER

Mothers of Asthmatics, Inc. Allergy and Asthma Network. 3554 Chain Bridge Road, Suite 200, Fairfax, VA 22030. 800-878-4403. <<http://www.aanma.org>>.

Barbara Wexler

Astigmatism

Definition

Astigmatism results from an inability of the cornea to properly focus an image as a single point onto the retina, instead focusing the image on two different locations. The result is a blurred image.

Description

The cornea is a transparent layer that bends light and helps to focus it onto the retina, where light is detected. Any incorrect shaping of the cornea results in an incorrect focusing of the light that passes through it. Usually the cornea is spherically shaped, like a baseball. However, in astigmatism the cornea is elliptically shaped with a long meridian and a short meridian. These two meridians generally have a constant curvature and are generally perpendicular to each other (regular astigmatism). Irregular astigmatism may have more than two meridians of focus and they may not be 90° apart. A point of light, therefore, will have two points of focus instead of one. This causes blurry **vision**.

Some astigmatism is caused by problems in the eye’s lens. Minor variations in the curvature of the lens can produce minor degrees of astigmatism (lenticular astigmatism). Infants generally have the least amount of astig-

matism. Astigmatism may increase during childhood as the eye develops.

Causes and symptoms

The main symptom of astigmatism is blurred vision. Patients may also experience headaches and eyestrain. Astigmatism is suspected when the child can see some part of a pattern or picture more clearly than others. For example, lines going across may seem clearer than lines going up and down.

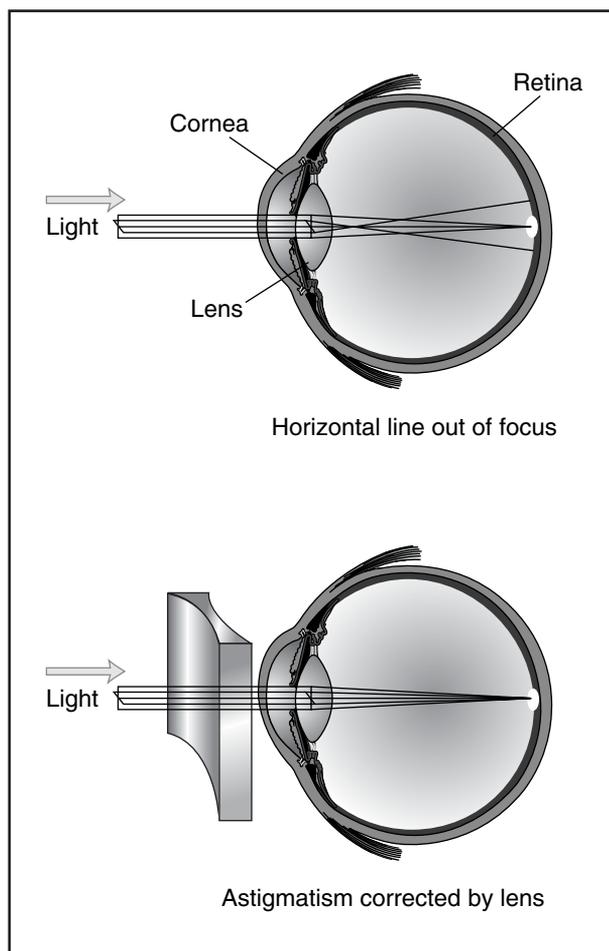
Regular astigmatism can be caused by the weight of the upper eyelid upon the eyeball, creating distortion; surgical incisions in the cornea; trauma or scarring to the cornea; tumors of the eyelid; or a developmental anomaly. Irregular astigmatism can be caused by scarring or keratoconus, a condition in which the cornea thins and becomes cone shaped. Although the etiology of keratoconus is unknown, it may be hereditary and may be worsened by chronic eye rubbing. Diabetes can also play a role in astigmatism. High **blood** sugar levels can cause shape changes in the intraocular lens. This usually occurs slowly and is often noticed only when the diabetic starts treatment. The return to a more normal blood sugar allows the lens to return to normal; this is sometimes manifested as farsightedness. Diabetics should wait until their blood sugar is under control for at least one month before being refracted for eyeglasses.

Diagnosis

Patients seek treatment because of blurred vision. Ophthalmologists and optometrists use a variety of tests to detect astigmatism. The patient may be asked to describe the astigmatic dial, a series of lines that radiate outward from a center. People with astigmatism will see some of the lines more clearly than others. Another diagnostic instrument is the keratometer, which measures the curvature of the central cornea. A computerized corneal topographer can measure a larger area encompassing the center and mid-periphery of the cornea. A keratoscope projects a series of concentric light rings onto the cornea. Misshapen locations of the cornea are revealed by noting areas of the light pattern on the cornea that do not appear concentric. It is also important to perform a refraction to determine if the lens is also contributing to the astigmatism. A refraction is when different lenses are placed in front of the eyes of the patient, who is asked which one permits better vision.

Treatment

Astigmatism is treated with cylindrical lenses. These can be eyeglasses or **contact lenses**. Lenses are shaped



Astigmatism can be treated by the use of cylindrical lenses. The lenses are shaped to counteract the shape of the sections of the cornea that are causing the difficulty.

(Illustration by Electronic Illustrators Group.)

to counteract the abnormalities of the cornea that are causing the difficulty.

Generally, if visual acuity is good and the patient experiences no overt symptoms, treatment is not considered necessary. Larger amounts of astigmatism, or astigmatism treated for the first time, may not be totally corrected. The cylindrical correction in the eyeglasses may be initially difficult. It may take a week or so to adapt to the corrective lenses. Patients experiencing ongoing problems should be referred back to their eye doctor, who might want to recheck the prescription.

Contact lenses used to correct astigmatism are called toric lenses. When a person blinks, a contact lens rotates. In toric lenses, it is important for the lens to return to the same position each time. Lenses have a prism to weight the lenses, thin zones, cut-off areas (truncations), or other methods of stabilization.

KEY TERMS

Meridian—A section of a sphere, for example, longitude or latitude on the globe. Or, on a clock, a section going through 12:00-6:00 or 3:00-9:00, etc.

Ophthalmologist—A medical doctor who specializes in eye surgery.

Optometrist—A primary eye care doctor who examines, diagnoses, treats, and manages diseases and disorders of the visual system, the eye, and associated structures as well as diagnoses related systemic conditions. An optometrist prescribes glasses, contact lenses, low vision rehabilitation, vision therapy, and medications, as well as performs certain surgical procedures.

In 1997, the Food and Drug Administration (FDA) approved laser treatment of astigmatism. Patients considering this should verify the surgeon's experience with the procedure and should discuss the possible risks or side effects. The most common **laser surgery** technique is known as LASIK (laser in situ keratomileusis). Another widely used technique is PRK (photorefractive keratectomy).

In the case of keratoconus, a corneal transplant can be performed if hard contact lenses do not provide adequate vision. Approximately 10–20% of keratoconus patients will require corneal transplantation. Early in 2001, the FDA approved an initial feasibility study of a keratoconus treatment involving prescription inserts instead of transplantation. The researchers hoped to also obtain approval to utilize the inserts to treat complications arising in some LASIK patients.

Prognosis

Astigmatism may be present at birth. It may also be acquired if something is distorting the cornea. It may worsen with time. Vision can generally be corrected with eyeglasses, contact lenses, or refractive surgery. The major risks of surgery (aside from surgical risks such as **infection**, night-vision problems, and reduced contrast sensitivity) are over- and under-correction of the astigmatism. Some lasers are able to treat over-correction, and under-correction can be solved by repeating the operation.

Health care team roles

Diagnosis is made by an ophthalmologist or optometrist; nurses, because of their roles in vision

screening programs in schools, day care institutions, and other settings, are often front-line workers in initial detection of astigmatism.

Prevention

At present, there are no known ways to prevent astigmatism, although early detection can prevent the condition from worsening.

Resources

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David L. Helwig

Ataxia see **Movement disorders**

Atherectomy see **Angioplasty**

Athetosis see **Movement disorders**

Audiology

Definition

Audiology is the study of **hearing**. An audiologist is a health care professional who diagnoses and treats disorders of the auditory (hearing) and vestibular (balance) systems.

Description

Audiologists are concerned with hearing and balance problems. According to the Auditory Foundation of America (AFA), **hearing loss** is the third most common chronic health problem affecting Americans. Approximately 28 million individuals in the United States are affected by some form of hearing loss, ranging from mild impairment (loss of sensitivity) to total deafness. Balance problems (caused by a defect in the structures of the inner ear) affect approximately two million Americans.

Audiologists provide diagnostic, rehabilitative, and preventative services for individuals suffering from hearing and balance problems. They dispense assistive devices



An audiologist uses tympanometry to detect fluid in the middle ear, perforation of the eardrum, and any disorders of the hammer, anvil, and stirrup bones of the inner ear. (William Gage/Custom Medical Stock Photo. Reproduced by permission.)

such as **hearing aids**, cochlear implants, and telecommunication systems according to the needs of each patient. They educate consumers on the importance of hearing protection in industry, military, music, and other workplace and recreational settings. Audiologists may also conduct research into the assessment, management, and prevention of hearing loss and balance disorders.

Work settings

An audiologist may choose to work in a variety of settings, including a private office, hospital, medical clinic, non-profit or community center, nursing home, primary or secondary school, college or university, long-term care facility, or industry clinic.

Education and training

The minimum level of education required to become an audiologist is a master's degree from an accredited university or professional school. As of 2001, approximately 115 colleges and universities offer graduate programs in the field of audiology. After completing a nine-month post-graduate clinical fellowship and passing a

national standardized examination, an audiologist may earn a Certificate of Clinical Competency in Audiology (CCC-A) from the American Speech-Language-Hearing Association (ASHA). Most states require that the audiologist become licensed by the state in which they will practice.

Advanced education and training

In the early 1990s, the first Doctor of Audiology (Au.D.) degree programs were instituted to address the need for increased clinical training and expanded consumer services. The Au.D. is a post-baccalaureate four-year program that includes a Clinical Fellowship Year (CFY), a 12-month supervised clinical experience, so that students are eligible for state licensure upon graduation. The Au.D. curriculum includes classes in the areas of anatomy and physiology, acoustics and amplification, math, genetics, diagnostic techniques, patient care, sign language, and business management.

The Au.D. was designed to replace the master's as the entry-level degree into the field of audiology. The CFY will become a requirement for national certification after December 31, 2006; by the end of 2011, the doctor-

KEY TERMS

Vestibular—Relating to one's sense of balance.

al degree will become an additional requirement. Audiologists with a master's degree may bypass the conventional four-year program by enrolling in a distance learning program offered at a number of universities.

The median starting income for an audiologist with a master's degree in 1999 was \$33,600, and \$61,300 for an audiologist with an Au.D. degree.

Future outlook

Employment growth in the field of audiology is projected to remain strong, in part due to the increasing population of persons over the age of 55 and improvements in hearing and assistive technologies and also due to recommendations by the National Institutes of Health in its "Healthy People 2000" program mandating newborn or infant hearing screening.

Resources

ORGANIZATIONS

American Academy of Audiology. 8300 Greensboro Dr., Suite 750, McLean, VA 22102. (800) AAA-2336. <<http://www.audiology.org>>.

American Speech-Language-Hearing Association (ASHA). 10801 Rockville Pike, Rockville, MD 20852. (888) 321-ASHA. <<http://www.asha.org>>.

Audiology Foundation of America. 207 North Street, Suite 103, West Lafayette, IN 47906-3083. (765) 743-6283. <<http://www.audfound.org>>.

National Institute on Deafness and Other Communication Disorders. 1 Communication Avenue, Bethesda, MD 20892-3456. (800) 241-1044. <<http://www.nidcd.nih.gov>>.

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Stéphanie Islane Dionne

Audiometry

Definition

Audiometry is performed to test a person's ability to hear the sound frequencies necessary for speech. The test is carried out by a trained specialist called an audiologist with an instrument called an audiometer.

Purpose

Audiometry tests are used to identify and diagnose **hearing** problems. Audiometry is routinely performed within the framework of general health screening programs, for example in primary schools to detect hearing problems in children or in a work setting to test employees. It is also used at the doctor's office or in hospital **audiology** departments as a diagnostic tool to screen for hearing problems in children, adults, and the elderly. A complete audiometric evaluation consists of two main tests. First, the audiologist records the softest sound that a person can hear under earphones at several different frequencies. This is called testing via air conduction. Then a bone vibrator is placed behind the patient's ear to determine the softest level that the patient can hear when the inner ear is directly stimulated, thus bypassing the outer and middle ear. This is called testing via bone conduction. An ear test with an **otoscope** will be performed by a health care provider to evaluate the patient's ear canal and ensure a clear path to the ear drum. A device will then be inserted in the ear that will change the pressure, produce a pure tone, and measure the patient's response to the sound and different pressures. This test is called *tympanometry*. The proper diagnosis of a patient's specific pattern of hearing impairment allows the selection of the appropriate treatment, which may include **hearing aids**, corrective surgery, or speech therapy.

KEY TERMS

Audiogram—A chart or graph of the results of a hearing test conducted with audiographic equipment. An audiogram typically shows hearing loss as a function of frequency, as measured by an audiometer. The chart reflects the softest (lowest volume) sounds that can be heard at various frequencies or pitches.

Audiologist—A specialist trained in detecting hearing loss.

Audiometer—An instrument for measuring hearing sensitivity.

Audiometry—The measurement of hearing ability, usually with the an audiometer.

Deafness—The complete inability to hear, often present at birth.

Decibel—A unit of measure for expressing the loudness of a sound. Normal speech is typically spoken in the range of about 20-50 decibels.

Frequency—The rate of repetition of the cycles of a periodic quantity, such as a sound wave.

Hearing loss—Decreased auditory perceptive ability. Hearing loss is always acquired.

Intensity level—The measurement of the intensity of a sound in comparison to another sound or to a fixed level, expressed in decibels.

Otology—The branch of medicine concerned with the ear.

Otoscope—A hand-held instrument with a tiny light and a funnel-shaped attachment called an ear speculum, which is used to examine the ear canal and eardrum.

Pitch—The subjective impression of the frequency of a tone. Pitch is thus a psychoacoustic variable, and people have variable degrees of sensitivity to it.

Pure tone—A tone having a single pitch, or frequency, such as a flute note. It is also called a pure tone.

Sound—Any vibration in the air liable to cause a sensation of hearing.

Sound wave—Alternations of sound pressure displacement following one another in cycles of compression through a medium such as air. On striking the ear, sound waves are heard as sound.

Threshold of hearing—The intensity level at which a sound becomes barely audible. For a continuous tone of between 2000 and 4000 Hertz, heard by a person with normal hearing, this is 0.0002 dyne/cm² sound pressure and is given the reference level of 0 dB.

Tone—A single sound of definite, recognizable pitch.

Tympanometry—A test where air pressure in the ear canal is varied to test the condition and movement of the ear drum. This test is useful in detecting disorders of the middle ear.

Precautions

Audiometry tests are performed with safe equipment and are simple and painless. They do not require any special precautions.

Description

Audiometry tests are carried out in a soundproof testing room equipped with audiometry equipment such as an audiometer, earphones, special headband, and a small listening booth for the audiologist. Audiometry equipment consists of devices emitting sounds or tones, like musical notes, at various frequencies, or pitches, and at various levels of loudness. In pure tone audiometry, pure tones, meaning tones that have a single frequency, are always channeled to each ear separately. For example, in a typical procedure, beginning with either ear of the patient, a 1kHz-tone is sent through the earphones. The volume of

the tone is set to a level that can be easily heard by a person with normal hearing. The patient is instructed to press a button or activate a switch when the tone is heard. The duration of the test tone is usually kept constant at some 1.5 seconds. The volume is then decreased by 10dB-increments until the patient can no longer hear it. At the first level at which the tone becomes inaudible, the volume is increased in 5dB-increments until the patient responds to the tone. The audiologist may need to decrease and increase the loudness of the tone a few times to establish the patient's hearing threshold. By definition, this threshold is the loudness level at which a person responds to the tone 50% of the time. After the threshold for the 1 kHz-tone has been recorded by the audiologist, the entire procedure is repeated with a 1.5 kHz tone, and further increasing the tone's frequency to 2, 3, 4, and 8 kHz. After the high-frequency range has been tested, the same procedure is performed for the lower frequencies,

starting again with a 1kHz-tone, but decreasing to 0.5, 0.25, and 0.125 kHz. The test results are plotted by the audiologist, and they show **hearing loss** as a function of frequency. Such a plot is called an audiogram and it usually shows the low frequencies or tones at one end and the high frequencies at the other end. A typical audiogram also reports results for both the left and right ears, since it is not unusual for levels of sensitivity to sound to differ from one ear to the other. The audiogram also plots the volume of the tones used for the test: from soft, quiet sounds at the top of the plot to loud sounds at the bottom. Hearing is measured in decibels, the unit of a logarithmic scale of sound intensity. Most of the sounds associated with normal speech patterns are usually found in the range of 20-50 decibels. An adult with normal hearing can detect tones between 0-20 decibels. Other tests that may have been performed with the pure-tone audiometry are also reported on the audiogram.

Another audiometry procedure is performed with a headband rather than earphones. The headband is fitted with small plastic rectangles that are placed behind the ears so as to channel the tones through the bones of the **skull**. The patient feels the vibrations of the tones as they are transmitted through the bones to the inner ear. As with the earphones, the tones are repeated at various frequencies and volumes.

Speech audiometry is another type of hearing test that uses a series of simple recorded words spoken at various volumes directly into earphones worn by the patient. The patient repeats the words heard to the audiologist as they are being heard. An adult with normal hearing will be able to recognize and repeat at least 90-100% of the words.

Speech reception threshold testing (SRT) is used to determine the lowest volume or intensity when speech can be understood and is reported in decibels (dB).

Preparation

The ears are first examined with an otoscope before audiometry testing to determine if there are any blockages in the ear canal. If excessive wax is present, the patient is sent to a doctor for removal of the wax.

Results

A person with normal hearing should be able to recognize and respond to all of the tone frequencies and the different volumes used during the audiometry test in both ears. Normal hearing detects a range of low and high-pitched sounds between 0-20 decibels, and normal speech is generally spoken in the range of 20-50 decibels.

Audiometry test results are considered abnormal if there is a significant variation between the levels of

sound recognized by the two ears, or if the patient is unable to hear within the normal range for test frequencies. Failure to pick out any tone of 20 dB or louder indicates a degree of hearing loss. The pattern of responses displayed on the audiogram are used by the audiologist to determine if a significant hearing loss has occurred and if the patient might benefit from further testing for differential diagnosis, hearing aids, or corrective surgery. An unexplained difference between the two ears in the tone test or the speech test may warrant another test, called an auditory **brain** stem response (ABR) to look for a possible acoustic tumor. Or, a difference in hearing between the two ears may be explained by case history information, such as noise exposure.

Health care team roles

Audiometry is performed by an audiologist. Any hearing problems found may be investigated by physicians and treated by physicians or speech-language pathologists, depending on the nature of the problem. If necessary, imaging studies, such as a CT scan, will be ordered by physicians and performed by radiologic technologists.

Resources

BOOKS

Goldstein, R. and W. M. Aldrich. *Evoked Potential Audiometry: Fundamentals and Applications*. New York: Allyn and Bacon, 1998.

"Pure-Tone Audiometry." In *The Yale University Patient's Guide to Medical Tests*, edited by Barry L Zaret, et al. Boston, MA and New York: Houghton Mifflin Company, 1997, pp.420-422.

ORGANIZATIONS

American Academy of Audiology. 8201 Greensboro Drive, Suite 300, McLean, VA 22102. (703) 610-9022. <<http://audiology.org>>.

Audiology Awareness Campaign. 3008 Millwood Avenue, Columbia, SC 29205. (800) 445-8629.

American Speech-Language-Hearing Association (ASHA). 10801 Rockville Pike, Rockville, MD 20852. (800)638-8255. <<http://www.asha.org/>>.

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"Tympanometry." *Health Central on Sympatico*, 2001. <<http://healthcentralsympatico.com/mhc/top/03390.cfm>>.

Understanding Your Audiogram: A brochure from the League for the Hard of Hearing, 71 West 23rd Street, New York, NY 10010-4162. (212) 741-7650. <<http://www.lhh.org>>.

Monique Laberge, PhD

Auditory evoked potential study see **Evoked potential studies**

Auditory integration training

Definition

Auditory integration training, or AIT, is one specific type of music/auditory therapy based upon the work of French otolaryngologists Dr. Alfred Tomatis and Dr. Guy Berard.

Origins

The premise upon which most auditory integration programs are based is that distortion in how things are heard contributes to commonly seen behavioral or learning disorders in children. Some of these disorders include attention deficit/hyperactive disorder (ADHD), autism, dyslexia, and central auditory processing disorders (CAPD). Training the patient to listen can stimulate central and cortical organization.

Auditory integration is one facet of what audiologists call central auditory processing. The simplest definition of central auditory processing, or CAP, is University of Buffalo Professor of Audiology Jack Katz's, which is: "What we do with what we hear." Central auditory integration is actually the perception of sound, including the ability to attend to sound, to remember it, retaining it in both the long- and short-term **memory**, to be able to listen to sound selectively, and to localize it.

Guy Berard developed one of the programs commonly used. Berard's auditory integration training consists of twenty half-hour sessions spent listening to musical sounds via a stereophonic system. The music is random, with filtered frequencies, and the person listens through earphones. These sound waves vibrate and **exercise** structures in the middle ear. This is normally done in sessions twice a day for 10 days.

Alfred Tomatis is also the inventor of the Electronic Ear. This device operates through a series of filters, and reestablishes the dominance of the right ear in **hearing**. The basis of Tomatis' work is a series of principles that follow:

- The most important purpose of the ear is to adapt sound waves into signals that charge the **brain**.

- Sound is conducted via both air and bone. It can be considered something that nourishes the nervous system, either stimulating or destimulating it.
- Just as seeing is not the same as looking, hearing is not the same as listening. Hearing is passive. Listening is active.
- A person's ability to listen affects all language development for that person. This process influences every aspect of self-image and social development.
- The capacity to listen can be changed or improved through auditory stimulation using musical and vocal sounds at high frequencies.
- Communication begins in the womb. As early as the beginning of the second trimester, fetuses can hear sounds. These sounds literally cause the brain and nervous system of the baby to develop.

Description

A quartet of CAP defects have been identified that can unfavorably alter how each person processes sound. Among these are:

- Phonetic decoding, a problem that occurs when the brain incorrectly decodes what is being heard. Sounds are unrecognizable, often because the person speaking talks too fast.
- Tolerance-fading memory, a condition with little or poor tolerance for background sounds.
- Auditory integration involves a person's ability to put together things heard with things seen. Characteristically there are long response delays and trouble with phonics, or recognizing the symbols for sounds.
- The fourth problem area, often called auditory organization, overlaps the previous three. It is characterized by disorganization in handling auditory and other information.

Certain audiological tests are carried out to see if the person has a CAP problem, and if so, how severe it is. Other tests give more specific information regarding the nature of the CAP problem. They include:

- Puretone air-conduction threshold testing, which measures peripheral **hearing loss**. If loss is found, then bone-conduction testing, or evaluation of the vibration of small bones in the inner ear, is also carried out.
- Word discrimination scores (WDS) determines a person's clarity in hearing ideal speech. This is done by presenting 25–50 words at 40 decibels above the person's average sound threshold in each ear. Test scores equal the percentage of words heard correctly.

- Immittance testing is made up of two parts, assessing the status of, and the protective mechanisms of the middle ear.
- Staggered sporadic word (SSW) testing delivers 40 compound words in an overlapping way at 50 decibels above threshold to each ear of the person being tested. This test provides expanded information that makes it possible to break down CAP problems into the four basic types.
- Speech in noise discrimination (SN) testing is similar to staggered sporadic word testing except that other noise is also added and the percentage correct in quiet is compared with that correct when there is added noise.
- Phonemic synthesis (PS) determines serious learning problems. The types of errors made in sounding out written words or associating written letters with the sounds they represent help in determining the type and severity of CAP problems.

Benefits

Upon completion of an auditory integration training program, the person's hearing should be capable of perceiving all frequencies at, or near, the same level. Total improvement from this therapy, in both hearing and behavior, can take up to one year.

Research and general acceptance

Auditory integration training is based upon newly learned information about the brain. Though brain structures and connections are predetermined, probably by heredity, another factor called plasticity also comes into play. Learning, we now know, continues from birth to death. Plasticity is the ability of the brain to actually change its structuring and connections through the process of learning.

Problems with auditory processing are now viewed as having a wide-reaching ripple effect on our society. It is estimated that 30–40% of children starting school have language-learning skills that can be described as poor. CAP difficulties are a factor in several different learning disabilities. They affect not only academic success, but also nearly every aspect of societal difficulties. One example to illustrate this is a 1989 University of Buffalo study where CAP problems were found to be present in a surprising 97% of youth inmates in an upstate New York corrections facility.

Training and certification

Both Tomatis and Berard have certification programs in their therapies.

Resources

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Joan Schonbeck

Autoimmune disease tests

Definition

Autoimmune disease tests are screening procedures used in the diagnosis of **immune system** disorders and other disease states to detect autoantibodies, which are antibodies produced against the body's own tissues.

Purpose

Hundreds of different autoantibodies have been described, not all of which are involved in disease. Autoantibodies are classified into two broad categories, organ-specific, in which the targeted antigen is located in a single organ or cell type, and organ-nonspecific, in which the targeted antigen is widely distributed, usually a ubiquitous component of all cell types. Autoantibodies may be further classified as primary pathogenic antibodies, which directly cause a disorder by blocking a normal

cellular function or by damaging tissue, or secondary antibodies, which are not pathogenic in themselves but are produced as a result of the disease and thus may be used as diagnostic markers.

Autoimmune diseases are illnesses in which the immune system produces autoantibodies that attack the body's own cells or tissues as though they are foreign substances. Autoimmune diseases are generally difficult to diagnose, as individuals exhibiting very different symptoms can have the same underlying disease. Like the causative autoantibodies, the diseases are classified as organ-specific and organ-nonspecific (or systemic). In organ-specific autoimmunity, the autoantibodies are produced against a specific target antigen in a specialized cell, tissue, or organ in response to injury, inflammation, or other stimulus. Examples include autoimmune hemolytic anemia, in which anti-erythrocyte antibodies are produced, insulin-dependent or type I diabetes, characterized by T cells and antibodies against beta-cells in the **pancreas**, and myasthenia gravis, involving antibodies against the acetylcholine receptor. In systemic autoimmune diseases, the tissue injury and inflammation is generally initiated by vascular leakage and deposition in multiple sites of circulating autoimmune complexes formed against ubiquitous soluble cellular antigens, usually nuclear in origin. Systemic lupus erythematosus (SLE), characterized by the production of multiple anti-nuclear and anti-DNA autoantibodies, is the classical example of a systemic autoimmune disease. Autoimmune disease tests can help to identify the causative autoantibody in the **blood**.

Precautions

For all autoimmune disease tests, a blood sample is required, usually taken from a vein on the back of the hand or the inside of the elbow. The nurse or phlebotomist collecting the sample should observe **universal precautions** for the prevention of transmission of blood-borne pathogens. Generally, blood samples that are grossly hemolyzed or lipemic are unacceptable.

The diagnosis of autoimmune diseases is very challenging; it can take months or even years for the health care team to put together the symptoms and laboratory findings to make an accurate diagnosis. New symptoms may appear over time to aid the process of reaching a diagnosis. Knowledge and awareness on the part of the doctor and effective communication between doctor and patient, including a complete and accurate medical history, together with a thorough **physical examination** and carefully chosen laboratory tests, are essential to the process.

Conditions other than autoimmune diseases can give rise to autoantibodies. In many cases, the tests performed on healthy individuals, especially the elderly, give positive results. It should be kept in mind that transient appearance of autoantibodies is a common feature of some infections, especially Epstein-Barr virus, adenovirus, and mycoplasmal **pneumonia**. Ideally, in the end, each positive result is interpreted in the context of the patient's symptoms and history, and all other diagnostic findings.

Access to a medical laboratory that specializes in autoantibody analysis is an advantage. Clinical immunology is a rapidly changing field: new, more convenient, and more specific test protocols are evolving, and a specialized laboratory is likely to have access to the most modern diagnostic tools.

In immunofluorescence-based tests, the tissues used in the assays must be carefully chosen and handled. It is important to use serum and not plasma, since the fibrinogen in the plasma can give rise to stray fluorescence and false-positive reports. The serum must be adequately diluted to avoid non-specific interactions with the target antigens. The ratio of FTIC-bound to unlabeled immunoglobulin must be sufficiently high to allow detection but not so high as to give rise to non-specific fluorescence. It is essential that control assays—a negative control that contains no antibody, as well as positive controls that contain known amounts of autoantibody at high and low levels—be included to ensure the accuracy of the test results.

In the tests for cryoglobulins and cold agglutinins, it is essential that the syringe used to draw blood and the container used to transport it to the laboratory be pre-warmed and maintained at 37°C. The sample in these tests must be brought to the laboratory immediately for processing, and the procedure should be scheduled with the laboratory in advance.

Description

Detection techniques

INDIRECT IMMUNOFLUORESCENCE. The standard detection technique for identification of many serum autoantibodies is immunofluorescence. In indirect immunofluorescence testing for the widest range of antibodies, a “multiblock” of commercial test tissues (for example, rat **liver**, kidney, and **stomach**) or a single tissue such as mouse kidney with both muscle and blood vessel cells can be used. The tissues are frozen and cut with a cryostat into sections about 4 micrometers thick, and the sections are mounted onto sections (wells) of a glass slide and frozen. Alternatively, other cells or tissues

may be used to demonstrate specific types of autoantibodies. For antinuclear antibody testing, commercially prepared monolayers of HEp-2 cells (human epithelioma cells) grown in wells on glass slides and frozen are used. For detection of antibodies to double stranded DNA, slides with *Crithidia luciliae* (a protozoan with a kinetoplast rich in DNA) are used. The tissue or cell samples are incubated for a specific time with an initial dilution of the patient's serum. Positive and negative control slides (treated with known reactive and nonreactive standard solutions, respectively) are also prepared. The slides are then washed and incubated with the anti-human immunoglobulin that is covalently bound to a fluorescent reporter molecule, usually fluorescein isothiocyanate (FITC). The cells are then visualized under the **microscope** by shining ultraviolet light on the slide, which causes the reporter molecule to fluoresce (in the case of FITC, this is the emission of apple-green light). The presence of fluorescent cells indicates a positive test. When a positive test result occurs, the serum is serially diluted, or titered, and the test is repeated to determine the highest dilution at which the test is positive. The reciprocal of the highest dilution showing fluorescence is reported as the titre. The pattern of fluorescent staining of discrete part(s) of the cell or nucleus, which gives clues to the type of disease, is also reported.

As an alternative to the fluorescence detection method, instead of FITC, the anti-human immunoglobulin antibody is bound to an enzyme, such as horseradish peroxidase, that produces a colored product when treated with the appropriate substrate. The advantage of enzyme-based test is that an ordinary high quality light microscope may be used for detection; however, extra wash and incubation steps are necessary to produce the color change.

In a related technique, direct immunofluorescence, the tissue to be tested is obtained from the patient, frozen, and thin-sectioned using a cryostat. The sections of tissue are mounted onto microscope slides and treated directly with the FITC-linked antibody. This method detects autoantibodies that have attached *in vivo* to the specific tissue.

ENZYME-LINKED IMMUNOASSAY (EIA), ALSO CALLED ENZYME-LINKED IMMUNOSORBENT ASSAY (ELISA). This detection procedure is similar to immunofluorescence, except that, instead of cells, a specific antigen covalently bound to a solid surface (usually a commercially available microwell plate) is allowed to react with the test serum. The plate is then washed and reacted with an enzyme-labeled antihuman immunoglobulin, then washed and allowed to react with a substrate that gives a quantifiable color change. This technique is generally costlier and less information-rich than immunofluorescence on multiblock tissues, but it is often used to confirm

a diagnosis based on the immunofluorescence result. Commercial EIA test kits are available for a wide variety of autoantibodies including anticardiolipin (antiphospholipid), and thyroid antibodies such as anti-thyroglobulin and anti-thyroid peroxidase.

PARTICLE AGGLUTINATION. Detection of antibodies by particle agglutination is an old—but reliable and relatively inexpensive—technique. The target antigen is coated onto an inert gelatin or latex particle and treated with the test serum. Agglutination or clumping of the particles indicates a positive response, and the serum is then titered as in the immunofluorescence assay.

IMMUNOPRECIPITATION. The Ouchterlony double diffusion test is the prototype immunoprecipitation technique. The serum to be tested for the presence of an antibody and the antigen are added to separated wells cut into an agar gel slab and allowed to diffuse towards one another. A positive test is indicated when a precipitation line forms in the zone of the gel where the antibody comes into contact with the antigen. The process, which may require up to 72 hours, can be accelerated by using agarose gels with an electrolyte and applying a current, in a technique called immunoelectrophoresis. In a related method called nephelometry, the immunoprecipitation, carried out in a solution containing the antigen, gives rise to turbidity that can be quantified by an instrument that measures light scattering.

Representative tests

ANTINUCLEAR ANTIBODY TEST (ANA), ALSO CALLED FLUORESCENT ANTINUCLEAR ANTIBODY TEST (FANA) AND ANTINUCLEAR ANTIBODY PANEL. The antinuclear antibody (ANA) test, which screens for antibodies to components of the nuclei of all cells, is generally performed first in the evaluation of a person for autoimmune diseases, particularly when systemic lupus erythematosus (SLE) is suspected. Usually HEp-2 cells are tested with 5–10 microliters of the patient's serum. HEp-2 cells are preferred because of their very large nuclei. Recognition of the patterns of immunofluorescence staining of the nucleus is critical in the interpretation of the ANA test. EIA kits for testing ANA IgG and IgM antibodies are also commercially available, but give only titre results without staining pattern information.

ANTIMITOCHONDRIAL ANTIBODY TEST. This test is primarily used when there are symptoms of liver or other organ damage, to confirm a diagnosis, or help to identify possible causes of tissue damage. Antimitochondrial antibodies are helpful in distinguishing primary biliary cirrhosis (PBC) from other extrahepatic obstruction, hepatitis, and alcoholic cirrhosis. Nine discrete subtypes of antimitochondrial antibodies, designated M1–M9, have been described and are associated with different disease

states: M1 antibodies are found in **syphilis**, M2 and M9 in PBC, M3 in lupus, M5 in connective tissue disorders, M6 in iproniazid-induced hepatitis. Specific M2 antigens are available for confirmation of a diagnosis of PBC by EIA detection.

ANTIPHOSPHOLIPID ANTIBODY TEST, ALSO CALLED CARDIOLIPIN ANTIBODY TEST. Antiphospholipid antibodies are detected in combination with circulation disorders (livedo reticularis and Sneddon's syndrome), in SLE, in Sjögren's syndrome, and in women suffering recurrent spontaneous abortions. In these conditions, collectively called antiphospholipid syndrome, the antibodies detected are of the IgG and IgM classes. In more than 75% of the patients with spontaneous abortions, only IgG antibodies are found. EIA detection is generally used to test for antiphospholipid antibodies, and antigens to detect each of the IgG-, IgM-, and IgA-type antibodies are commercially available.

CRYOGLOBULIN TEST. Cryoglobulins are tested in the presence of symptoms induced by cold, such as purpura and Raynaud's phenomenon, and when immune-complex-mediated disease is suspected. Cryoglobulins, often confused with cold agglutinins, are abnormal immunoglobulins that precipitate to varying degrees at temperatures below 37°C and become resolubilized upon rewarming; the precipitates formed can block small **blood vessels**. Cryoglobulins have been purified and immunochemically characterized, and three major types having distinct clinical features have been described. Type I cryoglobulins are associated with single monoclonal immunoglobulins (IgM, IgG, or IgA), Type II with mixed monoclonal immunoglobulins, and Type III with mixed polyclonal immunoglobulins. Cryofibrinogen and C-reactive protein-albumin complexes are non-immunoglobulin cryoprecipitable plasma **proteins** with similar clinical manifestations.

For the test, 10mL of blood is collected with a syringe warmed to 37°C, and 6mL is transferred to a specifically designed glass cryoglobulin tube, also prewarmed to 37°C. The sample should be hand carried to the laboratory and must be kept at 37°C until the blood has clotted and the serum is collected by centrifugation. The serum sample is then stored at 4°C for 24–72 hours and observed for formation of a white precipitate (cryoglobulins). An aliquot of the serum is rewarmed at 37°C for 24 hours to test for reversibility of cryoprecipitation. The amount of cryoglobulin is quantified by measuring the serum protein concentration before and after cryoprecipitation, or by collecting the precipitate from an aliquot of serum, dissolving it in an acidic buffer, and measuring the cryoglobulin protein level. The individual cryoglobulin components may be identified from the isolated cryoprecipitate by immunoelectrophoresis, per-

formed at 37°C to prevent precipitation of the cryoglobulin during the procedure.

COLD AGGLUTININS. Cold agglutinin disease is an acquired autoimmune hemolytic anemia. Cold agglutinins, which are frequently confused with cryoglobulins, are an IgM-type autoantibody directed against an antigen (I or i) on the surface of red blood cells and react only at temperatures lower than 37°C. The antibody reaction occurs in the extremities, which are generally cooler, causing red blood cells to briefly stick together, leading to obstruction of the small blood vessels; Raynaud's syndrome is commonly associated with cold agglutinins, and hemolytic anemia may result when red blood cells undergo lysis upon rewarming. As with the cryoglobulin test, blood for the cold agglutinins test must be collected with a warm syringe and kept at 37°C during transport to the laboratory for analysis. The test is performed by mixing serial dilutions of the patient's serum with group O red blood cells and incubating at 2–8°C overnight. The tubes are examined for clumping (agglutination) and the highest dilution giving agglutination is noted. Following this, the tubes must be incubated at 37°C for 30 minutes to reverse the agglutination that occurred in the cold. The test is positive only when the agglutination is reversed by 37°C incubation.

RHEUMATOID FACTOR TEST, ALSO CALLED RF OR RHF TEST. Rheumatoid factors are associated with many different conditions, including viral and chronic bacterial infections, lymphomas and myelomas, and connective tissue diseases. Standard tests are non-specific, detecting all classes of immunoglobulins that react with the Fc region of other immunoglobulins. Commercially available EIA kits have recently become available that allow testing of individual immunoglobulin classes. The test is used mainly in the diagnosis of rheumatoid arthritis, although it is not very specific unless the disease is progressive with vasculitis. Elevated rheumatoid factor is also found with other rheumatologic diseases, such as SLE. Rheumatoid factors are detected by particle agglutination, nephelometry, or by EIA.

Preparation

Certain drugs, including **antibiotics**, oral contraceptives, procainamide, tranquilizers, steroids, thiazide diuretics, and some **antihypertensive drugs** give a false positive result in the ANA test, and the patient should be advised to stop taking these before the test. For the antimitochondrial antibody and cryoglobulin tests, fasting for six hours or overnight before the test may be required.

No special preparations or diet changes are required for the antiphospholipid, cold agglutinin, or rheumatoid factor tests.

KEY TERMS

Agglutination—Antibody-induced clumping of cells.

Antibody—Y-shaped protein molecule produced by B cells as part of the primary immune defense; each molecule and its clones have a unique binding site that combines with a complementary site of an antigen, to disable the antigen and signal other immune defenses.

Autoantibody—An antibody produced by an organism against any of its own tissues, cells, or cell components.

Autoimmune disease—Any of a variety of diseases in which the body's immune system attacks its own tissues.

Capillary—A small-bored tube used to collect, store, or test fluid samples.

Cold agglutinins—An autoantibody found on the surface of red blood cells in certain diseases that can cause the cells to clump at temperatures below 37°C and cause red blood cell lysis.

Cryoglobulin—A plasma immunoglobulin that is insoluble when cold and dissolved at body temperature.

Cryoprecipitation—Cold-induced precipitation of a substance from solution.

Deoxyribonucleoproteins—A class of proteins associated with DNA, found in the nucleus of the cell.

Enzyme—A protein that produces specific chemical changes in an organic target molecule by catalytic action.

Fluorescein isothiocyanate (FITC)—An organic molecule that can be covalently bound to other

molecules, and that emits visible light when exposed to ultraviolet radiation.

Hemolytic anemia—Anemic condition characterized by the destruction of red blood cells.

Histone—Any of a group of five small alkaline proteins that occur in the nucleus of eukaryotic cells and form molecular complexes with DNA, around which the DNA is wound in the nucleosomes.

Immunofluorescence—Any of various techniques to detect an antigen or antibody in a sample by coupling its target antibody or antigen to a fluorescent compound and observing its reaction with the sample under an ultraviolet-light.

Immunoglobulin (Ig)—Any of several classes of structurally related proteins that function as antibodies and are found in plasma and other body fluids and in the membrane of certain cells; classes include IgA, IgD, IgE, IgG, and IgM.

Microwell plate—A rectangular disposable culture dish constructed with an array of small depressions used to carry out reactions.

Mitochondrion—An organelle in the cytoplasm of cells that functions in energy production.

Monoclonal—Pertaining to cells or cellular products that are derived from a single cell; a monoclonal antibody is an immunoglobulin directed against a specific epitope of an antigen, and isolated from a culture of identical cells grown from a single clone.

Aftercare

After the blood sample is drawn, pressure should be applied to the puncture site until the bleeding stops to reduce bruising, and a bandage may be applied to the site. A warm pack may be applied to the site to relieve discomfort.

Complications

Complications associated with blood drawing may be anticipated, but are minimal when the procedure is performed correctly. Multiple punctures to locate suitable veins may be necessary to obtain a blood sample from some patients. The patient may faint or feel dizzy while the blood sample is being drawn. Discomfort or

bruising may occur at the puncture site, and there is a slight risk of **infection**.

Results

With immunofluorescence detection, lower than reference level titers that produce a fluorescent pattern in the test cells is interpreted as a negative result. In EIA, a lower than reference level titer that produces a color change, or a level of color change less than or equal to that found for a reference negative control, is interpreted as a negative result. With particle agglutination, absence of particle clumping, and in immunoprecipitation the lack of a precipitation line or solution turbidity, at titers lower than reference levels is negative.

KEY TERMS CONTINUED

Mycoplasma pneumonia—Also called Eaton-agent pneumonia, primary atypical pneumonia, or walking pneumonia, a contagious lung infection caused by the bacterium *Mycoplasma pneumoniae*.

Nephelometry—A method for studying the density of suspended particles in a liquid sample by measuring the amount of light scattered by the particles.

Nucleolus—One or more densely staining bodies, composed mainly of RNA, within the nucleus of a cell.

Nucleus—A specialized spherical structure, present in most living eukaryotic cells and enclosed in a membrane, that is the center for metabolism of DNA and RNA.

Phospholipid—Any of a group of fatty biomolecules composed of phosphoric esters.

Polyclonal—Pertaining to cells or cellular products that are derived from several lines of clones; a polyclonal antibody is a mixture of immunoglobulins isolated from antisera that is directed against all epitopes of a single antigen.

Primary biliary cirrhosis (PBC)—A liver disease of unknown origin, found mainly in women 40 – 60 years old, with swelling of the liver and characterized by intense itching, malabsorption, and jaundice.

Raynaud's phenomenon—Sporadic attacks of blood flow interruption to the fingers, toes, ears, or nose caused by exposure to cold or by emotional stimulation, in which the affected area becomes

bluish white and numb, then red, warm, and tingly, before returning to normal.

Rheumatoid factor—An autoantibody found in the blood, often associated with rheumatoid arthritis.

Ribonucleoprotein—A class of protein found in the nucleus associated with RNA.

Scleroderma—An autoimmune disease in which the connective tissue becomes hardened and rigid.

Sjögren's disease—An autoimmune disease characterized by fatigue and malaise, dry gritty eyes and dry mouth, and recurrent gingivitis and respiratory infection.

Smith's (Sm) antibodies—A nuclear autoantibody specific for SLE, named for the patient in which first described.

Systemic lupus erythematosus (SLE)—An autoimmune inflammatory disease of the connective tissue that occurs mainly among middle-aged women, characterized by skin eruptions, joint pain, recurrent pleurisy, and kidney disease.

Titer—The concentration of substance in a solution described in terms of the degree of dilution required to achieve a threshold effect.

Vacutainer—A glass tube fitted with a rubber stopper from which air is evacuated to produce a slight vacuum, used for blood specimen collection.

Venipuncture—The puncture of a vein for therapeutic purpose or to collect a specimen.

Several factors should be considered as part of interpreting a positive test, and additional tests are often indicated to aid in identification of the individual causative autoantibodies.

Antinuclear antibodies test

Normal titer ranges for antinuclear antibodies is age-dependent:

- 18 years and younger: < 1:20
- 18–65: < 1:40
- older than 65: < 1:80

The pattern of immunofluorescent staining should be reported along with the titer. Homogeneous staining indicates antibodies to histones and deoxyribonucleopro-

teins. A speckled pattern is found with antibodies against ENA, a group of saline-soluble antigens that include non-histone proteins and nuclear ribonucleoprotein (RNP). Peripheral staining indicates double-stranded (ds) DNA, rheumatoid factor, and antiphospholipid. Nucleolar staining is positive for anti-nucleolar RNP, a result specific for the autoimmune skin disorder scleroderma. Specific staining of centromeres is indicative of a systemic sclerosis variant known as CREST syndrome. More than 95% of people with SLE have a positive ANA test. Scleroderma has a 60–71% positive rate; Sjögren's disease, 50–60%, and rheumatoid arthritis, 25–30%. Serum that tests positive for ANA can be further tested by EIA with specific antigens to confirm a diagnosis. Positive tests for anti-double-stranded (ds) DNA or anti-Sm

(Smith's) antibodies are definitive for SLE. Identification of anti-RNPs is positive for mixed connective tissue disease (MCTD) as well as SLE.

Antimitochondrial antibody test

The titer in a normal sample is < 1:40. A positive result is typified by granular staining in the cytoplasm of all tissue types in the commercial multiblock. Antimitochondrial antibody tests are positive in about 94% of patients with primary biliary cirrhosis (PBC), with typical titers of > 1:160, and in 25% of patients with chronic hepatic cirrhosis. Positive samples should be screened by EIA for antibodies specific to the M2 antigen to confirm the diagnosis of PBC.

Antiphospholipid antibody test

Reference levels will be dependent on the type of commercial EIA kit used and should be independently established in each laboratory. Antiphospholipid antibodies occur with a prevalence of 40% in patients with SLE. Over 75% of patients presenting with spontaneous abortions were positive for only IgG antibodies, while patients with thromboses had mainly IgM antibodies. IgG and IgM antibodies were found simultaneously in 31% of patients with Sjögren's syndrome.

Cryoglobulin test

The percent cryoprecipitation is reported (cryocrit). Although there is considerable overlap, Type I and Type II cryoglobulins, positive in Waldenström's macroglobulinaemia and in chronic lymphocytic leukemia, are often present in relatively high concentrations, with cryocrits usually > 5%, sometimes as high as 20–40%, especially with Type I cryoglobulins. Type III cryoglobulins generally give a cryocrit of < 1% and are associated with autoimmune diseases, including systemic lupus erythematosus (SLE), rheumatoid arthritis, scleroderma, and Sjögren's syndrome.

Cold agglutinins test

A normal titre for cold agglutinins is less than 1:64. Cold agglutinin disease associated with autoimmune hemolytic anemia usually produces titres between 1,000–100,000. Higher titers are also seen in about 60% of persons with *Mycoplasma pneumoniae* infections and other acute infectious diseases such as infectious mononucleosis. In cold autoimmune hemolytic anemia, the peripheral blood smear may show red blood cells present in clumps caused by their reaction with cold agglutinins. Some cases of chronic cold agglutinin disease occur in association with Waldenström's macroglobulinemia.

Rheumatoid factor test

Normal rheumatoid factor titer for adults is < 1:80 (by particle agglutination) or 60 U/ml (by nephelometry). A positive test may result with chronic hepatitis, chronic viral infection, dermatomyositis, infectious mononucleosis, leukemia, rheumatoid arthritis, scleroderma, or SLE. Adult Still's disease, chronic infection, juvenile rheumatoid arthritis, nephrotic syndrome, and Sjögren's syndrome may also give positive results. Reference levels with commercial EIA kits will be dependent on the type of kit used and should be independently established in each laboratory. IgM-type rheumatoid factors are present in 75% of patients with chronic polyarthritis (CP), in 50–65% of patients with interstitial pulmonary fibrosis, in only 30% of patients with mixed connective tissue disease (SLE, Sjögren's syndrome), and with a prevalence of 10–20% in viral hepatitis, liver cirrhosis, sarcoidosis, and **tuberculosis**. IgA-class rheumatoid factors can be an early finding in severe rheumatic disease and are also found in SLE patients. Specific determination of IgG class rheumatoid factors, mainly present as immune complexes, have been described in both juvenile and chronic polyarthritis.

Health care team roles

A nurse or phlebotomist usually collects the blood sample by venipuncture and sees to the timely and appropriate transport to the laboratory for analysis. A member of the health care team should observe the patient to ensure that bleeding from the puncture site is stopped.

Autoimmunity tests are performed by a clinical laboratory scientist/medical technologist. For immunofluorescence assays the technologist will usually have advanced training in fluorescent microscopy and the interpretation of immunofluorescence patterns.

A physician interprets the autoantibody test results and uses them in combination with a complete medical history and thorough physical examination to reach a diagnosis.

The physicians, nurses, and other caregivers should instruct the patient that diagnosis of an autoimmune disorder is a difficult process that may take considerable time and strive to allay the patient's feelings of frustration and **anxiety**.

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Patricia L. Bounds, Ph.D.

Autoimmune disorders

Definition

Autoimmune disorders are conditions in which a person's **immune system** attacks the body's own cells, causing tissue destruction.

Description

Autoimmunity is accepted as the cause of a wide range of disorders and suspected to be responsible for many more. Autoimmune diseases are classified as either general (the autoimmune reaction takes place simultaneously in a number of tissues) or organ specific (the autoimmune reaction targets a single organ).

Autoimmune disorders include the following:

- Systemic lupus erythematosus. A general autoimmune disease in which antibodies attack a number of differ-

ent tissues. The disease recurs periodically and is seen mainly in young and middle-aged women.

- Rheumatoid arthritis. Occurs when the immune system attacks and destroys the tissues that line bone joints and cartilage. The disease occurs throughout the body, although some joints may be more affected than others.
- Goodpasture's syndrome. Occurs when antibodies are deposited in the membranes of both the lung and **kidneys**, causing both inflammation of kidney glomerulus (glomerulonephritis) and lung bleeding. It is typically a disease of young males.
- Grave's disease. Triggered by an antibody that binds to specific cells in the **thyroid gland**, causing them to make excessive amounts of thyroid hormone.
- Hashimoto's thyroiditis. Also referred to as autoimmune thyroiditis and chronic lymphocytic thyroiditis; a chronic inflammatory glandular autoimmune disease. It is caused by an antibody that binds to cells in the thyroid gland. Unlike in Grave's disease, however, this antibody's action results in less thyroid hormone being made.
- Pemphigus vulgaris. A group of autoimmune disorders that affect the skin.
- Myasthenia gravis. A condition in which the immune system attacks a receptor on the surface of muscle cells, preventing the muscle from receiving nerve impulses and resulting in severe muscle weakness.
- Scleroderma. Also called CREST syndrome or progressive systemic sclerosis, scleroderma affects the connective tissue.
- Autoimmune hemolytic anemia. Occurs when the body produces antibodies that coat red **blood** cells.
- Autoimmune thrombocytopenic purpura. Disorder in which the immune system targets and destroys blood platelets.
- Polymyositis and dermatomyositis. Immune disorders that affect the neuromuscular system.
- Pernicious anemia. Disorder in which the immune system attacks the lining of the **stomach** in such a way that the body cannot metabolize **vitamin B₁₂**.
- Sjögren's syndrome. Occurs when the exocrine glands are attacked by the immune system, resulting in excessive dryness.
- Ankylosing spondylitis. Immune-system induced degeneration of the joints and soft tissue of the spine.
- Vasculitis. A group of autoimmune disorders in which the immune system attacks and destroys **blood vessels**.

- Type I **diabetes mellitus**. May be caused by an antibody that attacks and destroys the islet cells of the **pancreas** that produce insulin.

Causes and symptoms

The symptoms of the above disorders include:

- Systemic lupus erythematosus. Symptoms include **fever**, chills, fatigue, weight loss, skin rashes (particularly the classic “butterfly” rash on the face), vasculitis, polyarthralgia, patchy hair loss, sores in the mouth or nose, lymph-node enlargement, gastric problems, and, in women, irregular periods. About half of those who suffer from lupus develop cardiopulmonary problems, and some may also develop urinary problems. Lupus can also effect the **central nervous system**, causing seizures, depression, and psychosis.
- Rheumatoid arthritis. Initially may be characterized by a low-grade fever, loss of appetite, weight loss, and a generalized **pain** in the joints. The joint pain then becomes more specific, usually beginning in the fingers, then spreading to other areas, such as the wrists, elbows, knees, and ankles. As the disease progresses, joint function diminishes sharply and deformities occur, particularly the characteristic “swan’s neck” curling of the fingers.
- Goodpasture’s syndrome. Symptoms are similar to that of **iron deficiency anemia**, including fatigue and pallor. Symptoms involving the **lungs** may range from a cough that produces bloody sputum to outright hemorrhaging. Symptoms involving the **urinary system** include blood in the urine and/or swelling.
- Grave’s disease. This disease is characterized by an enlarged thyroid gland, weight loss without loss of appetite, sweating, **heart** palpitations, nervousness, and an inability to tolerate heat.
- Hashimoto’s thyroiditis. This disorder generally displays no symptoms. If symptoms do occur, it is most often weight gain, intolerance to cold, fatigue, enlarged neck or goiter, and constipation. About 25% of patients may be subject for developing pernicious anemia, diabetes, adrenal insufficiency, or other autoimmune diseases.
- Pemphigus vulgaris. This disease is characterized by blisters and deep lesions on the skin. It is associated with other autoimmune diseases, such as systemic lupus and myasthenia gravis.
- Myasthenia gravis. Characterized by fatigue and muscle weakness that at first may be confined to certain muscle groups, but then may progress to the point of **paralysis**. Myasthenia gravis patients often have expressionless faces as well as difficulty chewing and swallowing. If the disease progresses to the **respiratory system**, artificial respiration may be required.
- Scleroderma. Disorder is usually preceded by Raynaud’s phenomenon. Symptoms that follow include pain, swelling, and stiffness of the joints, and the skin takes on a tight, shiny appearance. The **digestive system** also becomes involved, resulting in weight loss, appetite loss, **diarrhea**, constipation, and distention of the abdomen. As the disease progresses the heart, lungs, and kidneys become involved, and malignant **hypertension** causes death in approximately 30% of cases.
- Autoimmune hemolytic anemia. May be acute or chronic. Symptoms include fatigue and abdominal tenderness due to an enlarged spleen.
- Autoimmune thrombocytopenic purpura. Characterized by pinhead-size red dots on the skin, unexplained bruises, bleeding from the nose and gums, and blood in the stool.
- Polymyositis and dermatomyositis. In polymyositis, symptoms include muscle weakness, particularly in the shoulders or pelvis, that prevents the patient from performing everyday activities. In dermatomyositis, the same muscle weakness is accompanied by a rash that appears on the upper body, arms, and fingertips. A rash may also appear on the eyelids, and the area around the eyes may become swollen.
- Pernicious anemia. Signs of pernicious anemia include weakness, sore tongue, bleeding gums, and tingling in the extremities. Because the disease causes a decrease in stomach acid, nausea, vomiting, loss of appetite, weight loss, diarrhea, and constipation are possible. Also, because vitamin B₁₂ is essential for the nervous system function, the deficiency of it brought on by the disease can result in a host of neurological problems, including weakness, lack of coordination, blurred **vision**, loss of **fine motor skills**, loss of the sense of **taste**, ringing in the ears, and loss of bladder control.
- Sjögren’s syndrome. Characterized by excessive dryness and itching of the eyes and dry mouth. Difficulty swallowing, hoarseness, loss of taste, and severe **dental caries** may also occur. Other symptoms are fatigue, joint pain, and swelling of the glands.
- Ankylosing spondylitis. Generally begins with lower back pain that progresses up the spine. The pain may eventually become crippling.
- Vasculitis. Symptoms depend upon the group of veins affected and can range greatly. Some forms of vasculitis may be caused by allergy or hypersensitivity to medications such as sulfa or penicillin, other drugs, toxins, and other inhaled environmental irritants. Other forms

may be due to **infection**, parasites, or viral infections. These causes need to be ruled out before considering an underlying autoimmune disorder.

- Type I diabetes mellitus. Characterized by fatigue and an abnormally high level of glucose in the blood (hyperglycemia).

To further understand autoimmune disorders, it is helpful to understand the workings of the immune system. The purpose of the immune system is to defend the body against attack by infectious microbes (germs) and foreign objects. When the immune system attacks an invader, it is very specific—a particular immune system cell will only recognize and target one type of invader. To function properly, the immune system must not only develop this specialized knowledge of individual invaders, but it must also learn how to recognize and not destroy cells that belong to the body itself. Every cell carries protein markers on its surface that identifies it in one of two ways: what kind of cell it is (i.e., nerve cell, muscle cell, blood cell, etc.) and to whom that cell belongs. These markers are called major histocompatibility complexes (MHCs). When functioning properly, cells of the immune system will not attack any other cell with markers identifying it as belonging to the body. Conversely, if the immune system cells do not recognize the cell as “self,” they attach themselves to it and put out a signal that the body has been invaded, that in turn stimulates the production of substances such as antibodies that engulf and destroy the foreign particles. In case of autoimmune disorders, the immune system cannot distinguish between “self” cells and invader cells. As a result, the same destructive operation is carried out on the body’s own cells that would normally be carried out on **bacteria**, **viruses**, and other such harmful entities.

The reasons why the immune systems become dysfunctional in this way is not well understood. However, most researchers agree that a combination of genetic, environmental, and hormonal factors play into autoimmunity. Researchers also speculate that certain mechanisms may trigger autoimmunity. First, a substance that is normally restricted to one part of the body, and therefore not usually exposed to the immune system, is released into other areas where it is attacked. Second, the immune system may mistake a component of the body for a similar foreign component. Third, cells of the body may be altered in some way, either by drugs, infection, or some other environmental factor, so that they are no longer recognizable as “self” to the immune system. Fourth, the immune system itself may be damaged, such as by a genetic mutation, and therefore cannot function properly.

KEY TERMS

Autoantibody—An antibody made by a person that reacts with their own tissues.

Autoimmune disease—A broad category of related diseases in which the person’s immune system attacks his or her own tissue.

Diagnosis

A number of tests that can help diagnose autoimmune diseases; however the principle tool used by doctors is antibody testing. Such tests involve measuring the level of antibodies found in the blood and determining if they react with specific antigens that would give rise to an autoimmune reaction. An elevated amount of antibodies indicates that a humoral immune reaction is occurring. Elevated antibody levels are also seen in common infections. These must be ruled out as the cause for the increased antibody levels. The antibodies can also be typed by class. There are five classes of antibodies and they can be separated in the laboratory. The class IgG is usually associated with autoimmune diseases. Unfortunately, IgG class antibodies are also the main class of antibody seen in normal immune responses. The most useful antibody tests involve introducing the patient’s antibodies to samples of his or her own tissue—if antibodies bind to the tissue it is diagnostic for an autoimmune disorder. Antibodies from a person without an autoimmune disorder would not reacting to “self” tissue. The tissues used most frequently in this type of testing are thyroid, stomach, **liver**, and kidney.

Treatment

Treatment of autoimmune diseases is specific to the disease, and usually concentrates on correction of any major deficiencies. For example, if a gland involved in an autoimmune reaction is not producing a hormone such as insulin, administration of that hormone is required. Administration of a hormone, however, will not restore the function of the gland damaged by the autoimmune disease. The other aspect of treatment is controlling the inflammatory and proliferative nature of the **immune response**. This is generally accomplished with two types of drugs. Steroid compounds are used to control inflammation. There are many different steroids, each having side effects. The proliferative nature of the immune response is controlled with immunosuppressive drugs. These drugs work by inhibiting the replication of cells

and, therefore, also suppress non-immune cells leading to side effects such as anemia.

Prognosis

Prognosis depends upon the pathology of each autoimmune disease, as well as early detection and the ability to put the disease process into remission.

Health care team roles

Health care teams should help patients to understand their illness and treatment plan. With any autoimmune disorder, communication between the patient and doctor is critical, so health care teams should be available to answer questions about the patient's particular condition, especially what changes and symptoms to expect.

Prevention

To date, prevention of many autoimmune disorders is unavailable since the exact causes of the disease are not understood in many cases. Genetic screening of an unborn fetus may be the only method of preventing some autoimmune disorders.

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Crystal Heather Kaczowski, MSc.

Automatic implantable cardioverter-defibrillator see **Implantable cardioverter-defibrillator**

Autonomic nervous system see **Nervous system, autonomic**

Autopsy

Definition

An autopsy is a postmortem assessment or examination of a body to determine the cause of death. An autopsy is performed by a physician educated in pathology. Often this physician also has forensic training.

Purpose

Most autopsies advance medical knowledge or provide evidence for legal action. Medically, autopsies may determine the exact cause and circumstances of death, discover the pathway of a disease, and/or provide valuable information to be used in the care of the living. When foul play is suspected, a government coroner or medical examiner performs an autopsy to collect data for legal investigation. This branch of medical study is called forensic medicine. Forensic specialists investigate deaths resulting from violence or occurring under suspicious circumstances.

Benefits of research from autopsies include the discovery of new medical information on diseases such as toxic shock syndrome, acquired **immunodeficiency syndrome (AIDS)**, and **Alzheimer's disease**.

Precautions

When performed for medical reasons, autopsies require formal permission (written consent), from family members or a legal guardian. Autopsies required for legal reasons when foul play is suspected require authorization from a coroner or medical examiner. Such autopsies do not need the consent of next of kin. During the autopsy, very concise notes and documentation must be made for both medical and legal reasons. Some religious groups prohibit autopsies, although special waivers apply where suspicious death occurs.

Description

An autopsy is the examination of a deceased human body with a detailed investigation of the person's remains. This procedure dates back to the Roman era when few human dissections were performed. Autopsies were utilized, however, to determine the cause of death in criminal cases.



A pathologist fills out an autopsy report during an autopsy. (Photograph by Glauber. Science Source/Photo Researchers. Reproduced by permission.)

At the beginning of the procedure, the exterior body is examined and the internal organs are removed and studied. Some pathologists argue that more autopsies are performed than necessary. However, recent studies show that autopsies can detect major findings about a person's condition which were not suspected when the person was alive. The growing awareness of the influence of genetic factors in disease has also emphasized the importance of autopsies.

Despite the usefulness of autopsies, fewer autopsies have been performed in the United States during the past 10 to 20 years. A possible reason for this decline is concern about **malpractice** suits on the part of the attending physician, although there are other reasons. Hospitals are performing fewer autopsies because of the expense. Modern technology, such as **CT scans** and **magnetic resonance imaging** (MRI), can often provide sufficient diagnostic information. Nonetheless, federal regulators and pathology groups have begun to establish new guidelines designed to increase the number and quality of autopsies being performed.

Many experts are concerned that if the number of autopsies increases, hospitals may be forced to charge families a fee for the procedure as autopsies are not normally covered by insurance companies or **Medicare**. However,

according to several pathologists, the benefits of the procedure for families and doctors justify the cost. In medical autopsies, physicians remain cautious, examining only as much of the body as necessary, taking into account the wishes of the family. It is important to note that in certain circumstances, autopsies can provide peace of mind for a bereaved family.

Preparation

If a medical autopsy is being performed, written permission is secured from the family member of record of the deceased.

Aftercare

After an autopsy has been completed, the body is prepared for final arrangements according to the family's wishes, or the funeral director's instructions.

Complications

There is some risk of **disease transmission** from the deceased. In fact, some physicians may refuse to do autopsies on specific persons because of a fear of contracting diseases such as AIDS, hepatitis, or Creutzfeld-Jakob disease.

KEY TERMS

Acquired immunodeficiency syndrome (AIDS)—

A group of diseases resulting from infection with the human immunodeficiency virus (HIV). A person infected with HIV gradually loses immune function, becoming less able to resist immune-related diseases and cancers, resulting in death.

Computed tomography scan (CT scan)—

The technique used in diagnostic studies of internal bodily structures in the detection of tumors or dysfunction. This diagnostic test consists of a computer analysis of a series of cross-sectional scans made along a single axis of a bodily structure or tissue that is used to construct a three-dimensional digital image of that structure.

Creutzfeld-Jakob disease—

A rare, often fatal disease of the brain, characterized by gradual dementia and loss of muscle control that occurs most often in middle age and is caused by a slow-acting virus.

Hepatitis—Inflammation of the liver, caused by infectious or toxic agents and characterized by jaundice, fever, liver enlargement, and abdominal pain, with abnormal blood chemistry readings.

Magnetic resonance imaging (MRI)—A diagnostic tool that utilizes nuclear magnetic energy in the production of digital images of specific atoms and molecular structures in solids, especially human cells, tissues, and organs.

Postmortem—After death.

Results

In most situations, the cause of death is determined from the autopsy without any transmission of disease. Results of tests performed on samples of tissue and bodily fluids provide information about the cause and mechanism of death.

Abnormal results include inconclusive results from the autopsy and transmission of infectious disease during the autopsy. By following proper procedures, these are both highly unusual.

Health care team roles

Bodies of persons dying in a hospital are taken to the morgue by hospital attendants. Bodies of persons from any other location are transported by funeral home personnel, coroners, or their assistants. An autopsy is conducted by a physician, usually by one trained in pathol-

ogy or forensic science. In some states, a coroner can legally carry out an autopsy. Laboratory personnel process any specimens or samples obtained during an autopsy. Once completed, funeral home personnel transport the remains to another location for burial preparation.

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- American Medical Association, 515 N. State Street, Chicago, IL 60610. (312) 464-5000. <www.ama-assn.org>.
- American Society of Clinical Pathologists, 2100 West Harrison Street, Chicago IL 60612. (312) 738-1336. <www.ascp.org/index.asp>.
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L. Fleming Fallon, Jr., MD, DrPH

Avulsions see **Wounds**

B

B-cell count see **Flow cytometry analysis**

Back and neck pain, physical therapy for

Definition

Physical therapy for back and neck **pain** is the treatment of this pain using professionally accepted techniques and procedures carried out by a physical therapist.

Purpose

The ultimate purpose of physical therapy is to restore normal function to the patient. Such a goal may not be possible, since the persons most likely to experience back pain in the future are those patients who have experienced back pain in the past. Regardless, the physical therapist will seek to ameliorate pain and improve musculoskeletal function to the best of their ability. To reach this goal, the physical therapist may apply various types of therapy to assist in the healing process, ranging from education to electrostimulation therapy to physical manipulation of the spine. Due to the less invasive nature of physical therapy, it may be indicated as an alternative to surgery on the back or neck. Physical therapy may also be prescribed after surgery, either because the surgery did not completely ameliorate the pain, or to ensure the patient achieves maximum benefit from the surgery.

Precautions

There are a number of symptoms in patients with low back pain that may require immediate medical attention. These symptoms may indicate that back or neck pain is related to potentially serious non-mechanical or mechanical disease. Non-mechanical disorders that are neurological or organic in nature can cause symptoms of

back pain, but in these cases treatment needs to be directed at the disease, not merely the associated pain. Bowel, bladder, kidney, or gall bladder diseases, some types of **cancer**, cauda equina syndrome, and other neurological disorders are among the serious conditions that should be screened for and treated directly.

If a patient has numbness in the area roughly corresponding to where a person would sit in a saddle (basically, the buttocks) with or without problems urinating, that patient should seek immediate medical attention (these symptoms may be an indication of cauda equina syndrome). **Fever**, confusion, back pain that occurs mostly at nighttime or when lying down, or problems with urination, bowel movements, or sexual function are other symptoms implicating non-mechanical disease that may also require immediate medical attention.

Although the following symptoms may or may not be caused by mechanical disease, patients with sudden severe or increasing weakness, numbness, or tingling should seek immediate medical attention. Other symptoms in conjunction with back pain may also require immediate attention. If any unusual symptoms arise, even should they seem unrelated to back pain, a physician should be consulted. Regardless of the severity of these symptoms, all of them should at the very least be brought to the attention of a physician.

Other precautions and contraindications will vary according to the cause of pain, the therapy used, and the presence of other diseases or conditions. Some conditions either related to or coexisting with the pain, such as severe cardiac disturbances or bone weakness due to **osteoporosis** or other conditions, may contraindicate **exercise**.

Modalities, such as electrical stimulation techniques and thermal modalities, have their own sets of precautions. Conditions that may contraindicate the use of electrical stimuli include thrombophlebitis, cardiac demand pacemaker, disturbances in cardiac rhythm, local inflammation or **infection**, and cancer. The use of heat may not

be indicated immediately after an injury, and should always be used with special caution to prevent **burns**. Electrical, heat, and cold therapies may all be contraindicated for use on sensory-impaired areas. Ultrasound should not be used on tissues with metal implants, because of its deep heating properties. Manipulation techniques can aggravate disk problems, or cause compression **fractures** in patients with osteoporosis. The physical therapist needs to be familiar with any risks involved with each condition and modality. A doctor's diagnosis is often recommended prior to beginning treatment, and the physical therapist needs to make a careful diagnosis in order to make appropriate treatment choices.

Description

Physical therapy treatment, also called physiotherapy, is performed by, or under the supervision of, a physical therapist. A physical therapist may have a baccalaureate, masters, or doctoral degree in physical therapy, and is required to pass a national licensure exam. Physical therapy treatment includes a wide range of exercises, procedures and modalities. However, **patient education** is also an extremely important part of the practice of physical therapy.

According to an American Physical Therapy Association (APTA) patient education brochure on back pain, "the patient is the most important participant in the healing and prevention process." The physical therapist can instruct correct posture and safe ways of performing activities of daily living (ADLs) and other tasks. Additionally the physical therapist can show the patient various kinds of exercise that promote **relaxation**, relieve pain, and improve the condition of the muscles and other tissues surrounding the spine. Patient education may extend the benefits of treatment by helping the patient to self-manage pain and avoid re-injury or recurrence of acute pain and injury. Avoiding re-injury is a goal of special importance, since most people who have one episode of back pain are likely to have another.

Before treatment begins, the patient's problem must be evaluated. Very often, a physician will have referred a patient to physical therapy. Physical therapy may be the lone method of treatment, or may be used in combination with medication, surgery, or other types of treatments. After the role of physical therapy is determined, the patient will be evaluated by the physical therapist. Evaluation includes an interview with the patient to assess the patient's medical history, and activities that affect the condition. After the interview, the therapist will proceed with a musculoskeletal exam to assess the patient's spinal movements, posture, muscular strength, and response to repeated movements. Any additional

tests considered necessary for a diagnosis will be performed. The physical therapist will then provide a diagnosis of the condition and a prognosis.

The prognosis includes the predicted level of improvement, goals, and the time needed to achieve them. Then an individualized treatment plan will be designed and implemented. Treatment plans may vary widely from physical therapist to physical therapist for the same patient. Patients may wish to seek advice from a different therapist if their condition does not improve under the first therapist's care.

Back and neck pain can have many causes, such as: injury caused by accident or misuse, disease, general strain, postural problems, or just simple wrong movement. Specific causes of back or neck pain can include sprained ligaments, muscle strain, disk problems, joint irritation, arthritis, congenital disorders, psychological **stress**, spinal stenosis, osteoporosis, compression fractures, and various other conditions (non-mechanical causes of back pain have been discussed briefly in "Precautions"). Due to the large number of causes for back pain, it should not come as a surprise that there are a large number of therapies that address back and neck pain.

Exercise is generally considered an essential part of the physical therapy regime. Different kinds of exercise are used according to the condition and the stage of recovery. Some controversy surrounds what types of exercise to use, perhaps depending on the cause of the back pain as well as other factors. Individual exercises may seek to increase one or more of the following: flexibility, range of motion, overall aerobic conditioning, and muscle strength.

According to recent guidelines suggested by Malanga and Nadler, tolerable exercise is superior to bed rest for back pain. Bed rest and inactivity have been shown to weaken muscles and bones (a phenomenon known as deconditioning), and may prolong or interfere with recovery. Exercise, in general, increases strength and flexibility of the muscles and aids in healing by increasing **blood** flow to the affected area.

Aquatic therapy is among the exercise options available to physical therapy patients. This form of exercise has the benefits of being low-impact and gentle on joints. As a supplement to whatever forms of guided exercise are chosen by the therapist and patient, the patient is also likely to be given a home exercise program to perform independently.

Another type of treatment the physical therapist may use is manual therapy. Manual therapy is defined in the APTA's *Guide to Physical Therapist Practice, Second Edition* as "skilled hand movements intended to improve tissue extensibility; increase range of motion; induce

relaxation; mobilize or manipulate soft tissue and joints; modulate pain; and reduce soft tissue swelling, inflammation, or restriction.” Manual therapy techniques include various forms of massage, manual traction, mobilization and manipulation of the soft tissues and joints, and passive range of motion movements. Manual therapy has a long and storied history. The first mention of manual therapy in Western culture can be traced to Hippocrates, who wrote several treatises on joint manipulation and traction (traction, in the context of back and neck physical therapy, is the extension of the spine using force).

Although mobilization and manipulation have changed from the time of Hippocrates (460–355BC), they remain important techniques today (along with other forms of manual therapy). There are a large number of manipulation and mobilization techniques available to physical therapists, based on a number of different “schools of thought.” Many of these therapies have scientific evidence supporting their efficacy, and many do not. In part because there are so many different types of manipulation, the techniques, and the level of familiarity with different techniques, can vary widely from one physical therapist to the next.

The most well-known forms of manipulation are those performed by chiropractors. Although physical therapists can be trained to perform the same manipulations as chiropractors, historically, physical therapists sought to use terminology such as mobilization to differentiate themselves from the chiropractic community. Part of this impetus was based on the bias against chiropractors found in allopathic physicians. However, the APTA has recently moved toward reclaiming the term manipulation as part of the physical therapy lexicon.

Traction has also advanced since the time of Hippocrates. In the modern era, traction to the neck or low back may be applied as steady traction, or as intermittent motorized traction (IMT). The goal of traction in both cases is to correct physical deformities of the spine. Some modern traction practitioners speculate the benefit from traction is derived from pulling the intervertebral disk back into the intervertebral space (due to the force exerted on the spine).

In steady traction (for the low back) weights are applied to the ankles and patients are required to remain in bed, flat on their backs, for a significant period of time (weeks). The constant nature of the traction, and the way in which it was applied, led to a number of important disadvantages. First, bed rest is not recommended for general back health (as previously discussed). Second, the patient’s muscles might spasm, which would cause less force to be applied to the spine, the structure of interest. Third, the apparatus and the position of the patient means

that much of the force being applied to the patient would be absorbed by non-spinal structures (e.g. the hips). Most importantly, patients who receive this kind of traction do not improve compared to those who do not receive this kind of therapy.

IMT seeks to avoid these complications by applying intermittent (occasional) force a few times a week directly to the area of interest. A hip belt or a neck harness, and the immobilization of the upper body allow force to be applied more directly. The intermittent nature of the force prevents excessive muscle spasm, and the patient is spared the potentially harmful effects of bed rest.

Modalities, or passive physical therapies, do not require the patient to participate. These methods usually employ some special equipment that can apply heat, cold, electricity, or other elements or forms of stimulation to the patient. One such modality would be applications of cold using ice packs or a cryo-stimulation device. Heat can be applied using diathermy (for dry heat), hydrocollator packs (for moist heat) or a heating pad. Ultrasound uses sound waves to create a deep heating effect. Electrical muscle stimulation (EMS) is used to exercise and strengthen specific muscle groups, while TENS (transcutaneous electrical nerve stimulation) units provide therapeutic nerve stimulation to reduce pain.

Physical therapy services are often covered by medical insurance. The patient may want to ask the physical therapist to check with the insurance company to see what services and how many treatments are covered. Physical therapy is generally a cost-effective form of treatment, and if can be used to avoid surgery, then the expense of surgery and a hospital stay is also avoided.

Preparation

The patient should provide all appropriate **medical records** for the physical therapist to review. The patient may also wish to keep a journal before attending physical therapy, detailing times and activities that cause pain.

Aftercare

Since physical therapy focuses on patient education, the patient may be better equipped after the physical therapy program to pursue self-care through proper posture and performance of activities, and by continuing a home exercise program. According to an APTA patient education guide, the goal of physical therapy is to help the patient return to normal activities as soon as possible and to teach the skills needed to avoid re-injury. The patient will not necessarily require additional episodes of therapeutic care.

KEY TERMS

Co-morbidity—A disease or condition that coexists with the disease or condition for which the patient is being primarily treated.

Disk (disc)—Soft, flexible, shock-absorbing material between each vertebra.

Modalities—Passive physical therapies that are done to the patient rather than requiring their active involvement. These may not require constant attendance by the physical therapist.

Soft tissue/joint mobilization—Application of specific stretching techniques to the body's soft tissues and joints.

Spinal stenosis—A condition caused by the narrowing of the spinal canal leading to compression of nerves in the back.

Ultrasound—A treatment modality that uses high frequency sound waves to effect deep heating of soft tissue.

Complications

Possible complications related to physical therapy treatments for back and neck pain depend on the cause of pain, other conditions present, and the type of interventions used. In general, physical therapy is a safe, gentle treatment option designed to work in harmony with the body's natural structure and movement mechanisms. Severe complications are not common, as long as the diagnosis and plan of care are accurate and carefully made. The therapist should be aware of possible complications related to exercise in general, as well as those involved with various primary and co-existing conditions, and with any of the modalities used. Some forms of manipulation can lead to injury in the case of bone weakness or other pathological conditions. Patients whose conditions cause excessive fatigue should be monitored closely during exercise.

If the precautions or contraindications relating to the patient's condition, evaluation, medical history, and diagnosis are properly attended to and procedures used are observed, the risk of complications will be minimized. The patient may feel some additional pain or soreness when beginning exercise, but this should be mild and temporary. In rare cases, the patient may have an allergic reaction to gels and creams used in ultrasound or massage.

Results

Results vary widely based on the cause of the dysfunction, the therapy used, and the skill of the therapist. The goal of returning patients to their original level of function may not occur. However, since physical therapy focuses on patient education, the patient may be better equipped after the physical therapy program to pursue self-care through proper posture and performance of activities, and by continuing a home exercise program.

Health care team roles

Physical therapists may work together with physical therapist assistants and aides, physicians, nurses, social workers, occupational therapists, or other health care professionals. Doctors may provide a diagnosis and prescription for physical therapy and recommend duration or types of therapy. The physical therapist assistant, under the physical therapist's direction and supervision, may undertake various aspects of the patient's treatment. Occupational therapists and social workers may also work with the patient to supplement physical therapy's role in the patient's return to normal life and work or adaptation to disability.

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Bacteria

Definition

Bacteria are prokaryotes (unicellular organisms with no membrane-enclosed nucleus) with simple structures that typically range in size from about 0.5 to 20 micrometers.

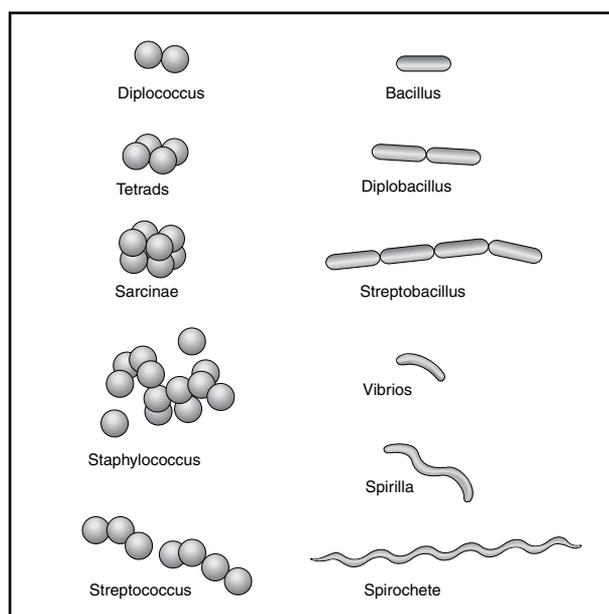
Description

Classification

Bacteria are named according to the binomial (two-name) system of nomenclature first used by Swedish botanist Carolus Linnaeus in the eighteenth century. The first name, or generic name, indicates the genus of the bacteria (a group of closely related species). The second name, or specific name, indicates the species (a group of bacteria that share a number of characteristics). Examples of generic names include *Staphylococcus* and *Esherichia*; *aureus* and *coli* are examples of specific names.

The genus and species names of bacteria often reflect their shape; for example, the *Bacillus* family of bacteria are bacilli- or rod-shaped. Others are named for their founders (e.g. *Yersinia pestis*, the causative agent of bubonic plague, is named for Alexandre Yersin) or for their preferred habitat (e.g., *Thermoplasma* prefer temperatures up to 149°F, or 65°C).

Under a **microscope**, different families of bacteria have different shapes. Typical cell shapes are straight rods (bacilli), spheres (cocci), bent or curved rods (vibrios), spirals (spirochetes), or thin filaments. Some bacteria exist as single cells, while others form clusters of



Morphology and arrangement of bacterial cells. (Delmar Publishers, Inc. Reproduced by permission.)

various shape and complexity. *Acetobacter aceti*, for example, excretes a substance called cellulose that surrounds the cells to form a skinlike layer. *Staphylococcus aureus* forms grapelike clusters of cells.

Many groups of bacteria have a cell wall, a structure surrounding the cell. Peptidoglycan (a chemical composed of **carbohydrates** and **proteins**) is a major component of the cell wall, although the exact composition of peptidoglycan varies according to bacteria group. Gram-positive organisms have a relatively thick layer of peptidoglycan and stain violet when applied with certain dyes; gram-negative organisms have a thin layer of peptidoglycan covered by an outer membrane and stain red under the same application of dyes. Gram staining is therefore an important method for identifying bacteria.

Bacteria may be classified by their biochemical composition, and analysis of the protein and lipid content of an organism is often a means of identification. Growth requirements are often used as a means of classification: *Mycobacterium tuberculosis*, for example, is an obligate aerobe and therefore requires oxygen for growth, while the presence of oxygen is toxic to the anaerobe *Clostridium tetani*.

The most precise method of classification, however, is genetic analysis. Each species of bacteria has a unique genetic makeup, and therefore a unique sequence of deoxyribonucleic acid (DNA) bases. Some sequences remain constant by genus or species, while others vary

considerably. These distinguishing factors are used to trace genetic relatedness and are often used for identification of unknown organisms.

Bacterial structure

Although prokaryotic organisms such as bacteria are considered to be “simple” in structure, each cell is equipped with all of the structures and macromolecules necessary for growth and survival. Complex functions such as energy production, synthesis of biomolecules, and assembly of new structures take place in a highly organized manner.

The genetic material of bacteria is carried on double-stranded molecules of DNA (deoxyribonucleic acid), which is arranged into a circular structure called the chromosome. The region of the cytoplasm where the chromosome is located is called the nucleoid and is not enclosed by a membrane, as in eukaryotic cells. Many bacteria carry additional genetic information (often required for survival in specific environments) on structures called plasmids, smaller circular strands of DNA that are independent of the chromosome. Also found in the cytoplasm are ribosomes, small cellular components important in the process of translating genetic information into proteins. The total collection of genes is called the bacterial genome.

Directly bordering the cytoplasm of the bacteria is the cytoplasmic membrane, which is important for various functions such as energy production and transport of materials in and out of the cell. The cell wall surrounds the cytoplasmic membrane of most bacteria. In gram-negative organisms, the cell wall is composed of a thin layer of peptidoglycan enclosed by an outer membrane. Lipopolysaccharide (LPS; also called endotoxin) is a major constituent of the outer membrane. The cell wall of gram-positive bacteria is distinctly different. Multiple peptidoglycan layers envelop the cytoplasmic membrane, and no outer membrane is present. The peptidoglycan layers form a meshlike shell around the cell that is important for maintaining structure, for replication, and for protection in extreme or toxic conditions. Proteins, **lipids**, and polysaccharides may also be found in the cell wall.

Many bacteria have additional means of protection in hostile conditions. Some have the ability to form a capsule, layers of polysaccharides and proteins attached to the cell wall, that provides protection against toxic substances and helps inhibit host **immune response**. Spores are made by some gram-positive bacteria. Under favorable conditions, the cells exist in a vegetative state; but when introduced to a hostile environment, the cells convert to a spore state and become dormant, awaiting conditions in which they may once again prosper.

The flagellum is a filamentous structure attached to many prokaryotes that provides motility. With flagella, bacteria may move toward food and away from toxins, a process called chemotaxis. Pili are hairlike structures shorter than flagella found on many bacteria; they are used for adherence to other bacteria and surfaces such as host cells.

Function

Energy requirements for growth

All living organisms must find in their environment a source of energy to fuel cellular processes. Bacteria are no different. Phototrophs are organisms that use light as an energy source; those that require organic carbon are called heterotrophs. Autotrophs use carbon dioxide. Lithotrophs oxidize inorganic compounds such as hydrogen or ammonia for energy.

Many bacteria have structures and processes that allow them to adapt to hostile environments, and they can exist under an enormous range of conditions. Those that require oxygen for growth are called obligate aerobes. In contrast, obligate anaerobes will not grow in the presence of oxygen. Acidophiles are bacteria that grow optimally under acidic conditions (pH of less than 7.0), while alkaphiles prefer alkaline or basic conditions (pH of greater than 7.0). Organisms that require a temperature near 99°F (37°C) (the body temperature of warm-blooded animals) for growth are called mesophiles; those that grow at temperatures above 113°F (45°C) are called thermophiles; and psychrophiles are able to grow at temperatures near 32°F (0°C). Halophiles require sodium chloride (salt) for growth; osmophiles are able to grow in environments high in sugar; and xerophiles grow under dry conditions.

Binary fission and the growth curve

Bacteria grow and replicate in a process known as binary fission. In this process, one parent cell divides to produce two daughter cells. The process begins with the growth of the parent cell; the chromosome unwinds and replicates, each copy moving to opposite ends of the cell. The cell is then partitioned in half by the production of a dividing wall (called the septum). The cell is cleaved at the septum, and the two daughter cells are freed. The daughter cells then go on to reproduce as parent cells (i.e., if necessary nutrients and energy sources are present).

The dynamics of a population of bacteria change during binary fission. The doubling time, or time required for one parent cell to produce two daughter cells, varies by bacteria species and strain and also by the

environmental conditions. All bacteria exhibit a characteristic pattern of growth when introduced to a new medium; this is known as the growth curve. There are four phases of the growth curve:

- During the lag phase, bacteria are adapting to the medium and begin to produce the cellular components necessary for **cell division**. There is no increase in cell population during the lag phase.
- Cell division occurs at a maximal rate during the log or exponential phase. The doubling time remains constant, so the number of cells increases exponentially.
- Cells stop growing exponentially and therefore remain constant during the stationary phase. This occurs when the medium begins to run out of the nutrients necessary for growth or when toxic products accumulate.
- The number of cells begins to decrease during the death phase as cells begin to die, usually due to toxic conditions or lack of nutrients.

Role in human health

Normal flora

Only a small percentage of the vast population of bacteria is pathogenic (disease-causing) to humans. Many species of bacteria colonize the human body and are called the normal flora. Organisms of the normal flora are normally found on surface tissues (i.e., the skin, mucous membranes, and the gastrointestinal system). It is when bacteria enter normally sterile areas of the body (e.g., the **brain, blood, muscle**, etc.) that disease may result.

Some organisms of the normal flora neither harm nor provide benefit to the human body; this relationship is called commensalism. Normal commensals are bacteria that can always be found on or in healthy individuals and rarely cause disease. Bacteria that occasionally colonize the human body without causing disease are called occasional commensals. Although a human fetus is sterile *in utero*, colonization with normal flora bacteria begins with birth when the baby comes into contact with the mother's vaginal bacteria; this continues with breastfeeding and subsequent contact with the environment.

Many other types of bacteria interact with the human body in a relationship called mutualism, from which both organisms benefit. There are a number of ways that bacteria benefit the human host:

- Normal flora bacteria on the skin such as *Staphylococcus epidermidis* protect against colonization by pathogenic bacteria, through a process called microbial competition.



Transmission electron micrograph (TEM) of a Group A *Streptococcus* bacterium. (Custom Medical Stock Photo, Inc. Reproduced by permission.)

- Bacteria in the vagina (e.g., *Lactobacillus acidophilus*) help to establish an acidic environment that inhibits colonization of pathogenic bacteria and yeast.
- The normal flora in the gastrointestinal (GI) tract (e.g., *Escherichia coli*) secrete **vitamins** such as K and B₁₂ that are essential for humans. The development of some GI tissues is stimulated by normal flora bacteria.
- Ruminants (animals with a four-chambered **stomach**) rely on enzymes secreted by bacteria such as *Ruminococcus albus* to digest cellulose (a major component of plant cell walls).

Pathogenic bacteria

Although normal flora bacteria are not normally pathogenic, disease may result from invasion of normal flora into normally sterile areas or if the host **immune system** is deficient. When bacteria that normally reside in the GI tract (such as *E. coli*) are introduced to the urinary tract, for example, a urinary-tract **infection** may result. This is considered an endogenous infection.

Exogenous infections result from invasion of non-commensal organisms (i.e., those not normally found on the human body). Transmission of exogenous bacteria may occur by various routes, including inhalation of aerosolized organisms, ingestion (e.g., contaminated food or utensils), or direct contact of a wound or mucous membrane with organisms.

When bacteria first enter the body, local inflammation may be the first sign of infection. Physical symptoms such as **pain**, erythema (redness), **edema** (swelling), or pus formation result from the response of the immune system against the invading bacteria. If the bacteria spread to the bloodstream (bacteremia), they may disseminate to and colonize at various sites in the body.

KEY TERMS

Antibiotics—Chemicals produced by microorganisms that inhibit bacterial growth or kill bacterial cells.

Binary fission—The process by which a single parent cell divides to produce two identical daughter cells.

Flagellum—A filamentous structure attached to some bacteria that provides motility.

Gram-negative—A class of bacteria that have a cell wall composed of a thin layer of peptidoglycan surrounded by an outer membrane made of polysaccharides and proteins.

Gram-positive—A class of bacteria that have a cell wall composed of a thick layer of peptidoglycan.

Growth curve—A characteristic growth pattern of bacteria when introduced into a new medium; it includes four phases (lag, log, stationary, and death).

Normal flora—Species of bacteria that colonize the human body and do not normally cause disease.

Nucleoid—Cytosolic region of a bacterial cell in which the chromosome is located.

Pathogen—A disease-causing microbe.

Peptidoglycan—A chemical composed of carbohydrates and proteins that is a major component of the bacterial cell wall.

Prokaryote—A unicellular organism lacking a membrane-enclosed nucleus.

Ribosome—A cytosolic structure important in the translating of genetic information into proteins.

Toxins—Proteins produced by bacteria that are toxic to host cells. Endotoxin is a component of the cell wall of gram-negative bacteria; exotoxin is secreted by both gram-negative and gram-positive bacteria.

VIRULENCE FACTORS. Bacteria have developed numerous mechanisms that allow them to invade a host and colonize an otherwise inhospitable site to cause disease. Many of these mechanisms enhance their ability to cause disease in humans; such traits are called virulence factors. Some common virulence factors include:

- **Bacterial growth.** The byproducts of normal bacterial growth may cause tissue destruction if colonization has occurred in a normally sterile site. For example, *Clostridium perfringens* is a normal flora bacteria of the GI tract but may cause gas **gangrene** if it infects a wound or trauma site.
- **Release of toxins.** Some pathogenic bacteria produce proteins (toxins) that are inevitably toxic to the host. An endotoxin is composed of lipopolysaccharides found in the outer membrane of gram-negative bacteria. Exotoxins are proteins produced intracellularly and secreted by either gram-negative or gram-positive bacteria.
- **Capsule formation.** The polysaccharide layers of a capsule form a protective shield around a bacteria and help the cell to evade immune response.
- **Internalization.** Some bacteria are able to escape intracellular killing when internalized by phagosomes and go on to survive in the cytoplasm (e.g., *Mycobacterium tuberculosis*). In this way they are protected from antibody-mediated immune responses.
- **Granuloma formation.** A granuloma is a lesion formed in response to infection by some intracellular pathogens. Viable bacteria are walled off in the granuloma and thus prevented from further colonization.
- **Antigenic mimicry.** A bacterial cell may be able to trick the immune system by presenting antigens (molecules recognized by antibodies) that are similar to host antigens. Immunological cells therefore have difficulty distinguishing between the bacterium and a host cell.

Antibiotic resistance

The emergence of bacterial strains that are resistant to treatment by current **antibiotics** is an important public-health concern. Antibiotics are chemical substances produced by microorganisms that inhibit bacterial growth or kill bacterial cells. Narrow-spectrum antibiotics target only a limited variety of bacteria, while broad-spectrum antibiotics have the ability to inhibit or kill a wide variety of bacteria.

Bacteria can resist the action of antibiotics using one or more of four basic mechanisms:

- inactivation or modification of the drug
- modifying the drug's target binding site
- decreasing uptake of the drug into the cell
- altering the biochemical pathway that the drug is targeting

In many developing countries, antibiotics are freely distributed as over-the-counter drugs, leading to their

widespread use for viral or noninfectious illnesses. This practice, coupled with the overuse of antibiotics in veterinary medicine, farming, and plant culture, has contributed to the spread of antibiotic-resistant bacteria.

Common diseases and disorders

The following list describes some of the most common bacteria that are pathogenic to humans.

- *Staphylococcus*. Staphylococci are gram-positive bacteria found as part of the normal flora of most individuals. *S. aureus* is the causative agent of many infections, including toxic shock syndrome (TSS), staphylococcal **food poisoning**, impetigo, and furuncles (**boils**). *S. saprophyticus* causes urinary-tract infections in sexually active women. *S. epidermidis* may infect damaged or artificial **heart** valves and cause a condition called endocarditis.
- *Streptococcus*. Streptococci are gram-positive bacteria that commonly colonize the oropharynx (the area of the throat at the back of the mouth). Example syndromes include pharyngitis (**sore throat**), scarlet **fever**, necrotizing fasciitis (streptococci are popularly known as the “flesh-eating bacteria”), and rheumatic fever. *S. pneumoniae* is a common cause of bacterial **pneumonia** and meningitis.
- *Neisseria*. *N. gonorrhoeae* is the causative agent of gonorrhea, a leading sexually transmitted disease (STD). *N. meningitidis* is a leading cause of adult meningitis.
- *Escherichia*. *E. coli* is the most commonly encountered species of this genus. The bacteria is a common cause of gastroenteritis (inflammation of the lining of the stomach and intestines) but also causes urinary-tract infections and neonatal meningitis.
- *Salmonella*. Most *Salmonella* infections result from ingestion of contaminated food and lead to enteritis. The febrile (fever-inducing) illness typhoid fever is caused by *S. typhi*.
- *Vibrio*. The most commonly known *Vibrio* infection is cholera, caused by *V. cholerae*. Spread by ingestion of contaminated food or water, cholera infection is an important cause of diarrheal disease in developing countries.
- *Clostridium*. *C. perfringens* causes a variety of human diseases, including myonecrosis (gas gangrene), clostridial food **poisoning**, and soft-tissue infections (cellulitis and fasciitis). Tetanus (also known as lock-jaw) is caused by *C. tetani*; *C. botulinum* causes food-borne botulism.

- *Mycobacterium*. **Tuberculosis**, caused by infection with *M. tuberculosis*, is a highly prevalent pulmonary disease. Hansen’s disease (also known as leprosy) is caused by *M. leprae*.
- *Chlamydia*. Chlamydiae, once thought to be **viruses** because of their small size, cause numerous human diseases. *C. trachomatis* is the causative agent of conjunctivitis (inflammation of the outer surface of the eye), infant pneumonia, and urogenital chlamydia. Bronchitis, pneumonia, and sinusitis are often caused by *C. pneumoniae*.

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ORGANIZATIONS

- American Society for Microbiology. 1752 N Street NW, Washington, DC 20036. (202) 737-3600. <<http://www.asmsusa.org>>.

Stéphanie Islane Dionne

Bacterial meningitis see **Meningitis**

Balance and coordination tests

Definition

Balance is the ability to maintain the center of gravity over the base of support, usually while in an upright position. Coordination is the capacity to move through a complex set of movements that requires rhythm, muscle tension, posture, and equilibrium. Balance and coordination depend on the interaction of multiple body organs and



A patient sits on a ball, working on his balance. He wears a belt so that the physical therapist can catch him if he loses balance. (Custom Medical Stock Photo. Reproduced by permission.)

systems including the eyes, ears, **brain** and nervous system, **cardiovascular system**, and muscles. Tests or examination of any or all of these organs or systems may be necessary to determine the causes of loss of balance, dizziness, or the inability to coordinate movement or activities.

Purpose

Tests of balance and coordination, and the examination of the organs and systems that influence balance and coordination, can help to identify causes of dizziness, fainting, falling, or incoordination.

Precautions

Tests for balance and coordination should be conducted in a safe and controlled area where patients will not experience injury if they become dizzy or fall. The

practitioner should first evaluate the patient's static and dynamic balance before leaving the patient unattended.

Description

Assessment of balance and coordination can include discussion of the patient's medical history and a complete **physical examination** including evaluation of the **heart**, head, eyes, and ears. A slow pulse or heart rate, or very low **blood pressure** may indicate a circulatory system problem, which can cause dizziness or fainting. During the examination, the patient may be asked to rotate the head from side to side while sitting up or while lying down with the head and neck extended over the edge of the examination table. If these tests produce dizziness or a rapid twitching of the eyeballs (nystagmus), the patient may have a disorder of the inner ear, which is responsible for maintaining balance.

An examination of the eyes and ears may also provide clues to episodes of dizziness or incoordination. The patient may be asked to focus on a light or on a distant point or object, and to look up, down, left, and right moving only the eyes while the eyes are examined. Problems with **vision** may, in themselves, contribute to balance and coordination disturbances, or may indicate more serious problems of the nervous system or brain function. **Hearing loss**, fluid in the inner ear, or ear **infection** might indicate the cause of balance and coordination problems.

Various physical tests may also be used. A patient may be asked to walk a straight line, stand on one foot, or touch a finger to the nose to help assess balance. The patient may be asked to squeeze or push against the doctor's hands, to squat down, to bend over, or stand on tiptoes or heels. Important aspects of these tests include holding positions for a certain number of seconds, successfully repeating movements a certain number of times, and repeating the test accurately with eyes closed. The patient's **reflexes** may also be tested. For example, the doctor may tap on the knees, ankles, and elbows with a small rubber mallet to test nervous system functioning. These tests may reveal muscle weakness or nervous system problems that could contribute to incoordination.

As ergonomics becomes a major emerging practice area in **occupational therapy**, balance and coordination is increasingly analyzed in workplace evaluations. Good balance and coordination, such as finger dexterity, may be needed for a worker to properly complete a specific task in his or her job. Assessments used to determine coordination include the Crawford Small Parts Dexterity Test, Bennett Hand-Tool Dexterity Test, Purdue Pegboard, and the Minnesota Rate of Manipulation Test.

Coordination tests	
Test	Description
Alternate heel to knee and heel to toe	While lying down, the patient is asked to touch his or her knee and big toe alternately with the heel of the opposite extremity.
Alternate nose to finger	The patient alternately touches the tip of his or her nose and the tip of the therapist's finger with the index finger. The therapist may move his or her finger during testing to assess ability to change distance, direction, and force of movement.
Drawing a circle	While sitting, standing, or lying down, the patient alternately draws an imaginary circle in the air, or on a table or floor, with either upper or lower extremity. Instead of a circle, a figure-eight pattern may be used.
Finger to finger	With both shoulders abducted to 90° and the elbows extended, the patient is asked to bring both hands toward the midline and approximate the index fingers from opposing hands.
Finger to nose	With the shoulder abducted to 90° and the elbow extended, the patient is asked to bring the tip of the index finger to the tip of the nose. The initial starting position may be changed to assess performance from different planes of motion.
Finger opposition	The patient touches the tip of the thumb to the tip of each finger in sequence. Speed may be gradually increased.
Finger to therapist's finger	The patient and therapist sit opposite each other. The therapist holds his or her index finger in front of the patient, and the patient is asked to touch the tip of the index finger to the therapist's index finger. The position of the therapist's finger may be altered during testing to assess ability to change distance, direction, and force of movement.
Fixation or position holding	Upper extremity: The patient holds arms horizontally in front. Lower extremity: The patient holds the knee in an extended position.
Mass grasp	The patient alternately opens and closes the fist (finger flexion to full extension). Speed may be gradually increased.
Pronation/supination	With elbows flexed to 90° and held close to body, the patient alternately turns his or her palms up and down. This test also may be performed with shoulders flexed to 90° and elbows extended. Speed may be gradually increased. The ability to reverse movements between opposing muscle groups can be assessed at many joints, including the knee, ankle, elbow, fingers, etc.
Rebound test	The patient is positioned with the elbow flexed. The therapist applies sufficient manual resistance to produce contraction of biceps. Normally when resistance is suddenly released, the opposing muscle group (triceps) will contract and "check" movement of the limb. Many other muscle groups can be tested for this phenomenon, such as the shoulder abductors or flexors, and elbow extensors.
Tapping	Foot: The patient is asked to "tap" the ball of one foot on the floor without raising the knee; heel maintains contact with floor. Hand: With the elbow flexed and the forearm pronated, the patient is asked to "tap" his or her hand on the knee.

SOURCE: O'Sullivan, S.B. and T.J. Schmitz. *Physical Rehabilitation: Assessment and Treatment*. 3rd ed. Philadelphia: F.A. Davis Co., 1994.

Standardized tests that evaluate gross motor coordination include the Bruinlinks-Oseretsky Test of Motor Proficiency, which evaluates gross and fine motor coordination, muscle strength, balance, and visual motor control; the Devereux Test of Extremity Coordination, which assesses static balance, motor attention span, and sequential motor activity; the Lincoln-Oseretsky Motor Development Scale, which assesses motor tasks such as walking backwards and one-foot standing; and the Miller Assessment for Preschoolers, which assesses gross motor function in young children.

Balance testing instruments

The Berg Balance Scale. This widely-used instrument identifies balance impairment. Functional activities such as reaching, bending, transferring, and standing are used as items on the test to measure balance. The test items are graded on a five-point scale to determine extent of impairment.

Clinical Test of Sensory Interaction and Balance (CTSIB). This test, also known as the Sensory Organization Test, assesses static balance under six combinations of sensory conditions. For example, visual conditions vary by testing while the eyes are closed, open,

and also when peripheral vision is restricted. The test also includes having the subject balance while standing on a hard floor and while standing on foam. The effect on posture and balance is graded and scored.

Functional Reach Test. This test measures a person's stability while leaning forward and reaching as far as possible with arm outstretched and parallel to the floor in front of the body. A normal reach is at least six inches, measured from the distance the fist has traveled during the reach.

The Tinetti Balance Test of the Performance-Oriented Assessment of Mobility Problems. This test measures balance and gait while performing typical daily activities. The activities are graded as normal, adaptive, or abnormal to determine the severity of balance impairment.

The Timed Up and Go Test. This test measures the time it takes a person to rise from a standard armchair and stand, walk three meters, turn around, and walk back to the chair and sit down.

The Physical Performance Test. This test evaluates a person's physical functional capabilities. The person performs nine separate activities, such as feeding and writ-

KEY TERMS

Incoordination—Uneven, inaccurate movement.

Meniere's disease—An abnormality of the inner ear that causes dizziness, ringing in the ears, and hearing loss.

ing, and is scored on each of the activities based on speed from 0-4.

Preparation

No special preparation is required prior to administration of balance and coordination tests. The patient may be asked to disrobe and put on an examination gown to make it easier for the doctor to observe muscles and reflex responses.

Aftercare

No special aftercare is generally required. However, some of the tests may cause episodes of dizziness or incoordination. Patients may need to use caution in returning to normal activities if they are experiencing any symptoms of dizziness, lightheadedness, or weakness.

Risks

These simple tests of balance and coordination are generally harmless.

Results

These tests do not normally cause dizziness, loss of balance, or incoordination.

The presence of dizziness, lightheadedness, loss of coordination, unusual eye movements, muscle weakness, or impaired reflexes are abnormal results and may indicate the problem causing the loss of balance or incoordination. In some cases, additional testing may be needed to diagnose the cause of balance or coordination problems.

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- American Academy of Otolaryngology-Head and Neck Surgery. One Prince Street, Alexandria, VA 22314. (703) 836-4444.
- Ear Foundation. 2000 Church Street, Box 111, Nashville, TN 37236. (615) 329-7807 or (800) 545-HEAR.
- Vestibular Disorders Association (VEDA). P.O. Box 4467, Portland, OR 97208-4467. (800) 837-8428 or (503) 229-7705. Fax: (503) 229-8064.

Meghan Gourley

Balance assessment see **Gait and balance assessment**

Balance impairments see **Gait and balance problems**

Ball and socket joint

Definition

Ball and socket joints are multiaxial, synovial joints. They are lubricated by a clear, sticky fluid called synovia.

Description

Also called spheroidal joints, the ball and socket joints are formed by the rounded or “ball-shaped” head of one bone fitting into the cup-like cavity of another bone. The articulating bone fits into the cavity and allows the distal bone to move around. The hip and shoulder joints are examples of the ball and socket joint.

Function

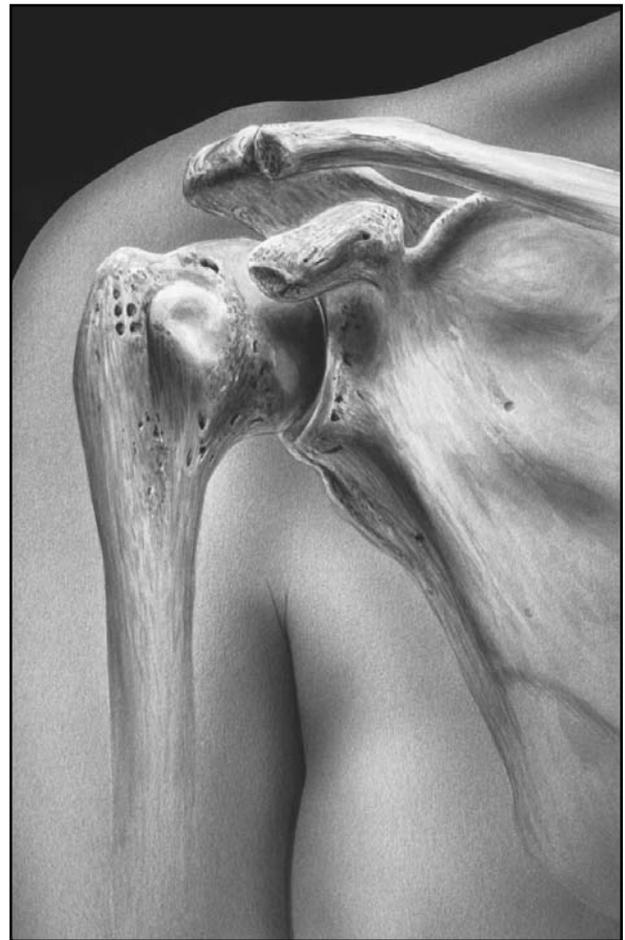
The purpose of joints is to provide movement for the body. Different types of joints move in different ways. The ball and socket joint is fully mobile under the control of muscles, ligaments, and tendons. The ends of the bones are covered with tough cartilage and are lined with the synovial membrane.

Each joint contains a small amount of synovial fluid which lubricates it. Synovial fluid provides protection for the ball and socket joint and allows for stress-free movement.

The ball and socket joint provides swinging and rotating movements. The articulating bone is received into the cavity of another bone, allowing the distal bone to move around three main axes with a common center. The joint has stabilizing ligaments that limit the directions and extent to which the bones can be moved. However, the ball and socket joint is the most mobile in the body.

Role in human health

Ball and socket joints are the most mobile and intricate of all the joints. They are also the most prone to disease and prone to require medical intervention. Hip or shoulder replacements are common forms of surgical intervention that restore a patient’s quality of life by replacing worn ball and socket joints with prosthetic ones.



The shoulder joint is supported by the scapula (shoulder blade) and the clavicle (collar bone). The humerus (upper arm bone) articulates with the glenoid cavity in a ball and socket type joint. (David Gifford. Science Source/Photo Researchers. Reproduced by permission.)

Common diseases and disorders

There are many disorders and diseases that can afflict the synovial joints, making the ball and socket joint vulnerable to **pain** and discomfort. Degenerative or inflammatory diseases, conditions involving the membranes around the joints, generalized and congenital disorders, and dislocations and **fractures** can all cause damage to ball and socket joints.

Arthritis is one of the conditions that causes pain and dysfunction in the ball and socket joint. There are several types of arthritis, but **osteoarthritis** and rheumatoid arthritis are the most common.

Osteoarthritis is a degenerative disease that affects the cartilage in the joints, and it can cause inflammation in the tissues surrounding the affected joint or joints. Degeneration is commonly thought to be caused by stress

KEY TERMS

Axis/axes—A central or principal structure about which something turns or is arranged. The cup-like structure of the ball and socket joint is the axis where the distal bone rotates.

Dysplasia—Dislocation of a bone from its proper place. Hip or shoulder displacement are two of the best-known types of dysplasia.

Multiaxial—Having more than one axis. The ball and socket joint has at least three axes on which it rotates.

Synovial fluid—A transparent, viscous fluid found in the synovial joints. It lubricates the ball and socket joint for easier movement.

on the joints or by injury to the joint lining. Osteoarthritis can affect all joints, but it is usually found in the fingers, feet, hips, spine, and knees. It causes joint stiffness and pain. Symptoms of osteoarthritis can be treated, but the disease is irreversible.

Rheumatoid arthritis is an inflammatory disease that involves the muscles and the membrane linings of cartilage and joints. The areas commonly affected are the hands, hips, knees, legs, and joints. The symptoms include low-grade **fever**, stiffness in the morning, and redness, pain, warmth, and tenderness in the affected joints. Rheumatoid arthritis can cause crippling pain and deformities of the hands and causes painful swelling of the joints.

Hip dysplasia is a dislocation of the hip joint that can be caused either by a congenital condition or by an accident. Dysplasia occurs when the thighbone (femur) does not fit correctly into or pops out of the cup-shaped socket at the hipbone (acetabulum). If hip dysplasia is caused by a congenital condition, the acetabulum is too shallow to hold the head of the femur. **Physical therapy** can help remedy the problem by deepening the cavity of the socket. Accidental hip dislocation is usually caused by a hip fracture.

Resources

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"WebMD—Joint." <http://my.webmd.com/content/dmk/dmk_article_1458178>.

Peggy E. Browning

Balloon angioplasty *see* **Angioplasty**

Balloon valvuloplasty

Definition

Balloon valvuloplasty is a minimally invasive procedure performed by an interventional radiologist and/or an interventional cardiologist in which a stenotic (narrowed) **heart** valve is stretched open using a special catheter with an inflatable balloon at its tip. The procedure is much less invasive than open heart surgery.

Purpose

There are four valves in the heart: the aortic valve, pulmonary valve, mitral valve, and tricuspid valve. The valves open and close to regulate the **blood** flow from one chamber to the next. They are vital to the efficient functioning of the heart.

Balloon valvuloplasty is performed on children and adults with stenosis (narrowing of the valves) to improve valve function and blood flow. The balloon stretches the thin muscular leaves of flaps of the valve, enlarging the valve opening. It is a treatment for aortic, mitral, and pulmonary stenosis. Balloon valvuloplasty is effective treatment for narrowed pulmonary valves, and results with mitral valve stenosis are generally good. For stenosis of the aortic valve, the procedure is more difficult to perform and less successful as a treatment.

Description

During balloon valvuloplasty, a contrast medium (dye) is administered to the patient to make the process visible. Then a catheter (thin tube) with a small deflated balloon at the tip is inserted in the groin area. It is then threaded back up to the heart, passing through the vessels leading to the chamber adjacent to the stenotic valve. The balloon is then inflated, which stretches the leaves of the valve open. The procedure repairs some valve obstructions quite successfully.

The procedure is performed in the **cardiac catheterization** laboratory and may take as long as four hours. About an hour before the procedure, the patient is given an oral sedative such as diazepam (Valium). The patient is also sedated intravenously, but is usually awake, and **local anesthesia** is administered to block **pain** sensation at the area of catheter insertion. After the insertion site is prepared and anesthetized, the cardiologist inserts a catheter, then passes a balloon-tipped catheter through the lumen (opening) of the first catheter. Guided by a video monitor and fluoroscopy, the physician slowly threads the catheter into the heart. The deflated balloon is positioned in the valve opening, and inflated repeatedly. The inflated balloon widens the valve's opening by splitting the valve leaflets apart. Once the valve is widened, the balloon is deflated, and the balloon-tipped catheter is removed by sliding it back out the entry route. The other catheter remains in place for six to 12 hours because in some cases the procedure must be repeated.

Preparation

For at least six hours before balloon valvuloplasty, the patient is instructed to take nothing by mouth. An intravenous line is inserted in the arm as a medication administration route. The patient's groin area is shaved and scrubbed with an antiseptic solution.

Aftercare

After balloon valvuloplasty, the patient is sent to the recovery room for several hours, where **vital signs** and heart rhythms are monitored. A 12-lead ECG (electrocardiogram) is performed. The leg in which the catheter is inserted is temporarily immobilized, and the catheter itself is secured so that it cannot come out. The insertion site is covered by a sterile dressing, on top of which is a sandbag to maintain pressure. The site is observed for bleeding until the catheter is removed. Intravenous fluids are administered to help eliminate (flush) the contrast medium; intravenous anticoagulants (blood thinners) or other medications to dilate the coronary arteries may be given. Pain medication is available.

For at least 30 minutes after removal of the catheter, direct pressure (in the form of a sand bag) is applied to the dressing at the groin where the catheter was inserted; after this, a pressure dressing is applied. Following discharge from the hospital, the patient can usually resume normal activities. After balloon valvuloplasty, lifelong followup monitoring is necessary because valve leaflets sometimes degenerate or stenosis recurs, requiring more invasive surgery.

KEY TERMS

Aortic valve—One of several valves in the heart that regulate blood flow.

Cardiac catheterization—The process of running a catheter—a long, thin, hollow tube—into the area of the heart for a variety of medical treatments.

Hematoma—Blood that has escaped from blood vessels and collected below the surface of the skin or under the surface of an organ. Also known as a blood blister or bruise.

Pulmonary valve—Any of several valves regulating blood flow to the lungs.

Stenosis—The narrowing of any valve, especially one of the heart valves or the opening into the pulmonary artery from the right ventricle.

Valve—Tissue in the passageways between the heart's upper and lower chambers that controls passage of blood and prevents regurgitation.

Valve leaflets—The tissues that form the moveable parts of a valve.

Valvuloplasty—Widening or forcing open the valves of the circulatory system, usually with a catheter equipped with a balloon.

Complications

Balloon valvuloplasty may have serious complications, such as cerebral or pulmonary embolism, in which pieces of the valve break off and travel to the **brain** or the **lungs**. Another complication is the potential for the valve opening to become distended so that it does not close completely. This condition is known as valvular incompetence. This condition permits blood backflow (regurgitation) and reduces the amount of blood pumped by the chamber through the valve, into the circulation. If the procedure causes severe damage to the valve leaflets, immediate surgery is required. Less frequent complications are bleeding and hematoma (a "bruise," or local collection of clotted blood) at the catheter insertion site, abnormal heart rhythms, reduced blood flow, **myocardial infarction**, cardiac rupture, **infection**, and circulatory problems.

Health care team roles

Balloon valvuloplasty is performed by interventional cardiologists in the cardiac catheterization laboratory. Clinical specialist nurses, radiology and laboratory tech-

nologists, and technicians assist during the procedures and provide pre- and postoperative education, monitoring, and supportive care.

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ORGANIZATIONS

- American College of Cardiology, Heart House, 9111 Old Georgetown Rd., Bethesda, MD 20814-1699. (800) 253-4636 or (301) 897-5400. Fax: (301) 897-9745. <<http://www.acc.org>>.
- American Heart Association. National Center. 7272 Greenville Avenue, Dallas, TX 75231-4596. (214) 373-6300. <<http://www.americanheart.org>>.

Barbara Wexler

Balneology see **Hydrotherapy**

Bandages and dressings

Definition

Bandages and dressings are both used in wound management. A bandage is a piece of cloth or other mate-

rial used to bind or wrap a diseased or injured part of the body. Usually shaped as a strip or pad, bandages are either placed directly against the wound or used to bind a dressing to the wound. A dressing can consist of a wide range of materials, sometimes containing medication, placed against the wound.

Purpose

The purposes served by dressings include protecting **wounds**; promoting healing; and providing, retaining, or removing moisture. Bandages can be used to hold dressings in place, and also to relieve **pain** and generally make the patient comfortable. Elastic bandages are useful to provide ongoing pressure on **varicose veins**, fractured ribs, swollen joints, etc.

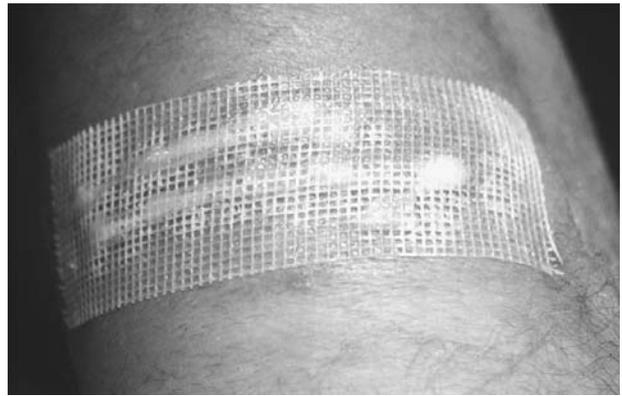
Description

There have been tremendous advances made in the design and composition of dressings and bandages in recent years. The field is becoming increasingly complex, and there are numerous reports of health care workers applying inappropriate products. Wound-care materials come in a wide variety of product classes, including the following:

- Alginate dressings. These are derived from brown seaweed, and contain **calcium** alginate, which turns into a sodium alginate gel when it comes in contact with wound fluid. Alginate dressings are available as pads or ropes.
- Biosynthetic dressings. Composites of biological (often animal-derived) and synthetic materials such as polymers.
- Collagen dressings. Made from collagen, a protein obtained from cowhide, cattle tendons, or birds. They are available as particles or gels.
- Composite dressings. These look like Band-Aids, and include an adhesive border, a nonadhesive or semiadhesive surface that is applied to the wound, an absorbent layer, and a bacterial barrier.
- Contact layers. A low-adherent layer of perforated or woven polymer material, designed to stop a secondary absorbent dressing from sticking to the wound surface.
- Gauze. This woven fabric of absorbent cotton is available in a number of formats and materials, including cotton or synthetic, nonimpregnated, and impregnated with water, saline, or other substances. Gauze is sold as surgical swabs, sheets, rolls, pads, sponges, and ribbon.
- Growth factors. These short-chain **proteins** affect specific target cells. They exist naturally in humans. They

can be transplanted from one part of the body to another, or manufactured outside the body.

- **Hydrocolloid dressings.** Used for leg ulcers, minor **burns**, pressure sores, and traumatic injuries, these self-adhesive dressings form a gel as they absorb fluid from the wound. They consist of materials such as sodium carboxymethylcellulose (an absorbent), pectin, and gelatin, attached to a foam sheet or a thin polyurethane film.
- **Hydrofibers.** Similar in appearance to cotton, carboxymethylcellulose fibers turn into a gel when they are brought into contact with wound fluid. They are available as ribbons or pads, and are highly absorbent.
- **Hydrogels.** These are sold as sheets and in gel form, and are primarily used to supply moisture to wounds. Depending on the state of the tissue, they can either absorb fluid or moisten the wound. An electrically conductive aloe vera gel is available to provide **electrotherapy** to wounds.
- **Hydropolymers.** These foamed-gel products consist of multiple layers. The surface layer is designed to expand to fill the wound's contours, at the same time drawing away fluids.
- **Leg compression/wrapping products.** Designed to apply external pressure to improve **blood** flow and resolve chronic **edema** in the feet and legs. Available in a broad range of formats including stockings, compression bandages, or pneumatic pump.
- **Polyurethane foam dressings.** These are sheets of foamed polymer solutions with small open chambers that draw fluids away from the wound. Some, but not all, of these foam products offer adhesive surfaces. They are available as sheets and rolls, as well as in various other formats suitable for packing wounds.
- **Skin substitutes.** Also known as allografts or skin equivalents, these are obtained from human cells cultured and expanded *in vitro* from neonatal foreskins.
- **Superabsorbents.** These are particles, hydropolymers, or foams that act like the material inside diapers, with a high capacity for rapid absorption.
- **Transparent films.** These consist of a thin, clear polyurethane sheet that, on one side, has a special adhesive that does not stick to moist surfaces like those found on a wound. They prevent **bacteria** and fluids from entering the wound through the dressing, but allow limited circulation of oxygen.
- **Wound fillers.** These can be bought as powders or pastes, or in strands or beads. They are used to fill wounds and also absorb wound fluid.



Dressings are used to protect wounds and promote healing. They are often held to the wound with bandages.
(Custom Medical Stock Photo. Reproduced by permission.)

- **Wound pouches.** Equipped with a special collection system for wounds that have a high flow of secretion. Designed to contain odors, and to be easily drained.
- **Other assorted wound-care products.** These include adhesive bandages, surgical tapes, adhesive skin closures, surgical swabs, paste bandages, specialty absorptive dressings, support bandages, retention bandages, elasticized tubular bandages, lightweight elasticized tubular bandages, foam-padded elasticized tubular bandages, and plain stockinettes.

Operation

Just as there is a large selection of bandage and dressing products to choose from, there is also a broad range of applications for these products:

- **Alginate dressings** are used on wounds that exude moderate to heavy amounts of fluid. They are useful for packing wounds, although strip-packing gauze may be preferable for deeper wounds because it is easier to retrieve. Common applications of alginate dressings include treatment of acute surgical wounds, leg ulcers, sinuses, and pressure sores. These dressings should not be used on third-degree burns. Neither are they advisable for wounds that are dry or are secreting only small amounts of fluid, because their powerful absorbing capability may dry out the wound. These are primary dressings that need to be covered by a secondary dressing.
- **Biosynthetic dressings** are used on burns and other wounds. Another application is as a temporary dressing for skin autograft sites. Some patients may be allergic to these dressing materials.
- **Collagen dressings** are believed to hasten wound repair and are often used on stubborn wounds. They are most effective on wounds that contain no dead tissue.

KEY TERMS

Edema—Swelling of body tissues, caused by collection of excess fluid.

Electrotherapy—The treatment of body tissues by passing electrical currents through them, stimulating the nerves and muscles.

Sinus—In the context of wound management, a narrow hollow in the body extending from an infected area to the skin's surface.

Stockinette—A soft elastic material used for bandages and clothing for infants.

Collagen dressings should not be used in dry wounds, third-degree burns, or on any patient who is sensitive to bovine (cow) products.

- Composite dressings are sometimes used alone, sometimes in combination with other dressings. Deep wounds should first be packed with wound filler material. These dressings should not be cut, and are not recommended for use of third-degree burns.
- Contact layers are designed for use in clean wounds that contain no dead tissue. They are not recommended for infected, shallow, dry, or infected wounds, or on third-degree burns.
- Gauze is used to pack wounds, and also for debridement and wicking. It is especially desirable for packing deep wounds. When using gauze to pack wounds, a loose packing technique is preferred.
- Growth factors. These have highly specific applications against such conditions as diabetic foot ulcers involving disease of the peripheral nerves. Growth factors are heat sensitive and often require refrigeration. Not recommended for patients with tumors, either benign or malignant.
- Hydrocolloid dressings are used for leg ulcers, minor burns, pressure sores, and traumatic injuries. Because they are not painful to remove, hydrocolloid dressings are often employed in pediatric wound management. Because of their absorbent capabilities, they are used on wounds that are secreting light to moderate amounts of fluid.
- Hydrofibers are highly absorbent, so they are particularly useful for wounds that are draining heavily. For this reason, they are not recommended for dry wounds or wounds with little secretion, because they may result in **dehydration**. Hydrofibers should not be used as surgical sponges or on third-degree burns.
- Hydrogels are often used on wounds that contain dead tissue, infected surgical wounds, and on painful wounds. They should not be used on wounds with moderate to heavy secretions. As with all dressings, it is important to check the manufacturer's directions. In the case of hydrogels, directions on some products indicate they are not to be used on third-degree burns.
- Hydropolymers are typically used on wounds with minimal to moderate drainage. They are not indicated for dry wounds or third-degree burns.
- Leg compression/wrapping products are used to increase blood flow and reduce edema in the lower extremities of the body. A medical doctor should be consulted before using these products on patients with edema. In many cases, topical dressings are used underneath these products.
- Polyurethane foam dressings are very absorbent and are typically used on wounds with moderate to heavy secretions. They should not be used on third-degree burns, or wounds that are not draining or have sinuses or tunneling.
- Skin substitutes are a relatively new product category, approved for treating venous leg ulcers. It is often advisable to cut slits in the artificial skin, so that wound secretions underneath do not lift the newly applied skin.
- Superabsorbents are employed on wounds that are secreting heavily, or in applications requiring extended wear. A packing material is commonly employed under this product. Superabsorbents should not be used on third-degree burns or wounds that are either dry or have minimal secretions.
- Transparent films are often employed as a secondary cover for another, primary dressing. They are used on superficial wounds, and on intact skin at risk of **infection**. It is important to remove transparent films very carefully, to avoid damaging fragile skin.
- Wound fillers are primary dressings that are usually used in conjunction with other, secondary dressings. Wound fillers are considered appropriate for shallow wounds with little or moderate secretions. They are not appropriate for use in third-degree burns, or in dry wounds. They are similarly not recommended for wounds with tunnels or sinuses.
- Wound pouches are useful in treating wounds with high volumes of secretion. They are not suitable for dry wounds.

Maintenance

Recommended intervals between dressing changes varies widely between product classes. Some dressings

are designed to be changed several times a day. Others can remain in place for one week. The manufacturer's directions should be consulted and followed.

Health care team roles

Wound-care nursing is a demanding field that can require its practitioners to also be administrators, educators, clinical experts, and researchers. Nurses are the front-line workers in **wound care**, often working as part of a multidisciplinary team of colleagues from other professions and disciplines. This approach is considered necessary because of the multifaceted nature of wounds. Its importance is especially noticeable in acute care, where 5.4% of hospital patients develop a stage one ulcer. Across the United States, such ulcers in acute care cost more than \$839 million a year. Other members of the wound-care team may come from **home care**, administration, **nutrition**, geriatrics, vascular surgery, plastic surgery, biomedical, general nursing, pharmacy, materials management, **infection control**, purchasing, quality assurance, and physical and **occupational therapy**. Numerous ad hoc members and consultants may also be involved, including representatives from dermatology, trauma, podiatry, risk management, staff development, orthotic specialists, rehabilitation, diabetology, and social services. To be successful, multidisciplinary wound-care teams must establish ongoing communication with primary-care physicians. Nurses are intensively involved in the initial assessment of tissue damage, a responsibility that demands both accuracy and consistency. Other responsibilities may include cleansing and dressing wounds, removal of non-viable tissue, **pain management**, **patient education**, nutritional counseling, statistical analysis, and helping the patient cope with the psychological effects of serious or disfiguring wounds. Determining the cause of wounds is often very important, especially the cause of chronic wounds such as skin ulcers. A physician should be advised of any signs of infection or other changes in the wound.

Training

Wound-care nursing is a rapidly advancing field that requires considerable training, clinical experience, and judgment, causing some observers to predict that it will eventually develop into advanced practice nursing or a specialty-based practice. Increasingly, the demands on wound-care nurses are expected to require that they undertake graduate studies. For all nurses working in the field, ongoing education is a must, to keep up with new knowledge, technologies, and techniques. Numerous organizations and institutions offer continuing education courses in wound care management. The Wound,

Ostomy and Continence Nurses Society is one such organization. It offers a variety of resident programs at several U.S. centers and also has distance-learning options.

Resources

BOOKS

Bryant, Ruth A. *Acute & Chronic Wounds*, 2nd ed. St. Louis, MO: Mosby, 2000.

ORGANIZATIONS

The Wound, Ostomy, and Continence Nurses Society. 1550 South Coast Highway, Suite #201, Laguna Beach, CA, 92651. (888) 224-WOCN (toll-free). <<http://www.wocn.org>>.

David L. Helwig

Barium enema

Definition

A barium enema (or BE), also known as a lower GI (gastrointestinal) series, is a radiographic exam used to view the **large intestine**. There are two types of barium **enemas**: the single-contrast technique where just barium sulfate is injected into the rectum to outline the large intestine; and the double-contrast (or "air contrast") technique in which barium and air are injected into the rectum.

Purpose

The purpose of a barium enema is to demonstrate the anatomy and morphology of the large intestine. The large intestine frames the abdomen and is divided into six sections. These include the rectum, sigmoid colon, descending colon, transverse colon, ascending colon, and cecum.

A barium enema may be performed for a variety of reasons, including abdominal **pain** or a change in bowel habits such as **diarrhea** or constipation, as well as a change in the caliber (size) of the stools. This exam is also requested when parasites, **blood**, mucus, or pus are found in the stools. Occult (hidden) blood found in the stools and anemia may be an indication of intestinal bleeding due to ulcers, inflammatory disease, or a cancerous lesion. Doctors may also order this exam as a screening tool for patients with a history of polyps (pre-cancerous growths extending outward from a mucous membrane) or a family history of **colorectal cancer**.

A barium enema may also be requested when the large intestine was not completely visualized during a



A barium enema exam allows any obstructions or tumors to be seen on a monitor. (Photo Researchers, Inc. Reproduced by permission.)

colonoscopy (examination of the large intestine with a fiber-optic tube) or when a **sigmoidoscopy** is done, which only partially visualizes the colon. Sometimes a barium enema may be used as a treatment for intussusception (telescoping of one section of the bowel into another causing obstruction). This is a rare disorder occurring most often in young children, but when it occurs immediate action must be taken.

A barium enema may also be done to evaluate the remaining colon on **colostomy** patients. The barium is injected into the stoma (external drainage opening in the abdominal wall) instead of the rectum. A barium enema may be done if obstruction, perforation, or fistula formation is suspected.

Precautions

As with any radiographic procedure there is the risk of radiation. The x-ray technologist must always make sure there is no risk of **pregnancy** and that the least amount of films as possible are done. No lead shielding can be used since all the abdominal area must be visualized on the films.

Description

All patients must be changed into a hospital gown. All clothing is removed, including shoes and socks, since some leakage of the barium mixture can occur. In some departments disposable slippers are supplied. The x-ray

technologist may take one preliminary view of the abdomen to determine how well the patient's bowel has been cleansed. Any retained fecal material can create false filling defects and mucosal abnormalities on the films. A single-contrast enema would usually be done on patients with a poor bowel preparation. After the films are taken and the patient has evacuated as much of the barium as possible air may be introduced into the large intestine and further films taken. This method takes longer and gives more radiation to the patient.

The patient will be instructed to lie on the left side on the x-ray table, and the radiography technologist will insert a lubricated enema tip into the rectum. The enema tips contain a small balloon which may be inflated to help the patient retain the barium. The patient may remain on their left side or turned prone (face-down) depending on the procedure and routine of the radiologist.

For a single-contrast barium enema, the barium sulphate solution is a thinner consistency but a larger amount is needed to completely fill the large intestine. High kilovoltage (100-125kvp) is used to get a good penetration of the barium filled colon, and it is important to take the films as quickly as possible since the patients are very uncomfortable when the bowel is completely distended. Routine films for a single contrast study include a supine and prone abdomen film as well as both obliques to see the hepatic and splenic flexures of the large bowel. The patient will completely evacuate the bowel and one more film, the post-evacuation film (PE) usually done AP (anteroposterior, or front-to-back) supine, will be taken.

In a double-contrast barium enema, a fine coating of thick barium is needed to outline the mucosal lining of the bowel. The patient will be placed prone so that gravity can assist the air in distributing the liquid around the large bowel. The patient is asked to turn over 360 degrees a few times during the exam to aid in the coating of the bowel. The patient is then placed upright, and more air is injected into the bowel so gravity again can assist in visualizing the large intestine. Patients may develop spasms of the bowel during this exam, so the radiologist may give the patient a glucagon injection to relax the large bowel. This injection should not be given to patients with a history of **glaucoma** and can cause temporary double-vision in these patients.

The radiologist will take spot-films under fluoroscopy of each segment of the bowel but most of the films will be made following the procedure by the x-ray technologist. Since less barium is used along with some air, less kilovoltage (90-100kvp) is needed to achieve a high contrast x-ray of the large intestine. The usual AP and PA (posteroanterior) abdomen films will be done as well as the two oblique views of the abdomen. An

upright film may be done as well depending on the routine of the radiologist. The most important films for the double-contrast exam are the two lateral decubitus films. The patient is placed on a large cushion or sponge and turned completely onto one side. A stationary grid is placed next to the patient and the x-ray tube is turned 90 degrees. This film allows the air to rise to the upper surface of the abdomen so that the air along with the thin coating of barium creates a detailed visualization of the intestinal lining. This is extremely important when looking for small polyps, cancers, and ulcerations of the bowel. Films of both sides are always taken.

Preparation

In order to conduct the most accurate barium enema test, the patient must follow a prescribed diet and bowel preparation prior to the test. This includes a diet of tea, coffee (black), clear soups, and gelatin 24-48 hours before the barium enema. **Laxatives** and cathartics such as magnesium citrate (X-Prep) or Dulcolax tablets may also be required as part of the bowel preparation. Each radiology department has their own specific requirements. A rectal suppository or cleansing enema may also be necessary on the morning before the exam. Patients must drink as much fluids as possible to prevent **dehydration**. Patients with **heart** disease, diabetes, or kidney disorders should consult their physician for an alternate bowel preparation. Children are usually placed on a clear liquid diet on the day before their examination.

A barium enema may be done in a hospital or a certified x-ray clinic and will take 30 minutes to one hour depending on what type of exam has been ordered and the physical ability of the patient.

Aftercare

Patients should follow several steps immediately after undergoing a barium enema, including:

- Drinking plenty of fluids to help counteract the dehydrating effects of the bowel preparation.
- Taking time to rest. A barium enema and the bowel preparation taken before it can be exhausting.
- A cleansing enema or laxative may be given to eliminate any remaining barium. White stools containing barium are normal for two or three days following a barium enema.

Complications

While a barium enema is considered a safe screening test used on a routine basis, it can cause complica-

tions in certain patients. The following contraindications should be kept in mind before a barium enema is performed:

- Those who have a rapid heart rate, severe ulcerative colitis, toxic megacolon, or a presumed perforation in the intestine should not undergo a barium enema.
- The test can be cautiously performed if the patient has a blocked intestine. Gastrograffin, an iodine-based contrast, will be used instead of the barium in case emergency surgery is needed following the barium enema.

Results

A normal result indicates no structural or filling defects of the large intestine. Radiologists look for any enlargement or narrowing of the large bowel as well as variations in the mucosal lining. The walls of the intestine should collapse normally after the post-evacuation film, and the bowel should have normal haustral markings (undulations of the colon wall).

Abnormal results may include colorectal polyps, diverticulosis (multiple abnormal sacs bulging through the intestinal wall), ulcerative colitis, abscesses, or tumors visualized on the walls or adjacent to the large intestine. Further evaluation such as a biopsy or CT scan may be necessary to determine the extent of any positive findings.

Health care team roles

It is the responsibility of the radiography technologist to prepare the barium, insert the enema tip, and take the overhead films after the radiologist has filled the entire colon with either the barium or a combination of barium and air. In some departments an interventional radiology technologist will perform the complete exam. He or she will have had additional education and training by the radiologists to complete this duty.

The x-ray technologist must work closely with the nurses to make sure all hospital patients follow the bowel preparation. Since the preparation is physically exhausting for the patient, care is taken to complete the exam as soon as possible so the patient may resume a normal diet.

Patient education

Since a good preparation is the most important step in a barium enema, all patients should receive detailed information on the reasons and requirements for the cleansing treatment. The x-ray technologist must explain the procedure in detail before starting the exam. The patient must be informed that the barium enema can sometimes cause cramps and that the urge to have a

KEY TERMS

Barium sulfate—A barium compound used during a barium enema to block the passage of x rays during the exam, allowing visualization of the intestinal lining.

Colonoscopy—An examination of the large colon performed with a colonoscope.

Diverticula (plural of diverticulum)—A sac or pouch in the colon walls which is usually asymptomatic (without symptoms) but may cause difficulty if it becomes inflamed.

Diverticulitis—A condition of the diverticula of the intestinal tract, especially in the colon, where inflammation may cause and pain.

Diverticulosis—A condition of the colon characterized by the presence of diverticula.

Glaucoma—A disease of the eye characterized by increased ocular pressure resulting in damage to the retina and optic nerve if not treated.

Sigmoidoscopy—A visual examination of the rectum and sigmoid colon using a fiberoptic sigmoidoscope.

Ulcerative colitis—An ulceration or erosion of the mucosa of the colon.

bowel movement is completely normal. Some leakage of the barium may occur and the patient should not feel embarrassed if this happens because it occurs fairly often, especially in elderly patients. Care should be taken when inserting the enema tip because the rectum is already irritated, due to the multiple bowel movements during the preparation. The x-ray technologist must take note of any history of glaucoma in case an injection of glucagon is needed. Patients should be completely covered at all times and care taken when placing the patient in the upright position since many patients are weak after undergoing the bowel preparation.

The x-ray technologist should also explain to the patient the need to drink plenty of fluids after the barium enema and that white stools following a barium enema are normal.

All radiography technologists must be certified, having completed a two to four year program depending on where the course was completed. All x-ray technologists must be registered with the A.S.R.T. and earn continuing education credits to remain registered.

Resources

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Segen, Joseph C., and Joseph Stauffer. "Barium Enema (lower GI series)." In *The Patient's Guide To Medical Tests: Everything You Need To Know About The Tests Your Doctor Prescribes*. New York, NY: Facts On File, Inc., 1998, pp. 44-45.

PERIODICALS

Friedenberg, Richard M.D. "The supertechnologist." *Radiology Review* (June 2000): 630-633.

ORGANIZATIONS

American Cancer Society. 1599 Clifton Road NE, Atlanta, GA 30329-4251. (800) ACS-2345. <<http://www.cancer.org/>>.

OTHER

Health Discovery. <<http://www.healthdiscovery.com/diseasesandconditions>>

Lorraine K. Ehresman

Barium swallow see **Upper GI exam**

Beds and bed preparation techniques

Definition

A hospital bed is the piece of equipment most frequently used by the hospitalized patient. Hospital beds are also found in long-term-care facilities, as well as patients' homes. The ideal hospital bed should be selected for its impact on patients' comfort, safety, medical condition, and ability to change positions.

Purpose

The purpose of a well-made hospital bed, as well as an appropriately chosen mattress, is to provide a safe, comfortable place for the patient, where repositioning is more easily achieved, and pressure ulcers are prevented.

Precautions

When selecting a bed, the nurse should consider the patient's mobility, overall medical condition, and risk for **pressure ulcer** development. Safety factors should also be considered. Unless a patient is accompanied by a

health care professional or other caregiver, the bed should always be placed in its lowest position to reduce the risk of injury from a possible fall.

Another precaution to take, especially for weak or bed-bound patients, or for those with altered mental status, is to elevate the side rails. However, health care professionals should be aware of a safety alert issued by the Food and Drug Administration (FDA) in 1995 concerning the use of hospital beds' side rails. Because of a number of injuries and deaths related to side rail entrapment, the FDA recommends the following actions to prevent potential deaths and injuries related to side rail entrapment:

- All hospital bed frames, side rails, and mattresses should be inspected regularly to identify potential areas of entrapment. The alignment of the bed frame, side rail, and mattress should leave no gap that is wide enough to entrap a patient's head or any other part of the body.
- Be alert for side rails or mattresses that have been replaced. Not all of these are interchangeable, and may increase the potential for entrapment.
- Check side rails for proper installation.
- Consider additional safety measures for those patients at high risk for entrapment. Side rail protective barriers may be used to close off open spaces.
- Do not use side rails as a substitute for patient protective restraints.

Description

The usual hospital bed consists of a mattress on a metal frame that can be raised or lowered horizontally. The frame is separated into three sections so the head and foot of the bed can be raised and lowered, in addition to inclining the entire bed with the headboard up or down. The majority of hospital beds are powered by electrical motors, but some are run manually (using a crank) or by hydraulic methods.

The bed's position is typically changed by using electrical controls that may be located on the side or foot of the bed, in a bedside table, or on a pendant. The electrical controls enable patients to reposition the bed with very little effort. Patients should be instructed how to use the bed controls. They should also be cautioned against raising the bed to a position that may contribute to injuries or **falls**. At its lowest level, a hospital bed is usually about 26–28 inches (65–70 cm) above the floor.



Two nurses change bedsheets with the patient in the bed.

(Photograph by Cliff Moore. Science Source/Photo Researchers. Reproduced by permission.)

Various safety features are present on hospital beds. These features include:

- **Wheel locks:** These should be used whenever the bed is stationary.
- **Side rails:** They help to protect patients from accidentally falling out of bed, as well as provide support to the upper extremities as the patient gets out of bed.
- **Removable headboard:** This feature is important during emergency situations, especially during cardiopulmonary resuscitation.

Most hospital beds have water-repellent mattresses. However, a number of specially designed beds, frames, and mattresses have been created to aid in caring for bed-bound patients. Some of these beds help to turn the immobile patient, and may make it easier for nurses to lift or reposition the patient. The major categories of specialized beds are:

- **Air-fluidized beds:** These are also known as bead beds, sand beds, and high-air-loss beds. Air is circulated via silicone microspheres, creating a fluid-like state.
- **Low-air-loss beds.** These beds have interconnected air cells with a minimum depth of five inches (12–13 cm). They allow air to escape from the surface of the bed.

There are also a variety of support surfaces that can be placed on top of the existing mattress, or specialized mattresses that can reduce the risk of pressure ulcer formation. These surfaces and mattresses include:

- static air-filled overlays
- alternating air-filled mattress overlays
- gel- or water-filled mattress overlays
- foam mattresses
- low-air-loss replacement mattresses

KEY TERMS

Draw sheet—A sheet placed over the bottom sheet to help lift or move a patient and to protect the bottom sheet from soiling.

Fowler's position—A bed position where the head of the bed is raised to an angle of 45° or more; a semisitting position.

Trendelenburg—A bed position where the entire frame of the bed is tilted with the head of the bed down.

The rotokinetic bed is used primarily for severely immobilized patients or patients with **spinal cord** injuries. The bed can rotate a patient up to 270°. Bariatric beds are available for especially obese patients.

Preparation

The nurse normally makes the bed in the morning after a patient's bath, or when the patient is out of the room for tests. The nurse should straighten the linens throughout the day, making certain they are neither loose nor wrinkled. Any sheets that become wet or soiled should be changed promptly.

When changing bed linen, the nurse should keep the soiled linen away from the uniform, and place it in the appropriate linen bag or other designated container. Never fan or shake linens, which can spread microorganisms and, if any of the sheets touch the floor, they should be replaced.

The bed can be made in a variety of ways, depending on the particular patient situation. The categories of unoccupied bed making include:

- **Open unoccupied:** In an open bed, the top covers are folded back so the patient can easily get back into the bed.
- **Closed unoccupied:** In a closed bed, the top sheet, blanket, and bedspread are pulled up to the head of the mattress and beneath the pillows. A closed bed is done in a hospital bed prior to the admission of a new patient.
- **Surgical, recovery, or postoperative:** These techniques are similar to the open unoccupied bed. The top bed linens are placed so that the surgical patient can transfer easily from the stretcher to the bed. The top sheets and bedspread are folded lengthwise or crosswise at the foot of the bed.

The other method of making a hospital bed is an occupied bed, where the patient is in the bed while the

linens are being changed. The nurse should perform the following when making the occupied bed:

- Raise the bed to a comfortable working height. Loosen the top linens, and help the patient assume a side-lying position.
- Roll the bottom linens toward the patient.
- Place the bottom sheet on the mattress, seam side down, and cover the mattress. Miter the corners of any non-fitted sheets.
- Place waterproof pads and/or a draw sheet on the bed.
- Tuck in the remaining half of the clean sheets as close to the patient as possible.
- Assist the patient to roll over the linen. Raise the side rail, and go to the other side of the bed.
- Remove the dirty linen and dispose of appropriately.
- Slide the clean sheets over and secure. Pull all sheets straight and taut.
- Place the clean top sheets over the patient and remove the used top sheet and blanket. Miter the corners of the top linens at the foot of the bed. Loosen the linens at the foot of the bed for the patient's comfort.
- Change the pillowcase.
- Return the patient's bed to the appropriate position, at its lowest level.

The nurse also needs to place the bed into one of the following positions, considering the particular needs of each patient:

- **Fowler's:** The head of the bed is raised to an angle of 45° or more; a semisitting position. This position is appropriate when the patient is eating. It is also used during nasotracheal suctioning or during nasogastric tube placement.
- **Semi-Fowler's:** In this position, the head of the bed is raised about 30°. This position helps to promote adequate lung expansion.
- **Trendelenburg:** The entire bed frame is tilted with the head of the bed down. This helps to promote postural drainage or to promote venous return in patients with poor peripheral circulation.
- **Reverse Trendelenburg:** The entire bedframe is tilted with the foot of the bed down. This position is not frequently used, though it may help to prevent esophageal reflux.
- **Flat:** Keeping the bed flat is appropriate for some patients with spinal injuries, and for those in cervical traction. It may also be used for patients with hypotension. It is a position preferred by many for sleeping.

Aftercare

After preparing the hospital bed, the patient should be assessed for comfort and safety.

Health care team roles

Selecting and preparing a bed for the patient are important responsibilities for the nurse. The nurse or nursing assistant normally makes up the bed, but it is important that all health care professionals be aware of the positive impact an appropriate, well-made bed has on a patient's care, safety, and sense of comfort.

Resources

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PERIODICALS

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ORGANIZATIONS

The Hospital Bed Safety Work Group.
<<http://www.fda.gov/cdrh/beds>>.

Deanna M. Swartout-Corbeil, R.N.

Bedside monitors see **Cardiac monitor**

Bedsore see **Pressure ulcer**

Behavioral optometry

Definition

Behavioral **optometry** is a system of eye care that emphasizes visual training as a way to improve the way a patient uses his or her eyes. Rather than simply prescribe lenses to compensate for eyesight weaknesses, behavioral optometrists attempt to train the patient to see better across a range of different circumstances.

Origins

Behavioral optometry traces its roots to the writings of Dr. William H. Bates, a New York City ophthalmologist. Bates began writing in the 1920s about alternatives to the use of corrective lenses. He believed that many physical and emotional stresses caused **vision** problems, and that alleviating these stresses could improve vision. He noted that modern humans spend an inordinate

amount of time doing close work such as reading, while the human eye may have been originally adapted for distance vision. Bates devised a program of eye training that allowed patients to gradually improve their vision without glasses. The English novelist Aldous Huxley recovered from near-blindness using Bates's system, and wrote a book about his experience. Other optometrists built on Bates's insights, supplementing his research and ideas. Some researchers focused on the fact that the need for corrective lenses rises in proportion to a person's level of education. They concluded that the stress of reading was probably responsible for poor eyesight. Others noted that vision problems increase as cultures become increasingly industrialized and developed. Practitioners of behavioral optometry who built on and extended Bates's ideas include Dr. Raymond L. Gottlieb and Dr. Jacob Liberman, both influential authors and teachers. Behavioral optometrists are distinctly a minority in the field of optometry, but they can be found across the United States and worldwide.

Benefits

Behavioral optometrists promise many benefits from this way of treating vision problems. Perhaps the foremost is that people can learn to live without the discomfort and bother of wearing eyeglasses or **contact lenses**. Behavioral optometry also focuses on children, particularly those with learning difficulties. These children can benefit from learning to train their eyes and so overcome reading problems due to inability to concentrate or inability to keep the eyes in place on the page. Behavioral optometry also tries to help patients deal with stress, so that vision training can lead to a more relaxed and healthy lifestyle. In addition, behavioral optometry has been used to develop the special visual acuity that is needed for sports, and some practitioners are trained to treat patients who have suffered vision trauma such as stroke, or to work with autistic or disabled children.

Description

Behavioral optometry aims to treat the whole patient, not just correct his or her vision. The first step in an examination may be a wide-ranging series of tests and questions, geared to determine the patient's overall visual abilities. This term means not just how well the eyes read letters on a chart, but such broader areas of visual perception as hand-eye coordination and color perception. Behavioral optometrists will prescribe corrective lenses, but these are usually somewhat different from traditional glasses. The lenses are designed to relieve the stress caused by such close-focus work as reading or working at a computer. But for distance seeing, the lens-

KEY TERMS

Ophthalmologist—A physician who specializes in treating diseases and disorders of the eye.

Optometrist—A professional who examines the eyes for vision defects in order to fit the patient with corrective lenses or prescribe other appropriate treatment.

es may not be as accurate as traditional lenses, since the behavioral optometrist seeks to teach the eyes to relearn distance vision skills that have atrophied. Many behavioral optometrists prescribe lenses that include a series of small prisms, which are supposed to help the eyes develop better vision patterns. Behavioral optometrists also practice vision therapy, in which the optometrist works closely with the patient in step-by-step exercises to help the eyes relax and relearn lost skills. These are not merely eye exercises, because exercising the muscles around the eye can fatigue them instead of strengthen them. The therapy might involve learning new skills such as juggling, drawing, dancing, or ball games, as well as **relaxation** techniques. The optometrist may also work with the patient to alter diet, sleep patterns, and lifestyle stress.

Research and general acceptance

Though behavioral optometrists are definitely a minority within the field of optometry, a body of research supports their methods. This can be found in professional journals such as *Journal of Behavioral Optometry* and *Journal of Optometric Vision Development*. Bates's method has been in use since the 1920s, and much anecdotal evidence attests to its efficacy, including the dramatic case of writer Aldous Huxley. Other patients and practitioners have written of their ability to function without glasses and overcome learning disabilities through behavioral optometry. And one of the major contentions of behavioral optometry is that conventional optometry does not cure the eye conditions it treats. Myopic patients are given glasses, and then a stronger pair of glasses, and then a stronger, as vision gradually worsens. Behavioral optometrists use this development as evidence that conventional optometry fails its patients.

Training and certification

In the United States, there are three major training institutions for behavioral optometry. The College of Optometrists and Vision Development offers courses and examinations leading to an international certificate in

behavioral optometry. Clinical education workshops are offered by the Optometric Extension Program Foundation in Santa Ana, California. The Baltimore Academy of Behavioral Optometry offers in-depth coursework in behavioral optometry to qualified optometrists. Only people who already have a degree in optometry can take these courses. Technicians also work with behavioral optometrists. These technicians need have no specific educational background, but to become certified, they must work for 2,000 hours under a certified behavioral optometrist and pass a written and oral examination.

Resources

BOOKS

Bates, William. *The Bates Method for Better Eyesight Without Glasses*. New York: Henry Holt & Co., 1981.

Lieberman, Jacob. *Take Off Your Glasses and See*. New York: Crown Publishers, 1995.

ORGANIZATIONS

Baltimore Academy of Behavioral Optometry. 16 Greenmeadow Drive, Suite 103. Timonium, MD 21093. (800) 447-0370.

College of Optometrists in Vision Development. 353 H. Street, Suite C. Chula Vista, CA 91910. (888) 268-3770.

Optometric Extension Program Foundation. 2912 South Daimler Street, Suite 100. Santa Ana, CA 92705. (949) 250-8070.

Angela Woodward

Bends see **Decompression sickness**

Beta-carotene see **Vitamin A**

Bicarbonate test see **Electrolyte tests**

Bilirubin test see **Liver function tests**

Bioelectricity

Definition

Bioelectricity refers to electrical potentials and currents occurring within or produced by living organisms. It results from the conversion of chemical energy into electrical energy. Bioelectric potentials are generated by a number of different biological processes, and are used by cells to govern **metabolism**, to conduct impulses along nerve fibers, and to regulate muscular contraction. In most organisms bioelectric potentials vary in strength from one to several hundred millivolts. The most impor-

tant difference between bioelectric currents in living organisms and the type of electric current used to produce light, heat, or power is that a bioelectrical current is a flow of ions (atoms or molecules carrying an electric charge), while standard electricity is a movement of electrons.

Description

Historical background

Prior to the eighteenth century, European physicians and philosophers generally believed that nervous impulses were conducted to the **brain** via an organic fluid of some kind. The experiments of two Italians, the physician Luigi Galvani and the physicist Alessandro Volta, demonstrated that the true explanation of nervous conduction is bioelectricity. Impulses within the nervous system are carried by electricity generated directly by organic tissue.

In the nineteenth century, such researchers as Emil du Bois-Reymond invented and refined instruments that were capable of measuring the very small electrical potentials and currents generated by living tissue. One of du Bois-Reymond's students, a German scientist named Julius Bernstein, is generally credited with the hypothesis that nerve and muscle fibers are normally polarized, with positive ions on the outside and negative ions on the inside; and that the current that can be measured results from the reversal of this polarization. In the early part of the twentieth century, several British scientists identified the chemical substances involved in the transfer of information between the nerves and muscles.

Cell membrane potential

Bioelectricity begins with the fact that all animal cells have electrical properties derived from the ability of the cell membrane to maintain unequal charges inside and outside the cell. The cell membrane is semipermeable, which means that it forms a selective barrier to ions, which are electrically charged atoms or atom groups. The semipermeability of the cell membrane allows the cell to maintain concentrations of ions in the cytosol (the fluid portion of cell cytoplasm) that differ from those in the fluid outside the cell. Potassium and chloride ions can diffuse through the membrane relatively easily, while sodium ions cannot diffuse into the cell at all.

Because of the semipermeability of the cell membrane, the concentration of sodium in the fluid outside the cell is higher than in the cytosol; the concentration of potassium is higher inside the cell than outside, and the concentration of chloride is higher outside the cell than

inside. There are thus two forms of energy stored across the cell membrane—a chemical force (the differences in ion concentration) and an electrical force. This bioelectric potential across the cell membrane is called the resting potential. In most cells the resting potential is about 50 millivolts.

Diffusion

The most important ions in bioelectrical phenomena are sodium (Na^+), potassium (K^+), **calcium** (Ca_2^+), and chloride (Cl^-). The first three types of ions carry a positive charge while the chloride ion carries a negative charge.

Ions can move across the cell membrane in two ways. First, they can move through pores called ion channels. Most ion channels are specific to a particular ion or group of ions. In addition, most ion channels are gated, which means that they require a stimulus to open them. Because ions move passively through the channels, the only direction they can travel via channels is from areas of high concentration to areas of low concentration. This movement from areas of higher to areas of lower concentration is called diffusion.

Active transport

A second kind of transport, which moves ions across the cell membrane *against* the electrochemical gradient is called active transport. Active transport involves an ion pump, which is sometimes called a sodium/potassium pump. Ion pumps differ from ion channels in that the pumps require energy to move the ions. The energy is derived from adenosine triphosphate, or ATP, which is a nucleotide that is the primary source of energy in all living cells. The sodium/potassium pump controls the volume of the cell and creates the electrical potential across the cell membrane. For example, the concentration of Na^+ is approximately 10 times higher outside the cell compared to the inside, and the concentration of K^+ is about 20 times higher on the inside of the cell. This difference is maintained by the action of the cell's ion pumps, which pump three sodium ions outside the cell for every two potassium ions that are pumped inside, consuming one molecule of ATP in the process. Because ions are charged molecules, a difference in chemical concentration establishes a difference in electrical charge as well. The ion channels and the ion pump work together to maintain this charge difference across the cellular membrane.

Bioelectrical functions

Synapses and synaptic transmission

A neuron, or nerve cell, consists of dendrites (receiving portions), a cell body, an axon, and the axon terminal.

KEY TERMS

Acetylcholine—A short-acting neurotransmitter involved in the process of muscle contraction.

Action potential—The change in electrical potential that occurs between the inside and outside of a nerve or muscle fiber when it is stimulated.

Active transport—The movement of ions across the cellular membrane against the electrochemical gradient by means of the sodium/potassium pump.

Adenosine triphosphate (ATP)—A nucleotide that is the primary source of energy in living tissue. It fuels the sodium/potassium pump.

Axon—The appendage of a neuron that transmits impulses away from the cell body.

Cytosol—The fluid portion of cell protoplasm.

Depolarization—Movement of the resting potential of a cell membrane back toward zero.

Diffusion—The movement of ions across the cell membrane from areas of higher concentration to areas of lower concentration.

Ion—An atom or atom group that acquires an electrical charge by the loss or gain of electrons.

Ion channel—A passive means of moving ions from one side of the cell membrane to another by diffusion.

Myosin—A protein found in muscle tissue that interacts with another protein called actin during muscle contraction.

Neurotransmitter—A chemical released by nerve endings that helps to transmit information from one nerve cell to another nerve cell, or from a nerve to a muscle.

Resting potential—A steady-state condition with no net flow of ions across the cell membrane. The resting potential can be observed on unstimulated nerve or muscle tissue.

Sodium/potassium pump—The mechanism of active transport that moves potassium ions into the cell and sodium ions out, consuming ATP in the process.

Synapse—A region in which nerve impulses are transmitted across a gap from an axon terminal to another axon or the end plate of a muscle.

The axon is a long appendage that conducts information in the form of action potentials away from the cell body. The site of contact between two **neurons** is called a synapse. The presynaptic neuron releases a chemical called a neurotransmitter into the synaptic cleft between the two neurons. The neurotransmitter passes on information to the postsynaptic neuron. Although most forms of communication between neurons are mediated by chemicals, some neurons also transmit information by direct electrical communication. Neurons may connect to other neurons, to muscles, or to receptor cells in the skin and other sensory organs.

Chemical or electrochemical stimulation of a neuron results in a temporary change in the permeability of the cell membrane. The membrane becomes more permeable to sodium and potassium ions. The sodium ions enter the cell because of their concentration and electrical gradient, while the potassium ions leave the cell because of their chemical gradient. The result is a depolarization (loss of electrical charge) of the cell. The nerve impulse, or action potential, can be defined as a localized region of depolarization that travels down the nerve fiber with the membrane potential being immediately restored behind it.

Transmission of nerve impulses to muscle

Muscle contraction is the end result of a process similar to the transmission of action potentials from one neuron to another. The neurotransmitter that is released from the presynaptic neuron is a chemical called acetylcholine. The postsynaptic cells on the muscle cell membrane receive the acetylcholine, which increases the permeability of the muscle cell membrane to sodium and potassium ions. As the sodium ions enter the cell, the potassium ions leave, producing a net depolarization of the cell membrane. This electrical signal travels along the muscle fibers. The muscle action potential is conveyed through the movement of calcium ions into actual muscle contraction through the interaction of two types of **proteins**, actin and myosin.

Role in human health

Bioelectricity is one of the fundamental forms of energy in the human body. In the form of moving action potentials, it is the basis for such central bodily functions as conduction of motor, autonomic, or sensory messages along the nerves; muscle contraction; and brain function. Specifically, motor nerve signals result in muscle contractions. Autonomic nervous signals control such basic functions of the body as breathing and heartbeat. Sensory nerve signals collect input from the outside world, including warnings of damage to the body in the form of **pain**.

Bioelectrical signals in humans

There are three types of electrical signals in human beings, two of which are routinely monitored or analyzed for diagnostic purposes. The first is the electroencephalogram, which is a relatively weak, fluctuating signal that originates in the brain. The second is the electrocardiogram, which is about 100 times stronger than the electroencephalogram, and is produced by the contractions of the **heart** muscle. The third type of electrical signal in humans, the surface electrical potential, is about as strong as the electrocardiogram but changes more slowly over time. The origin and significance of the surface electrical potential in humans are not yet known.

Common diseases and disorders

A large number of diseases and disorders are related to disturbances of the bioelectrical system. These conditions can be classified according to the component of the nerve cell/muscle cell group, or motor unit, that is affected. The motor unit can be divided into the motor neuron, the nerve root (paired bundles of nerves coming from the **spinal cord**), the nerve plexus (bundles of nerves further removed from the spinal cord), the peripheral nerve, the neuro-muscular junction, and the muscle fiber. Defects in any of these components may disrupt bioelectrical signals.

Defects in the motor neuron can be inherited, such as spinal muscular atrophies; or acquired, such as poliomyelitis or amyotrophic lateral sclerosis (Lou Gehrig's disease). Nerve root problems may result from herniated disks in the spine, metastatic **cancer**, neurofibroma, or trauma. Diseases of the plexus include acute brachial neuritis (inflammation of the nerves of the arm), damage caused by **diabetes mellitus**, **blood** clots, metastatic cancer, and trauma.

The peripheral nerves may be damaged through hereditary, infectious, inflammatory, and metabolic causes. Examples of some hereditary conditions include hereditary motor and sensory neuropathy (HMSN) and some autonomic neuropathies. **Infection** with diphtheria, herpes, HIV, leprosy, and Lyme disease can all cause types of peripheral neuropathies. Some inflammatory causes of peripheral neuropathy include chronic inflammatory demyelinating polyneuropathy (CIDP), Guillain-Barré syndrome, and vasculitis. Metabolic causes of peripheral nerve damage include amyloidosis, diabetes mellitus, dysproteinemic neuropathy, excessive ethanol intake (alcoholic neuropathy), and renal failure.

Disorders of the neuromuscular junction can result from botulism (severe **food poisoning** caused by ingesting the neurotoxin made by *Clostridium botulinum*), congenital myasthenic syndrome, Eaton-Lambert syn-

drome, myasthenia gravis, and toxic neuromuscular junction disorders.

Muscle fiber problems can be divided into dystrophies, channelopathies, and congenital, endocrine, and metabolic defects. Dystrophies are diseases characterized by progressive muscular weakness. Channelopathies are diseases caused by defects in the ion channels that control the membrane conduction system. These include familial periodic **paralysis** and Thomsen's disease. Central core disease, centronuclear myopathy, and nemaline myopathy are three examples of congenital muscle fiber damage. Endocrine disorders that may disrupt electrical signals to muscle tissue include acromegaly, Cushing's syndrome, hypothyroidism, and thyrotoxic myopathy. Metabolic causes of muscle fiber damage include glycogen storage disease and lipid storage disease.

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Michelle L. Johnson, M.S., J.D.

Bioethics

Definition

Bioethics is the study of moral issues in the fields of biology and health.

KEY TERMS

Cloning—The production of an organism that is genetically identical to its parent.

Deoxyribonucleic acid (DNA)—The genetic material of all cellular organisms and most viruses. DNA carries the information needed to direct proteins. Each molecule of DNA consists of two twisted strands, called a double helix.

Embryo—The initial developmental stage of human offspring following conception. After the eighth week an embryo is classified as a fetus.

Gene—The basic unit of heredity found in the cells of all living organisms, from bacteria to humans. Genes determine the physical characteristics that an organism inherits, such as hair and eye color.

Genetic engineering—Altering the genetic structure of an organism to provide it with traits deemed useful or desirable.

Hippocratic Oath—An oath taken by physicians to observe the ethical standards of their profession.

Human Genome Project—An international scientific collaboration that seeks to understand the entire human genetic blueprint.

In vitro fertilization—Fertilization of an ovum by sperm outside the body, and subsequent implantation in the womb.

Patent—A grant issued in the name of the United States under the seal of the Patent and Trademark Office, that gives the applicant exclusive rights related to ownership.

Stem cell—An undifferentiated cell from which specialized cells develop.

Description

Always complex and controversial, the field of bioethics has grown even more so with the advent of advanced technologies and treatments. The mechanical respirator and the heart-lung machine have blurred the line between life and death. The legalization of morning-after pills and the abortion drug RU-486, approved for use in the United States in 2000, have intensified the already volatile abortion debate. In vitro fertilization techniques to help infertile couples conceive raise a host of ethical issues including how couples should choose sperm or egg

donors, and what to do with fertilized eggs not implanted. Ethicists are also concerned with how scarce and expensive advanced treatments, such as in vitro fertilization, organ transplants, and the antiretroviral **AIDS** treatments should be distributed throughout society.

The rapidly evolving field of **genetic engineering** in particular, is introducing some of the greatest challenges ever faced in bioethics, as humans develop the ability to affect changes to living matter that were beyond imagining in the past decade or two. Current areas in experimental genetics of interest to bioethicists include:

- **Cloning.** The year 1997 marked the birth of the first clone, a sheep named Dolly produced from a cell of an adult female sheep. Since then hundreds of animals have been cloned, including bulls, cows, mice, monkeys, and pigs. Even clones of clones have been produced. The cloning controversy is multifaceted, with much of the controversy centered on the potential technical feasibility of cloning humans, although animal rights activists and others are also concerned that a substantial majority of cloned animals surviving to birth have significant birth defects. Humans should never be exposed to such risks, argue opponents of human cloning research. Some opponents fear a future in which cloning technology is used by narcissistic parents to custom design their offspring, while proponents see human cloning as a potentially useful technique to treat **infertility** or avoid known hereditary traits for disease. Several U.S. states have banned human cloning.
- **Stem cell research.** Stem cells, which are undifferentiated cells that give rise to specialized cells throughout the body, are considered one of science's best tools for finding cures for many diseases, as well as for developing bioartificial **blood**, skin, and organs that will not be rejected by the body. Stem cell research is currently hampered by the controversy surrounding the source of the cells, which are sometimes culled from aborted fetuses or from embryos left behind after **fertility treatments**, or are produced using cloning technology. Some religious groups such as the Roman Catholic Church condemn the use of human embryos for research, and Congress has passed restrictions on federal funding of embryonic stem cell research.
- **Gene patenting.** Advances in genome research wrought by the Human Genome Project and others have led many individuals and institutions, public and private, to apply for patents on genes and gene combinations. Many fear the patenting of genes may make **genetic testing** of patients prohibitively expensive. Although it will be technically possible in the not-too-distant future to analyze patients' genomes in the primary care en-

vironment and provide them with information about their future disease risk, this technology will not be economically feasible if it requires payment of multiple license fees.

- **Genetic testing.** Controversial genetic tests in use for several decades allow parents to learn about genetic diseases like sickle-cell anemia prior to birth. An experimental technique known as preimplantation genetic diagnosis gives couples even more control, enabling genetic analysis of embryos created through in vitro fertilization before they are implanted in the uterus. Many fear this technique may one day be used not just to pinpoint genetic diseases, but also to choose embryos with more desirable attributes. Other genetics tests that pinpoint flawed genes, and predict one's drug responses and vulnerability to disease offer numerous potential benefits, but ethicists are concerned about how this information will be used. Employers or insurers may use such information to discriminate, for example.

Viewpoints

A multitude of viewpoints exist regarding every area of health care influenced by bioethics. While some individuals believe bioethics results in legislation that unnecessarily impedes the progress of science (for example, it is costly and time consuming for researchers to comply with **informed consent** laws), most recognize the need for at least some bioethical guidelines (the costs of compliance pales in comparison to the safeguard of informed consent on human subjects). Some individuals believe the field of bioethics is increasingly important as research technologies develop with the potential to strip away human privacy, and even to alter the definition of human life. Private and public healthcare organizations have attempted to present ethical guidelines for practitioners. For example, the American Medical Association's Council on Ethical and Judicial Affairs sets ethics policy for the American Medical Association (AMA), and AMA's Institute for Ethics investigates how professional ethics can be integrated into health care. Other organizations such as the American Association of the Advancement of Science, take formal positions on various bioethical issues to guide health care practitioners and the general public. Also, the U.S. Department of Energy and the National Institutes of Health devoted 3% to 5% of their annual Human Genome Project budgets toward study of the bioethics of genetic information, making theirs the world's largest bioethics program.

Professional implications

Because many of the current technologic advances in health care, including the advances in genetics, offer

tremendous risks in addition to potent opportunities to predict and treat human diseases, there is a need for practitioners to main a bioethical framework in their use of these technologies, if they are to adhere to their professional oaths.

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American Society for Bioethics and Humanities. 4700 W. Lake, Glenview, IL 60025-1485. (847) 375-4745. Fax: (877) 734-9385. <<http://www.asbh.org/>>.

The American Society of Human Genetics. 9650 Rockville Pike, Bethesda, Maryland 20814-3998. (301) 571-1825. <<http://www.faseb.org/>>.

Center for Bioethics at the University of Pennsylvania, Suite 320, 3401 Market Street, Philadelphia, PA 19104-3308. (215) 898-7136. <<http://bioethics.org>>.

National Bioethics Advisory Commission, 6705 Rockledge Drive, Suite 700, Rockville, Maryland 20892-7979. (301) 402-4242. <<http://www.bioethics.gov>>.

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Ann Quigley

Biological rhythms

Definition

A biological rhythm is one or more biological events or functions that reoccur in time in a repeated order and with a repeated interval between occurrences.

Description

Biological rhythms are the ways that organisms adapt and live with the environmental rhythms around them, such as the spin of the earth, the movement of the earth around the sun, and movement of the moon around the earth. Often generated by “biological clocks” (the term for the internal physiological systems that track the environmental rhythms), biological rhythms allow an organism to harmonize successfully with its environment. Although biological rhythms have not been studied in every living thing, they have been found in every organism in which experiments were performed. Accordingly, scientists believe biological rhythms are ubiquitous.

Generally, there are two types of biological rhythms, exogenous and endogenous. Exogenous biological rhythms are driven directly by the environment or another external influence. Another term for this type of biological rhythm is a direct effect. An example of an exogenous biological rhythm is the hopping of sparrows on a perch when a light is turned on. Such rhythms are said to have a geophysical counterpart; in this case, the presence of light.

In contrast, endogenous biological rhythms are driven by internal biological clocks and are maintained even when environmental cues are removed. Some examples of endogenous biological rhythms are the wake-sleep cycle and the daily body temperature cycles. Sometimes it is difficult to determine whether the activity of an animal is due to a direct effect or that of an endogenous biological clock, because the two types of rhythms can mask each other.

True biological clocks have four important characteristics. First, the clock is endogenous, meaning it gives the organism an innate ability to maintain periods of a particular length between biological functions. Experiments in space, with animals completely isolated from earthbound geophysical input, have supported the innate nature of the clocks. Second, the clock is temperature independent—a very unusual situation in biology but an essential characteristic to avoid biological rhythms being governed by the weather. Third, biological clocks have the ability to be reset in order to maintain a relationship with environmental cues. Finally, biological clocks are an internal continuous monitor of the passage of time, allowing the organism to keep track of duration biologically.

Chronobiology, the study of biological rhythms, categorizes rhythms by the length of the cycle. The most studied type of biological rhythm are circadian rhythms, which fluctuate on a daily basis. Alertness, body temperature, and the circulating concentrations of growth hor-

mone, cortisol, and postassium are all examples of physiological functions that run on a circadian basis. Infradian cycles last about a month or longer. Menstruation in the human adult female is an example of an infradian biological rhythm. Circannual cycles last about a year; over-winter hibernation as a common example. The shortest cycles are ultradian, where the cycles are less than 24 hours. **Heart** rate and breathing are two examples of ultradian biological rhythms.

Function

The function of biological clocks and the resulting biological rhythms involves two factors: the capacity of the biological clock to freerun (operate without external cues), and the ability of timing signals, known as *Zeitgeber* (German for “time-giver”), to synchronize the cycles to the environmental signals. Some common Zeitgebers include light, temperature, and social cues such as clocks, sound, or physical contact. A biological clock is said to be freerunning when these external cues are removed. Based on multi-day isolation experiments, the average freerun period for circadian rhythms in humans is 25 hours. Thus, if isolated from outside input, people tend to go to sleep one hour later each day, quickly becoming out of sync with the rest of the 24 hour-based human world.

Entrainment is the process of aligning a biological rhythm with an environmental stimulus. There are limits to the time periods that biological rhythms can be entrained. For circadian rhythms in most animals, 18 hours is the shortest period tolerated, with an upper limit of about 28-30 hours. If Zeitgebers are provided for shorter or longer intervals, the organism reverts back to freerunning. A good example of entrainment is the acquisition of the 24-hour wake-sleep schedule by human infants after birth. Newborn circadian rhythms freerun, significantly disrupting the sleeping patterns of their parents. However, as they mature and become responsive to Zeitgebers such as light and dark, infants gradually adopt the 24-hour schedule of adults.

Physiology of biological clocks

The physiological location of biological clocks has been studied in a number of animal systems, including humans. In most vertebrates other than mammals—sparrows, for example—the primary biological clock has been located in the pineal gland. This gland is located at the base of the **brain** and is responsible for the production of melatonin, a hormone produced in high levels at night and low levels during the day.

In mammals, additional cells responsible for biological clock functions were located in the hypothalamus, in

two clusters of nerve cells called the suprachiasmatic nuclei (SCN). Light receptors in the retina are connected by nerves to the SCN. The SCN and the mammalian pineal gland are linked, by both nervous connections and by the presence of melatonin receptors on SCN cells. Thus, light is detected by the eye, which passes this information on to the SCN, which in turn passes the information on to the pineal gland, controlling melatonin production.

The exact function of melatonin in mammals is not completely understood. Scientists believe this hormone is likely involved in many aspects of biology, including the wake-sleep cycle, body temperature control, and (particularly with mammals that have seasonal mating) sexual maturity and reproduction.

Genetic control of biological clocks

The molecular basis for the control of circadian rhythms has been studied extensively in the fruit fly insect model, where the first genetic mutants that affected circadian rhythms were discovered. Because homologs to the fruit fly genes (genes which have a similar structure, and therefore likely have a similar function) have been discovered in mammals, including mice and humans, scientists strongly suspect that similar control mechanisms have been conserved in mammals.

In fruit flies, five genes are believed responsible for the baseline oscillation of the circadian rhythms: period (*per*), timeless (*tim*), clock (*clk*), cycle (*cyc*), and doubletime (*dbt*). The protein products of these genes work together to produce a negative feedback loop that allows the concentration of the period and timeless **proteins** to build in concentration slowly over the 12-hour day. Both clock and cycle are positive transcription elements. These proteins work together to result in the production of the period and timeless proteins.

When the period protein is produced, the doubletime protein modifies it, marking it with a phosphate molecule for quick destruction by the cell if not paired with the timeless protein. Thus, the period protein will be degraded until the concentration of timeless protein is high enough so that period and timeless dimers form. The destruction resulting from the phosphate modification delays the formation of the dimers, stretching out the process over the 12-hour evening.

Eventually, dimers of period and timeless are present in high enough concentrations to interact with clock and cycle proteins to turn off production of both period and timeless proteins, closing the feedback loop. At dawn, the highly light-sensitive timeless protein is degraded, leaving the phosphorylated period protein unpaired and vulnerable to degradation as well. In this way, light resets

KEY TERMS

Chronobiology—The study of biological rhythms.

Circadian—A biological rhythm that happens about once a day.

Dimer—A pair of proteins that noncovalently bond to each other during function.

Entrainment—The synchronization of a biological rhythm and an environmental cue.

Freerun—The length of the period of a biological rhythm in the absence of environmental cues.

Homolog—A gene found in a particular species that is similar in sequence and often in function to another gene from another species.

Zeitgeber—A cue from outside the body that resets the biological clock.

the feedback loop to start again, making it the Zeitgeber for this biological clock.

In early 2001, studies of the molecular basis of biological rhythms were extended to humans, with the report of the first known human gene homologous to the fruit fly genes. The gene is called hPer2 and is homologous to the period gene. A mutation in this gene is present in a Utah family and results in an advanced sleep phase syndrome. The mutation maps to the location where the period gene is marked with a phosphate, suggesting that the mutant protein would be not be phosphorylated. The details of the mutation fit the proposed function of the protein and the problems seen by those having the mutation. Lack of phosphorylation would cause the mutant protein to be degraded more slowly, speeding up the circadian rhythms of the person having the mutation.

Role in human health

The exact role of biological rhythms and biological clocks in human health is not fully understood. However, it is clear that humans are subject to biological clocks in a number of physiological areas, most notably hormone secretion and wake-sleep cycles. A well-functioning biological clock is important for falling asleep and getting enough of the various stages of normal sleep. This affects, in turn, alertness, job performance, interpersonal relationships, and day-to-day safety issues. Well-functioning circadian rhythms may also play a role in psychological health, particularly for persons living in areas with decreased light in the winter months.

Common diseases and disorders

The most common human disorders related to biological rhythms are due to disassociations of the endogenous biological clock and the external environmental cue. These displacements are called phase shifts and occur with rapid travel across time zones and shift work. The resulting disorientation produces the symptoms known as jet lag—sleep disturbances, fatigue, indigestion, and nausea. When occurring in the workplace these symptoms can have serious consequences. The *Exxon Valdez*, Chernobyl, and *Challenger* shuttle disasters all occurred on the night shift. Research is ongoing to develop methods of using melatonin and bright light exposure to help compensate.

The role of biological rhythms in seasonal affective disorder (SAD), a form of depression with symptoms more severe in the winter months, is much less clear. Studies have been unable to find other evidence of circadian disorder in persons diagnosed with SAD. However, treatment with light therapy does bring significant improvement in the majority of patients.

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Michelle L. Johnson, M.S., J.D.

Biomedical engineering

Definition

Biomedical engineering, also known as bioengineering, is the application of engineering principles to the study of medical and biological problems. The goal of biomedical engineering is to use electrical, chemical, and mechanical engineering principles to conduct studies and develop tools that can aid in the biomedical care of patients.

In 1997, the National Institutes of Health issued the following expansive definition of biomedical engineering/bioengineering: "Bioengineering integrates physical, chemical, or mathematical sciences and engineering principles for the study of biology, medicine, behavior, or health. It advances fundamental concepts, creates knowledge from the molecular to the organ systems levels, and develops innovative biologics, materials, implants, devices, and informatics approaches for the prevention, diagnosis, and treatment of disease, for patient rehabilitation, and for improving health."

Description

Biomedical engineering can trace its history to as far back as a hundred years ago, when the first x-ray machines and electrocardiographs dramatically illustrated how technology could be applied towards the diagnosis of disease. Today, the field of biomedical engineering is in full flower, propelled by the momentum of the post-World War II technology boom and the latest molecular, genetic, and computational developments. Having gone beyond its roots in imaging and instrumentation, biomedical engineering now encompasses at least 13 specialties, according to the 2000 edition of *The Biomedical Engineering Handbook*.

These specialties include

- biomechanics
- prosthetic devices and artificial organs
- transport phenomena
- biomaterials
- biomedical instrumentation
- biosensors
- medical and biologic analysis
- medical imaging
- physiologic modeling, simulation, and control
- biotechnology
- rehabilitation engineering

- clinical engineering
- medical informatics

Biomechanics, prosthetic devices and artificial organs, and transport phenomena

Biomechanics is the application of classical mechanics (the study of how objects move in response to forces placed on them) to biomedical problems. Classical mechanics provides general principles for understanding (for example) how fluids move, how objects become deformed under various forces, and how levers and forces move objects. Biomechanics uses these principles to understand how **blood** moves throughout the body, how injuries affect the shape and mechanics of body parts, and the mechanics of body movement (e.g. how an arm is lifted, or how a person walks). Biomechanics has contributed to an understanding of the mechanical function of the bones, cartilage, and soft tissue in the musculoskeletal system, as well as an understanding of other major organ systems, such as the **heart, lungs, and blood vessels**. Some of the technologies coming from biomechanics include artificial hearts and heart valves, and artificial joints such as prosthetic hip and knee replacements. These types of technologies have spawned another specialty in biomedical engineering, prosthetic devices and artificial organs. Another closely affiliated specialty is transport phenomena. This subfield concerns itself with the processes of fluid flow and heat transfer in biological systems.

Biomaterials

Biomaterials are living and artificial materials that can be used in implantation. Whereas biomechanics focuses on the mechanical design of an implant, biomaterials science focuses on the body's biochemical interactions with the material from which an implant is made. A biomaterial for an implant should be chemically inert, non-toxic, and non-carcinogenic. It should also be resilient enough to endure a lifetime of chemical and mechanical forces. Biomedical engineers in the specialty of biomaterials test and study materials possibly suited for implantation. Biomaterials science has contributed to the use and understanding of currently used implant materials, such as ceramics, polymers, metal alloys, and composite materials. Biomaterials science is also leading research into the use of living tissue as implant material with the goal of minimizing implant rejection and simulating the body's original biomechanical environment.

Biomedical instrumentation, biosensors, medical and biologic analysis

Biomedical instrumentation, or bioinstrumentation, uses mechanical, electrical, and optical principles and

systems to monitor the body's physiologic status. Many of the physiologic changes that occur in the body are mediated by electrical signals. Different ions (charged elements or molecules) are allowed to flow into and out of cells at different times, depending on cellular and systemic demands. Biomedical instrumentation attempts to infer aspects of the body's physiologic state by measuring and interpreting these electrical signals. Optical systems are used to measure the variable of interest indirectly; for example, because hemoglobin—the molecule that carries oxygen in the blood—changes its light absorptiveness according to whether it is attached to oxygen, changes in the oxygenation of blood can be inferred from the optical properties of blood and tissue.

The specialty of biosensors focuses on the development and instrumentation of measurement systems. Technologies emerging from biomedical instrumentation generally, and biosensors specifically, include electrocardiographs (ECGs) and pulse oximeters that measure blood oxygenation. The associated specialty of medical and biologic analysis seeks to refine current understanding of the biomedical signals received by the instruments. It attempts to discern and amplify the signals of interest while diminishing noise and unrelated signals. In addition to biomedical measurement, the specialty of biomedical instrumentation includes the development of devices to control and guide biomedical processes through mechanical or electrical means, e.g., cardiac **pacemakers** and respirators.

Medical imaging

Medical imaging uses energy phenomena and physics principles, in conjunction with high-speed data processing, to produce images of the body that reflect its anatomic structure and physiologic function. Developments in medical imaging include x-ray applications (**mammography, angiography**), ultrasound, computer tomography (CT), **magnetic resonance imaging** (MRI), single-photon emission computed tomography (SPECT), and **positron emission tomography** (PET). Each of these technologies is based on exploiting an understanding of electromagnetic or sound energy patterns to provide images of not readily observable aspects of body structure and function.

Physiologic modeling, simulation, and control

Physiologic modeling, simulation, and control—also known as systems physiology—attempts to provide formal quantitative models of the various systems of the body, from micro-level systems (at the level of the cell) to macro-level systems (at the level of large organ systems and full-body interactions). Using experimental

data and mathematical models, system physiology relies on computer simulation to describe and understand human physiology. These models provide a basis for thinking about how the body functions in an integrated way. Systems physiology is the source of such models as cardiovascular models, respiratory models, neural network models, and biochemical metabolic models.

Biotechnology

Biotechnology, also known as cellular, tissue, and **genetic engineering**, is the study of how biological materials can be modified at a micro-level for useful ends. Biotechnology studies the biochemistry and physics of cells to develop beneficial interventions and biomedical research and diagnostic tools. A sprawling specialty, biotechnology developments have included the development of new diagnostic tests for diseases, the invention of miniature devices that can deliver therapeutic drugs to specific sites, and the production of synthetic vaccines and therapeutic **proteins**.

Rehabilitation engineering

Rehabilitation engineering focuses on developing tools for cognitive and physical rehabilitation. Specifically, rehabilitation engineering is concerned with designing technologies that assist mobility and communication. These include the development of rehabilitation **prosthetics**, the design of living space modifications, the development of transportation alternatives, and the design of hardware and software to aid in communication and cognitive rehabilitation.

Clinical engineering

Clinical engineering focuses on how the latest biomedical technologies are used in a clinical setting. Aspects of this specialty include the adaptation of biomedical technologies to the needs of the hospital and clinicians, the management of medical instrumentation and equipment, and the purchase and use of current biomedical technologies. An important aspect of clinical engineering is the interface between the medical instrumentation and the clinical software that records data of interest to the hospital. Patient safety and progress are also important aspects of clinical engineering.

Medical informatics

Medical informatics is the study of how information is used and disseminated in health care settings. Medical informatics includes the study of health information systems, computer networks in clinical settings, and clinical decision systems. Tools used in medical informatics

include neural network models, artificial intelligence models, expert systems, and patient records and archives.

Work settings

Biomedical engineers and biomedical engineering technologists work in a variety of private and public sector settings. In the private sector, biomedical engineers and technologists find employment in industry, such as at biomedical device firms and pharmaceutical companies, and in hospitals. In the public sector, biomedical engineers and technologists are employed at research facilities, universities, and government agencies. Depending on the specialty, biomedical engineers may work in a laboratory setting, a clinical setting, a software development setting, or a managerial/administrative environment. Because of their multidisciplinary training, biomedical engineers often serve in a liaison or coordinating role, interacting with both engineering and medical professionals.

Education and training

A four-year university degree in a biomedical engineering or bioengineering program is the minimum required for a biomedical engineer. The undergraduate program gives training in both biological and engineering aspects of the field, and specialization in a subfield may be required. The undergraduate degree program should be accredited by ABET, or the Accreditation Board for Engineering and Technology, Inc., which imposes strict requirements on curriculum design and quality.

If a biomedical engineer wants to offer his/her services to the public, she or he must be registered as a Professional Engineer. To qualify for a license, an individual must (1) have graduated from a degree program approved by ABET, (2) have had a minimum of four years of engineering experience, and (3) pass the Professional Engineer exam offered by the National Council of Engineering Examiners. After a Professional Engineer license is issued, the license can be renewed every two years, contingent on satisfying the continuing education requirements.

To become a biomedical engineering technologist (BMET), a two-year (associate) degree in **biomedical equipment technology** or electronics technology is the minimum education typically required. In this program, the BMET learns the basic biomedical principles and the instrumentation skills required to operate and maintain biomedical equipment.

Certification for BMETs is given through the International Certification Commission (ICC) for Clinical Engineering and Biomedical Technology. To be eligible

for certification, an individual must have either the appropriate associate's degree and two years of full-time BMET work experience, or four years of full-time BMET work experience. The individual must also pass the biomedical equipment technician test given by the ICC.

Advanced education and training

To conduct research and develop designs in biomedical engineering, a PhD degree in biomedical engineering is required; in some cases, depending on the specialty, a master's degree may be sufficient. Some biomedical engineers also have advanced degrees in other fields such as clinical medicine.

BMETs are typically offered many opportunities for on-the-job training. In addition, continuing education is a requirement for the renewal of BMET certification.

Future outlook

The occupational outlook for biomedical engineering is good, particularly for those engineers who elect to work in industry. According to the University of Cincinnati Center for Economic Education, the medical instruments and supplies industry grew by 27% during the period from 1987 to 1994. The biotechnology industry has been expanding at an even faster rate. Although the recent economic downturn has slowed the expansion in the biotechnology sector somewhat, the health care industry and allied industries are expected to maintain strong growth.

The American Society for Engineering Education reports that, among biomedical engineering Ph.D. graduates who received their degrees during the academic year 1996–97, the average starting salary for those working in industry was \$62,000. About 50% of Ph.D. biomedical engineering graduates surveyed chose to work at universities, and the average salary of this group of graduates was \$48,000. The average salary of clinical engineers (who do not have PhDs) was also \$48,000.

For biomedical engineering technologists, particularly those who work at hospitals, the outlook is very bright. According to the Association for the Advancement of Medical Instrumentation, the high demand for and relative shortage of BMETs mean higher salaries and greater benefits for job candidates. According to the 2000 salary survey reported in the *Journal of Clinical Engineering*, the average salary for a BMET I position in 1999 was \$31,600, while that of a BMET III position was \$48,000.

Overall, the occupational outlook for biomedical engineers and biomedical engineering technologists is very good, especially in hospitals and private industry.

Because of the continuing interest in biomedical technology developments, demand for biomedical engineers in government and at research institutes will remain moderately strong.

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ORGANIZATIONS

The Association for the Advancement of Medical Instrumentation. 110 N. Glebe Road, Suite 220, Arlington, VA 22201-4796. (703) 525-0890. <<http://www.aami.org/>>.

The Biomedical Engineering Society. 8401 Corporate Drive, Suite 110, Landover, MD 20785-2224. (301) 459-1999. <<http://www.mecca.org/BME/BMES/society/index.htm>>.

Engineering in Medicine and Biology Society of the Institute of Electrical and Electronic Engineers. 445 Hoes Lane, Piscataway, NJ 08855-1331. (732) 981 3451. <<http://www.ewh.ieee.org/soc/embs/>>.

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The Biomedical Engineering Network of the Whitaker Foundation. <<http://www.bmenet.org/BMEnet/>>.

Genevieve Pham-Kanter

Biomedical equipment technology

Definition

Biomedical equipment technology professionals are employed at jobs involving the repair, sale, calibration, installation, troubleshooting, and management of biomedical instrumentation and electronics technology in the health industry.

Description

Biomedical equipment technology is a profession that requires broad knowledge of biomedical system instrumentation. Necessary knowledge includes system usage, maintenance responsibilities, and ways to obtain data on an extensive range of monitoring, diagnostic, therapeutic, and surgical instrumentation. Solutions to issues encountered while interacting with doctors, nurs-

es, and other technicians who use biomedical instrumentation are often studied and realized by those in the profession. A biomedical equipment technologist must study electronics, electronics management, medical physiology, and computer applications. After graduating, he or she may opt to specialize in particular types of equipment used, generally in nuclear medicine, surgery, radiology, clinical laboratory, dialysis, or intensive care.

Work settings

Graduates of biomedical equipment technology programs usually work

- in hospitals
- in medical clinics
- at medical colleges
- at medical research facilities
- at computer and electronic instrumentation manufacturers
- at companies as sales representatives or distributors
- in United States government agencies
- in the U.S. Armed Forces
- in **public health** services
- as field service technicians

On the job, a biomedical equipment technologist may work with machines used to diagnose and treat diseases or disorders, or those used to assist in the role of vital organs (e.g. a respirator). They often work under the supervision of biomedical engineers, performing such tasks as the evaluation, inspection, repair, maintenance, and installation of diverse instrumentation, including electrosurgical equipment; ultrasound devices; chemical analyzers; defibrillators; centrifuges; x-ray instrumentation; spectrophotometers; infusion pumps; **heart**, lung, and **kidney dialysis** machines; **pacemakers**; infant incubators; respirators; **blood pressure** and heart rate monitors; and **magnetic resonance imaging** (MRI or NMR) machines.

Education and training

Biomedical equipment technologists may be trained at vocational schools (which may lead to a job involving on-the-job training), technical colleges, community colleges, military training schools, or at various universities as part of a standard Bachelor of Science program. Education includes instruction in electronics, circuit theory, computer applications, bio-instrumentation, health and safety, and general knowledge of **human anatomy**, physiology, and terminology. Background knowledge of

physics and mathematics is essential and is expanded during coursework, especially involving applications of biomedical electronics. The technologist should possess solid communication skills, manual dexterity, and hand-eye coordination for labor on machine parts and electronic circuits. Education generally culminates in an associate's degree (two years) or a bachelor's degree (four years). Many programs associated with either degree sponsor extensive co-op or internship opportunities that provide ample occasion to sample some aspects of the field. Specialties are not commonly available during educational training, but one may choose to specialize upon graduation in a relevant type of instrumentation technology; it is possible to specialize in a specific instrument if the demand is great enough, or to specialize in education, repair, calibration, etc.

Upon graduation from an associate degree program, a graduate will be capable of performing a range of tasks. Erie Community College of western New York and the University of Florida (which adds the final four items) provide lists of what is expected of a typical graduate, reproduced below:

- Be able to use the resistor color code and component recognition.
- Be proficient at electronic soldering and terminating wire connections using solderless-type connectors.
- Use a curve tracer to check all types of diodes, bipolar transistors, and field effect transistors.
- Demonstrate proficiency in using electronic test instrumentation dual trace scopes, frequency counters, and function generators.
- Be proficient at troubleshooting half-wave, full-wave, and bridge power supplies. In addition, students should be able to troubleshoot and repair voltage doublers.
- Demonstrate proficiency in using electronic instrumentation.
- Prototype multi-stage analog and digital circuits.
- Interact with computer systems.
- Isolate data communications systems faults.
- Isolate and repair computerized process devices.
- Analyze system malfunctions by relating program execution to specific groups of circuits.
- Perform routine safety checks on equipment including ground and leakage current tests.
- Read and interpret instructions and maintenance manuals as well as blueprints, mechanical drawings, and schematic diagrams related to equipment serviced.
- Install equipment and provide instruction on its use to physicians, nurses, physical therapists, and others.

- Inspect and calibrate equipment such as radiation monitors, **blood** gas analyzers, electrocardiographs, dialysis machines, and many others to insure safety and accuracy.
- Modify components to meet specific therapeutic or diagnostic requirements.
- Maintain an inventory of parts and tools used in repair work.

Advanced education and training

Technicians with an associate's degree have advancement opportunities including progressing to senior technician or shop supervisor and becoming certified within five years (normally two years); graduation results in eligibility to take the certification exam to become a certified biomedical equipment technician (CBET). With more advanced education, technicians may become instructors, administrators, or research assistants in medical research facilities. One may also advance through specializing, becoming an expert, in a particular type of equipment.

Technicians with a bachelor's degree have all the options open to associate's degree holders with additional alternatives. Qualified students may further their education in biomedical equipment technology with a masters or doctoral degree, usually in a field such as electrical engineering or **biomedical engineering**; however, these graduates are then not generally classified as biomedical equipment technologists, but as biomedical engineers or an equivalent.

The International Certification Commission for Clinical Engineering and Biomedical Technology (ICC) is the group responsible for formally recognizing qualified biomedical equipment technicians (BMETs) through administration of written examinations. Certification is achieved by exhibiting high aptitude in both the theoretical aspects and practical applications of the central tenets of biomedical equipment technology. The exam board, which is overseen by the ICC and the United States Certification Commission (USCC), governs not only the CBET certification program, but also the programs of two specialties: radiology equipment specialists (CRES) and clinical laboratory equipment specialists (CLES). Each program requires a separate examination for certification and is entirely independent of the others. It is also possible to become certified by the Association for the Advancement of Medical Instrumentation (AAMI).

Future outlook

Biomedical equipment technologists are employed throughout the world, and there is always a need for professionals who can understand, operate, and instruct other health professionals in the increasingly complex, rarefied business of biomedical instrumentation. The outlook for biomedical equipment technologists is better than average in the near future (as of 2001), through at least the year 2005.

The field of biomedical equipment technology is still considered relatively new, so job opportunities abound as new types of jobs are found for professionals with a biomedical equipment technology education and related experience. The plethora of biomedical devices on the market and waiting to reach the market is still accelerating, and as such, requires the assistance of biomedical equipment technicians to install, calibrate, test, maintain, evaluate, assist with usage of, instruct doctors and other health professionals about, and to repair. As might be expected, however, jobs for biomedical equipment technicians tend to be significantly greater in larger cities that include more hospitals and comparable medical facilities.

Resources

BOOKS

Carr, Joseph J., and John M. Brown. *Introduction to Biomedical Equipment Technology*, 4th ed. Prentice Hall, 2001.

ORGANIZATIONS

Association for the Advancement of Medical Instrumentation (AAMI). 1110 N. Glebe Road, Suite 220, Arlington, VA 22201-4795. (703)525-4890. Fax: (701)525-1424. <<http://www.aami.org>>.

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Biomedical Equipment Technology Program.

<<http://www.siu.edu/~imsasa/elm/biomed.htm>>.

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Bryan Ronain Smith

Biophysical profile see **Fetal biophysical profile**

Biopsy see **Lung biopsy**

Biorhythms see **Biological rhythms**

Biotin

Description

Biotin is a member of the B complex family, but is not actually a vitamin. It is a coenzyme that works with them. Also known as vitamin H and coenzyme R, it was first isolated and described in 1936. It is water soluble and very unstable; it can be destroyed by heat, cooking, exposure to light, soaking, and prolonged contact with water, baking soda, or any other alkaline element. The body obtains biotin from food and can also synthesize this nutrient from **bacteria** in the digestive tract.

General use

Biotin is utilized by every cell in the body and contributes to the health of skin, hair, nerves, bone marrow, sex glands, and sebaceous glands. Apart from being a vital cofactor to several enzymes, biotin is essential in carbohydrate **metabolism** and the synthesis of fatty acids. It is also involved in the transformation of amino acids into protein. Biotin plays a role in cell growth and division through its role in the manufacture of DNA and RNA, the genetic components of cells.

Adequate biotin is required for healthy nails and hair, and biotin deficiency is known to be a factor in balding and the premature graying of hair. It has been claimed that, as part of an orthomolecular regime, it can reverse the graying of hair. When PABA and biotin are taken together in adequate amounts they can restore hair color. Biotin supplements will also effectively treat weak, splitting nails.

Biotin can be a valuable tool to combat yeast infections, which are notoriously difficult to eradicate. In their book *The Yeast Syndrome*, John Parks Trowbridge and Morton Walker describe how adequate levels of biotin can prevent *Candida albicans* from developing from its yeast-like state into fungal form, in which it sends out mycelium that further invade body organs.

Seborrheic dermatitis, or Leiner's disease, which is a non-itchy, red scaling rash affecting infants during the first three months of life, is also treated with biotin and other B complex **vitamins**.

Biotin has been used in conjunction with other nutrients as part of weight loss programs, as it aids in the digestion and breakdown of **fats**.

High doses of biotin are sometimes used by the allopathic medical profession to treat diabetes since it enhances sensitivity to insulin and effectively increases levels of enzymes involved in glucose metabolism. Biotin is also used to treat peripheral neuropathy, a com-

plication of diabetes, and those with Duchenne **muscular dystrophy**, who suffer from metabolic deficiencies.

Biotin can be found in beans, breads, brewer's yeast, cauliflower, chocolate, egg yolks, fish, kidney, legumes, **liver**, meat, molasses, dairy products, nuts, oatmeal, oysters, peanut butter, poultry, wheat germ, and whole grains.

Preparations

The recommended daily allowance for adults in the United States is 30 mcg. Daily requirements are estimated at 30 mcg for adults and 35 mcg for women who are nursing. Supplementation ranges from 100–600 mcg per day, and can be obtained in the form of brewer's yeast, which contains biotin as part of the B complex, or as an individual biotin supplement.

Precautions

The body needs biotin on a daily basis since it is not stored to any great extent. Biotin requirements increase during **pregnancy** and **lactation**, and should be supplemented in anyone who is taking **antibiotics**. Certain individuals are at risk for biotin deficiency, including infants fed biotin-deficient formula or with inherited deficiency disorders, patients who are fed intravenously, and anyone who habitually eats a lot of raw egg whites, because they contain a protein called avidin, which prevents the absorption of biotin.

Mild deficiency

Because it is synthesized in the digestive tract, deficiency symptoms of biotin are rare. However, they may include weakness, lethargy, grayish skin color, eczema (which may include a scaly red rash around the nose, mouth and other orifices), hair loss, cradle cap in infants, muscle aches, impaired ability to digest fats, nausea, depression, loss of appetite, insomnia, high cholesterol levels, eye inflammations, sensitivity to touch, anemia, and tingling in the hands and feet.

Extreme deficiency

Symptoms of extreme biotin deficiency include elevation of cholesterol levels, **heart** problems, and **paralysis**. When extreme deficiency is a problem, the liver may not be able to detoxify the body efficiently, and depression may develop into hallucinations. Infants may exhibit developmental delay and lack of muscle tone.

Biotin deficiency could result in a loss of immune function, since animal experiments have shown that biotin deficiency resulted in a decrease in white blood-

KEY TERMS

Coenzyme—A non-protein organic compound that plays an essential role in the action of particular enzymes.

Lactobacillus—A bacteria present in the digestive tract of healthy people.

Mycelium—Fine thread-like tendrils sent out by a fungus to seek nutrition, capable of invading body organs.

Peripheral neuropathy—Weakness and numbness of the nerves in the fingers and toes, which may progress up the limb—often a complication of diabetes.

cell function. Because biotin is essential to the body's metabolic functions, any deficiency could result in impaired metabolism as well.

Overdose

There have been no reports of effects of **overdose** of biotin, even at very high doses, primarily because any excess is excreted in the urine.

Side effects

There are no side effects associated with biotin supplementation.

Interactions

Biotin works in conjunction with all the B vitamins, which are synergistic, meaning they work best when all are available in adequate amounts.

Raw egg white contains the protein avidin, which prevents absorption of biotin.

Sulfa drugs, estrogen, and alcohol all increase the amount of biotin needed in the body. In addition, anti-convulsant drugs may lead to biotin deficiency. Long term use of antibiotics may prevent the synthesis of biotin in the digestive tract by killing off the bacteria which help the body produce biotin. Supplements of lactobacillus may help the body make sufficient amounts of biotin after long term antibiotic use.

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Patricia Skinner

Bipolar disorder

Definition

Bipolar, or manic-depressive disorder, is a mood disorder that causes radical emotional changes and mood swings, from manic highs to depressive lows. The majority of bipolar individuals experience alternating episodes of mania and depression. The switch between highs and lows often comes without warning. For instance, a “high” mood can quickly deteriorate into a “low,” which causes the sufferer exceptional **stress**.

Description

An estimate by the National Institute of Mental Health states that more than two million American adults—about 1% of the population age 18 and over in any given year—have bipolar disorder. Bipolar disorder typically develops in late adolescence or early adulthood. However, some people have their first symptoms during childhood, while others develop them late in life. Very often, bipolar disorder is not recognized as an illness. Many people suffer for years before it is properly diagnosed and treated. Like diabetes or **heart** disease, bipolar disorder is a long-term illness that must be carefully managed throughout a person's life.

An even grimmer survey by the National Depressive and Manic Depressive Association (NDMDA) estimates that over 17.4 million adults in the United States suffer with an affective disorder each year (one in seven people). Women are twice as likely as men to experience major depression, while manic depression occurs on an even percentage between the sexes. Onset of major or manic depression can occur at any age, however it most commonly develops between the ages of 25 and 44.

The problem is compounded by inaccurate or no diagnoses in the early stages. A survey taken by the NDMDA reports that half of respondents reported visiting three or more professionals before receiving a correct

diagnosis, and over one-third reported a wait of 10 years or more before they were correctly diagnosed.

The Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR), the diagnostic standard for mental health professionals in the United States, defines four separate categories of bipolar disorder: bipolar I, bipolar II, cyclothymia, and bipolar not-otherwise-specified (NOS).

Bipolar I disorder is characterized by manic episodes, the “high” of the manic-depressive cycle. A bipolar patient experiencing mania often has feelings of self-importance, elation, talkativeness, increased sociability, and a desire to embark on goal-oriented activities, coupled with the characteristics of irritability, impatience, impulsiveness, hyperactivity, and a decreased need for sleep. Usually this manic period is followed by a period of depression, although a few bipolar I individuals may not experience a major depressive episode. However, these individuals are usually characterized as mild, moderate, or severe without psychotic features. Mixed states, where both manic or hypomanic symptoms and depressive symptoms occur at the same time, also occur frequently with bipolar I patients (for example, depression with the racing thoughts of mania). Also, dysphoric mania is common (mania characterized by anger and irritability). Catatonic features occasionally occur. Two of the following must be present for the bipolar I diagnosis to move into bipolar I with catatonic features: 1. motor immobility; 2. excessive, purposeless motor activity that is not caused by external stimuli; 3. extreme negativity or mutism; 4. inappropriate or bizarre postures, movements, mannerisms, or grimaces; 5. repetitive or echoing speech patterns.

Bipolar II disorder is characterized by major depressive episodes alternating with episodes of hypomania, a milder form of mania. At least one hypomanic instance must occur before the bipolar II criteria are met. Bipolar depression may be difficult to distinguish from a unipolar major depressive episode. Patients with bipolar depression tend to have extremely low energy, retarded mental and physical processes, and more profound fatigue (for example, hypersomnia; a sleep disorder marked by a need for excessive sleep or sleepiness when awake) than unipolar depressives. Catatonic features may also be present in bipolar II disorder.

Cyclothymia refers to the cycling of hypomanic episodes with depression that does not reach major depressive proportions. For this diagnosis, symptoms must be present for at least two years for adults and one year for children and adolescents. During the one and two year diagnosis-gathering period, patients may not be symptom-free for more than a two-month consecutive period. After

the initial diagnostic periods, there may be superimposed mixed or manic episodes. In these instances, bipolar I and cyclothymic disorder may be diagnosed simultaneously. A third of patients with cyclothymia will develop bipolar I or II disorder later in life.

A phenomenon known as rapid cycling occurs in up to 20% of bipolar I and II patients. In rapid cycling, manic and depressive episodes must alternate frequently—at least four times in 12 months—to meet the diagnostic definition. In some cases of “ultra-rapid cycling,” the patient may bounce between manic and depressive states several times within a 24-hour period. This condition is very hard to distinguish from mixed states.

Bipolar NOS is a category for bipolar states that do not clearly fit into the bipolar I, II, or cyclothymia diagnoses. Examples include:

- Very rapid transitions (a matter of days) between manic and depressed symptoms;
- Recurrent hypomanic episodes without depressive symptoms;
- Manic or mixed episodes that are superimposed on delusional disorder, residual **schizophrenia**, or psychotic disorder NOS;
- Hypomanic episodes that alternate with depression, but are not frequent enough to qualify for a diagnosis of cyclothymia;
- Situations where it has been assumed that a bipolar condition exists, but a determination cannot be made as to whether it is the primary diagnosis, is substance-induced, or comes from another medical condition.

Causes and symptoms

The source of bipolar disorder has not been clearly defined. Because two-thirds of bipolar patients have a family history of affective or emotional disorders, researchers have searched for a genetic link to the disorder. Studies have uncovered a number of possible genetic connections to the predisposition for bipolar disorder. Another possible biological cause under investigation is the presence of an excessive **calcium** build-up in the cells of bipolar patients. Also, dopamine and other neurochemical transmitters appear to be implicated in bipolar disorder and these are under intense investigation.

Over half of patients diagnosed with bipolar disorder have a history of substance abuse. There is a high rate of association between cocaine abuse and bipolar disorder. Some studies have shown that up to 30% of abusers meet the criteria for bipolar disorder. The emotional and physical highs and lows of cocaine use correspond to the

manic depression of the bipolar patient, making the disorder difficult to diagnose.

For some bipolar patients, manic and depressive episodes coincide with seasonal changes. Depressive episodes are typical during winter and fall, and manic episodes are more probable in the spring and summer months.

Symptoms of bipolar depressive episodes include low energy levels, feelings of despair, difficulty concentrating, extreme fatigue, and psychomotor retardation (slowed mental and physical capabilities). Manic episodes are characterized by feelings of euphoria, lack of inhibitions, racing thoughts, diminished need for sleep, talkativeness, risk taking, and irritability. In extreme cases, mania can induce hallucinations and other psychotic symptoms such as grandiose illusions.

Diagnosis

Bipolar disorder is usually diagnosed and treated by a psychiatrist and/or a psychologist with medical assistance. In addition to an interview, several clinical inventories or scales may be used to assess the patient's mental status and determine the presence of bipolar symptoms. These include the Millon Clinical Multiaxial Inventory III (MCMI-III), Minnesota Multiphasic Personality Inventory II (MMPI-2), the Internal State Scale (ISS), the Self-Report Manic Inventory (SRMI), and the Young Mania Rating Scale (YMRS). The tests are verbal and/or written and are administered in both hospital and outpatient settings.

Psychologists and psychiatrists typically use the criteria listed in the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition, Text Revision (DSM-IV-TR) as a guideline for diagnosing this disorder and other mental illnesses. DSM-IV-TR describes a manic episode as an abnormally elevated or irritable mood lasting a period of at least one week that is distinguished by at least three of the mania symptoms: inflated self-esteem, decreased need for sleep, talkativeness, racing thoughts, distractibility, increase in goal-directed activity, or excessive involvement in pleasurable activities that have a high potential for painful consequences. If the mood of the patient is irritable and not elevated, four of the symptoms are required.

Although many clinicians find the criteria too rigid, a hypomanic diagnosis requires a duration of at least four days with at least three of the symptoms indicated for manic episodes (four if mood is irritable and not elevated). DSM-IV-TR notes that unlike manic episodes, hypomanic episodes do not cause a marked impairment in social or occupational functioning, do not require hospi-

talization, and do not have psychotic features. In addition, because hypomanic episodes are characterized by high energy and goal directed activities and often result in a positive outcome, or are perceived in a positive manner by the patient, bipolar II disorder can go undiagnosed.

Bipolar symptoms often present differently in children and adolescents. Manic episodes in these age groups are typically characterized by more psychotic features than in adults, which may lead to a misdiagnosis of schizophrenia. Children and adolescents also tend toward irritability and aggressiveness instead of elation. Further, symptoms tend to be chronic, or ongoing, rather than acute, or episodic. Bipolar children are easily distracted, impulsive, and hyperactive, which can lead to a misdiagnosis of attention deficit hyperactivity disorder (ADHD). Furthermore, their aggression often leads to violence, which may be misdiagnosed as a conduct disorder.

Substance abuse, thyroid disease, and use of prescription or over-the-counter medication can mask or mimic the presence of bipolar disorder. In cases of substance abuse, the patient must ordinarily undergo a period of detoxification and abstinence before a mood disorder is diagnosed and treatment begins.

Treatment

Treatment of bipolar disorder is usually involves medication. A combination of mood stabilizing agents with antidepressants, antipsychotics, and anticonvulsants is used to regulate manic and depressive episodes.

Mood stabilizing agents such as lithium, carbamazepine, and valproate are prescribed to regulate the manic highs and lows of bipolar disorder. Lithium (Cibalith-S, Eskalith, Lithane, Lithobid, Lithonate, Lithotabs) is one of the oldest and most frequently prescribed drugs available for the treatment of bipolar mania and depression. Because the drug takes 4–10 days to reach a therapeutic level in the bloodstream, it is sometimes prescribed in conjunction with neuroleptics and/or benzodiazepines to provide more immediate relief of a manic episode. Lithium has also been shown to be effective in regulating bipolar depression, but is not recommended for mixed mania. Lithium may not be an effective long-term treatment option for rapid cyclers, who typically develop a tolerance for it, or may not respond to it. Possible side effects of the drug include weight gain, thirst, nausea, and hand tremors. Prolonged lithium use may also cause hyperthyroidism (a disease of the thyroid that is marked by heart palpitations, nervousness, the presence of goiter, sweating, and a wide array of other symptoms.)

Carbamazepine (Tegretol, Atretol) is an anticonvulsant drug usually prescribed in conjunction with other mood stabilizing agents. The drug is often used to treat bipolar patients who have not responded well to lithium therapy. Blurred **vision** and abnormal eye movement are two possible side effects of carbamazepine therapy. As of early 1998, carbamazepine did not have an FDA-approved indication for mania.

Valproate (divalproex sodium or Depakote; valproic acid or Depakene) is one of the few drugs available that has been proven effective in treating rapid cycling bipolar and mixed states patients. Valproate is prescribed alone or in combination with carbamazepine and/or lithium. **Stomach** cramps, indigestion, **diarrhea**, hair loss, appetite loss, nausea, and unusual weight loss or gain are some of the common side effects of valproate. Note: valproate is also approved for the treatment of mania.

Because antidepressants may stimulate manic episodes in some bipolar patients, their use is typically short-term. Selective serotonin reuptake inhibitors (SSRIs) or, less often, monoamine oxidase inhibitors (MAO inhibitors) are prescribed for episodes of bipolar depression. Tricyclic antidepressants used to treat unipolar depression may trigger rapid cycling in bipolar patients and are, therefore, not a preferred treatment option for bipolar depression.

SSRIs, such as fluoxetine (Prozac), sertraline (Zoloft), and paroxetine (Paxil), treat depression by regulating levels of serotonin, a neurotransmitter. **Anxiety**, diarrhea, drowsiness, headache, sweating, nausea, sexual problems, and insomnia are all possible side effects of SSRIs.

MAOIs, such as tranylcypromine (Parnate) and phenelzine (Nardil), block the action of monoamine oxidase (MAO), an enzyme in the **central nervous system**. Patients taking MAOIs must cut foods high in tyramine (found in aged cheeses and meats) out of their diet to avoid hypotensive side effects.

Bupropion (Wellbutrin) is a heterocyclic antidepressant. The exact neurochemical mechanism of the drug is not known, but it has been effective in regulating bipolar depression in some patients. Side effects of bupropion include agitation, anxiety, confusion, tremor, dry mouth, fast or irregular heartbeat, headache, and insomnia.

ECT, or electroconvulsive therapy, has a high success rate for treating both unipolar and bipolar depression, and mania. However, because of the convenience of drug treatment and the stigma sometimes attached to ECT therapy, ECT is usually employed after all pharmaceutical treatment options have been explored. ECT is given under anesthesia and patients are given a muscle

relaxant medication to prevent convulsions. The treatment consists of a series of electrical pulses that move into the **brain** through electrodes on the patient's head. Although the exact mechanisms behind the success of ECT therapy are not known, it is believed that this electrical current alters the electrochemical processes of the brain, consequently relieving depression. Headaches, muscle soreness, nausea, and confusion are possible side effects immediately following an ECT procedure. Temporary **memory** loss has also been reported in ECT patients. In bipolar patients, ECT is often used in conjunction with drug therapy.

Adjunct treatments are used in conjunction with a long-term pharmaceutical treatment plan. Long-acting benzodiazepines such as clonazepam (Klonopin) and alprazolam (Xanax) are used for rapid treatment of manic symptoms to calm and sedate patients until mania or hypomania have waned and mood stabilizing agents can take effect. Sedation is a common effect, and clumsiness, lightheadedness, and slurred speech are other possible side effects of benzodiazepines.

Neuroleptics such as chlorpromazine (Thorazine) and haloperidol (Haldol) are also used to control mania while a mood stabilizer such as lithium or valproate takes effect. Because neuroleptic side effects can be severe (difficulty in speaking or swallowing, **paralysis** of the eyes, loss of balance control, muscle spasms, severe restlessness, stiffness of arms and legs, tremors in fingers and hands, twisting movements of body, and weakness of arms and legs), benzodiazepines are generally preferred over neuroleptics.

Because bipolar disorder is thought to be biological in nature, therapy is recommended as a companion to, but not a substitute for, pharmaceutical treatment of the disease. **Psychotherapy**, such as cognitive-behavioral therapy, can be a useful tool in helping patients and their families adjust to the disorder, in encouraging compliance to a medication regimen, and in reducing the risk of suicide. Also, educative counseling is recommended for the patient and family.

Calcium channel blockers (nimodipine or Nimotop), typically used to treat angina and hypotension, have been found effective in a few small studies for treating rapid cyclers. Calcium channel blockers stop the excess calcium build up in cells that is thought to be a cause of bipolar disorder. They are usually used in conjunction with other drug therapies such as carbamazepine or lithium.

Clozapine (Clozaril) is an atypical antipsychotic medication used to control manic episodes in patients who have not responded to typical mood stabilizing agents. The drug has also been a useful prophylactic, or preventative treatment, in some bipolar patients.

Common side effects of clozapine include tachycardia (rapid heart rate), hypotension, constipation, and weight gain. Agranulocytosis, a potentially serious but reversible condition in which the white **blood** cells that typically fight **infection** in the body are destroyed, is a possible side effect of clozapine. Patients treated with the drug should undergo weekly blood tests to monitor white blood cell counts.

Risperidone (Risperdal) is another atypical antipsychotic medication that has been successful in controlling mania in several clinical trials when low doses were administered. The side effects of risperidone are mild compared to many other antipsychotics (constipation, coughing, diarrhea, dry mouth, headache, heartburn, increased length of sleep and dream activity, nausea, runny nose, **sore throat**, fatigue, and weight gain).

Lamotrigine (Lamictal, or LTG), an anticonvulsant medication, was found to alleviate manic symptoms in a 1997 trial of 75 bipolar patients. The drug was used in conjunction with divalproex (divalproate) and/or lithium. Possible side effects of lamotrigine include skin rash, dizziness, drowsiness, headache, nausea, and vomiting.

rTMS, or repeated transcranial magnetic stimulation is a new and still experimental treatment for the depressive phase of bipolar disorder. In rTMS, a large magnet is placed on the patient's head and magnetic fields of different frequency are generated to stimulate the left front cortex of the brain. Unlike ECT, rTMS requires no anesthesia and does not induce seizures.

Alternative treatment

General recommendations include maintaining a calm environment, avoiding overstimulation, getting plenty of rest, regular **exercise**, and proper diet. Chinese herbs may soften mood swings. Biofeedback is effective in helping some patients control symptoms such as irritability, poor self-control, racing thoughts, and sleep problems. A diet low in vanadium (a mineral found in meats and other foods) and high in **vitamin C** may be helpful in reducing depression.

Prognosis

While most patients will show some positive response to treatment, response varies widely, from full recovery to a complete lack of response to all drug and/or ECT therapy. Drug therapies frequently need adjustment to achieve the maximum benefit for the patient. Bipolar disorder is a chronic recurrent illness in over 90% of those afflicted, and one that requires lifelong observation and treatment after diagnosis. Patients with untreated or

KEY TERMS

Affective disorder—An emotional disorder involving abnormal highs and/or lows in mood. Now termed mood disorder.

Anticonvulsant medication—A drug used to prevent convulsions or seizures; often prescribed in the treatment of epilepsy. Several anticonvulsant medications have been found effective in the treatment of bipolar disorder.

Antipsychotic medication—A drug used to treat psychotic symptoms, such as delusions or hallucinations, in which patients are unable to distinguish fantasy from reality.

Benzodiazepines—A group of tranquilizers having sedative, hypnotic, antianxiety, amnesic, anticonvulsant, and muscle relaxant effects.

DSM-IV—*Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)*. This reference book, published by the American Psychiatric Association, is the diagnostic standard for most mental health professionals in the United States.

ECT—Electroconvulsive therapy is sometimes used to treat depression or mania when pharmaceutical treatment fails.

Hypomania—A milder form of mania which is characteristic of bipolar II disorder.

Mixed mania/mixed state—A mental state in which symptoms of both depression and mania occur simultaneously.

Mania—An elevated or euphoric mood, or irritable state that is characteristic of bipolar I disorder.

Neurotransmitter—A chemical in the brain that transmits messages between neurons, or nerve cells. Changes in the levels of certain neurotransmitters, such as serotonin, norepinephrine, and dopamine, are thought to be related to bipolar disorder.

Psychomotor retardation—Slowed mental and physical processes characteristic of a bipolar depressive episode.

inadequately treated bipolar disorder have a suicide rate of 15–25% and a nine-year decrease in life expectancy. With proper treatment, the life expectancy of the bipolar patient will increase by nearly seven years, with work productivity increasing by ten years.

Prevention

The ongoing medical management of bipolar disorder is critical in preventing relapse or recurrence of manic episodes. Even in carefully controlled treatment programs, bipolar patients may experience recurring episodes of the disorder. **Patient education** in the form of psychotherapy or self-help groups is crucial for training bipolar patients to recognize signs of mania and depression and to take an active part in their treatment program.

Health care team roles

The health care team roles are crucial to the proper treatment of bipolar disorder. Bipolar disorder requires lifelong care, and regular monitoring is essential so that the optimum treatment goals are achieved. A treatment team comprised of family members and caregivers, as well as professional staff, is advised to meet regularly to discuss progress and assess new needs. The treatment plan is based on input from a psychological or psychiatric evaluation, as well as input from the caregivers and the patient. This plan of care should be regularly updated and personalized to fit the patient's individual needs. Periodic assessment will track the patient's progress/regression and will make use of current research.

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National Alliance for the Mentally Ill (NAMI). 200 North Glebe Road, Suite 1015, Arlington, VA 22203-3754. (800) 950-6264. <<http://www.nami.org>>.

National Depressive and Manic-Depressive Association (NDMDA). 730 N. Franklin St., Suite 501, Chicago, IL 60610. (800) 826-3632. <<http://www.ndmda.org>>.

National Institute of Mental Health (NIMH). 5600 Fishers Lane, Rm. 7C-02, Bethesda, MD 20857. (301) 443-4513. <<http://www.nimh.nih.gov/>>.

Jacqueline N. Martin, M.S.

Birth control *see* **Contraception**

Birth injuries

Definition

A birth injury is defined by the Centers for Disease Control and Prevention (CDC) as an impairment of the neonate's (a newborn; usually less than one-month old) body function or structure caused by adverse influences occurring at birth.

Description

Birth injuries can occur during any birth. In the CDC's April 1999 report on vital statistics, birth injuries were highest when mothers were 25 to 29 years of age and lowest when mothers were 40 to 54 years old. Birth injuries include:

- asphyxia
- shoulder dystocia
- brachial plexus injury
- fractures of the clavicle and humerus
- fractures of the long bones
- cerebral injury
- cephalhematoma
- facial nerve palsy

Causes and symptoms

Infants of diabetic mothers are particularly at risk for birth injuries due to macrosomia (large body size). Macrosomia is a problem in about 33% of diabetic pregnancies, even with efforts for strong glycemic control. However, when glycemic control approximates normal **blood** glucose levels, injury rates are reduced. Macrosomia is also a problem associated with multipari-

ty (at least two births of a large infant by the same woman) because, with each **pregnancy**, the developing infant tends to be larger than its predecessor. A post-due date infant can also result in a large infant. When gestational age fetuses are large, they stretch the uterus, which can result in dysfunction during labor or delivery and increase the risk for postpartum hemorrhage. Larger infants have a 15% perinatal mortality rate versus the 4% mortality rate of appropriately sized neonates. Large infants born vaginally also have a higher than normal risk of shoulder dystocia, resulting in nerve injuries or fractured clavicle. In general, birth injuries are more likely to occur during a difficult vaginal birth, with prolonged labor, use of instrumentation such as forceps or vacuum extractor, with cephalopelvic disproportion, with fetal malpresentation, or during a Caesarian delivery. The injury may occur during labor, delivery, or neonatal resuscitation. Infants born preterm are especially at risk for birth injuries. One reason for this is the relationship between prenatal infections and preterm birth. Prenatal **infection** appears to play a significant role in premature delivery.

Diagnosis

Asphyxia is defined as the presence of hypoxia and acidosis. Hypoxia is a decreased level of oxygen in the tissues. Acidosis is the increased concentration of hydrogen ions in the tissues, a metabolic imbalance. Asphyxia may occur *in utero*, due to umbilical cord compression, **placenta previa**, or **placental abruption** (a tearing away or detachment). It can also occur during birth and postpartum. Preterm infants are especially at risk for respiratory problems. Difficulty breathing can result in prolonged fetal circulation after birth because the ductus arteriosus fails to close.

Meconium aspiration (inhalation by the newborn of its first intestinal discharges during labor and/or delivery) can also lead to impaired breathing. Deep suctioning may be required to rid the **lungs** of meconium. Meconium aspiration syndrome (MAS) is a serious condition in which the airway can become obstructed leading to respiratory distress, **pneumonia**, and even death. MAS is associated with hypoxia, pulmonary **hypertension**, and persistent fetal circulation. MAS occurs in only a small percentage of infants who aspirate meconium. Postdates infants (born later than the estimated date of delivery) are especially at risk for meconium aspiration, as are infants who suffered hypoxia *in utero*. Hypoxia leads to a relaxation of the anal sphincter muscles, allowing leakage of meconium into the amniotic (pertaining to the membrane around the fetus) fluid. MAS is eight times more likely to

occur in the postdates infant than in the term infant. Meconium release is also more likely with a breech delivery because of the pressure against the buttocks. Small for gestational age infants and preterm infants are a risk for asphyxia because of the increased risk of hypoxia and because their underdeveloped chest muscles lead to ineffective respiration. Infants born by cesarian section are also at risk for respiratory distress. This is because they avoid delivery through the birth canal which causes thoracic compression and its accompanying expulsion of lung fluid.

The incidence of shoulder dystocia is increasing along with the rise in birth weight, although 40-50% of infants with shoulder dystocia have a birth weight under 4,000 grams. A large infant or cephalopelvic (size of the fetal head compared to the mother's pelvis) disproportion may not be diagnosed prior to birth. During delivery, the head can be born, but the shoulders become stuck. Danger to the mother arises with prolonged labor and delivery, the risk of cervical or vaginal tears, and postpartal hemorrhage. Fetal risks include cord compression, fractured clavicle, and brachial plexus (spinal nerve network in neck-shoulder region) injury. Shoulder dystocia should be suspected with prolonged labor and in a condition called *turtle sign*. In turtle sign the fetal head is born then partially retracts, looking like a turtle with its head partially pulled back into its shell. Brachial plexus injury is the most common of the nerve injuries seen in neonates. Injury can arise from traction to the head and neck during a vertex (crown of the head) vaginal delivery, or during shoulder traction in a breech delivery. In Erb's palsy (**paralysis** of the upper arm) the C5 and C6 nerves are affected, and the arm on the affected side is limp with the affected shoulder drawn toward or past the body's median axis. The arm is internally rotated, with the elbow extended. The forearm is pronated (palms facing backwards), with wrist flexion. When eliciting the Moro reflex (primitive reflex that disappears a few months after birth), an asymmetrical response is noted. The grasp reflex should remain intact. Klumpke's palsy results from an injury to the C8 and T1 nerves. Diagnosis is suspected if the hand appears paralyzed, with a limp wrist and absence of the grasp reflex. Diaphragmatic paralysis or respiratory compromise can occur with injury to other cervical nerves. Not all brachial plexus injuries occur during birth. They may have occurred earlier during the pregnancy. Care should be taken during immobilization of the affected area to avoid contractures. Treatment may be followed by **physical therapy**. Full recovery is seen four months for 88% of cases, with 93% resolving within two years. Periodic neurologic evaluation can help avoid long-term impairment.

KEY TERMS

Adduction—The limb is drawn in towards the body.

Apgar score—The results of an evaluation of a newborn's physical status, including heart rate, respiratory effort, muscle tone, response to stimulation, and color of skin.

Macrosomia—A condition in which the neonate is large for gestational age with a high body weight. The condition is particularly associated with infants of diabetic mothers, especially if the diabetes is not well controlled. The circulating hyperglycemia encourages rapid growth and weight gain.

Meconium aspiration—When a newborn inhales its first fecal discharges during labor or delivery.

Pronation—The palm of the hand faces backwards.

A fractured clavicle may result from a difficult **breech birth** and also from shoulder dystocia. The clavicle should be straight, but if fractured a lump may be felt. At the time of the fracture, a cracking sound may be heard. A fracture should be suspected with decreased or lack of movement of the affected arm, swelling, skin discoloration, localized **pain** or tenderness, and lack of symmetry of the Moro reflex. The condition may also be asymptomatic. Injury can be confirmed by imaging. Treatment usually involves immobilizing the affected arm and shoulder for seven to ten days.

Fractured long bones are usually caused by arm or leg rotation during a breech birth. It should be suspected with pain, swelling, and lack of movement on the affected side. The affected side may appear shorter. Imaging can confirm the diagnosis. Treatment usually involves casting the affected limb, with complete healing taking place in a month.

Cephalhematoma is subcutaneous swelling caused by accumulation of blood from ruptured **blood vessels** located in the back of the neonatal **skull** underneath the scalp. It starts forming after trauma, perhaps as a result of the use of forceps or vacuum extractor, and increases in size over the next few days after birth. The swollen area may be black and blue due to the pooled coagulated blood. Cephalhematoma may resolve in a few days or take several months. The cephalhematoma is located on one or both sides and does not cross the suture lines. It

may be associated with anemia or **jaundice**. Usually no treatment is undertaken unless it appears infected.

Facial nerve palsy is the paralysis of a facial nerve following injury. It can occur as a result of the use of forceps, or because of pressure on the nerve due to fetal position against the mother's pelvic bones during birth or during the pregnancy. Lack of symmetry is most obvious when the infant cries. The affected side of the face looks smooth and the corner of the mouth droops. If the affected eye stays open it is necessary to use ophthalmic drops to avoid injury to the cornea. It usually resolves in a few days to weeks.

Treatment

Treatment of asphyxia involves rapid recognition of a neonate in respiratory distress. A rapid respiratory may be the first warning sign of distress. Other signs include **cyanosis**, sternal retractions, and lack of respiratory effort. The Apgar evaluation (a physical assessment of newborns) scores respiratory rate at one and five minutes after birth. Should the infant appear in immediate distress, intervention and/or resuscitation is begun before the one-minute time period. Some infants have periods of apnea, or temporary stoppage of breathing. For some, stimulation of the soles of the feet may be enough to *remind* them to continue breathing. Others may need swift intervention. **Cerebral palsy** (CP) is associated with lack of oxygenation in utero, during birth, or shortly afterwards. However, some studies indicate that only 9% of cerebral palsy cases are directly caused by birth asphyxia. CP is also associated with maternal infection, a significant cause of preterm birth, and low birth weight and small for gestational age infants. Newborn infections such as **meningitis** or encephalitis can also result in cerebral palsy. Kernicterus (a severe form of jaundice) resulting from hyperbilirubinemia (a large amount of red bile pigment, or bilirubin, in the blood) can also lead to cerebral palsy. CP is also associated with premature rupture of membranes (PROM) due to the increased risk of infection and cord compression associated with PROM.

Damage to the neonate can occur with the traction and rotation that accompanies delivery of the infant with shoulder dystocia. Asking the mother to perform the McRobert's maneuver, or the sharp flexing of her thighs against her abdomen, can widen the pelvic outlet and facilitate delivery. Cesarean delivery does not avoid all cases of brachial plexus injuries because compression can occur *in utero*, not just with birth.

Prognosis

The prognosis for birth injuries depends on many factors. Most of the injuries related to shoulder dystocia or fractured bones tend to heal completely, although some may require physical therapy or surgical intervention. About 10% of nerve injuries are permanent. Complications resulting from compromised oxygenation have a poorer outcome the longer the oxygen deficit has occurred. Cephalhematoma rarely requires intervention, but may when associated with anemia or hyperbilirubinemia. Degree of organ development at the time of birth is a significant factor in prognosis.

Health care team roles

Physicians, nurses, and respiratory therapists all play an important role in neonatal resuscitation. Physical therapists and nurses may have ongoing interactions with infants with cerebral palsy, or who need rehabilitation after injury from shoulder dystocia. Radiology technicians play an important role in gestational dating with ultrasound. Accurate dating and identification of small or large for gestational age infants can facilitate appropriate interventions.

Prevention

Many birth injuries cannot be prevented, as they occur *in utero*. Although having a member of a neonatal resuscitation team at every birth can facilitate swift intervention by specially trained individuals, it would be difficult to provide such services for all births, especially in small rural hospitals. The earlier intervention occurs, the better the prognosis. Respiratory distress is decreased with proper thermal regulation of the neonate. Drying the newborn under a radiant heater, changing the wet blankets for heated dry ones, and using a cap facilitates neonatal **thermoregulation**. Poor temperature control of the newborn increases respiratory effort. This is especially true in the preterm infant who has a decreased amount of brown fat. Ultrasonography assists in the diagnosis of placental problems, as well as in measuring fetal size. However, even with such technology, not all potential problems will be diagnosed prior to birth. Careful fetal monitoring during labor can often recognize fetal distress before permanent damage takes place. Close monitoring of the postdates fetus can decrease risk of placental insufficiency and cord compression due to insufficient amniotic fluid volume. The use of **corticosteroids** given to the mother before the delivery of a preterm infant can also decrease the risk of cerebral palsy.

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Esther Csapo Rastegari, R.N., B.S.N., Ed.M.

Bites and stings

Definition

People can be injured by the bites or stings of many animals, including mammals such as dogs, cats, and fellow humans; arthropods such as spiders, bees, and wasps; snakes; and marine animals such as jellyfish and stingrays.

Description

Mammals

DOGS. In the United States, where the dog population exceeds 50 million, dogs surpass all other mammals in the number of bites inflicted on humans. Most come from family pets or other dogs known to the victim. Fortunately, most dog-bite injuries are minor. A 1994 telephone survey of American households indicated that there were 3,737,000 dog bites that did not require medical attention in the United States during that year, and 757,000 that did. Men and boys are more likely to be bitten than girls or women; not surprisingly, children face a greater risk than adults. Each year, about 10–20 Americans, mostly children under 10 years of age, are killed by dogs.

In the United States, dog bites send an estimated 340,000 people to the emergency room each year. Children under 10 are more likely than older people to need immediate medical treatment; this is especially true for boys between five and nine. Children under ten were also much more likely to be bitten on the face, neck, and head. Few of the injuries suffered by people seeking emergency treatment were serious; most patients were

treated and released without being admitted or referred to another facility.

CATS. Although cats are found in nearly a third of American households, their bites are far less common than dog bites. According to one study, cats inflict perhaps 400,000 harmful bites in the United States each year. Cat bites typically cause less tissue damage, but they carry a higher risk of **infection** (30-40%) than dog bites (15-20%). Young girls are the most likely to be bitten by cats.

HUMANS. There are approximately 70,000 human bites each year in the United States. They can be just as serious a medical problem as a bite from an animal. Because the human mouth contains a multitude of potentially harmful microorganisms, these tend to become have a higher infection rate than those inflicted by animals.

Arthropods

Arthropods are invertebrates such as insects, arachnids, crustaceans, and other subgroups of the phylum Arthropoda—a group that encompasses more than 700,000 species. The list of arthropods that bite or sting is extensive and includes lice, bedbugs, fleas, mosquitoes, blackflies, ants, chiggers, ticks, centipedes, scorpions, and other creatures. Spiders, bees, and wasps are the three that people encounter most often.

SPIDERS. In the United States, only two kinds of venomous spider have a truly life-threatening bite: black widow spiders and brown recluse spiders. The black widow, which is found in every state but Alaska, is probably the most infamous widow spider. It prefers dark, dry places such as barns, garages, and outhouses, and also lives under rocks and logs. Disturbing a female black widow or her web may provoke a bite. Red widow spiders are far more rare, but can be found in parts of Florida; their sting is also quite venomous. Brown recluse spiders also prefer sheltered places, including clothing, and may bite if disturbed.

BEEES AND WASPS. Bees and wasps will sting to defend their nests or if they are disturbed. Species common to the United States include honeybees, bumblebees, yellow jackets, bald-faced hornets, brown hornets, and paper wasps. More than 50 Americans die each year after being stung by a bee, wasp, or fire ant. Almost all of those deaths are caused by allergic reactions to the venom, not by its toxicity.

Snakes

There are 20 species of venomous snakes in the United States; they're found in every state except Maine,

Alaska, and Hawaii. Each year about 8,000 Americans receive a venomous snakebite, but no more than about 15 die; most of the deaths are from rattlesnake bites.

The venomous snakes of the United States are divided into two families: Crotalidae (pit vipers) and Elapidae. Pit vipers, which take their name from the small heat-sensing pit that lies between each eye and nostril, are responsible for about 99% of the venomous snakebites suffered by Americans. The group includes rattlesnakes, copperheads, and cottonmouths (also called water moccasins). This type of snake delivers its venom through two long, hinged fangs in the upper jaw. Some pit vipers carry a potent, fast-acting venom that can damage the **brain** and **spinal cord**. The venom of others, such as the copperheads, is less harmful.

The Elapidae include two kinds of venomous coral snakes indigenous to the southern and western states. Because coral snakes are bashful creatures that come out only at night, they almost never bite humans, and are responsible for only about 25 bites a year in the United States. Coral snakes also have short fangs and a small mouth, which lessens the risk of a bite actually forcing venom through the skin and subcutaneous tissues into muscles or veins. However, if ingested, their venom is quite poisonous.

Marine animals

Several varieties of marine animal bite or sting, including sharks, jellyfish, stingrays, anemones, and even a few types of coral. Although only a few have venom powerful enough to kill, they can inflict painful injuries. As with spider and bee stings, allergic individuals can also have anaphylactic reactions to these bites.

Causes and symptoms

Mammals

DOGS. A typical dog bite results in a laceration, puncture, or crush injury. Infected bites usually cause **pain**, cellulitis (inflammation of the connective tissues), and a pus-filled discharge at the wound site within 8–24 hours. Most infections are confined to the wound site, but microorganisms in dogs' mouths can cause systemic and possibly life-threatening infections such as sepsis and **meningitis**, especially among people with compromised immune systems that decrease their resistance to infection. Rabies is rare among pet dogs in the United States, most of which have been vaccinated against the disease. Tetanus is also a rare complication.

CATS. Cat scratches and bites can transmit the *Bartonella henselae* bacterium, which can lead to cat-

scratch disease, an uncommon and unpleasant but not usually life-threatening illness. The mouths of cats and dogs contain many of the same microorganisms, and many of the same types of infections can result.

Cat bites are mostly found on the arms and hands. Sharp cat teeth typically leave behind a deep puncture wound that can reach muscles, tendons, and bones, which are vulnerable to infection because of their comparatively poor **blood** supply. This is one reason why cat bites are much more likely than dog bites to become infected. People are also less inclined to give cat bites immediate medical attention, increasing the risk that infection will set in. Infected cat scratches on fingers or toes, in fact, have been known to spread inward to the bone, and result in the need for amputation of the digit.

HUMANS. Although children often bite other children, these bites are hardly ever severe. Most human bites that require medical attention result from fights (raising the possibility of domestic or **child abuse**), sexual activity, medical and dental treatment, and seizures. They can transmit a wide range of dangerous diseases, including hepatitis B, **syphilis**, **tuberculosis**, and HIV.

Human bites fall into two categories: occlusional (true) bites and clenched-fist injuries. The former present a low risk of infection. The latter, which are very infectious and can permanently damage the hand, usually result when a fist hits teeth during a fight. People often wait before seeking treatment for a clenched-fist injury, with the result that about half of such injuries are infected by the time they are seen by a medical professional.

Arthropods

SPIDERS. People do not always feel a black widow's bite. The first (and possibly only) evidence that a person has been bitten may be a mild swelling of the injured area and two red puncture marks showing where the spider's fangs entered the skin. Within a short time, however, some victims begin to experience severe muscle cramps and rigid abdominal muscles. Other possible symptoms include excessive sweating, nausea, vomiting, headaches, and vertigo as well as breathing, **vision**, and speech problems.

A brown recluse spider's bite can lead to necrotic arachnidism, in which the tissue in an area of up to several inches around the bite becomes necrotic, producing an open sore that can take months or years to heal completely. About 40% of all bites are accompanied by more severe symptoms: **fever**, chills, **edema**, nausea, vomiting, dizziness, muscle and joint pain, and a measles-like rash. The bite becomes hard and inflamed, and may turn gangrenous. In most cases, fortunately, the bite simply

produces a hard, painful, itchy, and discolored area that heals without treatment in two to three days.

BEEES AND WASPS. The familiar symptoms of bee and wasp stings include pain, redness, swelling, and itchiness in the area of the sting. Multiple stings can have much more severe consequences. If an allergic reaction occurs, there can be life-threatening symptoms of facial swelling, throat closure, tongue swelling, and airway blockage within a very short time.

Snakes

Many pit viper and coral snake bites (20–60%) fail to poison (envenom) their victims, or manage to introduce only a small amount of venom into the victim's body. The **wounds**, however, can still become infected by the harmful microorganisms that snakes carry in their mouths.

Venomous pit viper bites usually begin to swell within 10 minutes and are sometimes painful. Other symptoms include edema at the wound site, skin blisters, discoloration, weakness, sweating, nausea, faintness, dizziness, bruising, and tender lymph nodes. Symptoms of severe **poisoning** include tingling in the scalp, fingers, and toes, muscle contractions, an elevated **heart** rate, rapid breathing, large drops in body temperature and **blood pressure**, vomiting of blood, and **coma**.

Coral snake bites are painful but may be hard to see. After some time has passed, a bitten person begins to experience the effects of the venom, which include tingling at the wound site, weakness, nausea, vomiting, excessive salivation, and irrational behavior. Nerves in the head and neck can become paralyzed for six to 14 days, causing double vision, difficulty swallowing and speaking, **respiratory failure**, and other problems. Six to eight weeks may be needed before normal muscular strength is regained.

Marine animals

JELLYFISH. Jellyfish venom is delivered by barbs called nematocysts that are located on the creature's tentacles. They sting anyone who brushes up against them, causing a red lesion that is instantly painful and itchy. The pain can continue up to 48 hours. Severe cases may lead to necrosis, muscle spasms and cramps, vomiting, nausea, **diarrhea**, headaches, excessive sweating, and other symptoms. In rare instances, cardiorespiratory failure results.

STINGRAYS. Stingrays carry their venom in their tail spines, which can inflict deep puncture wounds. If, as often happens, pieces of spine become embedded in the wound, an infection can result. Most people are injured

by a stingray when they inadvertently step on one that's resting, and are lashed in the ankle by its tail. Stingray venom produces immediate, excruciating pain that lasts several hours. Sometimes the victim suffers a severe reaction, including vomiting, diarrhea, hemorrhage, a drop in blood pressure, and cardiac arrhythmia.

Diagnosis

Mammals

DOGS. Gathering information on the circumstances of a dog attack is a crucial part of bite treatment. Among other things, medical professionals need to know when the attack occurred (the chances of infection increase dramatically if the wound has been left untreated more than eight hours) and what led to the attack (unprovoked attacks are more likely to be associated with rabid animals). The patient's general health must also be assessed, including tetanus immunization history and possible **allergies** to medication.

A **physical examination** demands careful scrutiny of the wound, with special attention to possible bone, joint, ligament, muscle, tendon, nerve, or blood-vessel damage that may have been caused by deep punctures or severe crush injuries. Experts advise that serious hand injuries should be evaluated by a surgeon who specializes in such cases. Most of the time, laboratory tests to identify the microorganisms in bite wounds are ordered only if infection is present. X rays and other diagnostic procedures may also be necessary.

CATS. The diagnostic procedures used for dog bites also apply to cat bites.

HUMANS. Anyone who has received a human bite must be tested for hepatitis B and other diseases; ideally, the biter should be tested as well. Clenched-fist injuries require evaluation by a hand surgeon. Because many people will deny having been in a fight, medical professionals are advised to always consider lacerations over the fourth and fifth knuckle—a typical clenched-fist injury—to be evidence of a bite wound, no matter what an individual says. Medical professionals should also look for other indications of spousal or child abuse when evaluating human bites.

Arthropods

SPIDERS. Spider bites always require medical attention, although victims are often not aware that they've been bitten. To make matters worse, unless the spider is seen biting the victim, identifying which species is responsible is difficult. If possible, the spider should be

captured and taken to the emergency room or doctor's office for identification.

Snakes

Diagnosis relies on a physical examination of the victim, information about the circumstances of the bite, and a look at the snake itself (if it can safely be brought in for identification). Blood tests and **urinalysis** supply important data on the victim's condition. Chest x rays and EKG (electrocardiogram) may also be necessary.

Treatment

Mammals

DOGS. Minor dog bites can be treated at home. The American Academy of Family Physicians recommends gently washing the wound with soap and water and then applying pressure to the injured area with a clean towel to stop the bleeding. Next, apply antibiotic ointment and a sterile bandage to the wound. To reduce swelling and fend off infection, ice should be applied and the injured area kept elevated above the level of the heart. The wound should be cleaned and ointment reapplied twice a day until healing is complete.

Any dog bite that does not stop bleeding after 15 minutes of pressure must be seen by a medical professional. The same is true for bites that are deep or gaping; for bites to the head, hands, or feet; and for bites that may have broken a bone, damaged nerves, or caused a major injury of another kind. Bite victims must also watch for signs of infection: fever, redness, swelling, warmth, increased tenderness, and pus at the wound site. Diabetics, people with **AIDS** or **cancer**, individuals who have not had a tetanus shot in five years, and anyone else who has a medical problem that can increase susceptibility to infection should seek medical treatment no matter how minor the bite appears.

Medical treatment of dog bites involves washing the wound with an anti-infective solution. Dead and/or damaged tissue may be need to be removed, and any person whose tetanus shots are not up to date should receive a booster. Some wounds are left open and allowed to heal on their own, from the inside out, while others require stitches (stitching may be delayed a few days if infection is a concern). Many emergency departments prescribe **antibiotics** for all people with dog bites, but some researchers suggest that antibiotics are usually unnecessary and should be limited to those whose injuries or other health problems make them likely candidates for infection. A follow-up visit after one or two days is gen-

erally required for anyone who has received bite treatment.

Other than death by trauma, the biggest threat from a dog bite is rabies (although no one in the United States has contracted rabies from a dog bite for many years). Dogs who bite people should be contained and tested for rabies, unless the owner can prove the animal has been immunized. If this is not possible, a rabies vaccine series for the victim is effective if administered within two days of the bite.

CATS. Because of the high risk of infection, people who are bitten by a cat should always see a doctor. Cat scratches do not require professional medical treatment unless the wound appears infected or the victim has a weakened **immune system**. Cats, like dogs, can also transmit rabies, and cats that inflict a bite should be contained and tested for rabies, unless their immunization history is known.

Medical treatment for cat bites generally follows the procedures used for dog bites. Experts advise, however, that cat-bite wounds should always be left open (not stitched) to prevent infection. Persons bitten by cats are also more likely to receive antibiotics as a preventive measure.

HUMANS. Human bites should always be examined by a doctor. Such bites are usually treated with antibiotics and left open because of the high risk of infection. A person who has been bitten may also require immunization against hepatitis B and other diseases. A follow-up visit is required after an occlusional bite. Persons who are being treated for a clenched-fist injury will require a daily follow-up examination for three to five days.

Arthropods

SPIDERS. Brown recluse spider bites require immediate medical attention. Put an antiseptic on the bite, apply ice to reduce swelling, then get the patient to a doctor as quickly as possible. **Analgesics, antihistamines,** and a tetanus shot are the standard course of treatment, along with erythromycin and other antibiotics to combat infection. If necrosis results, the affected areas may need debridement.

Experimental treatment includes steroids to combat the hemolysis that can result from the spider venom. Surgical excision of the bite once eschar has developed may be an effective way to remove the venom and prevent further tissue damage. Interestingly, the leprosy drug dapsone has shown some promise in this area, and may prevent the need for surgery. Hyperbaric oxygen treatments may also restore blood flow to dying tissue. A



A close-up view of lacerations on the shin of an adult woman, inflicted by a Rottweiler dog. (Custom Medical Stock Photo. Reproduced by permission.)

promising antivenin has been developed, but it's not yet available for clinical use.

Black widow spider bites also need a doctor's care. Apply ice to the bite, then take the patient to an emergency room. If necessary, antivenin is administered. In less severe cases, the symptoms are treated with **calcium** and **muscle relaxants** for spasms, along with drugs to lower blood pressure.

BEEES AND WASPS. Most stings can be treated at home. A stinger can be scraped off the skin with a razor blade, fingernail, credit card, or piece of paper; using tweezers may push more venom out of the venom sac and into the wound. The area should be cleaned and covered with an ice pack. Aspirin and other pain medications, oral antihistamines, and calamine lotion can relieve the pain, itching, and swelling.

The biggest risk from a bee sting is anaphylactic reaction to bee or wasp venom. This requires immediate medical attention. The danger signs, which usually begin within minutes after a sting, (but may not appear for several hours) include nausea, chest pain, **hives** (both internal and external), abdominal cramps, diarrhea, and difficulty swallowing or breathing. These last symptoms can be life threatening if not treated immediately. Patients with a history of allergic response to stings are prescribed a self-injecting kit of adrenaline and antihistamine.

Snakes

Although most snakes are not venomous, any snakebite should immediately be examined at a hospital. While waiting for emergency help to arrive, the victim should wash the wound site with soap and water, and then keep the injured area still and at a level lower



An insect bite caused this person's lower lip to swell.
(Custom Medical Stock Photo. Reproduced by permission.)

than the heart. Ice should never be used on the wound, and no attempts should be made to extract the venom. Making a cut at the wound site is also dangerous. It is important to stay calm and wait for emergency medical aid.

When a snakebite victim arrives at a hospital, the medical staff must determine, if they can, whether the bite was inflicted by a venomous snake and, if so, how much venom the person received. Careful monitoring helps resolve doubtful cases. Fortunately, the effects of some snakebites can be counteracted with antivenin. Minor rattlesnake envenomations can be successfully treated without antivenin, as can copperhead and water moccasin bites. However, coral snake and the more dangerous rattlesnake envenomations require antivenin. Other treatment measures include antibiotics to prevent infection and a tetanus booster injection.

Marine animals

JELLYFISH. To stop envenomation from tentacles that cling to skin, various substances should be applied, depending on the species that delivered the sting. Vinegar, baking soda, meat tenderizer (papain), and other substances will neutralize nematocysts. Applying the wrong substance, however, can cause the nematocysts to fire again, increasing the dose of venom and the degree of pain for the victim. Once the tentacles have been neutralized, they can be scraped off, saved, and given to medical personnel for identification and diagnosis. Ice, topical anesthetics, antihistamines, steroids, and a tetanus booster can prevent further complications. As with bee stings, allergic reactions may occur, requiring emergency medical care.

STINGRAYS. Stingray wounds should be washed with salt water and then soaked in very hot water for 30–90

minutes to neutralize the venom. Afterwards, the wound should be examined by a doctor to ensure that no pieces of spine remain.

Alternative treatment

Arthropods

Several alternative self-care approaches are used to treat bee, wasp, and other minor arthropod stings, including aromatherapy, ayurvedic medicine, flower remedies, herbs, **homeopathy**, and nutritional therapy. The efficacy of these treatments has not been proven, however, and if alternative therapy delays the administration of traditional medical attention for dangerous bites or stings the risk of severe consequences increases.

Prognosis

Mammals

It is important to realize that apparently even minor bites can have serious consequences, and that prompt treatment is the key to a good outcome. Infected bites may require hospitalization and can be fatal if neglected. Surgery may be needed for severe bites.

Arthropods

SPIDERS. Even without treatment, adults tend to recover from black widow bites after two to three days. The risk of death, though rare, is highest for very young children, the elderly, and people with high blood pressure.

BEES AND WASPS. The pain and other symptoms of a bee or wasp sting normally fade after a few hours. People who are allergic to such stings, however, can experience a severe and occasionally fatal reaction.

Snakes

A snakebite victim's chances of survival are excellent if medical aid is rendered in time. Some bites, however, result in amputation, permanent deformity, or loss of function in the injured area.

Marine animals

STINGRAYS. Stingray venom only rarely kills its human victims.

Health care team roles

Persons trained in **first aid** provide initial support. **Emergency medical technicians** provide life support and transportation to medical facilities. Physicians

trained in emergency or environmental medicine supervise treatment of bite victims. Registered nurses support, treat, and care for patients in emergency rooms and other hospital departments. Surgeons debride and repair serious bite wounds. Laboratory technicians process fluid and tissue specimens. Pathologists interpret test results. Physical therapists provide therapeutic services during the recovery period.

Prevention

Mammals

DOGS. The risk of a dog bite can be reduced by avoiding sick or stray dogs, staying away from dogfights (people often get bitten when they try to separate the animals), and not provoking or upsetting dogs while they are sleeping, eating, or tending their puppies. Infants and young children must never be left alone with a dog. Pit bulls, rottweilers, and German shepherd dogs—breeds that caused nearly half of all fatal dog attacks in the United States between 1997 and 2000—are potentially dangerous pets in households where children live or visit. All dog breeds benefit from obedience training and spaying or neutering to lessen the chances of aggressive behavior.

CATS. Warn children to stay away from strange cats and to avoid rough play and other behavior that can anger cats and cause them to bite.

Arthropods

SPIDERS. Common-sense precautions include exercising caution when clearing webs out of garages, out-houses, and other places favored by venomous spiders; keeping one's hands away from places where spiders may be lurking; and, when camping or vacationing, checking clothing, shoes, and sleeping areas.

BEEES AND WASPS. When outdoors, avoid bee and wasp nests, and don't eat sweet food or wear bright clothing, perfumes, or fragranced cosmetics that attract bees and wasps.

Emergency medical kits containing self-injecting epinephrine to counter anaphylactic **shock** are available for people with a history of allergic response to insect stings; these should be carried with them at all times. People who suspect they are allergic should consult an allergist about immunotherapy shots that can build up resistance to bee and wasp venom.

Snakes

Mowing the lawn, trimming hedges, and removing brush from the yard discourages snakes from living close

to homes. Use tongs to move brush, lumber, and firewood in case snakes are lying beneath them. Similarly, golfers should never use their hands to retrieve golf balls from a water hole, since snakes can be hiding in the rocks and weeds. Caution is also necessary when walking through weedy or grassy areas, and children should be prevented from playing in weedy, vacant lots and other places where snakes may live. Leather boots and long pants offer hikers and campers some protection from bites. Approaching a snake, even a dead one, can be dangerous, for recently killed snakes can still inflict a venomous bite if there is contact with the fangs.

Marine animals

JELLYFISH. Obey posted warning signs at the beach. Also, since jellyfish tentacles are transparent and can be up to 120 ft (36.5 m) long, great caution must be exercised whenever a jellyfish is sighted nearby.

STINGGRAYS. Shuffling while walking through shallow areas that may be inhabited by stingrays will disturb the water, causing the animal to move before it can be stepped on.

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KEY TERMS

Antibiotics—Substances used to fight bacteria that cause infection.

Antibodies—Substances in the blood created by the body to combat infection.

Antihistamines—Drugs that treat allergic reactions by acting against a substance called histamine, which the body releases as part of its immune response.

Antivenin—An antitoxin to a specific animal venom. Antivenin is extracted from the blood serum of horses (or other animals) that have been immunized against the toxin.

Blood serum—The component of blood plasma that remains after coagulation.

Debridement—Removal of dead and/or damaged tissue.

Edema—Excessive fluid buildup in a body tissue.

Eschar—Sloughed off dead tissue.

Hemolysis—Breakdown of red blood cells.

Necrosis—Dead skin, muscle, bone, or other tissue in the body caused by insufficient blood flow.

Pus—A thick yellowish or greenish fluid composed of the remains of dead white blood cells, pathogens, and decomposed cellular debris; a definite sign of infection.

Sepsis—A serious systemic infection caused by bacteria that have entered the bloodstream through a wound.

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American Academy of Emergency Medicine. 611 East Wells Street, Milwaukee, WI 53202. (800) 884-2236. <<http://www.aaem.org>>.

American Academy of Family Physicians. 11400 Tomahawk Creek Parkway, Leawood, KS 66211-2672. (913) 906-6000. <<http://www.aafp.org>>.

American Academy of Pediatrics. 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. <<http://www.aap.org/default.htm>>.

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Bladder tumor antigen test see **Tumor marker tests**

Bladder ultrasound

Definition

A noninvasive method of assessing bladder volume and other bladder conditions using ultrasonography to determine the amount of urine retention or post-void residual urine.

Purpose

Bladder ultrasound is used in the acute care, rehabilitation, and long-term care environments. It is a noninvasive alternative to bladder palpation and intermittent catheterization used to assess bladder volume, urinary retention, and post-void residual volume in postoperative patients who may have decreased urine output; in patients with urinary tract infections (UTIs), urinary incontinence, enlarged prostate, urethral stricture, neurogenic bladder, and other lower urinary tract dysfunctions; or in patients with **spinal cord** injuries, stroke, diabetes, and mental handicaps that may reduce the sensation of bladder fullness, thereby interfering with appropriate

voiding. Bladder ultrasound may be used in rehabilitation for bladder assessment and training. Bladder ultrasound is used to evaluate bladder function in nursing home residents to monitor for UTIs, urinary incontinence, urinary retention, and bladder dysfunction associated with other medical conditions (e.g., pelvic organ prolapse).

Precautions

There are no contraindications for bladder ultrasound. However, users should be aware of errors in measurement that may occur. For the most accurate results, patients should be in a relaxed, supine (lying down) position, and the ultrasound scanning head should not be moved during the scan if a portable device is used. Measurements may be distorted in patients with staples or sutures, an indwelling catheter, or scar tissue. Fluid in a pelvic cyst or tumor may be misinterpreted as bladder volume.

Description

Bladder ultrasound is conducted using a portable, battery-operated ultrasound scanner that consists of a small, handheld unit and an attached ultrasound probe. It may also be performed with a conventional **ultrasound unit**. The probe, which is placed on the patient's abdomen over the bladder, holds a motorized scanning head with an ultrasonic transducer that transmits sound waves in a fanlike array that are reflected back from the patient's bladder to the transducer. Data from multiple cross-sectional scans of the bladder are then transmitted to a computer in the handheld unit, which automatically calculates bladder volume. The handheld unit also contains an integral digital screen and printer for displaying the bladder volume measurements. The entire scan only takes a minute or two, is noninvasive and painless, and eliminates the discomfort, embarrassment, and risks associated with catheterization.

The bladder ultrasound procedure is also referred to as bladder scanning or the bladderscan, after the brand name of the most widely available portable bladder ultrasound device. A dedicated portable bladder ultrasound scanner ranges in cost from approximately \$6,000 to \$10,000.

Although general-purpose ultrasound scanners, such as those used in the radiology department, can be used to measure bladder volume, they may be inconvenient for regular use at the patient's bedside due to their size and are much more expensive than portable units. However, they are often used for bladder ultrasound if there is no portable unit in the facility.

KEY TERMS

Post-void residual volume—The amount of urine remaining in the patient's bladder after voiding.

Transducer—The part in the ultrasound scanning head that transmits acoustic energy and converts it into electrical energy to produce image data.

Ultrasonography—An imaging modality that uses sound waves to produce anatomical images and measurements.

Preparation

Before scanning, the end of the transducer scanning head should be wiped with alcohol and allowed to dry. Ultrasound transmission gel should then be applied to the end of the scanning head. The portable bladder ultrasound device should be set to either male or female; the male setting should be used for a female patient who has had a hysterectomy. To begin scanning, the tip of the scanning head should be positioned approximately one inch (2.5 cm) superior to the symphysis pubis and pointing toward the bladder. During scanning, the scanning head should be held stationary when obtaining measurements. For obese or elderly patients, abdominal flesh may need to be gently moved to one side while scanning to obtain more accurate results.

Aftercare

After scanning is completed, the ultrasound gel should be wiped from the patient's skin and the scanning head. The scanning head should then be cleaned with alcohol. Bladder volume measurements can then be printed out and attached to the patient's chart. Depending on the bladder volume measured, urethral catheterization is performed to relieve urine retention if the patient cannot void on his/her own. If the patient has an indwelling catheter, the bladder volume measurement may indicate a need for catheter irrigation or checking for catheter blockage. The bladder scan may need to be repeated, depending on the catheterized or voided urine volume obtained.

Complications

There are no complications associated with the bladder ultrasound procedure.

Results

In general, if the bladder volume measured is greater than 300 milliliters, urethral catheterization or patient

voiding to relieve urine retention should be performed. Clinical studies have demonstrated that using the bladder ultrasound scan instead of intermittent catheterization to measure urine retention reduces the risk of urinary tract infections.

Health care team roles

In the acute care setting, the nurse and physician are responsible for monitoring urine output in postoperative patients. In the long-term care and rehabilitation settings, the primary responsibility for monitoring urine output and/or bladder function lies with the nursing staff. Device manufacturer representatives provide in-service training to nursing staff on using the bladder ultrasound scanner. Clinical and nurse managers may also implement bladder scanning protocols and results and outcomes tracking, particularly when bladder ultrasound replaces intermittent catheterization protocols with the goal of reducing catheterization-related costs and infections.

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Bleeding disorders

Definition

Bleeding disorders are disruptions in the body's ability to control **blood** clotting. Patients with these conditions bleed easily for longer periods of time than normal.

Description

Coagulation, or clotting, is a complex process involving at least 20 components of the blood, including various enzymes, messenger chemicals, and **proteins**. Under normal circumstances, the components necessary for coagulation circulate in the blood. When an injury occurs, they act together in a series of chain reactions to form a clot and prevent uncontrolled bleeding. Several disorders affect the blood's clotting components and diminish normal clotting capability. For people with these disorders, even a small injury could make them bleed to death.

Anatomy of a blood clot

In healthy individuals, clots begins when fibrin, an insoluble protein that forms the skeleton of the clot, forms at the wound site from fibrinogen, a soluble protein present in plasma. This chemical change is made possible by thrombin, an enzyme that itself is only created from the compound prothrombin when an injury occurs. Once fibrin strands are formed at the wound site, they trap platelets that flow past them. Platelets then initiate the contraction of damaged **blood vessels** so that less blood is lost. They also help plug damaged blood vessels and work with plasma to accelerate blood clotting.

Hemophilia A

Hemophilia A, also known as classic hemophilia, is a genetic disorder carried by females but expressed almost exclusively in males. The disorder is characterized by a lack of factor VIII, a glycoprotein found in blood plasma that, like all coagulation factors, is essential for blood clotting. Hemophilia causes uncontrolled

bleeding, often internally, which is not only painful, but can permanently damage muscles and joints. The disease can be mild to severe, depending on how much (or little) factor VIII the body produces. Hemophilia A affects about 20,000 Americans, and is found worldwide in about 1:10,000 males; the most severe form is less common, appearing in 1:16,000 males.

Hemophilia B

This X-linked genetic disorder, sometimes called Christmas disease (after one of the first patients in whom it was recognized) is a deficiency of the blood clotting factor IX, or plasma thromboplastin component, which is normally produced by the **liver**. Like hemophilia A, patients with hemophilia B bleed uncontrollably when injured, and the disease is carried almost exclusively by females; males are almost exclusively afflicted. The degree of severity depends where on the gene the defect is found. Hemophilia B is relatively rare, occurring in at least 1:50,000 people; some estimates are 1:25,000.

Hemophilia C

Hemophilia C is extremely rare, occurring in about 1:100,000 people; it is the only type of hemophilia that can be expressed equally in either males or females. It is marked by a deficiency of the blood clotting factor XI, although, unlike hemophilia A and B, the level of factor XI does not correspond to the disease's severity. Hemophilia C is especially prevalent (1:10,000) among Ashkenazi Jews; in Israel it is estimated to affect 8% of the population.

Disseminated intravascular coagulation disorder (DIC)

Unlike hemophilia, DIC, also known as consumption coagulopathy or defibrination syndrome, is neither hereditary nor common. It is almost always caused by another disease or condition, which in turn activates abnormal and uncontrolled clotting. This causes many small blood clots to form throughout the body, giving the disease its name. This overproduction of clots depletes the supply of clotting factors and platelets necessary to prevent hemorrhage when an injury (or surgery) occurs. Patients with DIC will bleed abnormally even though there is no history of coagulation disorder.

Thrombocytopenia (TCP)

Thrombocytopenia is a group of bleeding disorders characterized by severely diminished platelet counts, which cause internal bleeding. TCP can occur during **pregnancy**, as a reaction to certain medications, when the spleen and lymph produce antibodies against

platelets, or for no known reason, a type called idiopathic TCP.

Other bleeding disorders

Von Willebrand's disease (vWD), also called pseudo-hemophilia B, vascular hemophilia, or angiohemophilia, is a hereditary disorder, that, like hemophilia, is connected with a factor VIII deficiency and causes uncontrolled bleeding. Unlike hemophilia, however, the true deficiency is the von Willebrand factor, a blood plasma protein that helps transport and protect factor VIII platelets and also helps platelets adhere to tissue at wound sites and also. A further distinction is that both males and females can be affected, making vWD the most common type of bleeding disorder. There are three types of the disease: the first two are mild; the third is the most severe, and must be inherited from both parents.

Hypoprothrombinemia, or factor II deficiency, is a lack of prothrombin (or factor II) that can lead to hemorrhage. The genetic type of the disorder is very rare, and must be inherited from both parents to emerge. Acquired factor II deficiency can result from **vitamin K** deficiency, liver disease, and several types of gastrointestinal disorders.

Factor VII deficiency, also called proconvertin deficiency or serum prothrombin conversion accelerator (SPCA) deficiency, can be either congenital or acquired through disease, use of anticoagulants, or malnutrition. The congenital form is often diagnosed when newborns react to the trauma of birth with intracranial bleeding. The disease is quite rare, with 1:500,000 people, both males and females, afflicted.

Causes and symptoms

Hemophilia

Hemophilia A is usually inherited through a complex genetic system that passes a recessive gene on the female chromosome. If a woman carries the hemophilia gene, each of her male children has a 50% chance of having hemophilia; each female child has a 50% chance of carrying the gene. About a third of all hemophilia patients develop the disease with no known genetic risk; these cases, called sporadic hemophilia, are assumed to be the result of spontaneous genetic mutation.

Hemophilia A is suspected with when patients exhibit numerous large, deep bruises along with painful and swollen joints caused by internal bleeding. Mild hemophilia may first be discovered when prolonged bleeding follows a surgical procedure. If this involves bleeding into the neck, head, or digestive tract, or of the bleeding

is caused by an injury, emergency measures may be required.

Hemophilia B

Hemophilia B is also hereditary but less common than hemophilia A. Its severity varies from mild to severe, although mild cases are more common. Hemophilia B symptoms are similar to those of hemophilia A, including numerous large and deep bruises and prolonged bleeding. The more dangerous symptoms are those that represent possible internal bleeding, such as swollen joints or bleeding into internal organs upon trauma.

Hemophilia C

Nearly 50% of patients with this disorder experience no symptoms, but others may notice blood in their urine, nosebleeds, or bruising. Although joint bleeding seldom occurs, some patients will experience bleeding long after an injury occurs. Some women will experience prolonged bleeding after **childbirth**.

Disseminated intravascular coagulation

DIC has a number of causes, and it is not thoroughly understood why or how they lead to the coagulation problem. It is known, however, that DIC's underlying causes share factors that affect proteins, platelets, or other clotting factors and processes. For example, uterine tissue can enter the mother's circulation during prolonged labor, thus introducing foreign proteins into the blood; the venom of some exotic snakes can activate one of the clotting factors; severe head trauma can expose blood to **brain** tissue. No matter the cause, the results are a malfunction of thrombin (an enzyme) and prothrombin (factor II), which activate the fibrinolytic system, releasing clotting factors in the blood. DIC can alternate from hemorrhage to thrombosis, and both can exist, which further complicates diagnosis and treatment.

Symptoms may include minute hemorrhage spots on the skin, and purple patches or hematomas caused by bleeding in the skin. Patients may also bleed from surgery or intravenous injection (IV) sites. Related symptoms include vomiting, seizures, **coma**, shortness of breath, **shock**, severe **pain** in the back, muscles, abdomen, or chest.

Thrombocytopenia

Thrombocytopenia, a defective or decreased production of platelets (thrombocytes), may be acquired or congenital. The most common cause of acquired TCP is medication use—mainly heparin or **chemotherapy** agents (also some **antibiotics**). Symptoms include sudden onset

of petechia or purpura, or bleeding into mucous membranes (such as nosebleeds). The disorder may also be evident as blood in vomit or stools, or unusually heavy menstrual flow in women. Some patients show none of these symptoms, but complain of fatigue and general weakness.

Thrombocytopenia has several causes, most of which are more commonly acquired as a result of another disorder. Common underlying disorders include leukemia, drug toxicity, or aplastic anemia, all of which lead to decreased or defective production of platelets in the bone marrow. Other diseases, such as severe **infection**, disseminated intravascular coagulation, and cirrhosis of the liver may destroy platelets outside the marrow. The idiopathic form most commonly occurs in children, and is most likely the result of production of antibodies in the spleen and liver that destroy platelets.

Other bleeding disorders

Von Willebrand's disease is caused by a defect in the von Willebrand clotting factor, a blood chemical that regulates the production and availability of factor VIII. In rare cases, it may be acquired. Symptoms include easy bruising, bleeding in small cuts that stops and starts, abnormal bleeding after surgery, and abnormally heavy menstrual bleeding. Nosebleeds and blood in the stool with a black, tarlike appearance are also signs of von Willebrand's disease.

Hypoprothrombinemia is a very rare deficiency in prothrombin, or factor II, a glycoprotein formed and stored in the liver. Unlike hemophilia, both parents must be carriers for the disease to occur. Under normal conditions, prothrombin is converted to thrombin as part of the clotting cascade, which activates fibrin and begins the process of coagulation. Some patients may show no symptoms while others will suffer severe hemorrhaging. Patients may experience easy bruising, profuse nosebleeds, postpartum hemorrhage, excessively prolonged or heavy menstrual bleeding, and postsurgical hemorrhage. Hypoprothrombinemia may also be acquired rather than inherited, usually as a result of vitamin K deficiency caused by liver diseases, newborn hemorrhagic disease, or a number of other factors.

Factor VII deficiency causes varying types and degrees of bleeding, depending on the severity of the disease. Patients may bleed from the gums or nose, within the skin, or into the joints, **stomach**, intestine, and urinary tract. Women may experience heavy menstrual bleeding.

Diagnosis

There are hundreds of different tests to detect various bleeding disorders, each one geared to the hallmarks

of the specific disease. In addition to blood tests, physicians will compile a medical history and perform a **physical examination**. In the case of acquired **blood coagulation** disorders, information such as prior or current diseases and medications will be important in determining the cause of the bleeding disorder.

Hemophilia A

Hemophilia A (factor VIII deficiency) will be diagnosed with laboratory tests detecting presence of clotting factor VIII, factor IX (to distinguish it from hemophilia B), and others, as well as the presence or absence of clotting factor inhibitors.

Hemophilia B

Tests for hemophilia B look for diminished levels of factor IX, along with analyses of prothrombin and thromboplastin.

Hemophilia C

Hemophilia C (factor XI deficiency) is diagnosed with a test to measure the amount of factor XI in the blood.

Disseminated intravascular coagulation

Disseminated intravascular coagulation can be diagnosed through a number of laboratory tests that measure the concentration of platelets and fibrinogen in the blood with normal counts and prolonged prothrombin time. Other supportive data include diminished levels of factors V, VIII, and fibrinogen, hemoglobin, and other chemicals. Since many of the test results also indicate other disorders, the physician may have to put together several results to reach a diagnosis of DIC. Serial tests may also be recommended, because a single examine at one moment in time may not reveal the process that is occurring.

Thrombocytopenia

Tests for thrombocytopenia include **coagulation tests** revealing a decreased platelet count, prolonged bleeding time, and others. If these tests indicate that platelet destruction is causing the disorder, the physician may order bone marrow examination.

Other bleeding disorders

Von Willebrand's disease will be diagnosed with laboratory tests that show prolonged bleeding time, absent or reduced levels of factor VIII and von Willebrand factor, a normal platelet count, and others.

Hypothrombinemia is diagnosed by medical history and tests that measure deficiencies in vitamin K, prothrombin, and clotting factors V, VII, IX, and X.

Factor VII deficiency can be diagnosed with blood tests that show a diminished level of factor VII in the blood, along with other blood tests showing a prolonged prothrombin time and normal partial thromboplastin time.

Treatment

For mild bleeding disorders, treatment may involve drugs that help the body increase the amount of clotting factors available. In severe cases, however, bleeding may only stop if the missing clotting factor that is replaced through fresh frozen plasma or cryoprecipitate, the blood fraction containing factor VIII. Every care must be taken to ensure that these infusions are free of HIV and other contaminants. Unfortunately, for many patients, this was not always the case, and many hemophiliacs, like Ryan White, contracted **AIDS**. New bioengineered therapies that rely on recombinant DNA technology should prevent any possibility of transferring HIV/AIDS.

Hemophilia A

Mild-to-moderate forms of hemophilia A may be controlled with desmopressin acetate, a synthetic form of a pituitary hormone that rapidly increases that amount of available factor VIII and von Willebrand factor. This drug is called DDAVP in the injectable form, and Stimate when formulated as a nasal spray. Severe bleeding episodes will require transfusions of human blood clotting factors. Many hemophiliacs, however, have become resistant to this form of treatment and have developed antibodies against it. For these patients, a synthetic protein called factor VIIa (tradename NovoSeven) can increase coagulation or prevent bleeding episodes altogether. Factor VIIa is made with recombinant DNA technology. Fetal tissue implants and gene therapies are also being studied as possible treatments for hemophilia.

Hemophilia B

The treatment for hemophilia B is similar to that for hemophilia A, with the infusion of synthetic and human blood products, such as factor IX concentrate or factor IX complex (prothrombin) concentrate, to promote coagulation.

Hemophilia C

Hemophilia C is most often treated with plasma, since concentrates of factor XI are not universally available in the United States, due to the disease's extreme rarity.

KEY TERMS

Blood clot—A clump of blood that forms as a result of coagulation when a blood vessel is injured. Without this process a person would bleed to death from a relatively small wound.

Coagulation—The blood's change from a liquid to a semisolid state through chemical reaction.

Clotting factor—Any of several components normally found in blood that are essential for clotting to occur.

Enzyme—A substance that causes a chemical reaction, usually a protein. Enzymes are secreted by cells.

Hemorrhage—Abnormal, uncontrolled bleeding from the blood vessels, usually internally.

Heparin—An anticoagulant; a drug used to dissolve or prevent the formation of blood clots.

Idiopathic—Refers to a disease of unknown cause.

Petechiae—Small pinpoint bruises caused by bleeding under the skin.

Platelets—Also called thrombocytes, these are small, colorless particles found in the only in mammalian blood that help form clots, keep various body chemicals in circulation, and devour foreign bodies, such as viruses.

Purpura—Purplish discoloration of the skin caused by bleeding into the skin and mucous membranes.

Thrombosis—Formation of a clot that either blocks or partially blocks a blood vessel. The thrombus may lead to infarction, or tissue death.

Disseminated intravascular coagulation

Treatment for DIC depends on what other disease is causing it. If the patient is not yet actively bleeding, the underlying cause should be dealt with. This supportive treatment may eliminate the DIC and the need for emergency measures. In some instances, heparin, an anticoagulant, is used to dissolve the small clots throughout the body; given that DIC can result in hemorrhage, this therapy is controversial. If bleeding has begun, however, the patient may need infusions of blood, platelets, plasma, and other blood products. Heparin should not be used to treat DIC caused by heatstroke, snakebite, trauma, mismatched transfusions, and acute problems resulting from

obstetrical complications, nor should it be administered to patients with head injuries or **central nervous system** bleeding.

Thrombocytopenia

Secondary acquired thrombocytopenia is best alleviated by treating the underlying cause or disorder. Sometimes, no treatment is necessary; the condition will resolve by itself. If treatment is required, it will depend on the underlying cause. Platelet transfusions can help alleviate TCP caused by chemotherapy, for example. In other cases, **corticosteroids** or immune globulin may be given to improve platelet production.

Other bleeding disorders

Von Willebrand's disease often requires no treatment because the bleeding is mild and controllable. DDAVP can help raise levels of the Von Willebrand factor and is the treatment of choice for many cases. However, if trauma or surgery is scheduled there are several methods that will reduce bleeding time and replace factor VIII, which will consequently replace the von Willebrand factor. This may include infusion of cryoprecipitate or plasma. For severe bleeding, infusions of a viral inactivated factor VIII products such as Humane-P, Alphanate, and Koate DVI may be required.

Hypoprothrombinemia may be treated with concentrates of prothrombin. Acquired cases are often treated with vitamin. In bleeding episodes, the patient may receive plasma products.

Factor VII deficiency patients may be treated with normal plasma or concentrates containing factor VII or the biomedically engineered VIIa.

Prognosis

The prognosis for patients with mild forms of bleeding disorders is good; many lead normal lives and enjoy a normal life expectancy. Untreated bleeding episodes, however, cause severe muscle and joint pain that eventually becomes permanent damage. Any incident that causes blood to collect in the head, neck, or **digestive system** can be fatal without immediate medical attention.

The clots that form throughout the body with DIC can produce **gangrene** in the fingers, nose, or genitals, and can even cause strokes. The prognosis depends on early intervention and treatment of the underlying condition.

Health care team roles

Patients must communicate with their health care providers before undergoing procedures or tests that

could cause bleeding. The best care is obtained when treatment is coordinated by a health care team with expertise in the field. The Centers for Disease Control and Prevention found that patients with severe or moderate hemophilia had 60% less mortality and morbidity when their treatment was coordinated by a comprehensive hemophilia treatment compared to those not seen by a comprehensive hemophilia treatment center.

Other health care providers, such as counselors, may help patients cope with their conditions or illnesses. Support groups can also be helpful in understanding the specific condition and in achieving goals for personal wellness.

Prevention

It is not always possible to prevent bleeding disorders. Some acquired conditions may be prevented by preventing underlying diseases such as cirrhosis, or discontinuing medications whose side effects cause bleeding. Hereditary disorders can be predicted with prenatal testing and **genetic counseling**. Severe bleeding episodes may be prevented by refraining from activities that could cause injury, such as contact sports.

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National Hemophilia Foundation. 116 West 32nd St., 11th Floor, New York, NY 10001. 800-42-HANDI. <<http://www.hemophilia.org>>.

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Crystal Heather Kaczkowski, MSc.

Bleeding time test see **Coagulation tests**

Blindness see **Visual disorders**

Blood

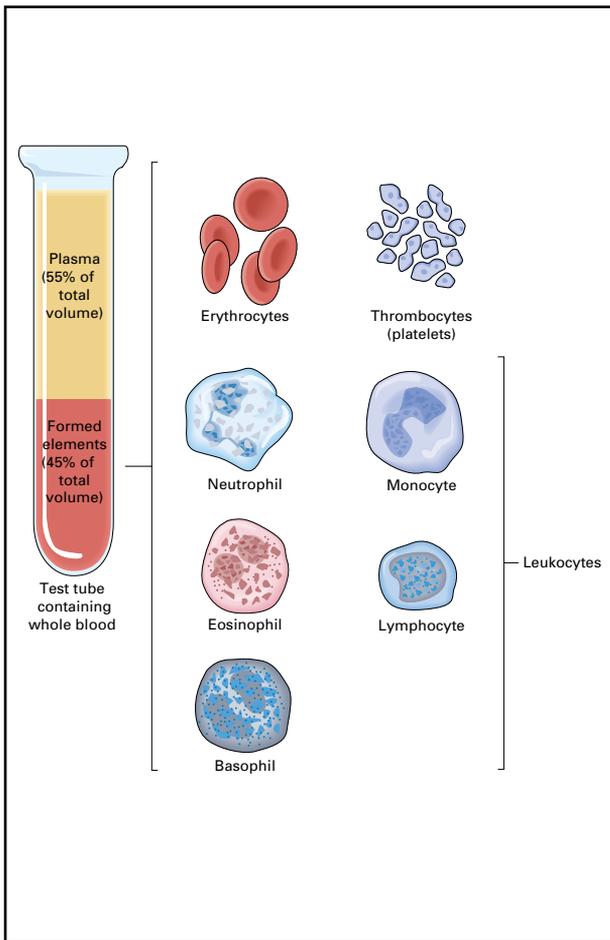
Definition

Blood is a liquid connective tissue that performs many functions in the body, including transport of oxygen, carbon dioxide, nutrients, waste products, and hormones; clotting; and defense against microorganisms. Blood consists of blood cells suspended in plasma, a fluid that contains **proteins**, salts, and other substances. When a blood sample is placed in a test tube and spun rapidly (a process called centrifugation), the heavier blood cells sink to the bottom of the test tube, while the straw-colored plasma floats on top.

Description

All vertebrates circulate blood within **blood vessels**. Because blood is enclosed within blood vessels, the circulatory systems of vertebrates are called closed circulatory systems. (Some invertebrates have open circulatory systems that do not contain blood vessels and circulate a blood-like fluid called hemolymph.)

The human body contains about 4 to 6.3 qt (4 to 6 L) of blood. Men have more blood than women, due to the presence of higher levels of testosterone, a hormone that regulates sex characteristics and function and also stimulates red blood cell formation. Plasma makes up 55% of the blood, while the blood cells constitute the other 45%. The various types of blood cells are red blood cells (erythrocytes), white blood cells (leukocytes or leucocytes), and platelets.



The major components of blood. (Delmar Publishers, Inc. Reproduced by permission.)

Plasma

Plasma contains mostly water, which accounts for 91.5% of the plasma content. The water acts as a solvent for carrying other substances.

PLASMA PROTEINS. Proteins account for 7% of plasma. The higher concentration of protein in blood prevents water from moving from the blood into the interstitial fluid. Without this osmotic protection, water would move from the blood into the interstitial fluid, causing a rapid loss of blood volume.

The most abundant of the plasma proteins is albumin, a protein also found in egg white. Albumin concentration is four times higher in the blood than in the interstitial fluid (the watery fluid that bathes tissues, but is located outside and between cells). This high concentration of albumin in plasma serves an important osmotic function.

Other proteins that are present in plasma are immunoglobins and fibrinogen. Immunoglobins, also called antibodies, are proteins that function in the **immune response**. Antibodies attach to invading **bacteria** and other microorganisms, marking them for destruction by immune cells. Fibrinogen is a protein that functions in a complex series of reactions that leads to the formation of blood clots.

OTHER PLASMA COMPONENTS. The other components of plasma are salts, nutrients, enzymes, hormones, and nitrogenous waste products. Together, these substances account for 1.5% of plasma. The salts present in plasma include sodium, potassium, **calcium**, magnesium, chloride, and bicarbonate. These salts function in many important body processes. For instance, calcium functions in **muscle contraction**; sodium, chloride, and potassium function in nerve impulse transmission in nerve cells; and bicarbonate regulates pH. These salts are also called electrolytes. An imbalance of electrolytes, which can be caused by **dehydration**, can be a serious medical condition. Many gastrointestinal illnesses, such as cholera, cause a loss of electrolytes through severe **diarrhea**. When electrolytes are lost, they must be replaced with intravenous or oral solutions of water and salts.

The remaining substances present in plasma are elements that the plasma is transporting from one place to another. For instance, plasma contains nutrients that nourish tissues. The nutrients found in plasma include amino acids, the building blocks of proteins; glucose and other sugars; and fatty acids and glycerol, the components of **lipids (fats)**. In addition to nutrients, plasma also contains enzymes, or small proteins that function in chemical reactions, and hormones, which are transported from glands to body tissues. Waste products from the breakdown of proteins are also found in plasma. These waste products include creatinine, uric acid, and ammonium salts. Blood transports these waste products from the body tissues to the **kidneys**, where they are filtered from the blood and excreted in the urine.

Red blood cells

The human body contains an estimated 25 trillion red blood cells; approximately 4.8 million to 5.4 million are found in every microliter of blood. The structure of a red blood cell is eminently suited to its primary function, the transport of oxygen from the **lungs** to body tissues. Red blood cells are very small (about 6 nanometers wide), shaped like a disk, and contain a small depression on either side. Their small size allows them to squeeze through the tiniest of blood vessels (capillaries). In addition, their size allows a greater diffusion of oxygen across

the blood cells' plasma membranes than if the cells were larger—because blood contains so many of these small cells, their combined surface areas translate into an extremely large surface area for the diffusion of oxygen. The disk shape and the depressions on either side also contribute to a greater surface area.

TRANSPORT OF OXYGEN. Red blood cells are unusual in that they do not contain nuclei or mitochondria, the cellular organelles in which aerobic **metabolism** (the breakdown of nutrients that requires oxygen) is carried out. Instead, red blood cells acquire energy through metabolic processes that do not require oxygen. The lack of nuclei and mitochondria therefore allow the red blood cell to function without depleting its cargo of oxygen, leaving more oxygen for the body tissues.

The molecule that binds oxygen in red blood cells is called hemoglobin. Hemoglobin is a large, globular protein consisting of four protein chains surrounding an **iron** core. Hemoglobin is densely packed inside the red blood cell; in fact, hemoglobin accounts for a third of the weight of the entire red blood cell. Each red blood cell contains about 250 molecules of hemoglobin.

In the lungs, oxygen diffuses across the red blood cell membrane and binds to hemoglobin. As blood circulates to the tissues, oxygen diffuses out of the red blood cells and enters tissues. The waste product of aerobic metabolism, carbon dioxide, then diffuses across red blood cells and binds to hemoglobin. Once circulated back to the lungs, the red blood cells discharge their load of carbon dioxide, which is then breathed out of the lungs. However, only 7% of carbon dioxide generated from metabolism is transported back to the lungs for exhalation by red blood cells; the majority is transported in the form of bicarbonate, a component of plasma.

HEMOPOIESIS. Red blood cells are formed in red bone marrow from precursor cells called pluripotent stem cells. The process of red blood cell formation is called hemopoiesis (alternatively, hematopoiesis). In adults hemopoiesis takes place in the marrow of ribs, vertebrae, the breastbone, and the pelvis. On average, a red blood cell lives only three to four months. Constant wear and tear on the red blood cell membrane, caused by squeezing through tiny capillaries, contributes to the red blood cell's short life span. Worn out red blood cells are destroyed by phagocytic cells (cells that engulf and digest other cells) in the **liver**. Parts of red blood cells are recycled for use in other red blood cells, such as the iron component of hemoglobin.

White blood cells

White blood cells are less numerous than red blood cells in the human body; each microliter of blood con-

tains 5,000 to 10,000 white blood cells. The number of white blood cells increases, however, when the body is fighting off **infection**. Their numbers are maintained until the **immune system** detects the presence of a foreign invader. When the immune system is activated, chemicals called lymphokines stimulate the production of more white blood cells.

White blood cells function in the body's defense against invasion and are key components of the immune system. They usually do not circulate in the blood vessels, and are instead found in the interstitial fluid and in lymph nodes. Lymph nodes are composed of lymphatic tissue and are located at strategic places in the body. Blood filters through the lymph nodes, and the white cells present in the nodes attack and destroy any foreign invaders.

TYPES OF WHITE BLOOD CELLS. The human body contains five types of white blood cells: monocytes, neutrophils, basophils, eosinophils, and lymphocytes. Each type of white blood cell plays a specific role in the body's immune defense system.

Under a **microscope**, three kinds of white blood cells appear to contain granules within their cytoplasm. These three types are the neutrophils, basophils, and eosinophils. Together, these three types of white blood cells are called granulocytes. The granules are specific chemicals that are released during the immune response. The other two types of white blood cells, the monocytes and lymphocytes, do not contain granules. These types are known as the agranular leukocytes.

Monocytes, which comprise 3% to 8% of the white blood cells, and neutrophils, which comprise 60% to 70% of white blood cells, are called phagocytes. They ingest and digest cells, including foreign microorganisms such as bacteria. Monocytes differentiate into cells called macrophages. Macrophages can be fixed in one place, such as in the **brain** and lymph nodes, or can "wander" to areas where they are needed, such as the site of an infection. Neutrophils have an additional defensive property: they release granules of lysozyme, an enzyme that destroys cells.

Basophils comprise 0.5% to 1% of the total composition of white blood cells and function in the body's inflammatory response. **Allergies** are caused by an inflammatory response to relatively harmless substances, such as pollen or dust, in sensitive individuals. When activated, basophils release various chemicals that cause the characteristic symptoms of allergies. Histamines, for instance, cause the runny nose and watery eyes associated with allergic reactions; heparin is an anticoagulant that slows blood clotting and encourages the flow of blood to the site of inflammation, inducing swelling.

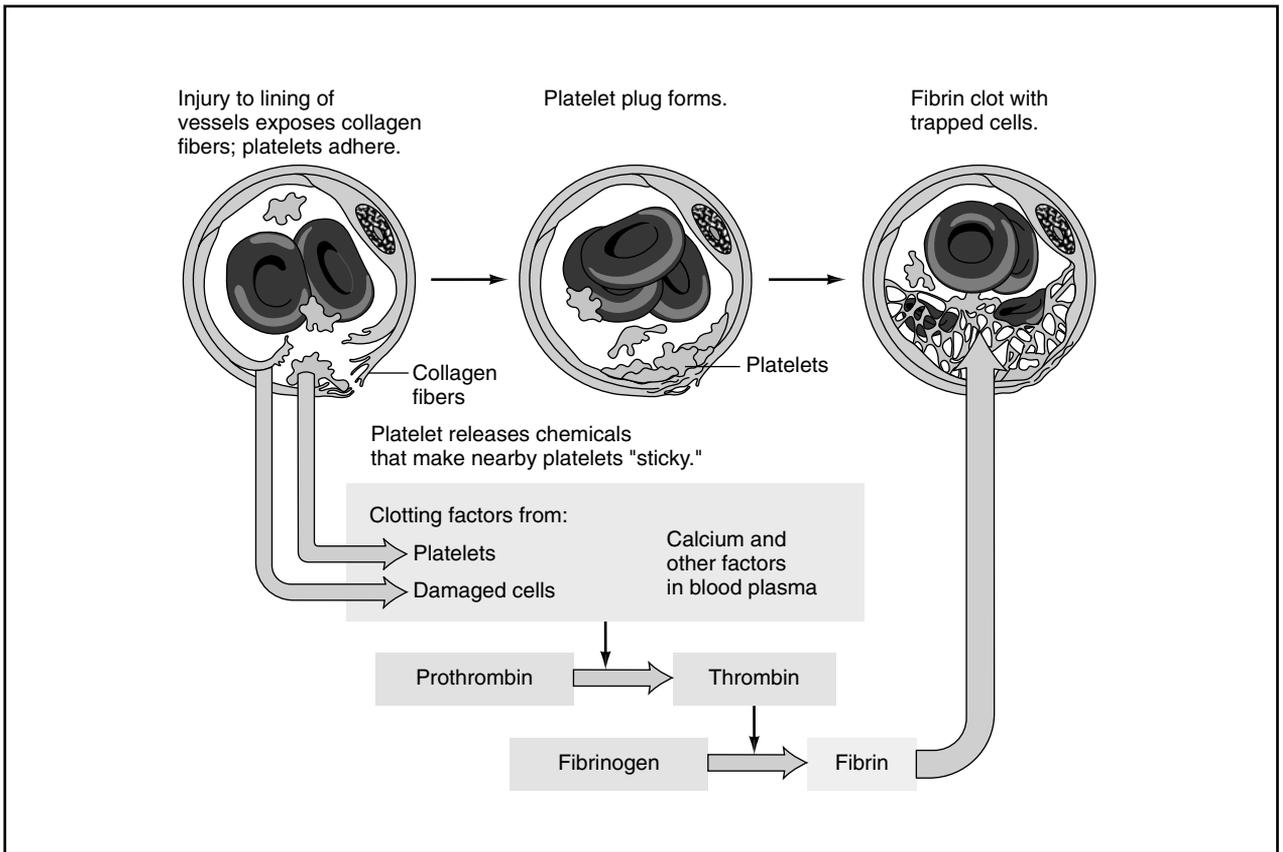


Illustration of blood clotting. (Illustration by Hans & Cassidy. Courtesy of Gale Group.)

Eosinophils, which comprise 2% to 4% of the total composition of white blood cells, are believed to counteract the effects of histamine and other inflammatory chemicals. They also phagocytize bacteria tagged by antibodies.

Lymphocytes, which comprise 20% to 25% of the total composition of white blood cells, are divided into two types: B lymphocytes (also called B cells) and T lymphocytes (also called T cells). The names of these lymphocytes are derived from their origin. T lymphocytes are named for the thymus, an organ located in the upper chest region where these cells mature; and B lymphocytes are named for the bursa of Fabricius, an organ in birds where these cells were discovered.

T lymphocytes play key roles in the immune response. One type of T lymphocyte, the helper T lymphocyte, activates the immune response when it encounters a macrophage that has ingested a foreign microorganism. Another kind of T lymphocyte, called a cytotoxic T lymphocyte, kills cells infected by foreign microorganisms. B lymphocytes, when activated by helper T lymphocytes, become plasma cells, which in turn secrete large amounts of antibodies.

All white blood cells arise in the red bone marrow. However, the cells destined to become lymphocytes are first differentiated into lymphoid stem cells in the red bone marrow. These stem cells undergo further development and maturation in the spleen, tonsils, thymus, adenoids, and lymph nodes.

Platelets

Platelets are not cells; they are fragments of cells that function in blood clotting. Platelets number about 250,000 to 400,000 per liter of blood. Blood clotting is a complex process that involves a cascade of reactions that leads to the formation of a blood clot. Platelets contain chemicals called clotting factors. These clotting factors first combine with a protein called prothrombin. This reaction converts prothrombin to thrombin. Thrombin, in turn, converts fibrinogen (present in plasma) to fibrin. Fibrin is a thread-like protein that traps red blood cells as they leak out of a cut in the skin. As the clot hardens, it forms a seal over the cut.

This process works for relatively small cuts in the skin. When a cut is large, or if an artery is severed, blood loss is so severe that the physical pressure of the blood

leaving the body prevents clots from forming. In addition, in the inherited disorder called **hemophilia**, one or more clotting factors are lacking in the platelets. This disorder causes severe bleeding from even the most minor cuts and bruises.

Platelets have a short life span; they survive for only five to nine days before being replaced. Platelets are produced in red bone marrow and are broken off from other red blood cells.

Role in human health

Blood substitutes

Researchers hope to create synthetic blood substitutes to ease the burden of dwindling blood donations that are needed to meet the demand for surgeries, transfusions, and emergencies. Currently under development are blood substitutes that use perfluorocarbons or modified hemoglobin to carry oxygen to tissues.

Perfluorocarbons are long, fatty hydrocarbon chains containing fluorine that have the ability to pick up oxygen in lungs and release it into tissues. The artificial blood is a mixture of perfluorocarbons with saline (physiological salt water) using surfactants, substances that allow the mixing of oil and water. The solution then can be administered to patients. Over time, as the artificial blood helps deliver oxygen to tissues, the perfluorocarbon molecules are exhaled from the body.

Hemoglobin solutions contain hemoglobin that has been isolated from red blood cells and chemically altered to increase its lifespan in the bloodstream and to ensure adequate oxygen-carrying capabilities.

Strictly, these substances are not whole blood substitutes since they only have the ability to carry oxygen and cannot replace the other important functions of blood. However, they would be valuable in eliminating the risk of transmitting disease during transfusions as well as preventing accidental blood type mismatches.

ABO BLOOD GROUPS. An interesting aspect of red blood cells is that they carry certain proteins, called antigens, on their plasma membranes. These antigens are responsible for the various blood groups known as A, B, AB, and O:

- A person with A antigens is type A and has antibodies to B antigens.
- A person with B antigens is type B and has antibodies to A antigens.
- A person with both antigens is type AB and does not have antibodies to either antigen.

- A person with none of the antigens is type O and has antibodies to both A and B antigens.

These combinations are necessary to know when performing a blood transfusion. For instance, if a type A individual donates blood to a type B individual, the A antibodies in the recipient's B blood will react with the A antigens of the donor's A blood. This reaction, called the agglutination reaction, causes the blood cells to clump together. Agglutination can be fatal. Until blood typing was worked out early in this century, many deaths from blood transfusions occurred due to incompatibility of antigens and antibodies.

HLA ANTIGEN GROUPS. Like red blood cells, the plasma membranes of white blood cells also contain antigens. These surface antigens are called the human leukocyte associated (HLA) antigens. Like the red blood cell types, these HLA antigens represent different white blood cell "groups." When a person receives an organ transplanted from a donor, the recipient and the donor must have the same HLA antigen group for the transplant to be successful. If the donor and recipient are two different HLA antigen groups, the recipient's body will "reject" the organ; in other words, the recipient's immune system will be activated by the foreign cells of the organ and initiate an immune response against the organ.

Common diseases and disorders

Sickle cell anemia

Sickle cell anemia is an inherited disorder caused by a defect in one of hemoglobin's four protein chains. The defective hemoglobin distorts the shape of the red blood cells and injures the red blood cell membrane. Water and potassium leak from the cells, causing the red blood cells to become rigid and "sickle-shaped." As a result of these changes, oxygen transport is severely interrupted and circulation of the blood through the blood vessels can become blocked. These irregular blood cells do not carry as much oxygen as their normally shaped counterparts. Although the prognosis for individuals with sickle cell anemia was historically poor, improvements in life expectancy and quality have been made due to early diagnosis and treatment.

Hemophilia

Hemophilia is hereditary group of **bleeding disorders** that results in insufficient clotting and excessive bleeding. Types are hemophilia A, hemophilia B, and von Willebrand's disease. Hemophilia A is the most common type. It results from a deficiency in clotting factor VIII. Only males have this sex-linked disease, but women may be carriers. Uncontrolled bleeding, both internal and

KEY TERMS

Aerobic metabolism—Metabolic processes that require oxygen.

Antibody—An immune protein that marks foreign microorganisms in the body for destruction by other immune cells.

Antigen—A protein that is attached to a cell's plasma membrane.

Centrifugation—A laboratory procedure in which a test tube of blood or other liquid is spun at a high speed.

Clotting factor—A set of substances released by platelets that function in the clotting mechanism.

Electrolytes—The salts and other substances present in the plasma that function in crucial body processes.

Fibrin—A protein that functions in the clotting mechanism; forms mesh-like threads that trap red blood cells.

Fibrinogen—The inactive form of fibrin present in plasma; activated by clotting factors released by platelets.

Hemoglobin—The protein found in red blood cells that binds oxygen; consists of four protein chains surrounding an iron core.

Hemophilia—A genetic disorder in which one or more clotting factors are not released by the platelets; causes severe bleeding from even minor cuts and bruises.

Hemopoiesis—The process of red blood cell formation in the bone marrow.

Histamine—A chemical released by basophils during the inflammatory response; causes blood vessels to dilate.

Immunoglobulin—An antibody.

Inflammatory response—A type of non-specific immune response; involves the release of chemicals from basophils that increase blood circulation and white blood cell migration to the affected area.

Interstitial fluid—The fluid that bathes cells.

Lymph node—A small structure located at several points in the body; consists of lymphatic tissue that filters blood and removes microorganisms.

Lymphocyte—A type of white blood cell; includes B and T lymphocytes.

Lysozyme—An enzyme released by neutrophils that kills cells.

Lymphoid stem cell—The cell from which B and T lymphocytes are derived.

Phagocytize—To engulf and digest a cell.

Plasma cell—The cell derived from the B lymphocyte, which secretes antibodies.

Pluripotent stem cell—The type of stem cell from which red blood cells and more white blood cells are derived in the bone marrow.

Sickle cell anemia—A genetic disorder caused by a defect in one of hemoglobin's four protein chains; causes red blood cells to be sickle-shaped.

external, may be caused by the smallest of injuries. Treatment involves clotting factor supplementation, and transfusions are common when blood is lost, or prophylactically.

Human immunodeficiency virus

Human **immunodeficiency virus** (HIV), the causative agent of acquired immune deficiency syndrome (**AIDS**), attacks and kills T lymphocytes. This disease cripples the immune system and leaves the body helpless to stave off infections. As AIDS progresses, the number of helper T lymphocytes drops from a normal 1,000 per cubic millimeter to below 200.

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ORGANIZATIONS

- American Sickle Cell Anemia Association. 10300 Carnegie Avenue, East Office Building (EEb18), Cleveland, OH 44106. (216) 229-8600. <<http://www.ascaa.org>>.
- America's Blood Centers. 725 15th Street NW, Suite 700, Washington, DC 20005. (202) 393-5725. <<http://www.americasblood.org>>.
- National Hemophilia Foundation. 116 West 32nd Street, 11th Floor, New York, NY 10001. (800) 42-HANDI. <<http://www.hemophilia.org>>.

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Kathleen Scogna

Blood alcohol test *see* **Drug tests**

Blood coagulation

Definition

Blood coagulation is the process that causes blood to clot and helps prevent excessive blood loss when a vein or artery is pierced or broken.

Description

Blood coagulation is the body's natural way of preventing its blood supply from being lost through a cut, puncture, or other trauma to **blood vessels**. All of the components necessary for coagulation are found in the blood. The coagulation process involves a series of **proteins**, protein cofactors, and enzymes that interact on membrane surfaces. It is normally activated by damaged tissue.

Function

Normal blood coagulation is a complex process that involves 20 to 30 components, called blood coagulation factors, and a series of complex chemical reactions. When a blood vessel is injured, platelets in the area of the damage clump together and stick to the edges of the cut to begin the coagulation process. Platelets are fragments of cells containing clotting factors. These clotting factors combine with a protein called prothrombin in a reaction that converts prothrombin to thrombin. Thrombin then converts fibrinogen (a protein present in plasma) into long, sticky threads of another protein called fibrin. The fibrin forms a mesh-like net over the opening and traps red blood cells as they try to leak out of the cut. As the clot hardens, it forms a protective seal over the cut.

The platelets also release messengers into the blood that perform additional functions including: constriction of the damaged blood vessels to reduce bleeding, attracting more platelets to the injury site to enlarge the clot, and activating other clotting factors, such as fibrinogen.

Role in human health

The ability of the blood to form a self-sealing clot when a blood vessel is injured is crucial. Without coagulation, a cut or puncture wound, no matter how minor, would continue to bleed and quickly lead to death. A deficiency in any of the protein coagulation factors can result in hemorrhages following injury. In some coagulation disorders, such as **hemophilia**, the deficiency is due to an inherited defect. In others, the deficiency is due to an acquired condition, such as **vitamin K** deficiency.

Common diseases and disorders

Hemophilia is an inherited coagulation disorder characterized by the blood's inability to clot. Both types of the disorder, hemophilia A and hemophilia B, are caused by an inherited sex-linked recessive trait, with the defective gene located on the X chromosome. This means only males are affected with the disorder but females can carry the abnormal gene and pass it on to their children.

About 80% of hemophiliacs have type A, which is the result of a deficiency of clotting factor VIII. Symptoms can vary and include bruising, spontaneous bleeding, bleeding into joints, hemorrhaging in the gastrointestinal and urinary tracts, and most notably, prolonged bleeding even from the most minor of cuts.

Prevention of injury is paramount for people with the disorder. When bleeding occurs, the standard treatment is infusion of blood plasma with concentrations of

KEY TERMS

Coagulation—The process of becoming gel-like or solid.

Enzymes—Numerous complex proteins produced by cells in the body and catalyze specific biochemical reactions at body temperatures.

Hemorrhaging—Heavy or uncontrollable bleeding.

Protein cofactor—A substance that acts in conjunction with protein to bring about certain effects.

X chromosome—A sex chromosome that usually occurs in pairs in females and single in male cells.

clotting factor VIII. This clotting factor has been cloned through **genetic engineering**, eliminating the possibility that the blood may contain **viruses** such as hepatitis and human **immunodeficiency** virus (HIV). Hemophilia A occurs in about one out of 10,000 males.

Hemophilia B (also called Christmas disease) is a result of a deficiency of clotting factor IX. Symptoms are generally the same as for type A. Treatment is usually infusion of blood plasma with clotting factor IX. The condition occurs in one out of about 70,000 males.

The most common coagulation disorder is thrombosis, which is a blood clot that blocks otherwise normal blood vessels. This is most disastrous when the clot blocks a blood vessel leading to the **heart** (causing a heart attack), **brain** (causing a stroke), a limb, or other organ.

Thrombocytopenia is a blood disease characterized by an abnormally low number of platelets in the bloodstream. The normal amount of platelets is usually between 150,000 and 450,000 cells per microliter of blood. When this number drops below 150,000, the patient is said to be thrombocytopenic. This blood disorder is one of the most common causes of hemorrhaging.

Treatment and management

Individuals at high risk for developing clots or those who have had them previously can prevent further clots by taking anticoagulant drugs, such as sodium warfarin and heparin. Anticoagulant drugs help prevent the formation of harmful clots in the blood vessels by reducing the blood's ability to clump together. Although these drugs are sometimes called blood thinners, they do not actually thin the blood. Furthermore, this type of medicine will

not dissolve clots that have already formed, although the drug may prevent an existing clot from worsening. Because these drugs affect the blood's ability to clot, they can increase the risk of severe bleeding and heavy blood loss. Anticoagulant drugs must be used exactly as directed and a physician should be consulted regularly while taking the medicine.

Medications called fibrinolytic agents are sometimes used to dissolve clots and include streptokinase, urokinase, and tissue plasminogen activator. These are most commonly used for thrombosis.

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Ken R. Wells

Blood coagulation disorders see **Bleeding disorders**

Blood count see **Complete blood count**

Blood crossmatching see **Type and screen**

Blood culture

Definition

A **blood culture** is a lab test designed to detect the presence of **bacteria**, yeast, or **fungi** in the bloodstream.

A routine blood culture involves injecting a sample of the patient's blood into two bottles of sterile nutrient broth (one for aerobes and one for anaerobes), incubating the bottles at 35°C, and monitoring the bottles for growth over a period of five days. For positive cultures, it also involves identifying any organism that grows and performing antibiotic sensitivity tests to determine which **antibiotics** will be effective in treating the **infection**.

Purpose

Physicians normally order this test for patients with symptoms of bacteremia. Symptoms can include **fever**, chills, mental confusion, **anxiety**, rapid heartbeat, hyperventilation, blood clotting problems, and **shock**. These symptoms are especially significant if the patient already has another illness or infection, is hospitalized, or has trouble fighting infections because of a weak **immune system**. Because bacteremia can be a serious clinical condition that, untreated, can lead to death, a blood culture should be performed as soon as an infection is suspected. Early detection will give the patient the best chance for effective treatment and survival.

Blood cultures are sometimes used to determine the causes of infections in other parts of the body because these infections often spread to the blood. For example, bacterial **pneumonia** (an infection of the lung) and infectious **endocarditis** (an infection of the inner layer of the **heart**, including the heart valves) are known to leak bacteria into the bloodstream. Other sources might be **boils**, urinary tract infections, and oral bacteria spread during mouth trauma (such as injury or dental treatment).

Precautions

Patients who have **bleeding disorders** or are taking blood thinners might have trouble with bleeding following a venipuncture. Before having a blood sample drawn, such patients should tell the phlebotomist about their condition.

Description

There are many variables involved in performing a blood culture. Before ordering a blood culture, the physician must make the following decisions based on a knowledge of infections and the patient's clinical condition and medical history.

- type of blood culture that will best target the suspected microorganism
- number of blood cultures to request
- how often the blood cultures should be performed

Some factors influencing these decisions are the patient's symptoms or previous culture results, and whether or not the patient has had recent antibiotic therapy.

Types, numbers, and timing of blood cultures

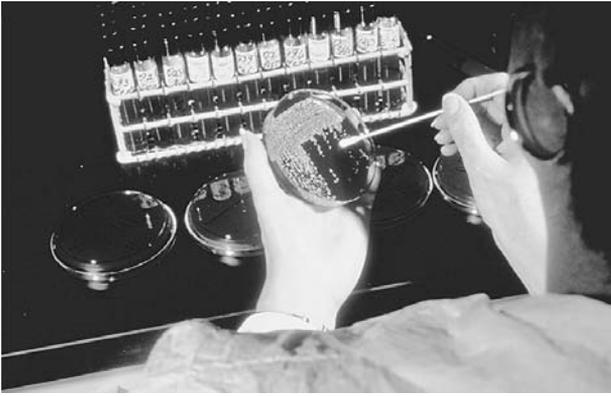
Several groups of microorganisms can cause blood infections. These groups include bacteria (both aerobes and anaerobes), yeast, fungi, **viruses**, and mycobacteria. Routine blood culture medium will normally grow both aerobic and anaerobic bacteria, yeast, and most fungi. Viruses, mycobacteria, and certain other fungi require special media or special collection techniques and a longer incubation period. For example, *Histoplasma* is a fungus that requires a six-week incubation period.

A single set of blood cultures, which consists of two bottles of growth medium (one for aerobes and one for anaerobes) is not recommended. Two to three sets are usually adequate. After a blood infection has been diagnosed, confirmed by culture, and treated, an additional blood culture might be performed to ensure that the infection is gone.

Timing can be an important factor in performing blood cultures. Most blood infections are intermittent bacteremias, which means the microorganisms enter the blood at various times. For such infections, blood drawn randomly might miss the microorganisms. Since the microorganisms enter the blood 30–90 minutes before the person's fever spikes, collecting the culture just after the fever spike offers the best probability of finding the microorganism. The second and third cultures can be collected at the same time, but from different areas of the body. The physician might want to have the collections spaced at 30-minute or one-hour intervals. In continuous bacteremias, such as infective endocarditis, microorganisms are always in the blood, so the timing of culture collection is less important. Blood cultures should always be collected before antibiotic treatment begins, if possible. However, some studies of the effectiveness of automated computer-assisted blood cultures in detecting microorganisms in the blood of newborns show that the newer technology with improved media is faster in detecting positive cultures even when antibiotic therapy had already been started.

Laboratory analysis

Bacteria are the most common microorganisms found in blood infections, so routine blood cultures target bacterial growth, although they also support the growth of many other microorganisms. Laboratory analysis of a bacterial blood culture differs slightly from that of a **fungal culture**, and significantly from that of a viral culture.



Cultures on agar plates. (Photograph by T. McCarthy, Custom Medical Stock Photo. Reproduced by permission.)

For a routine blood culture, 20 ml of blood is drawn from the patient (see Preparation), put directly into a paired set of blood culture bottles (aerobic and anaerobic), and delivered to the lab immediately for incubation.

For a blood culture to be successful, the laboratory must complete several processes:

- Provide an environment suitable for microbial growth.
- Detect growth when it occurs.
- Identify any microorganisms that grow.
- Test any isolated microorganisms against certain antibiotics to determine which antibiotic will be effective.

The broth in the blood culture bottle is the first step in providing an environment suitable for microbial growth. It contains all the required nutrients. A commonly used medium for blood culture is tryptic soy broth supplemented with amino acids and **carbohydrates**. The aerobic bottles have ideal conditions for growing aerobes, while the anaerobic bottles have ideal conditions for growing both strict anaerobes and facultative anaerobes. The second step is providing an ideal temperature for growth by placing the bottles in an incubator at body temperature (35°C).

To detect growth when it occurs, the laboratories can monitor the bottles by a daily manual (visual) method. Visual signs of growth include cloudiness or a color change in the broth, gas bubbles, or clumps of bacteria. Many laboratories use one of the newer continuous-monitoring blood culture (CMBC) systems. CMBC systems are considered important technical advances in blood cultures. The instruments automatically monitor the bottles containing the patient's blood for evidence of microorganisms, usually every 10 minutes. A common approach is to measure the production of carbon dioxide in the culture medium which causes a color change that is sensed

by the instrument. Many data points are collected daily for each bottle, and input into a computer for analysis. Sophisticated mathematical calculations can determine when microorganisms have grown. When growth is detected, an alarm is triggered to alert the technologist. This, combined with more frequent blood tests, make it possible to detect microbial growth earlier. In addition, all CMBC system instruments have the detection system, incubator, and agitator in one unit.

To identify any microorganisms that grow, the laboratory does a **Gram stain** and a subculture. If there is no evidence of growth after five days, the laboratory usually performs a Gram stain and subculture before discarding a bottle and reporting a negative result.

For the subculture, a drop of blood is placed on a culture plate and spread over the surface of the plate. The plate is then placed in an incubator at 35°C. If a bacterium is isolated, the laboratory identifies it using biochemical tests and the Gram stain. The bacterium is also tested against many different antibiotics to see which antibiotics can effectively treat the infection. This process is called sensitivity (or susceptibility) testing.

All test results are reported to the physician as soon as possible. An early report, known as a preliminary report, is usually available after one day. This report indicates whether any bacteria have been found yet and, if so, the results of the Gram stain. The next preliminary report might include a description of the bacteria growing on the subculture. The laboratory notifies the physician immediately when an organism is found and as soon as sensitivity tests are complete. Sensitivity tests could be complete before the bacterium is completely identified. The final report, which might not be available for five to seven days, includes a complete identification and a list of the antibiotics to which the bacterium is sensitive.

Preparation

To prevent contamination from the patient's skin, the blood sample must be drawn using strict sterile technique. Before drawing the blood, the phlebotomist should disinfect the skin by swabbing it first with 70% alcohol, then with iodine in a circular motion, starting at the puncture site and moving outward. The iodine should be allowed to dry completely before the blood culture is drawn. During this time, the caps of the blood culture bottles should be removed and the rubber stoppers should be cleansed with 70% alcohol.

Aftercare

After drawing the blood sample, the phlebotomist should use alcohol to remove the iodine from the skin to prevent hypersensitivity. Then, to reduce bruising, pressure should be applied to the puncture site until the bleeding stops. If the patient is taking blood thinners or has a blood disorder that causes bleeding, special care should be taken to ensure that the bleeding has stopped completely before pressure is withdrawn.

Complications

After having blood drawn, the patient might feel dizzy or faint, and might have discomfort or bruising at the puncture site. Warm packs can relieve discomfort.

Results

A negative (normal) blood culture indicates that there are no microorganisms growing in the patient's bloodstream. However, a single negative set of blood cultures does not completely rule out a blood infection. Three sets of negative cultures are needed to rule out bacteremia. False negatives can occur for the following reasons:

- Antibiotic therapy was started before the blood was drawn.
- Time of blood collection was inappropriate.
- Environment was not right for growth.
- Fastidious bacteria did not grow.

A positive blood culture indicates that microorganisms are growing in the patient's bloodstream. Finding the same microorganism in more than one set of bottles helps to rule out the possibility of contamination from poor collection or handling techniques. The physician's skill in interpreting the results is essential in distinguishing a blood culture that is positive because of a true infection from one that is positive because of contamination.

In a true bacteremia, the patient's clinical condition is consistent with a blood infection caused by the microorganism that was isolated. The microorganism usually grows soon after the bottles are incubated, is usually found in more than one set of bottles, and is often the cause of an infection somewhere else in the patient's body.

When a culture is positive because of contamination, the patient's clinical condition usually is not consistent with an infection from the microorganism that was isolated. The microorganism is often one that is commonly found on the skin and that rarely causes infection. It is

KEY TERMS

Aerobe—An organism that grows in the presence of oxygen. If an aerobe cannot grow without oxygen, it is called a strict or obligate aerobe.

Anaerobe—An organism that grows in the absence of oxygen. If an anaerobe cannot grow when oxygen is present, it is called a strict or obligate anaerobe. An anaerobe that can also grow in the presence of oxygen is called a facultative anaerobe.

Bacteremia—Bacteria in the blood.

Continuous bacteremia—A kind of bacteremia in which bacteria are always in the blood.

Intermittent bacteremia—A kind of bacteremia in which the bacteria enter the blood at various time intervals.

Phlebotomist—A person who draws blood from a vein.

Venipuncture—The puncture of a vein to withdraw a blood sample.

usually found in only one set of bottles after several days of incubation. Contaminated cultures frequently contain more than one microorganism.

Health care team roles

Several health care professionals work together to ensure a successful blood culture. The physician uses his training and expertise to decide when a blood culture should be ordered. A phlebotomist, or sometimes a nurse, collects the blood, and the clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) monitors the cultures and performs appropriate tests when the cultures are positive.

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Blood gas analysis

Definition

Blood gas analysis, also called arterial blood gas (ABG) analysis, is a procedure to measure the partial pressure of oxygen (O₂) and carbon dioxide (CO₂) gases and the pH (hydrogen ion concentration) in arterial blood.

Purpose

Blood gas analysis is used to diagnose and evaluate respiratory diseases and conditions that influence how effectively the **lungs** deliver oxygen to and eliminate carbon dioxide from the blood. The acid-base component of the test is used to diagnose and evaluate metabolic conditions that cause abnormal blood pH.

Because high concentrations of inhaled oxygen can be toxic and can damage lungs and eyes, repeated blood gas analysis is especially useful for monitoring patients on oxygen, for example, **premature infants** with lung disease, so that the lowest possible inhaled oxygen concentration can be used to maintain the blood oxygen pressure at a level that supports the patient. In intubated patients under artificial ventilation, monitoring the levels of arterial carbon dioxide and oxygen allow assessment of respiratory adequacy so that the rate or depth of ventilation, the ventilator dead space, or airway pressure can be changed to preserve the patient’s optimal physiologic balance.

The measurement of arterial blood pH and carbon dioxide pressure with subsequent calculation of the concentration of bicarbonate (HCO₃⁻), especially in combination with analysis of serum electrolytes, aids in the diagnosis of many diseases. For example, **diabetes mellitus** is often associated with a condition known as diabetic acidosis. Insulin deficiency often results in the excessive production of ketoacids and lactic acid that lower extracellular fluid and blood pH. Unabated acid-base disorders are life threatening. Acidosis is associated with severe consequences, including **shock** and cardiac arrest, and alkalosis with mental confusion and **coma**.

Precautions

The syringe used to collect the sample for a blood gas analysis must contain a small amount of heparin to prevent clotting of the blood. It is very important that air be excluded from the syringe both before and after the sample is collected. The syringe must be filled completely and never exposed to air. For transportation, the syringe should be capped with a blind hub, placed on ice, and immediately sent to the laboratory for analysis to guarantee the accuracy of the results.

A blood gas analysis requires a sample of arterial blood in order to evaluate **gas exchange** by the lungs. Arterial puncture is associated with a greater risk of bleeding than venipuncture. The test may be contraindicated in persons with a bleeding disorder such as **hemophilia** or low platelet count. During the arterial puncture, the patient may feel a brief throbbing or cramping at the puncture site. In cases where the primary concern is ascertaining that the blood is adequately oxygenated, a **pulse oximeter** may be used in lieu of arterial blood gas analysis. Medical personnel must follow standard precautions for prevention of exposure to bloodborne pathogens when performing arterial blood collection.

Description

The sample of choice for blood gas analysis is arterial blood. This is usually collected from the radial artery in the wrist, but in cases where no radial pulse is obtained, the femoral or brachial artery may be used. The sample may also be collected from an arterial line after flushing the line to remove excess anticoagulant and fluid. In neonates and in adults when arterial puncture is contraindicated or unsuccessful, a capillary blood sample may be used.

The sample is inserted into an analytical instrument that uses electrodes to measure the concentration of hydrogen ions (H⁺), which is reported as pH, and the partial pressures of oxygen [PO₂] and carbon dioxide PO₂ gases. The pH-measuring electrode consists of a special

glass membrane that is selectively permeable to hydrogen ions. An electrical potential develops across the inner and outer surfaces of this membrane that is related to the log of hydrogen ion activity in the sample. A Severinghaus electrode is used to measure PCO_2 . The measuring principle is the same as for hydrogen ions, except that the electrode tip is covered with a gas permeable membrane, so that the pH change is proportional to carbon dioxide diffusing from the sample to the electrode surface. The PO_2 is measured using a polarographic (Clark) electrode. Oxygen diffuses from the sample to the cathode, where it is reduced to peroxide ions. The electrons come from a silver anode that is oxidized, generating current in proportion to oxygen concentration at the cathode. Electrode signals are dependent upon temperature as well as concentration, and all measurements are performed at 37°C . Since the *in vivo* pH and levels of oxygen and carbon dioxide are temperature dependent, results may need to be adjusted for the patient's actual temperature. Portable blood gas analyzers are available that can be used at the bedside.

Blood gas analyzers calculate blood bicarbonate concentration using the formula: $\text{pH} = 6.1 + \text{Log bicarbonate}/.0306 \times \text{PCO}_2$. They also calculate oxygen content, total carbon dioxide, base excess, and percent oxygen saturation of hemoglobin. These values are used by physicians to assess the extent of hypoxia and acid-base imbalance.

Preparation

Patients do not need to restrict food or drink before the test. For patients receiving **oxygen therapy**, the oxygen concentration must remain constant for 20 minutes before sample collection; if the test is specifically ordered to be without oxygen, the gas must be turned off for 20 minutes before the blood sample is taken to guarantee accurate test results. The patient should breathe normally during sample collection.

Infants and children may require physical and psychological preparation appropriate to the child's age. A parent or other trusted adult may be enlisted to restrain the child during sample collection.

Aftercare

After the blood sample has been taken, the health care practitioner or patient applies pressure to the puncture site for about 10 minutes or until bleeding has stopped, after which a dressing is applied. The patient should rest quietly while applying pressure to the puncture site and be observed for signs of bleeding or impaired circulation at the puncture site.



A blood gas analyzer from Corning Corporation.
(Photograph by Hank Morgan, Photo Researchers, Inc.
Reproduced by permission.)

Complications

Complications posed by the arterial puncture are minimal when the procedure is performed correctly, but may include bleeding or delayed bleeding or bruising at the puncture site, or, rarely, impaired circulation around the puncture site.

Results

Normal values

The following results are for arterial blood at sea level (at altitudes of 3,000 feet and above, the values for oxygen are lower).

- Partial pressure of oxygen (PO_2 75–100 millimeters of mercury (mm Hg). Note that PO_2 values normally decline with age.
- Partial pressure of carbon dioxide PCO_2 35–45 mm Hg.

KEY TERMS

Acid—A chemical compound that reacts with a base to form a salt, that can give off hydrogen ions in water solution, or that contains an atom that can accept a pair of electrons from a base.

Acidosis—A blood condition in which the pH is < 7.35 and the bicarbonate concentration is below normal.

Alkalosis—A blood condition in which the pH is > 7.45 and the bicarbonate concentration is above normal.

Base—A chemical compound that reacts with an acid to form a salt, that takes up or accepts protons, or that contains an atom with a free pair of electrons to be donated to an acid.

Buffer—A chemical substance that resists changes in pH in response to changes in acid and base concentration; a buffer system consists of a weak acid or weak base in combination with its salt.

Hemoglobin—The red-colored, iron-containing protein in red blood cells that carries oxygen to the tissues.

Heparin—A biochemical that may be isolated from various animal tissues that has anticoagulant properties.

Ketoacidosis—An excessive level of acid accompanied by an increase in the level of ketones in blood that occurs as a complication of diabetes mellitus; ketones are substances normally processed by the liver from fats.

Oxygen saturation of hemoglobin—The percentage of hemoglobin that is bound to oxygen.

pH—An exponential measurement scale for expressing the concentration of acid in solution $\text{pH} = -\log [\text{H}^+]$.

- pH: 7.35–7.45.
- Oxygen content (O_2CT): 15–23 volume%.
- Oxygen saturation (SaO_2): 94%–100%.
- Concentration of bicarbonate (HCO_3^-): 22–26 millimoles per liter (mEq/liter).

Total CO_2 is often reported with blood gas analysis results and is defined as the sum of carbonic acid and bicarbonate concentrations. Normally, the ratio of bicarbonate to carbonic acid at physiological pH is about 20:1,

thus, the total CO_2 is normally about 5% higher than the bicarbonate value.

The A-a gradient (alveolar-arterial PO_2 difference) is calculated from the partial pressures of oxygen and carbon dioxide as returned from the blood gas analysis, and the partial pressure of oxygen in the air and a factor called the respiratory quotient that are specific to the site of the test. A normal value for A-a gradient may be estimated as one-fourth the patient's age plus 2.5.

Abnormal results

Values that differ from the normal values may indicate the presence of respiratory, metabolic, or renal diseases.

For most clinical decisions, the bicarbonate value, PCO_2 , and pH are used to evaluate acid-base status. The pH value defines the magnitude of the disturbance and the bicarbonate and PCO_2 determine the cause. The bicarbonate level is under the control of the **kidneys**, which may increase or decrease bicarbonate blood levels in response to pH changes. Bicarbonate is also the principal blood buffer anion, and it functions as the conjugate base to increase pH. PCO_2 is the respiratory component because it is regulated by the lungs. It is determined by the concentration of dissolved carbon dioxide (anhydrous carbonic acid) and is the principal acid component of the blood. Abnormal results are classified on the basis of pH and whether the abnormal pH is caused by the metabolic or respiratory component. pH <7.35 indicates acidosis, either metabolic (non-respiratory) or respiratory, and pH >7.45 indicates alkalosis.

Metabolic or non-respiratory acidosis is characterized by pH <7.35 (i.e. increased $[\text{H}^+]$) and decreased $[\text{HCO}_3^-]$. In most cases, the decrease in pH stimulates the respiratory center causing hyperventilation. The loss of carbon dioxide that results serves to decrease the severity of the acidosis and is referred to as compensation. Metabolic acidosis is caused by bicarbonate deficit which may result from increased H^+ formation or ingestion, from decreased H^+ excretion, or failure to produce or retain bicarbonate. Common causes of metabolic acidosis are diabetes mellitus, **alcoholism**, lactic acidosis (associated with hypoxia), acid **poisoning**, renal failure, renal tubular acidosis (an inherited defect of the renal tubules), and **diarrhea**.

Respiratory acidosis is caused by deficient ventilation that results in retention of carbon dioxide. The pH is <7.35, and PCO_2 is increased. If time has permitted renal compensation, the $[\text{HCO}_3^-]$ is somewhat increased. Respiratory acidosis is associated with airway obstruction such as occurs with asthmatic bronchial spasm, bronchitis, and **emphysema**; pulmonary diseases such as

severe **pneumonia** and pulmonary fibrosis; thoracic conditions such as multiple broken ribs and kyphoscoliosis. Respiratory acidosis is also caused by neuromuscular disease, and by depression of the respiratory center in the **brain** due to drugs, head trauma, or cranial tumor. The blood gas analysis results may deviate only slightly from normal values, and pH may even fall within the normal range (compensated respiratory acidosis) in cases of chronic compared to acute acidosis.

Metabolic alkalosis is caused by excess blood bicarbonate and usually involves a renal factor. Metabolic alkalosis is characterized by pH >7.45 and elevated $[\text{HCO}_3^-]$. The PCO_2 is usually elevated due to respiratory compensation. Metabolic alkalosis can be caused by mineralocorticoid excess (e.g. Cushing's or Conn's syndromes), which promotes increased acid excretion and bicarbonate retention by the kidney. Other causes are diuretic therapy, vomiting, severe **dehydration**, hypokalemia (low blood potassium), and hypoparathyroidism.

Respiratory alkalosis is caused by hyperventilation. The pH is >7.45 and the PCO_2 is low. If the kidneys are functioning normally and given sufficient time, the HCO_3^- will be decreased in compensation. Respiratory alkalosis may be caused by hyperventilation psychologically induced (**anxiety**), by drugs that stimulate the respiratory center, excessive ventilation therapy, and mild hypoxia.

A decrease in PO_2 is a sensitive measure of respiratory function and hypoxia. In addition to ventilation defects that also result in increased PCO_2 , PO_2 will be low in persons with poor ratios of ventilation to perfusion; mild emphysema and other gas diffusion defects; pulmonary arterial-venous shunts; and those breathing air with a low oxygen content. Elevated PO_2 is caused by excessive administration of oxygen which can lead to optic nerve damage and acidosis by displacing hydrogen ions from hemoglobin.

It is important to note that in cases of **carbon monoxide poisoning** the PO_2 will be normal, but life-threatening hypoxia may be present. Blood gas analyzers calculate the oxygen saturation of hemoglobin from PO_2 , temperature, and pH. In cases of CO poisoning, the calculation will be falsely elevated. Accurate assessment of hypoxia in CO poisoning requires direct measurements of carboxyhemoglobin and oxygen saturation of hemoglobin by oximetry or colorimetry methods.

Health care team roles

A physician, nurse, respiratory care technician, or laboratory technician collects the blood sample by arteri-

al puncture and sees to the timely and appropriate transport to the laboratory for analysis. A member of the health care team should observe the patient for 10–15 minutes to ensure that bleeding from the puncture site has stopped. Blood gas measurements are performed by a registered respiratory therapist, RRT; certified respiratory technician, CRTT; clinical laboratory scientist CLS (NCA) or medical technologist MT (ASCP); clinical laboratory technician CLT (NCA) or medical laboratory technician MLT (ASCP). A physician interprets the blood gas analysis results with a thorough understanding of the acid-base chemistry and physiology of blood and in view of the clinical situation, and applies the results to the diagnosis, treatment, and management of the patient.

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Blood gases

Definition

Blood gases are defined as the mixture of gases, including oxygen (O_2), carbon dioxide (CO_2), and nitrogen (N_2), dissolved in the fluid fraction of blood.

Description

Oxygen from the air is transported from the **lungs** to all tissues of the body, where it is needed for **metabolism**; and carbon dioxide, a by-product of metabolism, is taken from the tissues to the lungs to be eliminated.

Respiration

The overall process of delivering oxygen to the tissues and carrying carbon dioxide away is called respiration. When the blood reaches the tissues, oxygen diffuses into the cells, and carbon dioxide diffuses from the cells into the blood. In the lungs, the air enters a branching complex of multiple air sacs, called alveoli, where tiny capillaries separate the air from the red blood cells by only a very thin membrane, about 0.3 μm thick. During respiration the inspired air is filtered and moistened by the nose and tracheal linings and is completely saturated with water vapor by the time it enters the alveolar sac.

In the alveolus, oxygen diffuses into the blood, and carbon dioxide diffuses out of the blood to mix with the alveolar air. Diffusion is a very rapid process, and the gases do not have time to totally equilibrate across the alveolar membrane. A small pressure difference for each gas develops. About 2% of the blood flow through the lungs bypasses the pulmonary capillaries and does not become oxygenated; thus, the partial pressure of oxygen is somewhat higher in the alveolus than in the blood. This pressure difference, calculated for the lung as a whole, is called the arterial-alveolar (A–a) gradient.

Composition of gases in air

Dry air is made up of 20.98% oxygen, 0.04% carbon dioxide, 78.06% nitrogen, and 0.92% other gases (mostly argon). In blood-gas analysis, the content of the gases oxygen and carbon dioxide are reported in terms of their partial pressures, with normal values for oxygen (PO_2) of 75 mm to 100 mm of mercury (mm Hg) and for carbon dioxide (PCO_2) of 35 to 45 mm Hg. The partial pressure of water vapor in the lung, where the air is completely water-saturated, at body temperature (98.6°F, or 37°C) is 47 milliliters of mercury (mm Hg).

Function

As blood circulates through the body, oxygen diffuses from the area of higher partial pressure. The blood moves toward the area of lower partial pressure, the cells, and carbon dioxide diffuses from the cells into the blood. In the lung, oxygen diffuses into the blood, where it is taken up by hemoglobin, and carbon dioxide diffuses out of the blood, to be exhaled.

Oxygen

Oxygen in the blood is carried by hemoglobin. The hemoglobin content of normal blood is about 15 to 16 grams per 100 ml, and each gram of hemoglobin binds

about 1.34 ml of oxygen gas. Thus, arterial blood contains about 20 ml of oxygen per 100 ml when fully saturated. The volume of oxygen in the blood, the O_2 content, is dependent on the hemoglobin concentration and does not provide as good a measure of lung function as the partial pressure of oxygen (PO_2) in arterial blood.

The amount of oxygen in the blood relative to the carrying capacity of the hemoglobin is called the oxygen saturation. The oxygen saturation of hemoglobin is directly proportional to the PO_2 ; the relationship is not linear but is described by a sigmoidal (S-shape) curve. Oxygen saturation is affected by the acid-base status of the blood: at a given PO_2 , the degree of oxygen saturation may be lowered by increasing the acidity of the blood. Oxygen saturation is expressed as a percentage; hemoglobin in arterial blood is about 97% saturated, while the more acidic venous blood is about 75% saturated.

Carbon dioxide

Carbon dioxide is formed in the cells during aerobic metabolism and diffuses into the capillaries, where only a small amount remains dissolved. It enters the red blood cells, where carbonic anhydrase quickly catalyzes its conversion to carbonic acid, which dissociates to hydrogen ion and bicarbonate. About two-thirds of the bicarbonate diffuses out into the plasma and is replaced by chloride in the red cell. The hydrogen ion binds to hemoglobin, and is transported to the lungs.

Arterial blood normally contains an amount of bicarbonate that is the equivalent of about 50 ml of carbon dioxide gas per 100 ml of blood. About 5 ml of additional carbon dioxide enters the blood in the capillaries and is converted to bicarbonate and hydrogen ion, making the blood more acidic and causing the pH to drop from 7.4 to 7.36. On reaching the lungs, the bicarbonate and hydrogen ion are converted back to carbon dioxide, which diffuses into the alveoli for exhalation. Over a period of 24 hours at rest, about 200 ml of carbon dioxide, the equivalent of 12,500 milliequivalents of acid, is produced by metabolism and eliminated via the lungs. The carbonic-acid concentration can change in seconds in response to hypo- or hyperventilation, while changes in the bicarbonate concentration take much longer—hours or days—because elimination by the kidney is relatively slow.

Carbon monoxide

Small amounts of carbon monoxide (CO) are produced during metabolism. Carbon monoxide binds tightly to hemoglobin to form a CO-hemoglobin complex called carboxyhemoglobin in which the binding of oxygen molecules is prevented. Thus, carbon monoxide reduces the oxygen saturation of hemoglobin at any

given PO_2 . City dwellers and smokers are exposed to a much higher level of carbon monoxide in the air: in heavy smokers, as much as 10% of hemoglobin may be carboxyhemoglobin.

Nitrogen and other gases

The nitrogen and other gases inhaled are, under normal circumstances, inert and play no role in human health. A painful and potentially fatal condition, called **decompression sickness** or the bends, can be caused by formation of nitrogen bubbles in the blood and tissues by moving too quickly from areas of higher atmospheric pressures to lower pressures, such as when deep-sea divers return too quickly to the surface of the water.

Role in human health

Acid-base balance in the blood

Carbon dioxide in the blood is transported as bicarbonate, since carbon dioxide combines with water to form carbonic acid:



which is in equilibrium with hydrogen ions and bicarbonate:



The concentration of hydrogen ions (H^+) determines the pH, a measure of the acidity, of the blood. The carbonic acid-bicarbonate equilibrium is an example of a buffer system and is involved in the maintenance of the **acid-base balance** in the body. The pH of the blood is related to the ratio of bicarbonate to carbonic acid, which is normally about 20:1. The carbonic acid-bicarbonate buffering system is extended by the body's ability to convert carbonic acid to carbon dioxide (catalyzed by the enzyme carbonic anhydrase) and the removal of CO_2 in respired air. In addition, the body has the ability to eliminate hydrogen or bicarbonate ions via the **kidneys** to maintain pH.

Since most body systems function best at a pH near 7.4, the pH of the body must be maintained within a narrow range. When the blood pH is higher or lower than the normal level of 7.35 to 7.45, enzymes may function less effectively or not at all, nerve and muscle activity weakens, and finally all metabolic activity is undermined.

Proteins also function as buffers; hemoglobin in particular is an important buffering agent in the blood. Oxygen-bound hemoglobin is a stronger acid than hemoglobin without oxygen, and tends to release hydrogen ions; when hemoglobin is exposed to the lower oxygen concentrations in the capillaries, oxygen is released, the

Normal arterial blood gas values

Arterial	Term infant	Child	Adult
pH	7.26–7.41	7.35–7.45	7.35–7.45
PaCO ₂	34–54 mm Hg	35–45 mm Hg	35–45 mm Hg
PaO ₂	60 mm Hg	75–100 mm Hg	75–100 mm Hg
O ₂ sat	40%–95%	95%–98%	95%–98%
CO ₂ content	20–28 mEq/L	18–27 mEq/L	23–29 mEq/L
Base excess	–7 to –1 mEq/L	–4 to +2 mEq/L	–2 to +2 mEq/L

SOURCE: Rothstein, J.M., S.H. Roy, and S.L. Wolf. *The Rehabilitation Specialist's Handbook*. 2nd ed. Philadelphia: F.A. Davis Co., 1998

hemoglobin becomes a weaker acid, and hydrogen ions are taken up. The relationship between pH and the ability of hemoglobin to bind oxygen, which is reflected in saturation levels of hemoglobin in arterial versus venous blood, is known as the Bohr effect.

Buffer base and base excess

The buffer base is the sum of all anionic buffer components in the blood, including bicarbonate, sulfates, and phosphates. The base excess refers to how much a patient's buffer base is higher than normal, and is expressed in terms of the amount of acid in milliequivalents per liter (mEq/L) that would have to be added to the patient's blood to bring it to a normal pH of 7.4. Many physicians rely only on the difference between the patient's bicarbonate and an average value for bicarbonate of 24 mEq/L as an indication of the need for bicarbonate replacement. However, the base excess is more meaningful, since other buffers are taken into account and is accurate also in anemic patients, where the buffering capacity of hemoglobin is diminished. Base excess can be negative in value for acidotic patients; that is, acid would have to be taken away to bring the pH to normal.

The clinical determination of how much bicarbonate to administer in the treatment of severe acidosis is usually based on the base excess of the blood. The base excess of blood, however, is not a true indication of the base excess of the extracellular fluid (ECF) of the whole body. Only blood contains hemoglobin, and other extracellular fluids have different protein contents and buffering capacities. Furthermore, fluid distribution in the body varies with the state of hydration, and ECF as a percentage of body weight varies with age and fat content. In general, however, the recommendation for bicarbonate therapy is 0.1 to 0.2 mEq × body weight × base excess.

KEY TERMS

Acid—A chemical compound that reacts with a base to form a salt, that can give off hydrogen ions in water solution, or that contains an atom that can accept a pair of electrons from a base.

Acidosis—A blood condition in which the pH is <7.35 and is below normal.

Alkalosis—A blood condition in which the pH is >7.45 and is above normal.

Alveoli—Air sacs of the lungs located at the termini of the bronchial passageways.

Base—A chemical compound that reacts with an acid to form a salt, that takes up or accepts protons, or that contains an atom with a free pair of electrons to be donated to an acid.

Buffer—A chemical substance that resists changes in pH in response to changes in acid and base concentration; a buffer system consists of a weak acid or weak base in combination with its salt.

Carbonic anhydrase—An enzyme that catalyzes the reversible reaction of carbon dioxide with water to form carbonic acid in red blood cells.

Hemoglobin—The red-colored, iron-containing protein in red blood cells that carries oxygen to the tissues.

Ketoacidosis—An excessive level of acid accompanied by an increase in the level of ketones in blood that occurs as a complication of diabetes mellitus; ketones are substances normally processed by the liver from fats.

Metabolism—The physical and chemical processes carried out by an organism to produce, maintain, and destroy material substances and to make energy available.

pH—An exponential measurement scale for expressing the concentration of acid in solution $\text{pH} = -\log [\text{H}^+]$.

Control of respiration

The levels of blood gases act to control the rate of respiration. The aortic and carotid bodies, special chemical receptors near the aorta and carotid arteries, respond to changes in the levels of acid, carbon dioxide, or oxygen, stimulating the **brain** respiratory centers in the brain stem to regulate the speed and depth of breathing. When blood acid is increased, such as during diabetic

ketoacidosis, or when there is a rise in CO_2 during the increased metabolism of **exercise**, respiration is stimulated. The respiratory centers in the brain also respond directly to increases in PCO_2 and stimulate respiration. The resulting deep, rapid breathing acts to mix alveolar air with CO_2 -poor air to decrease the carbon dioxide in the blood as it passes by the alveolus, and the reduction in CO_2 returns the blood toward normal. Lack of oxygen can also weakly stimulate respiration. Oxygen levels usually play little role in the regulation of respiration in healthy individuals at normal altitudes, but at very low PO_2 (i.e., <60 mm Hg), as in patients suffering from severe chronic bronchitis and **emphysema**, respiration can be stimulated.

Common diseases and disorders

Disorders involving the levels of blood gases are primarily diagnosed on the basis of disturbances in the acid-base balance as acidosis or alkalosis. Acid-base disorders may be respiratory or nonrespiratory (metabolic) in origin, or of mixed origin.

Acidosis with elevated PCO_2 is classified as respiratory acidosis. Causes include:

- airway obstruction due to chronic conditions such as bronchitis or emphysema, or acute causes such as bronchospasm or aspiration of foreign material
- neuromuscular diseases such as poliomyelitis, motor-neuron disease, or tetanus, or due to neurotoxins such as botulin or curare
- pulmonary diseases including **pneumonia** and pulmonary fibrosis, and extrapulmonary thoracic disorders such multiple broken ribs or kyphoscoliosis
- respiratory-center depression due to cerebral trauma or tumor, or secondary to anesthesia or application of sedatives

Alkalosis with depressed PO_2 is classified as respiratory alkalosis. Causes include:

- hypoxia due to high altitude, anemia, or pulmonary disease
- hyperventilation, whether voluntary or secondary to trauma, **infection**, cerebral tumor, or ingestion of a respiratory stimulant
- pulmonary **edema** or embolism
- artificial overventilation

Acidosis with depressed PCO_2 and bicarbonate is classified as nonrespiratory, or metabolic, acidosis. Causes include:

- diabetic or alcoholic ketoacidosis

- acid **poisoning**, including secondary to alcohol poisoning
- decreased elimination of acid due to renal failure
- loss of bicarbonate, such as during diarrhea

Alkalosis with elevated PO_2 and bicarbonate is classified as nonrespiratory, or metabolic, alkalosis. Causes include:

- loss of unbuffered acid due to gastrointestinal and/or renal disturbances
- chronic ingestion of antacid preparations, or a high-fruit, low-protein diet

A low value for PO_2 (hypoxemia) is also indicative of respiratory disturbance. Hypoxemia may be caused by:

- low inspired levels of oxygen, such as at high altitude
- hypoventilation due to respiratory depression or neuromuscular disease
- mixing of arterial and venous blood, as in cyanotic congenital **heart** disease
- impaired oxygen diffusion as in pulmonary fibrosis
- chronic diseases of airway obstruction, such as bronchitis and emphysema

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Blood pressure

Definition

Blood pressure is the pressure of the blood against the blood vessel walls as blood flows through the vessels.

Description

The **heart** beats about 60 to 70 times a minute. With each beat as the heart contracts, a surge of blood is pumped from the heart into the arteries. The pressure in the artery walls during this surge is measured as the systolic blood pressure (a higher number). Between beats, the heart is relaxed and there is much less pressure on the artery walls. This is measured as the diastolic blood pressure (a lower number). Blood pressure is given as two numbers written as 120/80 mm Hg and is measured with a device called a **sphygmomanometer** in millimeters (mm) of mercury (Hg). The pressure depends on the amount of blood pumped through the heart in addition to the resistance and elasticity of the **blood vessels** to the amount of blood flowing.

Function

Blood pressure is necessary to sustain life. It continuously forces blood carrying oxygen and nutrients from the heart to the organs and tissues of the body. Blood pressure levels can go up or down in the course of a day depending on activity and **stress** levels, medications, or diet.

A person's blood pressure is determined by the contraction of the heart's ventricles, which pump blood into the aorta and subsequently throughout the body. The normal adult blood pressure has a systolic number of 120 and a diastolic number of 80. Systolic pressure is taken when the heart contracts; diastolic pressure is taken when the heart is relaxed.

Normally, about 5.5 quarts (5.25 liters) of blood goes through the heart and blood vessels each minute, an amount called cardiac output. The body is dependent on its volume of blood to maintain blood pressure. If a person experiences heavy blood loss, blood pressure will plunge. Similarly, an increase in blood volume, in cases like water retention, will cause blood pressure to rise.

The brain's medulla contains a cluster of nerves, called the cardiovascular center, that control heart rate, the contraction of the ventricles, and blood vessel diameter. Sensory receptors monitor the stretching of blood vessel walls. During **exercise**, the heart rate rises and the ventricles contract more forcefully. The cardiovascular center then monitors the dilation (expansion) or constriction of peripheral blood vessels. For example, the blood vessels to organs directly involved the exercise will expand. Blood flow to **skeletal muscles** may increase by a factor of 10 and that to the heart and skin can triple. Simultaneously, constriction will occur in the blood vessels of the **digestive system**.

The sensory receptors in the walls of blood vessels continually monitor blood pressure. When the receptors

Classification of blood pressure (BP)

Category	Range (mm Hg)	Recommendation
Normal BP	Systolic <140; diastolic <85	Recheck in 2 years
High-normal BP	Diastolic 85–89	Recheck in 1 year
Mild hypertension	Diastolic 90–104	Confirm within 2 months
Moderate hypertension	Diastolic 105–114	Evaluate within 1 month
Severe hypertension	Diastolic ≥115	Evaluate immediately or within 1 week
Borderline isolated systolic hypertension	Systolic 140–159; diastolic <90	Confirm within 2 months
Isolated systolic hypertension	Systolic ≥160; diastolic <90	Confirm within 2 months

SOURCE: Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure.

detect an increase in aortic pressure, for example, the cardiovascular center directs the lowering of the heart rate and the stretching of blood vessels, which decreases the blood pressure. A decrease in blood pressure causes an increased heart rate and vasoconstriction.

As people age, the blood vessels become less flexible and the heart muscle is less strong, resulting in a smaller output and lower maximum heart rate. Systolic pressure tends to rise as a person ages. **Coronary artery disease**, which causes the blood vessels in the heart to receive inadequate oxygenation, can cause chest **pain** or heart attack. Atherosclerosis (clogging of the arteries) can also cause an increase in blood pressure.

Role in human health

The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC) develops high blood pressure prevention and control recommendations for healthcare providers. According to the JNC, optimal blood pressure (BP) measurement is a systolic blood pressure (SBP) of 120mm Hg or less and a diastolic blood pressure (DBP) of 80mm Hg or less. Blood pressure is still considered normal at levels of 130mm Hg SBP or less and 85mm Hg DBP or less.

Periodic **blood pressure measurement** is recommended every one to two years for adults with normal blood pressure. A healthcare provider should determine the frequency of blood pressure measurement based on each patient's individual risk factors for high blood pressure. Individual risk factors that contribute to high blood pressure, such as diabetes, a family history of high blood pressure, a diet high in fat and cholesterol, being African-American, elderly, overweight, a smoker, or heavy drinker, are important to consider when advising patients on the frequency of periodic blood pressure measurement. Prevention and management of high blood pressure requires not only active participation by the patient but also education and support from health care

providers. **Patient education** is a shared responsibility among physicians, nurses, dietitians, and allied health professionals. While patient education is time-consuming, it is very important to the process of maintaining health and preventing disease.

Common diseases and disorders

High blood pressure, also called **hypertension**, is a cardiovascular disease affecting nearly 50 million Americans. The higher than normal pressure pushes blood against the artery walls causing the heart to work harder in order to pump blood to the body. The JNC defines high blood pressure as a systolic blood pressure (SBP) of 140mm Hg or greater, a diastolic blood pressure (DBP) of 90mm Hg or greater, or taking high blood pressure (antihypertensive) medications.

High blood pressure often has no warning signs or symptoms. So, if it is not identified or treated, high blood pressure can damage the arteries and organs causing serious medical problems over time. If not properly managed, high blood pressure can increase the risk of developing, among other problems, the following:

- Atherosclerosis, also called “hardening of the arteries”—High blood pressure can cause atherosclerosis or a thickening and narrowing of the blood vessel walls. This can slow or prevent blood flow through the arteries and may lead to heart attack or stroke.
- Stroke—High blood pressure can cause the arteries to narrow and lead to a stroke if a blood clot blocks one of the narrowed arteries (thrombotic stroke) or if a weakened blood vessel in the **brain** ruptures (hemorrhagic stroke).
- Coronary heart disease—High blood pressure can cause the coronary arteries to narrow and harden. The coronary arteries carry oxygen to the heart muscle so it can function to pump blood to the body. If blood cannot flow properly through the coronary arteries to the heart, the heart cannot get enough oxygen. This can cause chest pain (angina). If the blood flow to the heart mus-

cle is blocked, it can cause a heart attack. Heart disease is the leading cause of death in the United States.

- **Congestive heart failure**—Over years, uncontrolled high blood pressure can cause the heart muscle to compensate by becoming larger (dilatation) to allow more blood to fill it, by thickening the heart muscle (hypertrophy) to pump more forcefully, or by beating faster to increase circulation. According to the National Institutes of Health, uncontrolled high blood pressure increases the risk of **heart failure** by 200%, compared with those who do not have high blood pressure.
- **Kidney failure**—Over years, high blood pressure can damage the blood vessels of the kidney. The damage may cause the **kidneys** to no longer filter waste from the blood adequately, which could require dialysis treatment or possibly a kidney transplant.

The cause of high blood pressure is usually unknown, in which case it is called primary or essential hypertension. This cannot be cured. However, it can be easily diagnosed and, in most cases, controlled with lifestyle modifications and/or medications.

Lifestyle modifications

Some of the lifestyle modifications for high blood pressure prevention and management include:

- Weight loss if the patient is overweight. As weight increases, blood pressure rises.
- Cutting down on alcohol, no more than one drink per day for women and no more than two drinks per day for men.
- Decreasing salt and sodium, saturated fat, and cholesterol.
- Increasing physical activity, especially aerobic activity 30 to 45 minutes on most days.
- Stopping smoking.

Medications

High blood pressure medications work in various ways. They can affect the force of the heartbeat, the blood vessels, and the amount of fluid in the body. Some of the different types of medications prescribed to treat high blood pressure are:

- Diuretics, also called “water pills,” decrease the amount of fluid in the body by flushing excess water and sodium from the body through the urine.
- Beta blockers make the heart beat less often and with less force by reducing nerve impulses to the heart and blood vessels.

KEY TERMS

Angiotensin converting enzyme (ACE) inhibitor—A drug used to decrease pressure inside blood vessels.

Artery—A blood vessel that carries blood from the heart to the body.

Beta blocker—A drug used to slow heart rate and reduce pressure inside blood vessels.

Calcium channel blocker—A drug used to relax blood vessels and the heart muscle.

Cardiovascular—The heart and blood vessels.

Congestive heart failure—A cardiovascular disease that involves the heart muscle’s diminished or loss of pumping ability, generally causes fluid that cannot be completely ejected from the heart to back up in the lungs.

Diastolic blood pressure—The lower number of a blood pressure measurement or the pressure when the heart is at rest.

Diuretic—A drug that eliminates excess fluid in the body.

Fat—One of the nutrients that supply calories to the body.

Hypertension—High blood pressure.

Hypertrophy—Enlargement of tissue or an organ.

Millimeter (mm)—A unit of measurement equal to one-thousandth of a meter.

Risk factors—Behaviors, traits, or conditions in a person that are associated with an increased chance (risk) of disease.

Sign—An objective observation of an illness.

Sphygmomanometer—A manual device used to measure blood pressure.

Symptom—Any indication of disease noticed or felt by a patient.

Systolic blood pressure—The higher number of a blood pressure measurement or the pressure when the heart is contracting.

- **Calcium channel blockers** relax the blood vessels by preventing calcium from entering the muscle cells of the heart.
- **Alpha blockers** relax the blood vessels by way of the nervous system. They decrease renin secretion, which is involved in angiotensin II formation.

- Vasodilators widen blood vessels by relaxing the muscle in the vessel walls.
- Angiotensin converting enzyme (ACE) inhibitors relax the blood vessels by preventing angiotensin II from being formed.

High blood pressure can sometimes be traced to a cause such as an adrenal gland tumor, kidney disease, hormone abnormalities, birth control pills, or **pregnancy**. This is called secondary hypertension and can usually be cured if the cause disappears or is corrected.

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American Heart Association. National Center. 7272 Greenville Ave., Dallas, TX 75231. (800) AHA-USA1. <<http://www.americanheart.org>>.

American Society of Hypertension. 515 Madison Ave., Ste. 1212, New York, NY 10022. (212) 644-0650. <<http://www.ash-us.org>>.

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Blood pressure measurement

Definition

Measurement of the pressure exerted by the circulating **blood** on the walls of the **blood vessels**, especially the arteries.

Purpose

The purpose of **blood pressure** measurement is to establish a baseline and detect any abnormalities from the normal state. Measurement is also performed to monitor the effectiveness of medication and other methods used to control **hypertension**.

Blood pressure should be routinely checked every one to two years. Hypertension often has no symptoms that would make the patient immediately aware that there is a problem and the patient may have had high blood pressure for many years. In most cases there is no known cause for the condition.

Precautions

As there may be no prior knowledge of the patient's previous blood pressure for comparison, it is important that the nurse is aware of the wide range of normal values that apply to patients of different ages. The inflated cuff can cause slight discomfort and this should be taken into account when dealing with very ill patients.

Description

Blood pressure is usually recorded by measuring the force of the blood in the **heart** where the pressure is greatest, during the contraction of the ventricles as blood is pumped from the heart to the rest of the body (systolic pressure), and during the period when the heart is relaxed between beats and pressure is lower (diastolic pressure).

The flow, resistance, quality, and quantity of blood circulating through the heart, and the condition of the arterial walls are all factors that influence the blood pressure. If blood flow in the arteries is restricted, the reading will be higher.

Hypertension is an elevation in the blood pressure above normal values, with the diastolic pressure being the indicator most commonly used.

Hypotension is a reduction in the blood pressure below normal values.

The blood pressure is taken using a **sphygmomanometer**, a hand bulb pump, and a cuff that is the correct size to give a more accurate reading. Children and



Technique for blood pressure measurement. (Delmar Publishers, Inc. Reproduced by permission.)

adults with smaller or larger than average-sized arms require special sized cuffs appropriate for their needs.

The sphygmomanometer may be electronic or mercury-based. The mercury-based unit has a manually inflatable cuff attached by tubing to the unit that contains mercury and is calibrated in millimeters of mercury. The electronic unit is similar, but is mercury free and inflates and deflates automatically with the reading displayed digitally. Blood pressure can be measured with either unit, although electronic units are becoming more commonplace.

To record blood pressure, the patient should be seated with the left arm bent slightly, the palm facing upwards and the arm bare or with the sleeve loosely rolled up. With an electronic unit, the cuff is placed level with the heart and wrapped around the upper arm, one inch above the elbow. Following the manufacturer's guidelines, the cuff is inflated and then deflated automatically and the nurse records the reading.

If the blood pressure is monitored manually, a cuff is placed level with the heart and wrapped firmly but not too tightly around the arm one inch above the elbow over the brachial artery, with any creases in the cuff smoothed

out. A **stethoscope** is placed over the brachial artery in front of the elbow, the cuff is then inflated until the artery is occluded and no sound is heard through the stethoscope. The cuff is then inflated a further 10 mm Hg above the last sound heard. The valve in the pump is slowly opened no faster than 5 mm Hg per second to deflate the pressure in the cuff to the point where a tapping sound is heard over the brachial artery. This point is noted as the systolic pressure. The sounds continue as the pressure in the cuff is released and the artery is no longer occluded. At this point, the noises are no longer heard and this is noted as the diastolic pressure.

With children, the tapping noise changes to a soft muffled sound. That point is noted as the diastolic pressure, as commonly in children, sounds continue to be heard as the cuff deflates to zero.

The results are charted with the systolic pressure first, then by the diastolic pressure in the following manner, xxx/xx (e.g. 120/70).

Preparation

Medical staff should explain the procedure fully to the patient and reassure them that recording their blood

KEY TERMS

Blood pressure—The pressure of the blood in the arteries measured in millimeters of mercury by a sphygmomanometer or by an electronic device.

Diastolic—Minimum arterial blood pressure during ventricular rest.

Hypertension—High blood pressure.

Hypotension—Low blood pressure.

Pre-eclampsia—A toxic disease occurring in pregnancy with symptoms including hypertension.

Systolic—Maximum arterial blood pressure during ventricular contraction.

pressure is part of normal health checks and that it is necessary to ensure their health is being correctly monitored. The appropriate sized cuff should be used for the patient to give an accurate reading.

The test can be performed at any time but is best performed when the patient has been resting for at least five minutes so that any exertion, such as climbing stairs prior to the test, will not unduly influence the outcome of the reading.

Devices should be checked and calibrated annually by a qualified technician to ensure accurate readings.

Aftercare

Make the patient comfortable. The medical staff should be notified if the blood pressure measurement is above or below normal values. Repeated measurements are required for screening purposes. One elevated reading does not mean that hypertension is present.

Complications

Certain physical or psychological conditions can affect a blood pressure measurement by elevating or lowering the reading. These include the following factors:

- stress, anger, or fear
- drugs, prescribed and illegal
- pre-eclampsia in pregnant women
- neurological disorders
- urological disorders
- cardiological disorders
- shock

- hemorrhage
- burns

There is a nationwide initiative to ban the sale of mercury thermometers and mercury devices for monitoring blood pressure. Health activists are concerned about mercury contaminating the environment after disposal of this equipment. Several states have banned the use of products containing mercury and stores such as Wal-Mart, CVS, and Kmart have already stopped selling mercury thermometers. According to a study by the Mayo Clinic in March 2001, mercury-free devices can monitor information without compromising accuracy. The Environmental Protection Agency (EPA) “Reducing Mercury Use in Health Care” in October 1999 advises using alternative devices to avoid the need for increased regulations in years to come and to protect human health and wildlife by reducing unnecessary exposure to mercury.

Results

The normal values for blood pressure measurement is a systolic pressure of 120 mm Hg and a diastolic pressure of 70-80 mm Hg.

Mild hypertension is a diastolic pressure above 90 mm Hg.

The American Heart Association states that a systolic pressure above 130-139 mm Hg needs to be watched carefully.

Significant hypertension is a systolic pressure above 200 mm Hg.

The blood pressure measurement is recorded and compared with normal ranges for the patient’s age and medical condition. Based on the results a decision is made as to whether any further action is required.

Hypertension increases the risk of serious diseases such as heart attack and stroke.

Health care team roles

Older children and parents may ask questions about specific concerns they have regarding their blood pressure measurement or a particular disease. The nurse can provide counseling on the normal values of blood pressure, the prevention of illness and injuries, or suggest visiting the patient’s doctor who can advise on additional methods to help maintain a healthy blood pressure.

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Blood pressure measurement device see
Sphygmomanometer

Blood specimen collection

Definition

Blood specimen collection is performed routinely to obtain blood for laboratory testing. Blood can be obtained from venous access devices and sometimes by fingerstick. Blood is most frequently obtained via a peripheral vein puncture (venipuncture).

Purpose

Blood is usually drawn and collected in order to perform a variety of laboratory tests. Specimens are often sent to help diagnose conditions such as electrolyte imbalances, to screen for risk factors like high cholesterol levels, and to monitor the effects of treatments and medications.

Precautions

Although obtaining blood specimens is a routine function, it is one of the riskiest procedures nurses per-

form. To increase the safety of blood collection, these precautions should be followed:

- Avoid using syringes. Use vacuum tube blood-collection devices instead, preferably those with needle-stick prevention features.
- Do not use a needle when withdrawing blood from a peripheral intravenous line or from a central venous access device. Using a needleless system allows the blood to be drawn directly into specimen containers.
- Do not use an exposed needle to inject blood into specimen containers or vacuum tubes.

When drawing blood, the health care professional should follow **universal precautions** as set forth by the Centers for Disease Control and Prevention (CDC). Universal precautions help reduce the risk of exposure of the health care professional's skin and/or mucus membranes to infectious materials. It includes the use of a variety of protective barriers, such as gloves, masks, gowns, and eyewear. Good hand washing practices before and after drawing blood also reduce the exposure risk.

These precautions were designed to prevent the transmission of hepatitis B virus (HBV), human **immunodeficiency** virus (HIV), and other bloodborne pathogens. Universal precautions apply to blood, semen, vaginal secretions, and any other body fluids containing blood. They also apply to tissues, as well as pleural, cerebrospinal, synovial, peritoneal, pericardial, and amniotic fluids. Universal precautions do not apply to stool, nasal secretions, sputum, sweat, tears, urine, saliva, and vomit unless these visibly contain blood.

Description

Prior to obtaining blood specimens, the nurse should assess the patient, noting factors that may affect test results, including medications, **pregnancy**, age, and sex. Make sure the patient has followed any special instructions, which could include fasting for a number of hours or taking a medication at a certain time.

Patients should also be assessed for their knowledge level regarding the tests ordered. Instruct the patient as needed about the test and the procedure itself. Although most blood work does not require any special consent, some tests, like those for HIV, usually do. If needed, obtain consent prior to collecting the specimen.

There are four patient "rights" the nurse should consider when collecting blood specimens. These rights are:

- Right specimen. Make sure the specimen collected is the specimen ordered.



A health care professional uses a needle and syringe to take a blood sample from a patient. (Photograph by Faye Norman. Science Source/Photo Researchers. Reproduced by permission.)

- **Right time.** Certain blood tests must be obtained at specific times. For example, when drawing antibiotic levels, trough specimens should be obtained immediately prior to the next dose. The time to draw peak levels may be dependent upon whether the antibiotic is given intravenously, orally, or intramuscularly.
- **Right patient.** Always verify the patient's identification before drawing a blood specimen. The person drawing the specimen should also label the container it is drawn into.
- **Right method.** Always follow universal precautions when performing a venipuncture.

Before puncturing, the patient's skin should be cleaned. Povidone-iodine (Betadine) can be used, or alcohol, unless an ETOH level is being drawn (alcohol on the skin may elevate an ETOH result). Povidone-iodine should always be used if blood cultures are to be drawn.

Techniques to find a vein include lowering the arm into a dependent position to help dilate the veins; applying warm soaks on the arm to improve venous dilation; and having the patient open and close the fist after apply-

ing a tourniquet. The health care provider can also attempt to palpate a vein where it is expected to be, since veins can often be felt, yet not seen. Arteries pulsate and have a thick wall. Thrombosed veins feel cord-like, and roll easily.

There are three veins in the antecubital (the inner or front surface of the forearm) area that are appropriate for venipuncture: the medial, cephalic, and basilic veins. The vein of choice is the medial, because it is usually the closest to the skin's surface, the largest, and usually the least painful to puncture. If the antecubital sites cannot be accessed, wrist and hand veins are also acceptable for venipuncture.

Venipuncture is usually done using a vacuum container (Vacutainer) system. This system consists of vacuumized specimen tubes, a needle, and a plastic holder. When the tube is placed into the holder and pressed against the needle, negative pressure results, and blood is pulled into the tube. Normally, a 21-gauge needle is used to collect blood. Occasionally, depending on the test ordered and specific patient circumstances, a larger or smaller diameter needle may be appropriate. Never insert the needle at greater than a 30 degree angle. Doing so

increases the possibility of passing through the vein and into those structures lying underneath, raising the chances of permanent injury to the patient.

A number of other guidelines should be considered when performing venipunctures for blood specimen collection. These include:

- Avoid drawing blood from an arm affected by a stroke or neurological injury that has resulted in a loss of sensation. The patient may not be able to alert you if they experience **pain** or other problems.
- Avoid drawing blood from the arm on the affected side if a woman has had a mastectomy (full or partial breast tissue removal).
- Avoid areas with extensive scarring. Scar tissue is difficult to puncture.
- Attempt to collect the blood specimen from the opposite arm if a patient is receiving intravenous fluids, since fluid may dilute the blood sample.
- Do not use a site that is swollen, affected by certain skin conditions like eczema, or is infected.
- Use the right specimen tubes. Using the wrong tubes will cause the specimen to be rejected by the laboratory.
- Try using pediatric tubes when a patient has fragile veins that may not provide a large enough specimen. Though the smaller tubes store less blood, they will still give reliable results.
- Remove the tourniquet when the final tube of blood to be drawn is filling.
- Send the specimen to the laboratory as soon as possible.

Blood collection tubes come with a variety of colored stopper caps, and may contain additives. The following tubes are the most commonly used types:

- **Red top.** This tube contains no additives. It is used for a variety of tests, including blood typing and cross-matching.
- **Tiger top or serum separator tube (SST).** This tube contains a polymer gel and clot activator. When placed in a centrifuge, the serum is separated out. The SST is commonly used for blood chemistries.
- **Lavender top.** These tubes are used primarily for obtaining complete blood counts. They contain EDTA, an anticoagulant additive that chelates **calcium**.
- **Dark green top.** Green top tubes contain the anticoagulant heparin and are often used to obtain lithium and ammonia levels.

KEY TERMS

Hemoconcentration—An increased concentration of larger molecules and formed elements in the blood.

Hemolysis—The destruction of red blood cells which leads to the release of hemoglobin from within the red blood cells into the blood plasma.

- **Light blue top.** The light blue top tubes contain sodium citrate, an agent that removes calcium, and are used to obtain protime (PT) and prothrombin time (PTT).
- **Light gray top.** This specimen tube contains sodium fluoride and potassium oxylate, antiglycolytic agents that preserve glucose for up to five days. The tube is used primarily to obtain glucose levels.

It is important that blood collection tubes be drawn in a certain order to avoid the cross-contamination of additives between tubes. It is recommended that tubes be drawn in the following order:

- **Yellow-black stopper (blood culture tube).**
- **Red top.**
- **Light-blue top.** This should not be the first tube drawn. If a coagulation assay is ordered alone, draw a non-additive tube first (red or SST), then draw the light-blue top tube.
- **Additive tubes in the following order:** dark green, lavender, light gray.

All tubes containing additives should be thoroughly mixed. Not doing so can result in inaccurate test results.

Venipuncture is not always possible or appropriate for the blood specimen required. In these cases, a fingerstick or heelstick may be the method of choice for obtaining the specimen.

The best locations for fingersticks are the third and fourth fingers of the patient's non-dominant hand. Avoid using the center, tip, or side of the finger. Avoid sticking areas that are thick or callused, where there is little soft tissue, or where the bone is close to the surface. Do not puncture a finger that is swollen, cyanotic (blue because of oxygen deficiency), or scarred. The fingerstick is done using a sterile lancet. The first drop of blood should be wiped away, as this first drop tends to contain extra fluid from the tissues. Instead of firmly milking the finger, it should only be gently massaged to gain drops of blood. Milking can squeeze tissue fluid into the drops of blood and alter laboratory results.

A heelstick is the preferred method of blood collection on a newborn baby or infant. In order to increase the flow of blood to the heel, the baby's heel should be prewarmed. (Avoid using too high a temperature as a baby's skin is easily injured.) The site to be punctured should be cleaned with alcohol, then dried with a dry cotton ball. The baby's foot should be held firmly to avoid sudden movements, then the side of the heel is punctured using a sterile lancet. Puncturing the center area of the heel should be avoided, as this can injure the underlying bone. Gentle pressure can be used to increase the flow of blood. To avoid diluting the specimen with excess tissue fluid, do not apply too much pressure.

After performing either a fingerstick or heelstick, a gauze pad or cotton ball should be applied for about a minute, making certain the bleeding has stopped.

Preparation

The patient should be instructed about what blood tests have been ordered and why. Furthermore, explain the procedure and what the patient can expect. Ask the patient if anyone has had trouble drawing blood from him or her in the past. This may be an alert to potential problems in finding an appropriate vein. Also ask the patient what position would be most comfortable for them when drawing the specimen. Venipuncture makes many patients nervous, and having them lie down may help them to relax and better tolerate the procedure.

Aftercare

After obtaining the ordered specimens, remove the needle from the vein and discard into a puncture-proof container. Pressure should be applied to the site for about a minute (longer if the patient is on any anticoagulants). After applying pressure, inspect the site for any signs of bleeding or hematomas. Apply a bandage to the site. The specimen containers should then be labeled and sent to the laboratory. Make sure the patient is comfortable and not experiencing any adverse effects before allowing them to get up.

Complications

Though venipuncture is routinely done and relatively safe, there are a few complications that can occur, including hematoma formation, hemolysis, and hemoconcentration. In addition, excessive bleeding can occur, and many patients have been known to faint during the procedure.

Health care team roles

Blood specimen collection is performed primarily by nurses and phlebotomists. The physician orders the laboratory tests. The nurse is responsible for instructing the patient regarding the procedure and assessing the patient's response. In addition, the nurse should be knowledgeable about the implications laboratory results may have on patient care.

Resources

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Deanna M. Swartout-Corbeil, R.N.

Blood sugar test see **Glucose tests**

Blood typing see **Type and screen**

Blood urea nitrogen test see **Kidney function tests**

Blood vessel scan see **Doppler ultrasonography**

Blood vessels

Definition

Blood vessels compose a continuous system of channels through which blood transports oxygen and nutrients to and waste materials from all body tissues.

Description

Structure

All blood vessels (except capillaries) share a similar three-layered structure. The innermost layer, called the tunica intima, is composed of a monolayer of endothelial cells called the endothelium. The tunica intima helps to restrict the entry of substances into the vascular wall, control blood vessel diameter, and regulate coagulation.

The hollow center of a blood vessel is called the lumen and is the space through which blood flows.

The middle layer is called the tunica media and is separated from the tunica intima by a sheath of high-flexible material called the internal elastic lamina. The tunica media is composed of a circular arrangement of smooth muscle cells, collagen, and elastic fibers; it composes the bulk of the wall of most arteries but in veins is thinner and contains fewer smooth muscle cells. Smooth muscle contains contractile elements that are responsible for contraction (vasoconstriction) and relaxation (vasodilation). The tunica media, therefore, imparts strength, elasticity, and contractile abilities to the vessel wall.

Surrounding the tunica media is the tunica adventitia (the two layers are separated by the external elastic lamina). This outermost layer contains a matrix of collagen and elastic fibers that support fibroblasts (cells that secrete the fibrous **proteins** collagen and elastin), nerves, and vasa vasorum (small blood vessels that supply the walls of large arteries and veins with oxygen and nutrients).

Arteries and arterioles

Arteries are blood vessels that carry blood away from the **heart**. Arterial blood is oxygen-rich, with the exception of blood carried by the pulmonary artery from the heart to the **lungs** to be oxygenated. The aorta is the largest artery in the human body and originates at the left ventricle of the heart. This vessel and its major branches (the common carotid, common iliac, subclavian, and brachiocephalic arteries) are called elastic arteries because they expand and recoil in response to the pulsing flow of blood and to changing blood volume.

The elastic arteries branch to become muscular arteries, vessels with thick walls that transport blood to specific organs. Muscular arteries give rise to resistance vessels; these include small arteries and arterioles. As arteries become smaller, their walls become thinner and are composed of less collagen and elastin. The walls of small arteries have multiple layers of smooth muscle cells, while arterioles have only one or two. Resistance vessels are thus less stretchy but more active in regulating the flow of blood into capillary beds.

Anastomoses are formed where arteries and arterioles merge to provide alternative channels for blood delivery. They provide collateral circulation in the event that an artery becomes occluded (blocked).

Exchange vessels

Exchange vessels include capillaries and postcapillary venules. The walls of capillaries are composed of only a tunica intima (a thin layer of endothelial cells). The average diameter of the lumen is just large enough to

allow erythrocytes (red blood cells) to pass through in single file. Exchange vessels are the site where gases, nutrients, and wastes are exchanged between blood and surrounding tissues.

There are three major type of capillaries: continuous, fenestrated, and discontinuous. Continuous capillaries are the most abundant type in the human body and are found in skin, muscle, lungs, and the **central nervous system**. They have low permeability and therefore allow only limited passage of substances across the capillary wall. Fenestrated capillaries are much more permeable than continuous capillaries; their walls contain circular pores or fenestrae closed by a thin diaphragm. Discontinuous capillaries, also called sinusoids, have gaps between endothelial cells that are large enough to allow even erythrocytes to pass through the capillary wall. They are found in the **liver**, spleen, and bone marrow, as well as some endocrine glands.

The capillary bed is a network of capillaries that connect arterioles with venules; there are typically 10 to 100 capillaries per bed. Arterioles give rise to either capillaries or metarterioles, vessels that are wider than true capillaries and directly connect arterioles to venules. True capillaries branch off arterioles or metarterioles and are encircled at their origin by the precapillary sphincter, permitting the regulation of blood flow into the capillary. Arteriovenous (A-V) shunts are anastomoses that bypass the capillary bed completely; they are frequently seen in tissues that require increased blood flow.

Veins and venules

Veins are blood vessels that carry blood from the capillary beds to the heart. Capillaries give rise to venules (small veins that have walls composed of a thin layer of endothelial cells), which in turn converge to form veins. Blood from the head, neck, and arms is carried to the superior vena cava, while the inferior vena cava receives blood from the trunk and legs; these large veins empty into the right atrium of the heart. The veins carry blood that is oxygen-poor, with the exception of the pulmonary vein, which carries oxygenated blood from the lungs to the heart.

The walls of veins are thinner and the lumens larger than those of arteries. They can accommodate a large blood volume and may act as blood reservoirs, containing up to 70% of the body's total blood volume. Veins and venules are therefore called capacitance vessels. Most veins have a system of valves, paired folds of the tunica intima that prevent the backflow of blood.

KEY TERMS

Anastomoses—Connections formed where arteries and arterioles merge to provide alternative channels for blood delivery.

Arteries—Blood vessels that carry blood away from the heart.

Diastolic pressure—Diastole is the period in which the left ventricle relaxes so it can refill with blood; diastolic pressure is therefore measured during diastole.

Hydrostatic pressure—Force per unit area exerted by a fluid (blood) against a vessel wall.

Lumen—The hollow center of a blood vessel.

Osmotic pressure—The pressure required to prevent osmosis of fluid across a semi-permeable membrane. It is an indirect measurement of the water and solute concentrations of the solution.

Systolic pressure—Systole is the period of the cardiac cycle in which the aortic valve opens and blood flows into the aorta; systolic pressure is the maximal pressure during systole.

Tunica intima, media, adventitia—The three layers that compose the walls of large arteries and veins.

Vasa vasorum—Small blood vessels that supply the walls of large arteries and veins with oxygen and nutrients.

Veins—Blood vessels that carry blood from the capillary beds to the heart.

Function

Blood pressure

Blood pressure is defined as the force per unit area that flowing blood exerts on the wall of a vessel; it can be represented by the equation $Blood\ pressure = flow \times resistance$. Blood pressure is typically expressed in mm Hg (read as “millimeters of mercury”). It is usually recorded as two numbers: systolic pressure over diastolic pressure. Systole is the period of the **cardiac cycle** in which the aortic valve opens and blood flows into the aorta; systolic pressure is the maximal pressure during systole. Likewise, diastole is the period in which the left ventricle relaxes so it can refill with blood; diastolic pressure is therefore measured during diastole. It is generally assumed that a healthy young adult should have a blood

pressure of 120/80 mm Hg (i.e. systolic pressure of 120 mm Hg and diastolic pressure of 80 mm Hg).

Blood pressure is proportional to blood flow (the amount of blood flowing through a vessel per unit time) and vascular resistance. Pressures vary throughout the **cardiovascular system** depending on the type and size of blood vessel. The highest systemic blood pressure is found in the aorta and diminishes progressively along the arterial system; it reaches its lowest point in the veins.

There are a number of factors that influence blood pressure. An individual’s physical characteristics (i.e. sex, age, weight, race, or socioeconomic status) may positively or negatively affect blood pressure. Activities such as eating, drinking, sleeping, or smoking cause changes in pressure, as do mental activities or emotions such as **anxiety** or apprehension. Various disorders such as atherosclerosis, anemia, and **diabetes mellitus** have adverse effects on blood pressure.

Capillary dynamics

The capillary bed is the site at which gases, nutrients, and wastes are exchanged between the blood and surrounding tissues. It is surrounded by interstitial fluid, or lymph, which is produced by the **lymphatic system**. Substances are moved between blood and interstitial fluid across the capillary wall by means of diffusion (movement from a high to a low concentration). Oxygen and nutrients move from the blood to interstitial fluid, while carbon dioxide and wastes move in the opposite direction. Gases such as oxygen or carbon dioxide and lipid-soluble nutrients diffuse across the **cell membranes** of endothelial cells. Small openings in the capillary wall called slit pores or clefts exist where endothelial cells border each other; small water-soluble nutrients or wastes may diffuse through these clefts.

There are two types of pressure that are involved in capillary dynamics. Hydrostatic pressure is the force per unit area exerted by a fluid (blood) against a vessel wall. Colloid osmotic pressure is the pressure required to prevent osmosis of fluid across a semi-permeable membrane. Transcapillary filtration is determined not only by these pressures inside the blood vessels, but also by the same pressures outside the blood vessels. Osmotic pressure is an indirect measurement of the relative concentrations of water and solute in a solution; the higher the osmotic pressure of the solution, the lower the water concentration and therefore the higher the solute concentration of the solution. In a capillary, osmotic forces are exerted primarily by proteins, which are relatively impermeable to the capillary wall.

Role in human health

The 2001 “Heart and Stroke Statistical Update,” published by the American Heart Association, states that cardiovascular diseases (CVD) have been the leading cause of death in the United States every year since 1900, with the exception of 1918. CVD accounted for 40.6% of all U.S. deaths in 1998; over 60 million Americans are estimated to suffer from one or more CVD.

There are numerous factors that increase the risk of cardiovascular disease. These include:

- Major risk factors: tobacco smoke, race, genes, diabetes mellitus, high cholesterol levels, **hypertension**, physical inactivity, and **obesity**.
- Contributing risk factors: **stress**, high triglycerides, alcohol, oral contraceptives, **pregnancy**, **menopause**, and Syndrome X (a cluster of risk factors that include obesity, glucose intolerance, hypertension, and high cholesterol).

Blood vessels and blood flow can respond to a variety of local control factors, including neural (such as **shock**) or hormonal impulses (such as anger or fear). Blood vessels themselves can also grow (a process called angiogenesis) or remodel themselves in response to diseases such as ischemia and hypertension.

Common diseases and disorders

- Atherosclerosis: According to the American Heart Association, atherosclerosis accounts for nearly 75% of all cardiovascular-related deaths. It involves the accumulation of **lipids** and other substances on the inner lining of an artery; the area of buildup is called a plaque. As a result, the arterial wall thickens and hardens, losing elasticity. Thrombi (blood clots) form when plaques rupture; if these occlude the artery, a heart attack or stroke may result.
- Stroke: A stroke occurs when the **brain** has been deprived of oxygen due to interrupted blood flow, often caused by a blood clot or burst blood vessel. Depending on the area of the brain that is damaged, neurological damage may be reversible or irreversible and may include **coma**, **paralysis**, visual or speech problems, seizures, or impaired memory.
- Varicose veins: Permanent changes in the diameter and/or length of veins may result from damage to or failure of the venous valves. Gravity, obesity, pregnancy, and increasing age may also play a role in the development of varicose veins.
- Hemangiomas: These are usually benign vascular anomalies that may result in small, harmless birthmarks or sacs of vascular tissues of varying sizes that

may protrude from the skin. Hemangiomas are often only cosmetic blemishes but may, depending on their location, cause obstruction of the airway, block **vision**, or obstruct a vital organ.

- Aneurysm: An aneurysm results from the dilation of the wall of a blood vessel due to the weakening of the wall by disease, high blood pressure, or congenital defects. An abdominal aortic aneurysm is the most common type. A ruptured aneurysm is a serious medical emergency and requires surgical intervention.

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ORGANIZATIONS

- American Heart Association. 7272 Greenville Ave., Dallas, TX 75231. (800) AHA-USA1. <<http://www.american-heart.org>>.

Stephanie Islane Dionne

Body dysmorphic disorder see **Somatoform disorders**

Body positioning in x-ray studies

Definition

Body positions in x-ray exams are based on body part, suspected defect or disease, and condition of the patient. The radiographer, also known as the x-ray tech or more formally as the radiologic technologist, uses standardized body positions in performing an x-ray exam. Positions are learned by the radiographer according to body part in relation to body habitus, anatomical position and bisecting planes, and relationship of the body to the x-ray equipment.

Purpose

Since many body parts overlay other internal structures, the radiographer uses positioning of the body part as well as specific positions of the x-ray equipment to obtain clearer views of the overlapping structures. X-ray exams usually consist of two or more radiographs, taken in orthogonal planes or variations to the relationship of body part and x-ray equipment. Exams require radiographs to be taken at 90 degrees to each other where anatomy is superimposed over important structures, where alignment of fracture ends is questioned, or for localization of **foreign bodies**. Exams require a minimum of three radiographs when joints or articulations are in the area of interest, although some referring physicians may ask for only two. This allows for evaluation of the bones and well as the joints.

Precautions

The radiographer applies principles of immobilization in performing the exam. The use of immobilization has two purposes. First, the patient's safety is of primary importance to the radiographer. Second, immobilization assists the patient in maintaining the applied body position during the exam. Some x-ray exams require the patient to suspend breathing during the exposure such as for chest x rays. Suspension of breathing is a method of immobilization that the patient voluntarily performs. In other cases, the radiographer assists the patient in maintaining a position with the use of radiolucent sponges or other positioning aids.

Radiation protection is used to reduce or prohibit x-ray exposure to areas of the body that are biologically sensitive. The determinants of x-ray exposure include time spent under irradiation, distance of x-ray unit, and shielding practices. The most common practice of radiation protection is to protect the reproductive organs, especially in children and young adults. It is standard practice to question women of childbearing age if there is a possibility of **pregnancy**. Radiographic exams are not usually performed on pregnant women as the developing fetus is biologically sensitive to radiation.

Description

The use of body positioning requires an understanding of terminology that refers to the relationship of the body to the x-ray equipment and to anatomical references. All body positions and exam requirements are expressed in terms of projection, position, and view. A projection refers to the path the x rays take through the body, from entrance to exit. Position describes the body and its relationship to the x-ray film device (film cassette,

image intensifier, image receptor). View is not a positioning term but instead is used in discussion the radiograph. For example, the physician orders an upright chest x ray with two views of an ambulatory patient. The standard positions are P. A. (back to front) and lateral (from the side). The radiographer positions the patient standing at the x-ray image receptor for a posterior-anterior projection (the x rays pass from the patient's back to the front) and a left lateral projection (patient's left side closest to image receptor and x rays pass from the patient's right to left). Body positioning may also require adjacent areas be addressed, i.e., moving the arms out of the way.

Anatomical position

Anatomical position is the fundamental term used in body positioning. In this position, the patient is standing and facing front. The arms are down at the sides and the palms are turned forward so that you can see them. Feet are pointed straight ahead and the toes are lying down on the floor. The surface of the body that is facing front is known as the anterior, or ventral, surface. Any anatomical structure located in the half of the body that is adjacent to the anterior surface is considered to be anterior within the body. The surface of the body facing the rear is the posterior, or dorsal, surface. Any anatomical structure located in the half of the body that is adjacent to the posterior surface is considered to be posterior within the body. The body is also discussed in right and left sides using an imaginary line dividing the sides through the body's center.

Posture and relationship to x-ray equipment

X-ray exams are performed with either stationary or mobile equipment. Stationary equipment may be specialized for upright exams such as a chest x-ray unit or panoramic chair unit. Some stationary equipment only allows for the patient to lie down on a table for the exam. Other stationary equipment has a rotating table that allows for upright exams in addition to having the patient lie on the table. Mobile, or portable, x-ray equipment can accommodate a variety of patient positions. Regardless of the equipment used, the same principles and terminology of positioning are applicable.

Positions for x-ray exams may require description of posture, that is, whether the patient is to be lying down, standing, or seated. The patient's physical condition or ability to cooperate may also affect the positioning procedures used for the exam. If the patient is standing, the body is referred to as upright or erect. The general term for lying down is recumbent. It is necessary to describe the position as face up or face down. Supine position of a

patient describes lying on the back and facing up in anatomical position. Prone position describes the patient lying on the abdomen and facing down. For comfort, the patient may turn the head to the side unless the part to be x-rayed is the face, head, or neck. For some exams, the patient is slanted in a head-down position known as Trendelenburg.

Descriptions of the patient's position also varies by the projection. If an oblique projection is required, the body or body part (or the x-ray tube) is rotated 45 degrees from anatomical position. The side and surface closest to the image receptor describe the position. For example, a left anterior oblique describes the patient as having the left, anterior surface of the body closest to the receptor at 45 degrees from anatomical position. Another variation of position is decubitus. In the decubitus position, the patient is lying down and the x rays pass through the patient 90 degrees from the table or bed surface. In a lateral decubitus, the patient is lying on either the right or left side and the x-ray beam passes through the patient from anterior to posterior or posterior to anterior. The position is named for the side that the patient is lying on, i.e., left lateral decubitus describes the patient as lying on their left side. Lateral decubitus positions are used to image the chest or abdomen when it is necessary to demonstrate the presence of an air-fluid interface. In a dorsal decubitus, the patient is supine and the x rays pass through the body from right to left or left to right. This type of position is commonly used in lateral x rays of the spine when the patient cannot be moved into a standard lateral position.

Additional anatomical and movement terms

Additional terms are used to describe relationships of body parts or directions. These terms are often paired describing opposites. Cephalic, or superior, describes a direction toward the head of the body while caudal, or inferior, refers to the feet or away from the head. Proximal describes the source or beginning, i.e., the knee is proximal to the ankle. Distal directs you away from the source or beginning. Medial refers to the middle or toward the center of the body while lateral refers to the outside or away from the center. The surfaces of the hand and foot have special anatomical terms. Plantar refers to the sole of the foot, dorsum to the top or anterior surface of the foot, and palmar to the palm of the hand.

Movements of the joints are also important in body positioning. Flexion refers to decreasing the angle between two parts such as the bending of the elbow. Its opposite movement is extension. The hyperextended joint is straightened beyond neutral or bent so as to increase the normal angle beyond neutral. In describing



A technologist positions a patient's arm for an x ray.

(Photograph by Will & Deni McIntyre. Science Source/Photo Researchers. Reproduced by permission.)

flexion and extension of the spine, bending forward is flexion, neutral position is extension, and bending backward is hyperextension. Movement of the arms or legs toward the body's median line is known as adduction while moving them away from the body is abduction. Specialized movements are used to demonstrate stress on a joint. Such movements of the ankle and foot are performed without moving the leg. They are described as eversion, an outward movement, and inversion, an inward movement. Other specialized movements may be described for their effect on adjacent joints or articulations. If the hand is supinated, it is in anatomical position (palm facing up). If pronated, the palm faces down. X-ray exams of the shoulder may require views of both pronation and supination of the hand to completely evaluate structures of the head of the humerus as it articulates in the shoulder joint.

KEY TERMS

Articulation—A joint, a connection between bones.

Orthogonal planes—Intersecting planes, planes at right angles to each other.

Position—A body posture such as upright, recumbent, supine, prone, lateral, also the description of the posture of an anatomical part such as oblique.

Radiograph—X-ray image, either physical (on film or paper) or digital.

Radiographer—Allied health professional who performs diagnostic imaging exams using x rays, magnetic resonance imaging, computed tomography, sonography, and others.

Body habitus

The body habitus describes the basic body shape. Body shape is important in x-ray exams as the size, shape, and position of the organs varies by body type. The technologist should adjust the x-ray unit accordingly, in order to obtain an adequate image. There are four terms used to describe body habitus:

- Hyperstenic (large to massive). Chest and abdomen are broad and deep, **lungs** are short, diaphragm is high.
- Stenic (average).
- Hypostenic (slender).
- Asthenic (very slender). Chest is narrow, shallow, and long so diaphragm is low.

In the hyperstenic patient, the **stomach** typically lays across the abdomen at or above waist level. The stomach of a stenic patient is shaped like a comma laying slightly skewed from left to right and centered at the waistline. The stomach of a hypostenic patient is elongated into a “J” shape and may extend into the pelvis. Since the astenic patient appears to have little abdominal space between the diaphragm and pelvis, the stomach is quite long and slender lying primarily in the pelvis. An understanding of body habitus and the relationship of the organs in the chest, abdomen, and pelvis are essential in positioning for upper and lower gastrointestinal exams. In addition, other positioning considerations are important, including posture, respiration, and stomach contents.

Preparation

Most x-ray exams require little if any preparation by the patient. In many cases, the change from street clothes to a hospital gown is all that is required. Some exams may require the patient to fast for several hours while others may require ingestion of a radiopaque liquid that will define the gastrointestinal system in the radiographs. Special imaging procedures such as nuclear medicine, sonography, or **magnetic resonance imaging** may have additional preparation requirements.

Aftercare

Few x-ray examinations require aftercare. If the examination required an injection of medication or contrast media, instructions will be given about the contrast and care of the puncture site. Following examination of the gastrointestinal system, patients are typically instructed to drink plenty of fluids and are advised how the exam may affect bowel movements.

Complications

Complications following x-ray exams are rare. If an injection is required or catheter is used, there may be the typical complications at the puncture site—bruising, bleeding, and discomfort. Patients should be advised of the possibility of complications from their exam, preferably in writing.

Health care team roles

Although the radiographer actually performs the examination in most cases, there are other members of the health care team in the radiology department or imaging center. Many facilities have transport personnel whose job it is to move patients in and out of the imaging rooms and department. These individuals are trained in the safe handling of patients and support equipment as well as proper lifting techniques and **universal precautions** against infections. Many hospitals provide a radiology nurse to perform injections, assist the physician in special procedures, or provide patient care as required. The radiologist will interpret the resulting images.

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- American Society of Radiologic Technologists. 15000 Central Ave. SE. Albuquerque, NM 87123-3917. 505-298-4500. 800-444-2778. Fax 505-298-5063. <<http://www.asrt.org>>.
- Radiological Society of North America. 820 Jorie Boulevard. Oak Brook, IL 60523-2251. (630) 571-2670. Fax (630) 571-7837. <<http://www.rsna.org>>.

Elaine R. Proseus, MBA/TM, BSRT, RT(R)

Boils

Definition

Boils, also called furuncles, and carbuncles are bacterial infections of hair follicles and surrounding skin that form pustules (small blister-like swellings containing pus) around the follicle. A carbuncle results when several boils merge to form a single deep **abscess** with several heads, or drainage points.

Description

Boils and carbuncles are firm reddish swellings about 0.2–0.4 inches (5–10 mm) across that are slightly raised above the skin surface. They are sore to the touch. A boil usually has a visible central core of pus; a carbuncle is larger and has several visible heads. Boils occur most commonly on the face, back of the neck, buttocks,

upper legs and groin area, armpits, and upper torso. Carbuncles are less common than single boils; they are most likely to form at the back of the neck. Males are more likely to develop carbuncles.

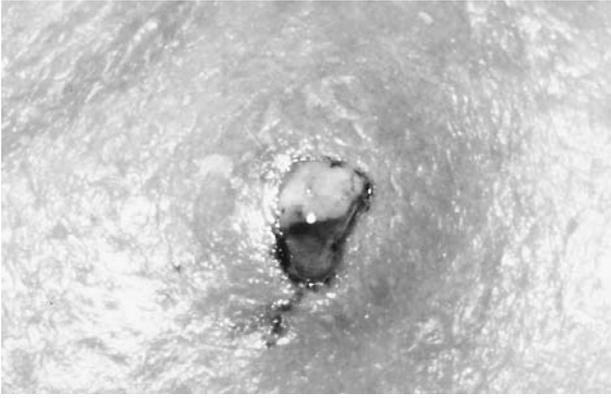
Boils and carbuncles are common problems in the general population, particularly among adolescents and adults. People who are more likely to develop these skin infections include those with:

- diabetes, especially when treated by injected insulin
- alcoholism or drug abuse
- poor personal hygiene
- crowded living arrangements
- jobs or hobbies that expose them to greasy or oily substances, especially petroleum products
- allergies or **immune system** disorders, including **HIV infection**
- family members with recurrent skin infections

Causes and symptoms

Boils and carbuncles usually are caused by *Staphylococcus aureus*, a bacterium that causes an infection in an oil gland or hair follicle, or they might be caused by other **bacteria** or **fungi**. Although the surface of human skin is usually resistant to bacterial infection, *S. aureus* can enter through a break in the skin surface—including breaks caused by needle punctures for insulin or drug injections. Hair follicles that are blocked by greasy creams, petroleum jelly, or similar products are more vulnerable to infection. Bacterial skin infections can be spread by shared cosmetics or washcloths, close human contact, or by contact with pus from a boil or carbuncle.

As the infection develops, an area of inflamed tissue gradually forms a pus-filled swelling or pimple that is painful to touch. As the boil matures, it forms a yellowish head or point. It may either continue to swell until the point bursts and allows the pus to drain, or it may gradually be reabsorbed into the skin. Boils can cause a lot of **pain** when they occur in the ear canal, nose, or other sensitive areas. It takes between one and two weeks for a boil to heal completely after it comes to a head, discharges pus, and crusts over. The bacteria that cause the boil can spread into other areas of the skin and even into the bloodstream if the skin around the boil is squeezed. If the infection spreads, the patient will usually develop chills and **fever**, swollen lymph nodes (lymphadenitis), and red lines in the skin running outward from the boil. Fatigue and general discomfort are other possible symptoms.



Boils often occur from a bacterial infection in a hair follicle or skin gland. (Custom Medical Stock Photo. Reproduced by permission.)

Furunculosis is sometimes used to refer to recurrent boils. Many patients have repeated episodes of furunculosis that are difficult to treat because their nasal passages carry colonies of *S. aureus*. These bacterial colonies make it easy for the patient's skin to be re-infected. They are most likely to develop in patients with diabetes, HIV infection, or other immune system disorders.

Carbuncles are formed when the bacteria infect several hair follicles that are close together. Carbunculosis is sometimes used to refer to the development of carbuncles. The abscesses spread until they merge with each other to form a single large area of infected skin with several pus-filled heads. Patients with carbuncles may also have a low-grade fever or feel generally unwell.

Diagnosis

The diagnosis of boils and carbuncles is usually made by the patient's primary care doctor on the basis of visual examination of the skin. In some cases involving recurrent boils on the face, the doctor may consider acne as a possible diagnosis, but, for the most part, boils and carbuncles are not difficult to distinguish from other skin disorders.

S. aureus can easily be cultured in the laboratory if the doctor needs to rule out inclusion cysts or deep fungal infections that gardeners sometimes get. The doctor can take a culture from pus taken from the boil or carbuncle to confirm the diagnosis of a staphylococcal infection. He or she can also culture the patient's nasal discharge to test for the presence of a *S. aureus* colony.

Treatment

Some boils heal spontaneously before progressing to pustules. Often, they become pustules that eventually burst, drain and then heal by themselves. Boils usually occur and are healed in about two weeks. Patients who have boils that take longer than two weeks to heal should see a doctor. Other reasons to seek professional medical advice are if boils recur, are located on the spine or the middle of the face, or are accompanied by symptoms such as fever. These boils are most at risk for spreading the infection.

Patient and family education

Patient education is an important part of the treatment of boils and carbuncles. Patients need to be warned against picking at or squeezing boils because of the danger of spreading the infection into other parts of the skin or bloodstream. It is especially important to avoid squeezing boils around the mouth or nose because infection in these areas can be carried to the **brain**. Patients should also be advised about keeping the skin clean, washing their hands carefully before and after touching the boil or carbuncle, avoiding the use of greasy cosmetics or creams, and keeping their towels and washcloths separate from those of other family members. Some doctors may recommend an antiseptic soap or gel for washing the infected areas. People who have boils often benefit from applying warm compresses several times a day to help the boils come to a head and drain.

If the patient has had several episodes of furunculosis, the doctor may examine family members or close contacts to see if they are carriers of *S. aureus*. In many cases, some of the family members may also need treatment for boils or carbuncles. Skin infection and re-infection involving small groups or clusters of people are being reported more frequently in the United States.

Medications

Boils are usually treated with application of topical antibiotic creams, such as clindamycin or polymyxin, following the use of hot compresses to help the infection drain, which speeds healing.

Carbuncles and furunculosis are usually treated with oral **antibiotics** as well as topical antibiotic creams or ointments. The specific medications that are given are usually dicloxacillin (Dynapen) or cephalexin (Keflex); erythromycin may be given to patients who are allergic to penicillin. The usual course of oral antibiotics is 5–10 days, although patients with recurrent furunculosis may be prescribed oral antibiotics for longer periods. Furunculosis is also treated with a combination of

dicloxacillin and rifampin (Rifadin). Still, many experts agree that topical antibiotics help very little once the boil has formed.

Patients with bacterial colonies in their nasal passages are often given mupirocin (Bactroban) to apply directly to the lining of the nose.

Surgical treatment

Boils and carbuncles that are very large, or that are not draining, may be opened by a doctor with a sterile needle or surgical knife to allow the pus to drain. The patient is usually administered a local anesthetic if a knife is used as surgical treatment of boils is painful, and frequently leaves noticeable scars.

Alternative treatment

Naturopathic practitioners usually recommend changes in the patient's diet as well as applying herbal poultices to the infected area. The addition of **zinc** supplements and **vitamin A** to the diet has been reported to be effective in treating boils. The application of a paste or poultice containing goldenseal root (*Hydrastis canadensis*) is recommended by naturopaths on the grounds that goldenseal helps to kill bacteria and reduce inflammation.

Homeopaths maintain that taking the proper homeopathic medication in the first stages of a boil or carbuncle will bring about early resolution of the infection and prevent pus formation. The most likely choices are *Belladonna* or *Hepar sulphureus*. If the boil has already formed, *Mercurius vivus* or *Silica* may be recommended to bring the pus to a head.

A variety of herbal remedies can be applied topically to boils to fight infection. These include essential oils of bergamot (*Citrus bergamia*), chamomile (*Matricaria recutita*), lavender (*Lavandula officinalis*), and sage (*Salvia officinalis*), as well as tea tree oil (*Melaleuca* spp.). Herbalists also recommend washing the skin with a mixture of goldenseal and witch hazel. To fight the inflammation associated with boils, herbalists suggest mixing marsh mallow (*Althaea officinalis*) ointment, tinctures (herbal solutions made with alcohol) of blue flag (*Iris versicolor*) or myrrh (*Commiphora mol mol*), and slippery elm (*Ulmus fulva*) into a poultice.

Prognosis

The prognosis for most boils is excellent, although some patients suffer from recurrent carbuncles or furunculosis. In addition, though the spread of infection from boils is relatively unusual, there have been deaths reported from brain infections caused by squeezing boils on the

KEY TERMS

Abscess—A localized collection of pus in the skin or other body tissue.

Carbuncle—A large, deep skin abscess formed by a group or cluster of boils.

Follicle—The small sac at the base of a hair shaft. The follicle lies below the skin surface.

Furunculosis—A condition in which the patient suffers from recurrent episodes of boils.

Pustule—A small raised pimple or blister-like swelling of the skin that contains pus.

upper lip or in the tissue folds at the base of the nose. Some patients also experience permanent scarring of the skin.

Health care team roles

Nurses help to educate patients about how to avoid infection of boils, ensure proper healing, and prevent recurrence. The nurse might also take a culture of the affected area to confirm the doctor or nurse practitioner's diagnosis. If in-office surgery to drain the boil is indicated, the nurse might assist in preparation for the procedure and during the procedure.

Prevention

There are some precautions that people can take to minimize the risk of developing bacterial skin infections:

- Cleanse the skin properly with soap and water, and take showers rather than tub baths.
- Do not share washcloths, towels, or facial cosmetics with others.
- Cut down on greasy or fatty foods.
- Always wash hands before touching the face.
- Consider using antiseptic soaps and shower gels.
- Consult a doctor if furunculosis is a persistent problem—it may indicate an underlying disease such as diabetes.

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Lisette Hilton

Bone cancer see **Sarcomas**

Bone densitometry

Definition

A bone densitometry test, or scan, is designed to check for **osteoporosis**, a disease that occurs when the bones become thin and weak. Osteoporosis happens when the bones lose **calcium** and other **minerals** that keep them strong. Osteoporosis begins after **menopause** in many women, and worsens after age 65, often resulting in serious **fractures**. These fractures may not only bring disability, but may affect longevity. As many as one-fourth of women who fracture their hip after age 50 die within one year.

Most people today will get a bone density scan from a machine using a technology called dual energy x-ray absorptiometry, or DEXA. This machine takes a picture of the bones in the spine, hip, total body and wrist, and calculates their density. If a DEXA machine is not available, bone density scans can also be done with dual photon absorbtometry (measuring the spine, hip and total body) and quantitative computed tomography scans (measuring the spine). Bone density scanners that use DEXA technology to just measure bone density in the wrist (called pDEXA scans) provide scans at some drugstores. Yet these tests are not as accurate as those that measure density in the total body, spine or hip—where most fractures occur. The DEXA scanner is most commonly found in large medical groups and medical centers.

Two newer devices are also available to check bone density. The Sahara Clinical Bone Sonometer, introduced in 1998, uses the velocity of sound waves to determine bone density. The device is much smaller than the DEXA scanner and requires that the seated patient place the foot in the scanner for about one minute. The device sends

ultrasound waves through the heel. Since the device is much smaller and cheaper than the DEXA machine, it is found most commonly in doctor's offices. The second device, introduced in 2000, is the Alara MetriScan, a tabletop scanner that allows clinicians to perform the test in a doctor's office. The patient puts the nondominant hand on the device's platform and the scan is done by x-raying the fingers.

Purpose

A bone density scan measures the strength of an individual's bones and determines the risk of fracture.

Precautions

The test is not recommended for people who cannot lay flat for the test, and people with **heart failure** or back problems. People who are severely overweight may not be able to take the test if the machine cannot support their weight.

Description

To take a DEXA bone density scan, the patient lies on a bed underneath the scanner, a curving plastic arm that emits x rays. These low-dose x rays form a beam that scans the patient. During the test, the scanner moves to capture images of the patient's spine, hip or entire body. A computer then compares the patient's bone strength and risk of fracture to that of other people in the United States at the same age and to young people at peak bone density. Bones reach peak density at age 30 and then start to lose mass. The test takes about 20 minutes to do and is painless. The DEXA bone scan costs about \$250. Some insurance companies and **Medicare** cover the cost. pDEXA wrist bone scans in drugstores are available for about \$30.

A patient may need a bone density scan and can discuss this with the doctor if he or she:

- is near menopause
- has broken a bone after a modest trauma
- has a family history of osteoporosis
- uses steroid or antiseizure medication
- has had a period of restricted mobility for more than six months
- has **hypertension** (high **blood** pressure)
- smokes

Bone densitometry scans are used primarily in women, due to the relationship between bone density loss and menopause. However, there are some instances

where a bone density scan may be in order for men with the following risk factors:

- low testosterone levels
- a family history of osteoporosis
- has been taking glucocorticoids (a group of steroids involved in carbohydrate, fat, and protein metabolism)
- has hyperparathyroidism (the presence of excess of the parathyroid hormone parathormone that is associated with calcium utilization)
- has suffered a fracture with a minimum amount of trauma
- has or has had **prostate cancer** that was treated with hormones or radiation

Preparation

The patient wears comfortable but loose clothing, such as a sweatsuit, and lies on the table underneath the scanner. The patient must not be wearing any metal objects that would interfere with the scan, including zippers, fasteners, and jewelry.

Aftercare

No post-treatment procedures or care are required following a bone densitometry scan.

Complications

The DEXA bone scan exposes the patient to only a small amount of radiation—about one-fiftieth that of a **chest x ray**.

Results

The patient's bone density is compared with the normal bone density (called a T-score.) A T-score above 1 means that a patient has a better bone mass than is typical. Scores from 0 to -1 mean that the patient has normal bone mass and should repeat the test in two to five years.

If patients' T-scores range from -1 to -2.5, they have low bone mass and are at risk for osteoporosis. A T-score below -2.5 means osteoporosis is already evident. These patients should have a repeat bone density scan every year or two to assess the response to therapy.

Health care team roles

The DEXA test is done primarily by a radiology or nuclear medicine technician. The ultrasound and hand x-ray scans are administered mainly by registered nurses (RNs). The tests are reviewed and treatment prescribed

KEY TERMS

Calcium—A mineral that helps build bone. After menopause, when women start making less of the bone-protecting hormone estrogen, they may need to increase their intake of calcium.

DEXA bone density scan—A bone density scan that uses a rotating x-ray beam to measure the strength of an individual's bones and his or her fracture risk.

Osteoporosis—A disease that occurs when the bones lose the calcium and structure that keep them strong. It often occurs after menopause (around age 50) in women and in old age in men.

by a physician. RNs also help educate the patient on the role **nutrition** and **exercise** play in bone health.

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Ken R. Wells

Bone density test see **Bone densitometry**

Bone marrow aspiration and biopsy

Definition

Bone marrow aspiration, which is also called bone marrow sampling, is the removal by suction of the soft, spongy semisolid tissue (marrow) that fills the inside of the long and flat bones. Bone marrow biopsy, or needle core biopsy, is the removal of a small piece (about 0.75 by 0.06 inch, or 2 by 0.16 cm) of intact bone marrow. The bone marrow is where **blood** cells are made.

Purpose

Examination of the bone marrow may be the next step that follows an abnormal clinical finding, abnormal **complete blood count** (CBC), and/or an abnormal peripheral blood smear. It may be performed following an abnormal bone image such as the finding of a mass lesion on x ray.

A biopsy of bone marrow shows the intact tissue, so that the fat cells, lymphocytes, plasma cells, fibrous connective tissue cells, and other cells can be seen in their overall structure, and in their relationships to each other. Bone marrow biopsy is used to:

- Aid in the diagnosis and management of any form of leukemia or other myeloproliferative condition such as multiple myeloma.
- Rule out or identify bone marrow infiltration of other malignancies such as Hodgkin's disease, non-Hodgkin's lymphoma, and metastatic carcinoma.
- Monitor the effects of **chemotherapy** and the response or lack of response to treatment of blood disease.
- Evaluate the success of bone marrow transplantation.
- Diagnose certain genetic diseases (e.g., lipid storage disease).
- Investigate pancytopenia (a decrease of all blood cells in peripheral blood), neutropenia (decreased phagocytic white blood cells), or thrombocytopenia (decreased platelets).
- Diagnose an **infection** of unknown origin.
- Investigate rare **anemias** for which a cause cannot be found or which does not respond to treatment as anticipated.

- Obtain intact bone marrow for laboratory analysis.
- Diagnose some types of **cancer** or anemia and other blood disorders.
- Identify the source of an unexplained **fever** (e.g. granulomatous lesions).
- Diagnose fibrosis of bone marrow and myeloma when bone marrow aspiration has failed to provide an appropriate specimen.

The combination of aspiration and biopsy procedures are commonly used together to ensure the availability of the best possible bone marrow specimen. The aspirate is collected at the same time as the bone core biopsy by attaching a syringe to the bone marrow needle and withdrawing the sample before the cutting blades are inserted and the bone core is removed. The aspirate is the sample of choice for studying and classifying the nucleated blood cells of the bone marrow (e.g., determining the ratio of immature white blood cells to red blood cells, the M:E ratio). The biopsy is the only sample that shows the blood forming cells in relation to the structural and connective tissue elements (i.e., the microarchitecture) of the bone marrow. It is the best sample to evaluate the cellularity of the bone marrow (the percentage of blood forming tissue versus fat).

Precautions

The bone marrow procedure is performed with strict attention to **aseptic technique** and **universal precautions** for the prevention of transmission of bloodborne pathogens. Fixation fluids, slides, and tubes with proper anticoagulant should be at the bedside so that the specimen can be preserved immediately and slides prepared that are of suitable quality. **Obesity** can affect the ease with which a bone marrow biopsy can be done, and the results can be affected if the patient has had radiation therapy at the biopsy site.

Description

Bone marrow aspiration and biopsy are performed by a pathologist, hematologist, or oncologist with special training in this procedure. The procedure may be performed on an outpatient basis. In adults, the specimen is usually taken from the posterior superior iliac crest (hip). The sternum may be used for aspiration, but is less desirable because it carries the risk of cardiac puncture. Other sites that are rarely used are the anterior superior iliac crest or a spinous process of a vertebra, a spinal column bone. When the patient is a child, the biopsy site is generally the anterior tibia, the larger of the two bones in the lower leg. A vertebra may also be used.

The skin covering the biopsy site is cleansed with an antiseptic, and the patient may be given a mild sedative. The patient is positioned, and a local anesthetic such as lidocaine is administered first under the skin with a fine needle and then around the bone at the intended puncture site with a somewhat larger gauge needle. After the area is numb a small incision is made in the skin and the biopsy needle is inserted. Pressure is applied to force the needle through the outer bone and a decrease in resistance signals entry into the marrow cavity. The needle most often used for bone marrow biopsy is a Jamshidi trephine needle or a Westerman-Jensen trephine needle. A syringe is placed on the hub of the needle and 1-2 mL of the bone marrow is aspirated into the syringe. In some instances, the marrow cannot be aspirated because it is fibrosed or packed with neoplastic cells. The syringe is removed and the medical technologist uses this sample to prepare several smears containing small bone spicules. Another syringe is fitted onto the needle hub and another sample of 3 mL is removed and transferred to a tube containing EDTA for analysis by flow cytometry, cytogenetic testing or other special laboratory procedure. Following aspiration, the cutting blades are inserted into the hollow of the needle until they protrude into the marrow. The needle is then forced over the tips of the cutting blades and the needle is rotated as it is withdrawn from the bone. This process captures the core sample inside the needle. A wire probe is inserted at the cutting end and the bone marrow sample is pushed through the hub of the needle onto sterile gauze. The specimen is used to make several touch preparations on glass slides or coverglasses and is transferred to a fixative solution.

In the laboratory the aspirate slides are stained with Wright stain or Wright-Giemsa stain. The biopsy material is sectioned onto glass slides and stained with hematoxylin-eosin, Giemsa, and Prussian blue stains. Prussian blue stain is used to evaluate the amount of bone marrow **iron** and the other stains are used to evaluate cell morphology. In addition, special stains may be used that aid in the classification of malignant white blood cells.

Preparation

The physician should be told of any medication the patient is using and any **heart** surgery that the patient has undergone.

Aftercare

After the needle is removed, the biopsy site will be covered with a clean, dry pressure bandage. The patient must remain lying down and is observed for bleeding for one hour. The patient's pulse, breathing, **blood pressure**, and temperature are monitored until they return to



Medical workers filter the bone marrow following aspiration. (Custom Medical Stock Photo. Reproduced by permission.)

normal. The biopsy site should be kept covered and dry for several hours.

The patient should be able to leave the clinic and resume most normal activities immediately. Patients who have received a sedative often feel sleepy for the rest of the day; so driving, cooking, and other activities that require clear thinking and quick reactions should be avoided. Walking or prescribed **pain** medications usually ease any discomfort felt at the biopsy site, and ice can be used to reduce swelling.

A doctor should be notified if the patient:

- Feels severe pain more than 24 hours after the procedure.
- Experiences persistent bleeding or notices more than a few drops of blood on the wound dressing.
- Has a temperature above 101°F (38.3°C). Inflammation and pus at the biopsy site and other signs of infection should also be reported to a doctor without delay.

Complications

A small amount of bleeding and moderate discomfort often occur at the biopsy site. Rarely, reactions to anesthetic agents, infection, and hematoma (blood clot) or hemorrhage (excessive bleeding) may also develop. In rare instances, the heart or a major blood vessel is pierced when marrow is extracted from the sternum during bone marrow biopsy. This can lead to severe hemorrhage.

KEY TERMS

Aspiration—A procedure to withdraw fluid and cells from the body.

Connective tissue—Cells such as fibroblasts, and material such as collagen and reticulin, that unites one part of the body with another.

Fibrosis—A condition characterized by the presence of scar tissue, or reticulin and collagen proliferation in tissues to the extent that it replaces normal tissues.

Hematologist—A specialist who treats diseases and disorders of the blood and blood-forming organs.

Hematoma—Blood that collects under the skin, forms a blood clot, and causes swelling.

Hemorrhage—Heavy bleeding.

Lymphocytes—Certain white blood cells that have an immune function. The lymphocytes are composed of three main cell lines; B lymphocytes, T lymphocytes, and natural killer (NK) cells.

Myeloma (multiple myeloma)—A tumor of plasma cells that originates in bone marrow and usually spreads to more than one bone.

Needle biopsy—The procedure of using a large hollow needle to obtain a sample of intact tissue.

Pathologist—A medical doctor that specializes in the study of diseases and laboratory tests.

Plasma cells—Cells in the blood and bone marrow that are formed from B lymphocytes, and that produce antibodies.

White blood cells (leukocytes)—Cells of the blood that are composed of neutrophils, monocytes, lymphocytes, eosinophils, and basophils.

Results

Healthy adult bone marrow contains yellow fat cells, connective tissue, and red marrow that produces blood. Bone marrow is evaluated for cellularity, megakaryocyte production, M:E ratio, differential (classification of blood forming cells), iron content, lymphoid, bone, and connective tissue cells, and bone and blood vessel abnormalities. The bone marrow of a healthy infant is primarily red (75-100% cellularity), but the distribution of blood forming cells is very different than adult marrow. Consequently, age related normal values must be used.

Microscopic examination of bone marrow can reveal leukemia, granulomas, myelofibrosis, myeloma, lymphoma, or metastatic cancers, bone marrow infection, and bone disease. Bone marrow evaluation is usually not needed to diagnose anemia, but may be useful in cases that cannot be classified by other means.

Health care team roles

A physician requests or orders the procedure. The aspirate and biopsy are most often performed by a hematologist or pathologist that has been trained in the procedure. The analysis of the bone marrow is done by a pathologist, and a written report is added to the patients medical record. A histologic technician performs special stains for bone marrow. Clinical laboratory scientists/medical technologists perform smear reviews and analysis of bone marrow cells by flow cytometry. Cytogenetic technologists may perform chromosomal analysis of bone marrow white blood cells.

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National Cancer Institute Cancer Information Service. 31 Center Drive, Bethesda, MD 20892-2580. (800) 422-6237. <<http://www.nci.nih.gov/>>.

National Marrow Donor Program. Suite 500, 3001 Broadway Street NE, Minneapolis, MN 55413-1753. (800) 627-7692. <<http://www.marrows.org/>>.

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Mark A. Best

Bone radionuclide scan

Definition

A bone scan is a diagnostic imaging procedure used to evaluate abnormalities involving bones and joints. A radionuclide is injected intravenously, and its distribution in the **skeletal system** is analyzed to detect certain diseases or conditions.

Purpose

Bone scans are performed to evaluate metastases, trauma, arthritis, metabolic diseases, bone marrow hyperplasia, and Paget's disease. Bone scans are most frequently ordered to investigate the cause of bone **pain** or to check whether a **cancer** originating in another organ has spread to the bones. For example, certain cancers, such as breast and prostate, are most likely to spread, or metastasize, to the bones. If metastases are found, periodic bone scans may be ordered to determine if therapeutic treatment has been effective.

If there is a suspected fracture that is not revealed on x ray, a bone scan is performed to confirm the suspicion of a fracture. When an abnormality is found on an x ray of a bone, a bone scan may be helpful in determining the nature of the abnormality. **Infection** in the bone (osteomyelitis) can be detected or confirmed by a bone scan, often days or weeks before an x ray would reveal it. Bone scans are useful in diagnosing early arthritic changes, and monitoring both the progression of the disease and the effectiveness of treatment. Unexplained pain may be evaluated with a bone scan, because it can demonstrate **fractures** which are difficult to detect on x ray. Bone scans can be used to see if artificial joints have loosened or become infected. Suspected **child abuse** may be evaluated with a bone scan, due to its ability to see an overall pattern of repeated trauma. Abnormalities caused by altered circulation to the bone may be diagnosed with a bone scan.

Precautions

The use of a radioactive substance is required to perform a bone scan, and therefore women who are pregnant should not have this test unless her physician indicates that the benefit will outweigh the risks. If a woman is breastfeeding, she will be advised to stop for a specified period of time, usually for one day, depending on the dose. A patient who is unable to remain still for an extended period of time may require light sedation for a bone scan.

Description

This test is performed in a radiology or a nuclear medicine facility, either in a hospital department or an outpatient x-ray center. The patient usually sits or lies down while a radioactive substance is injected through a vein in the arm. For a bone scan, the radionuclide used is specifically chosen because it accumulates in bone tissue. The patient then waits from three to four hours for the substance to collect within the skeletal system. Excess radionuclide is excreted through the **urinary system** and it is customary that, during the waiting time, the patient will be asked to drink several glasses of water. Patients are free to get up and move around as they desire during the waiting time. Just before the scanning begins, the patient will be asked to empty their bladder so that pelvic bones will not be obscured by residual radioactivity collected in the bladder. During the scan, the patient lies on his or her back on a table, but may be repositioned onto the **stomach** or side during the study. It is important for the patient not to move, except when directed by the technologist.

The radionuclide scanner, sometimes called a gamma camera, or scintillation camera, is positioned against the body part to be examined. Either the camera, the table, or both, may change position during the study. For a total body bone scan, the patient is scanned from head to foot, over a period of 30 to 60 minutes. Images are obtained both anteriorly and posteriorly and occasionally, a lateral image may be obtained. Patients should experience no discomfort from this examination. A special kind of bone scan, called a SPECT (Single Photon Emission Computed Tomography) scan may be added, to study a particular part of the body in more detail. Suspected diseases of the hips, lower back, or jaw are often evaluated using this study. It usually takes an additional 30 to 45 minutes. The camera circles completely around the area in question and helps pinpoint the location of the abnormality being evaluated.

Another variation is called a triple-phase, or three-stage, bone scan, which demonstrates **blood** flow to the bones. The procedure is the same, except the scanning takes place immediately after the radioactive substance is injected for approximately 20 minutes after the injection, and then again two to four hours later.

Preparation

Some specialized blood studies should be drawn before this study is performed. Jewelry or metallic objects need to be removed. No other special physical preparation is required. The patient should understand that there is no danger of any significant radioactive exposure to themselves or others, as only small amounts of the radioisotope

are used. The total dose of radiation absorbed is minimal, often less than the amount received from ordinary x rays. The radionuclide scanner does not emit any radiation at all, but detects and records it from the patient.

Aftercare

Fluids are encouraged after the scan to aid in the excretion of the radionuclide. It is almost completely eliminated from the body within 24 hours.

Complications

There are no complications associated with this test.

Results

The normal appearance of the scan will vary according to the patient's age. In general, a uniform concentration of radionuclide uptake is present in all bones in a normal scan. A high concentration of radionuclide occurs in areas of increased bone **metabolism**. These regions appear brighter and may be referred to as "hot spots." They may indicate healing fractures, tumors, infections, inflammations, or other processes which trigger new bone formation. Lower concentrations of radionuclide may be called "cold spots." Poor blood flow to an area of bone, or bone destruction from tumor may produce a cold spot. The bone scan is a very sensitive test and can detect subtle conditions more readily than other studies. However, it is not a very specific examination, and often cannot distinguish exactly what disease process is causing an abnormality. Results need to be correlated with the patient's medical history, and other radiologic and laboratory studies to make a definite diagnosis.

Health care team roles

Bone scans are performed by a nuclear medicine technologist. In most facilities, the nuclear medicine technologist is a trained individual with certification. The technologist administers the radioactive material, obtains pertinent medical history from the patient, and instructs the patient about the procedure. The data collected is interpreted by a doctor who is a radiologist or nuclear medicine specialist and the results of the bone scan are obtained from the referring physician. Since there is no preparation for this test the services of other medical personnel are generally not required.

Resources

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Bone x rays

Definition

Bone x rays are a diagnostic imaging test in which ionizing radiation passes through the bone. This enables an image of the bone to be produced either digitally or on film.

Purpose

Bone x rays are ordered to detect disease or injury to the bones, such as broken bones (**fractures**), tumors, or other problems. They are often used to rule out a fracture vs soft-tissue injury. They can determine bone density, texture, erosion, and changes in bone relationship and anatomy. Bone x rays also evaluate the joints for diseases such as **osteoarthritis**.

Precautions

Precautions should be taken to protect patients from unnecessary exposure to radiation. Patients should be shielded with lead aprons as much as possible especially when undergoing numerous x rays over short periods of time. Women of childbearing age who could be pregnant should avoid x rays of their pelvic region, lumbar spine, and abdomen unless absolutely necessary. The fetus is especially at risk during the first trimester of **pregnancy**. If other types of x rays are necessary, a lead apron should be used to shield the abdominal and pelvic regions.

Description

X rays are a common diagnostic test in which a form of energy called ionizing radiation penetrates the patient's body. In bone x rays, electrical current passes through an x-ray tube and produces a beam of ionizing radiation that passes through the bone(s) being examined. This produces a picture of the inside of the body on film. The physician reads the developed film on a wall-mounted light box.

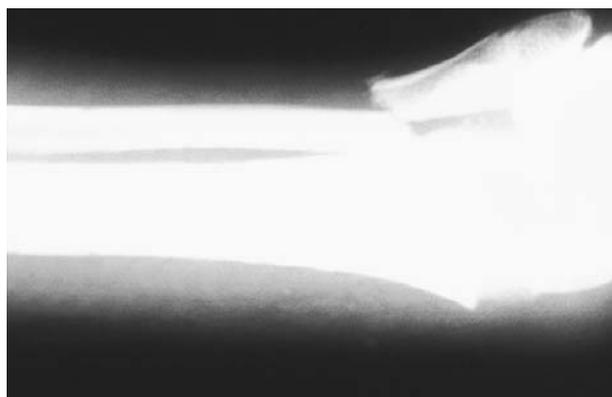
Alternatively, digital x rays are a new type of x ray in which conventional equipment is used to take the x ray but the image is produced via computer. In a digital x ray, the image is created on a reusable plate. After being read by a laser reader, the information is sent in digital form to a storage unit connected to a computer network from which the radiologist reads the image. An electronic report can then be sent to the patient's physician. In addition, these digital images can be reviewed by any radiologist that has access to the digital viewers anywhere in the world.

Bone x rays can detect injury or disease from many causes, including malfunctions in the patient's bone chemistry, bone breaks, and bone fractures. X rays are especially helpful in diagnosing simple and incomplete fractures that cannot be detected during a **physical examination**. X rays can also be used to check the position of the fracture site. Some bone diseases can be definitively diagnosed with bone x rays, while others may require additional tests.

Osteoporosis, a common bone disease, can be detected in bone x rays, but other tests are then ordered to determine the extent of the disease. For osteomalacia and rickets, a **blood** test and x rays of the affected bone are usually definitive; in some cases a bone biopsy (microscopic analysis of a small amount of tissue) is also done. In a rare bone disease called Paget's disease, x rays may be used in conjunction with bone, blood, and urine tests to make a diagnosis. In another rare bone disease, fibrous dysplasia, bone x rays or a bone biopsy (microscopic analysis of a small amount of tissue) are used to confirm the diagnosis. Bone x rays are definitive in diagnosing osteogenesis imperfecta. For osteomyelitis, bone x rays are used in conjunction with a blood test, bone scan, or needle biopsy to make the diagnosis. For arthritis, x rays of the bone commonly taken, and are occasionally combined with blood tests. In bone tumors, bone x rays are helpful but they are not always definitive.

Bone x rays are performed by a radiographer (technologist), and interpreted by a radiologist. They are taken in a physician's office, radiology unit, outpatient clinic, or diagnostic clinic. Bone x rays generally take a few minutes to complete. There is little or no discomfort associated with the test, but some people find it difficult to remain still or in the positions required for the image. The results are often available in minutes.

During the test, the patient lies on a table or sits on a stool (for most upper extremities). The technologist taking the x ray will check the patient's positioning and place the x-ray machine over the part of the body being examined. After asking the patient to remain motionless, he or she



X rays are used to “see” bone problems, such as this ankle fracture. (Custom Medical Stock Photo. Reproduced by permission.)

steps out of the area and sets appropriate technical factors to create the proper exposure, and takes the x ray.

Preparation

The patient is asked to remove clothing, jewelry, and any other metal objects from the area being x rayed. If appropriate, a lead shield will be placed over other body parts to minimize exposure to radiation.

Aftercare

The patient can immediately resume normal activities.

Complications

The human body contains some natural radiation and is also exposed to radiation in the environment. There is a slight risk from exposure to radiation during bone x rays, however, the amount of radiation is small and the risk of harm is very low. If reproductive organs are exposed to radiation, genetic alterations may occur. Excessive or repeated doses of radiation can cause changes in other types of body tissue. In addition, the radiology professional is continually monitored for his/her occupational exposure. This data is reviewed by a physicist monthly. If the exposure level exceeds the safety level, the technologist or radiologist is removed from that area temporarily while the exposure data and radiation safety measures are evaluated.

Results

Normal bones show no fractures, dislocations, or other abnormalities. Results indicating the presence of bone injury or disease differ in appearance according to the nature of the injury/disease. For example, fractures

KEY TERMS

Arthritis—A disease of the joints that arises from wear and tear, age and less often from inflammation.

Osteogenesis imperfecta—Also called brittle bones, this is a condition present at birth in which bones are abnormally fragile, brittle, and break easily.

Osteomalacia—A disease in which bones gradually soften and bend.

Osteomyelitis—An infection of the bone marrow and the bone.

Osteoporosis—A disease which occurs primarily in post-menopausal women in which the amount of bone is reduced or skeletal tissue wastes away.

Paget's disease—A disease, whose cause is unknown, which is generally found in older people. Symptoms include bone pain, bowed legs, curves spine, and broken bones. Another name for this disease is osteitis deformans.

Radiographer—A person who takes x rays. Must be registered with the American Registry of Radiologic Technology (ARRT).

show up as clear breaks in the bones, while osteoporotic bone has the same shape as a normal bone on an x ray but is less dense.

Health care team roles

The radiology professional most likely in contact with the patient having bone x rays is the radiologic technologist. He or she should take a moment to explain the procedure that the patient will have, especially if this patient has had an injury. The patient's fear of **pain** can be profound, and because the technologist must touch and/or move the patient, care should be taken to calm the fears of the patient. In addition, the technologist must protect him- or herself from exposure to the patient's bodily fluids, and unnecessary radiation where possible.

Training

A technologist must complete a 24 month **radiologic technology** program, that consists of didactic (classroom) and clinical education and rotations. The student radiographer will rotate through all areas of radiology. Upon completion, they will take a national registry exam

given by the American Registry of Radiologic Technology (ARRT) that will encompass areas of physics, radiation safety, exposure factors, positioning, anatomy and physiology, and chemistry. The technologist that performs bone x rays is a highly trained professional and must comply with continuing education yearly.

Resources

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Botulism see **Food poisoning**

Bowel surgery with ostomy see **Colostomy**

BPP see **Fetal biophysical profile**

Braces, foot see **Foot orthoses**

Braces, lower limb see **Lower limb orthoses**

Braces, orthodontic see **Orthodontic appliances**

Brain

Definition

The brain is the part of the **central nervous system** (CNS) inside the **skull** (the part outside the skull is the **spinal cord**). It gives rise to cognitive thought processes and controls various body functions including muscular activity, speech, sight, **hearing**, breathing, and digestion.

Description

The brain is the organ that is located inside the skull and is connected to the spinal cord. The brain has four major parts: the brainstem, the cerebellum, the diencephalon, and the cerebral hemispheres.

The brainstem is located at the base of the brain and connects the brain to the spinal cord. The brainstem has three parts: the medulla oblongata, the pons, and the midbrain. Nine of the twelve cranial nerves originate in the brainstem. The brainstem is responsible for controlling basic functions that require no cognitive thought, such as **blood pressure**, digestion, breathing, and **heart** rate. The brainstem is also the information freeway between the cerebral hemispheres and the spinal cord.

The cerebellum is located immediately below the back part of the cerebral hemispheres and is attached to the brainstem through bands made of nerve fibers called peduncles. The cerebellum plays a major role in balance, coordination, and the learning of motor skills. Damage to the cerebellum can result in incoordination, otherwise known as ataxia.

The diencephalon lies above the midbrain and houses the thalamus and the hypothalamus. The thalamus serves as a major relay system between the brainstem and the cerebral hemispheres. The hypothalamus is involved in controlling a variety of functions that don't require conscious thought (autonomic functions) such as appetite, **blood** pressure, thirst, temperature, and sexual arousal.

The largest part of the human brain is the cerebrum. It is divided into left and right cerebral hemispheres by a deep groove called the longitudinal fissure. A band of fibers called the corpus callosum connects the hemispheres with each other. Each cerebral hemisphere has four major parts called lobes. In addition, there is a fifth small lobe called the island (insula) hidden deep inside each hemisphere. The four major lobes are named for the bones of the skull closest to which they lie: the frontal, parietal, temporal, and occipital lobes.

The frontal lobe is located in the front part of the brain and is responsible for higher cognitive functions such as speech, problem-solving, planning, organizing, awareness, motor activity, **memory** storage, and intelligence. The frontal lobe is also involved in emotions and other aspects of personality.

The parietal lobe is located behind the frontal lobe and is the highest part of the brain. The parietal lobe is involved in perceptions such as touch, **pain**, and pressure. It also discriminates fine sensations such as the weight of an object. In addition to sensory processing,

the parietal lobe is also involved in understanding language and in writing.

The temporal lobes form the side parts of the cerebral hemispheres at the level of the ears. The temporal lobes control hearing, speech, **smell**, and memory.

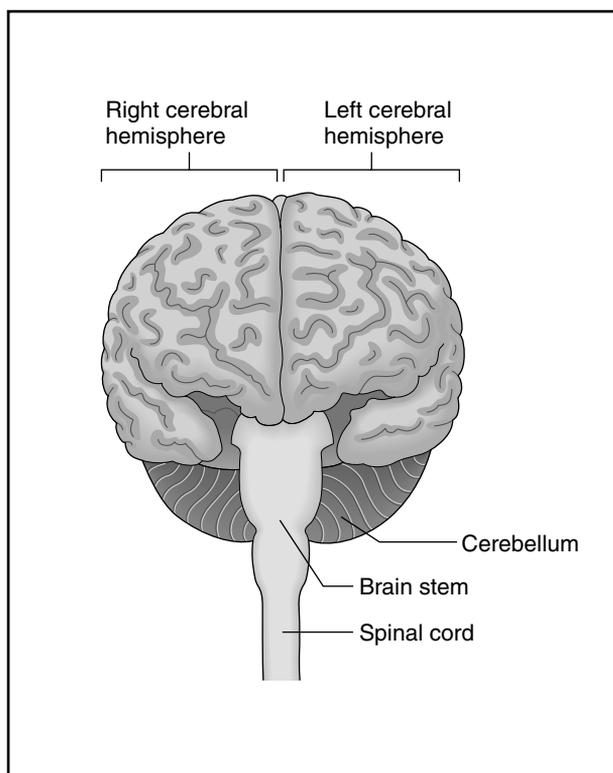
The fourth lobe, located in the back of the head, is the occipital lobe. It is involved in the processing of visual information, such as the recognition of shapes and colors.

The outer surface of the cerebral hemispheres is arranged in convolutions known as gyri (singular "gyrus") which are separated by grooves called sulci (singular "sulcus"). Two sulci are especially important as borders between lobes: the central sulcus lies between the frontal and parietal lobes; the lateral sulcus separates the temporal lobe from the frontal and parietal lobes.

The brain is composed not only of solid matter but also of four ventricles. These ventricles are the two lateral ventricles inside the hemispheres, the third ventricle inside the diencephalon, and the fourth ventricle located among the cerebellum, the medulla oblongata, and the pons. The third ventricle is connected to the fourth ventricle by a narrow channel called the cerebral aqueduct. Cerebrospinal fluid (CSF) flows in the ventricles and in the cerebral aqueduct. The CSF serves to protect the brain by cushioning it from dangerous shocks that would otherwise injure it. It also carries nutrients to the brain cells and transports waste products away from them.

Other protectors of the brain include the blood-brain barrier and the meninges. The blood-brain barrier prevents foreign substances in the blood from entering the brain. The meninges are membranes consisting of connective tissue which cover the brain in three layers. The outermost of these layers, the dura mater, is the thickest and toughest of the three. The middle layer, the arachnoidea, is loosely attached to the third layer by fibers resembling a spider's web. The innermost layer, the pia mater, is made of a delicate connective tissue which has many **blood vessels**.

The names of the meninges have a fascinating story behind them. Medieval European scientists borrowed heavily from Arab anatomists who were in turn building upon ancient Greek science. The Arabs called the meninges "the tough covering, the spider-web covering, and the delicate covering." The Arabic word for "covering" could also mean "mother" or "matrix." The Arabic terms for the outer and inner layers were mistranslated into Latin for "hard" (dura) mother, and "tender, devoted" (pia) mother, but the Arabic made no such personification and was merely contrasting a rough, tough covering with a fine, delicate one. However, the Europeans did



Frontal view of the exterior of the brain. (Delmar Publishers, Inc. Reproduced by permission.)

get the Arabic for “like a spider’s web” (Latin *arachnoidea*) correct.

The microanatomy of the brain is highly specialized and organized. The brain is composed of two major types of cells called **neurons** and glial cells.

There are several types of neurons including motor neurons, sensory neurons, and interneurons. Neurons are the basic operating cells of the brain. They are specially designed to communicate rapidly with other neurons and with organs. They do this by sending electrical signals known as action potentials down the length of their axons.

Axons are fiber processes of neurons (they are unique to neurons) that generally conduct electrical impulses away from the cell body of the neuron. The word “axon” comes from the Greek word for an axis and refers to the fact that the axon is the central part of the nerve fiber. Specialized glial cells called oligodendrocytes generally wrap the axons of the neurons in myelin.

A dendrite is a protoplasmic process of a neuron that conducts electrical impulses toward the cell body of the neuron. Usually it spreads out into many branches (its name comes from the Greek *dendron* meaning “tree” because of its resemblance to the branches of a tree).

The other type of glial cell in the brain is the astrocyte, which aids the neuron in its function.

Cell bodies of neurons, part of their processes, and glia form the gray matter of the brain. The gray matter which forms the outer layer of the cerebrum is called the cerebral cortex. This cerebral cortex contains from about nine to fourteen billion nerve cells and weighs on average 1.3 lb (581 g). Of this 1.3 lb, only 0.044 lb (20 g) is made up of cell bodies (that is, approximately one part in thirty). Another part of the cerebral gray matter forms a few islands called basal ganglia. Basal ganglia are masses of gray matter located deep within each cerebral hemisphere. These groups of neurons help regulate body movement and facial expressions.

Inside, the cerebral hemispheres are made largely of white matter. Axons form this white matter, and it is the high lipid content of their myelin coating that gives the white matter its characteristically white color.

Neurons communicate by releasing chemical compounds called neurotransmitters. The major neurotransmitters in the brain are serotonin, dopamine, acetylcholine, gamma-aminobutyric acid (GABA), and glycine. Neurotransmitters bind to protein receptors on the surface of the neuron and cause changes to occur inside the neuron. It is believed that many psychiatric diseases are due to imbalances in these chemical neurotransmitter systems.

Function

The brain is the ultimate controller of the human body and performs functions with and without conscious thought. The brain enables the mind to conduct conscious thoughts and feelings. The brain allows human beings to respond to the environment. It also regulates functions without conscious thought such as digestion, blood pressure, balance, and sleep.

The brain allows one to interpret and respond to the stimuli given to the five senses: **taste**, touch, hearing, smell, and **vision**. The brain helps us learn to recognize a certain smell or remember how to ride a bike. The brain enables human communication. The brain contains regions devoted to speech production and speech comprehension. Certain regions of the brain are employed in reading, and writing. The brain is also involved in reproductive behavior and regulates the release of sex hormones. The hypothalamus in the brain tells the body when it is time to drink and when it is time to eat. The brain also regulates sleep and **biological rhythms**. The brain is likewise involved in generating emotions and largely determines personality.

It is within the cerebral cortex that impulses are received, analyzed, and answered. The body contains

nerve cells that are specialized for detecting environmental events and other cells that are specialized for producing movement. Information in the form of light, sound waves, odors, tastes as well as contact with objects is gathered from the environment by specialized cells which are called sensory neurons. In response to this information, movements are performed by the contraction of muscles, which are controlled by motor neurons. Communication between sensory neurons and motor neurons is carried on by interneurons.

Specialized sensory cells of the ear called cells of Corti perceive sound waves and send corresponding impulses to the brain, where they reach the projector auditory center which is located in the superior temporal gyrus (field 41 of Brodmann). The cells of this center receive and analyze the separate impulses. Near this field 41 is located field 37, the associative auditory area, cells of which form one integral or complete auditory image of the object from the separate impulses sent by the neurons of field 41. If we destroy field 37, the person can hear sounds but cannot make sense out of them. For example, he or she can hear the speech sounds “p” and “e” and “n” but does not imagine a pen as a result of hearing these sounds. The parietal lobe contains a sensory area which is located in the post-central gyrus (fields 1, 2, 3 of Brodmann), and in the nearby part of the superior parietal lobulus (fields 5, 7 of Brodmann). In this area, impulses of general sensation such as touch, pain, pressure, and temperature are interpreted. The occipital lobe contains the visual region which is located in the area of the calcarine sulcus (field 17 of Brodmann) and an adjacent area (fields 18, 19, of Brodmann). In this visual area, the impulses arising from the retina of the eye are interpreted.

The frontal lobe contains the motor area (field 4 of Brodmann) with about 25,000 giant pyramidal neurons. It is located in the precentral gyrus, the superior frontal gyrus, and the paracentral lobulus. The uppermost part of the precentral gyrus together with the paracentral lobulus controls the movement of the legs. The hindmost part of the superior frontal gyrus controls the movement of the torso. The middle part of the precentral gyrus controls the movement of the arms, and the lowest part of the precentral gyrus controls the movement of the neck and head. The premotor area located in front of the motor area is responsible for coordination and integration of movements. If one suffers destruction of the back part of the middle frontal gyrus, one can still wiggle one’s fingers, but one cannot write, although the movement of the corresponding muscles is normal, because writing requires a high degree of coordination and integration of hand and finger movements.

KEY TERMS

Axon—A fiber process of a neuron that generally conducts electrical impulses away from the cell body of the neuron.

Cell body—The part of a neuron that contains the nucleus and other cell organelles.

Dementia—Decline in mental ability.

Dendrite—A protoplasmic process of a neuron that conducts electrical impulses toward the cell body of the neuron. Usually it spreads out into many branches.

Neuron—The highly specialized cell that is the basic structural and functional unit of the nervous system.

The brain controls the functions of the body that do not require conscious thought (the autonomic functions). Located in the medulla oblongata are the centers controlling digestion, breathing, the functioning of the heart, blood vessels, of the **urinary system**, and of the glands which produce saliva, tears, and sweat.

The sympathetic and parasympathetic nerves extending from these centers cause the arousal and inhibition of these systems. The sympathetic nerves speed up the heart, raise the blood pressure, dilate the pupils of the eyes, contract the sphincters of the hollow organs, and relax the longitudinal muscles. They prepare a person for crisis situations and they remain active during **stress**.

The parasympathetic nerves slow the heart, lower the blood pressure, constrict the pupils of the eyes, relax the sphincters of the hollow organs, and help promote the digestion and absorption of nutrients.

Common diseases and disorders

There are hundreds of diseases and disorders of the brain. There are conditions in which learning is impaired, for example, disorders of speech called aphasia and disorders in writing called dyslexia. There are disorders of thought, such as **schizophrenia** and Tourette syndrome. Mood disorders include depression, mania, and **anxiety**. There are also disorders of sleep such as insomnia and narcolepsy. The brain is subject to strokes and to **cancer**. The brain can also cause seizures in which neurons uncontrollably fire electrical signals. This is the hallmark of epilepsy. The basis of drug abuse and addiction is intertwined with reward pathways in the brain. There are several diseases which are involved

in mental retardation, such as Fragile X syndrome and lissencephaly. There are also several diseases in which neurons degenerate or die. These diseases are collectively known as neurodegenerative diseases, and clinical symptoms depend on where in the brain the neurons are dying.

- **Alzheimer's disease.** Alzheimer's disease usually occurs later in life and is characterized by a decline in cognitive functions such as memory, judgment, and reasoning. The hallmark of Alzheimer's disease is deposits in the brain of a protein called amyloid beta. These deposits are found in abnormal structures called neurofibrillary tangles. Risk factors for Alzheimer's disease include mutation in genes that are responsible for production of the following **proteins**: amyloid precursor protein, presenilin-1, presenilin-2, and apolipoproteins. However, the role of these proteins in the development of the disease is not known.
- **Huntington's disease.** Huntington's disease is a genetic disease in which neurons in the brain that are involved in controlling movement die. This leads to uncontrollable, jerky, and spastic movements. There is also slowness of movement, difficulty in swallowing, and **dementia**. Huntington's disease occurs in the fourth or fifth decade of life and usually results in death 10 to 12 years after the first symptoms appear. The gene involved in the disease is responsible for producing a protein called huntingtin, but the role this protein plays in causing the disease is not clear.
- **Parkinson's disease.** Parkinson's disease is a disorder of bodily movement caused by the death of neurons that release the neurotransmitter dopamine. Symptoms include tremor, slowness of movement, rigidity, and a loss of **reflexes**. It is a progressive disease in which patients become unable to move. There are cases of inherited Parkinson's disease in which a gene linked to alpha-synuclein has been identified. However, the role alpha-synuclein may play in Parkinson's disease is not clear.

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- Society for Neuroscience. 11 Dupont Circle, NW, Suite 500, Washington, DC 20036. (202) 462-6688.
<<http://www.sfn.org>>.

Brain circulation scan see **Transcranial Doppler ultrasonography**

Brain injury see **Head injury**

Brain tumor

Definition

A **brain tumor** is an abnormal growth of tissue, either malignant (cancerous) or benign (noncancerous), in the brain. Each year, more than 17,000 brain tumors are diagnosed in the United States.

Description

Benign brain tumors

A benign brain tumor is composed of slow-growing noncancerous cells that never spread (by local extension or any other means) beyond the site where they originate. Common benign tumors are meningiomas, acoustic neuromas, **pituitary gland** tumors, craniopharyngiomas, germinomas, pinealomas, and hemangioblastomas. Even though a tumor is benign it may still be dangerous because, depending on its location, it may be inoperable and/or affect one or more brain functions.

Benign brain tumors have clearly defined borders, can often be removed completely, especially if they are on the brain's surface, and are unlikely to recur. Benign brain tumors do not infiltrate nearby tissues but as they continue to grow can cause severe **pain**, permanent brain damage, and death. Benign brain tumors sometimes become malignant.

Malignant brain tumors

A brain tumor is considered malignant if it contains **cancer** cells. Unlike other tumors, these spread by local extension and rarely metastasize beyond the brain. About half of all brain tumors are malignant.

Malignant brain tumors do not have distinct borders. They tend to grow rapidly, increase intracranial pressure, and metastasize to other parts of the brain or **spinal cord**. It is highly unusual for malignant brain tumors to spread beyond the **central nervous system** (CNS).

Primary brain tumors

Primary brain tumors originate in the brain. They represent about 1% of all cancers and 2.5% of all cancer deaths.

Metastatic or secondary brain tumors

Most brain tumors do not originate in the brain; they are metastases from other primary cancer sites. Approximately 25% of all cancer patients develop secondary or metastatic brain tumors when cancer cells spread from another part of the body. Secondary brain tumors are most apt to occur in patients who have melanoma, breast, colon, kidney, or **lung cancer**. Brain metastases can develop on any part of the brain or spinal cord.

Patient demographics

Primary brain tumors may develop at any age, but are most common in children between the ages of three and 12, and in adults aged 40–70. Primary brain cancer is the second-most common cause of cancer death between birth and the age of 34, and the third-most common cause of cancer death in men aged 35–54. Primary tumors of the brain and central nervous system are associated with **AIDS** in some patients.

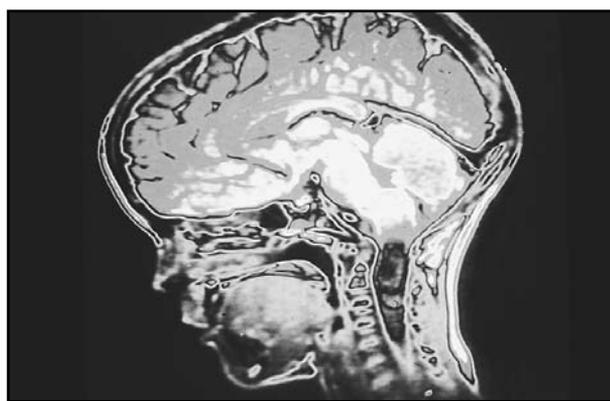
Naming and grading brain tumors

A brain tumor's name describes its origin, how it grows, and the cell type it contains. A tumor in an adult is also graded or staged according to the extent or degree to which it is malignant; how rapidly it is growing, and how likely it is to invade other tissues; and how closely its cells resemble normal cells. (The less normal a tumor cell appears, the faster it is likely to grow.)

Low-grade tumors usually have well-defined borders. Some low-grade brain tumors form or are encapsulated (enclosed) in cysts. Low-grade brain tumors grow slowly, if at all. They may spread throughout the brain, but rarely metastasize to other parts of the body.

Mid- and high-grade tumors grow more rapidly than low-grade tumors; these tumors usually infiltrate healthy tissue. Their growth pattern makes it difficult to remove the entire tumor, and they recur more often than low-grade tumors.

A single brain tumor can contain several different types of cells. The tumor's grade is determined by the highest-grade (most malignant) cell detected under a **microscope**, even if most of the cells in the tumor are less malignant. An infiltrating tumor is a tumor of any grade that grows into surrounding tissue.



A magnetic resonance imaging (MRI) scan of brain tumor located at the base of patient's brain. (Photograph by Howard Sochurek, *The Stock Market*. Reproduced by permission.)

Types of brain tumors

Glioblastomas, also known as gliomas, are the most prevalent primary brain tumors. They arise from glial tissue, which supports and nourishes cells that send messages from the brain to other parts of the body. Gliomas can be either malignant or benign. Astrocytomas, ependymomas, and mixed glioblastomas are three of the most common types.

ASTROCYTOMAS. Named for their star-shaped cells and the tumor's radiating tentacles, astrocytomas can develop on any part of the brain or spinal cord. Noninfiltrating astrocytomas grow slowly, and rarely spread to nearby tissue. Mild-to-moderately anaplastic (malignant) astrocytomas with well-differentiated borders grow more quickly, and tend to infiltrate surrounding tissues. These are grade I and II astrocytomas.

Anaplastic, or grade III astrocytomas, look more abnormal and grow more rapidly than noninfiltrating or mild-to-moderately anaplastic tumors. Grade IV astrocytomas are also called glioblastoma multiforme (GBM) tumors. Accounting for 30% of all primary brain tumors, GBMs are the most common brain tumors in middle-aged adults. GBMs are also the most malignant of all brain tumors. Because they contain a greater mixture of cells than any other brain tumor, they are the most difficult to treat.

EPENDYMOMAS. Also called ependymal tumors, ependymomas account for 9% of all gliomas, 5% of all intracranial tumors, and are the most common brain tumors in children and adolescents. They begin in the ependymal cells that line the central canal of the spinal cord and the ventricles of the brain, where cerebrospinal fluid (CSF) is manufactured.

Ependymomas are often benign, have well-differentiated borders, resemble normal cells, and grow very slowly. The cells of anaplastic ependymomas look abnormal and grow more rapidly than the cells of benign tumors.

MIXED GLIOMAS. These heterogeneous tumors contain elements of astrocytomas, ependymomas, and/or oligodendrogliomas. These rare tumors usually occur in middle-aged adults, grow slowly, and do not usually spread beyond the part of the brain where they originate. Mixed gliomas follow the patterns of growth related to the highest-grade cells they contain.

Nonglial brain tumors

MEDULLOBLASTOMAS. Scientists once thought medulloblastomas (MDLs) developed from glial cells. These fast-growing malignant tumors are now believed to originate in embryonal cells not normally present in the body after birth. They are sometimes called primitive neuroectodermal tumors (PNET).

MDL tumors are most common in children and are found more often in males than females; only 30% occur in adults. MDL tumors usually originate in the cerebellum and often metastasize to other parts of the brain via cerebrospinal fluid. They rarely metastasize beyond the brain and spinal cord.

MENINGIOMAS. Meningiomas, which represent more than 20% of all primary brain tumors, originate in the meninges (the membranes that cover the brain and spinal cord). These tumors are usually benign and most often occur in women aged 30–50 years old. Meningiomas grow so slowly that the brain can sometimes become accustomed to their presence. Meningiomas compress brain tissue rather than invade it, and may grow to be quite large before any symptoms appear.

ACOUSTIC NEUROMA. These benign tumors, also known as vestibular schwannomas, are named for the cells in which they originate. In this case, the tumor is named for the Schwann cells, which produce myelin, the material that sheaths all nerves. Acoustic neuromas are usually found on the auditory nerve, which controls **hearing**. They are twice as common in women as in men, and are most often diagnosed in patients between the ages 30–60.

Acoustic neuromas grow very slowly, and many patients adapt to the **hearing loss** balance problems, and tinnitus that are the tumors' earliest symptoms. As the tumor progresses, it can press on the nerves that control movement and sensation in the face, and cause headaches and facial numbness or tingling. The patient

may have trouble walking, swallowing, or controlling eye movements, and the sense of **taste** can be affected. An acoustic neuroma that grows large enough to press on the brainstem can be deadly.

CHILDHOOD BRAIN TUMORS. Brain tumors that occur in children are treated differently than those found in adults because they usually appear in different parts of the brain, cause different symptoms, and require different treatment because of the patient's age and stage of development. They also often have a better prognosis than adult tumors.

Brain tumors are rare in children—only about 2,200 are diagnosed in the United States each year. Children under seven are most likely to be afflicted, with boys affected more often than girls. Headaches, nausea, vomiting, difficulty walking, **vision** problems, and changes in schoolwork are the chief symptoms.

Unlike adult tumors, childhood brain tumors are identified primarily by their location, either supratentorial (above the tentorium, the membrane that separates the brain from the cerebellum) or infratentorial (below the tentorium). Astrocytomas and ependymomas are common supratentorial tumors. Infratentorial tumors include medulloblastomas, astrocytomas, and ependymomas.

Causes and symptoms

The causes of primary brain tumors are unknown, but people who work with vinyl chlorides, polycyclic hydrocarbons, nitrosoureas, and certain pesticides have a greater-than-average risk of developing them. There is no evidence that **head injury** causes brain tumors, but researchers are trying to determine the relationship, if any, between brain tumors and **viruses**, genetic susceptibilities, and long-term exposure to electromagnetic fields.

Although brain tumor symptoms resemble those of many other illnesses, the presence of a brain tumor may be suspected in patients who have persistent headaches with vomiting or convulsions; progressive deterioration of sight, speech, hearing, touch; or deterioration in the ability to use an arm, hand, foot, or leg. Symptoms often do not appear until the tumor grows large enough to displace, damage, or destroy delicate brain tissue.

Diagnosis

When a patient experiences one or more of the above symptoms, a primary care physician will perform a focused **physical examination**, take a detailed medical history, and conduct a basic neurologic examination to evaluate:

- balance and coordination

- abstract thinking and **memory**
- eye movements
- hearing, touch, and sense of **smell**
- reflexes
- control of facial muscles and movements of the head and tongue
- awareness

If the results of these examinations suggest a patient may have a brain tumor, the patient is referred to a neurologist or neurosurgeon, who will recommend any or all of several diagnostic tests:

- a computed tomography scan (CT scan) to reveal brain abnormalities
- magnetic resonance imaging (MRI) to detect tumors beneath the bones of the **skull**
- electroencephalography (EEG) to measure the electrical activity in the brain when seizures are suspected
- angiography can outline a tumor and the **blood vessels** that lead to it
- a lumbar puncture (spinal tap) to see if spinal column pressure has increased and if the spinal fluid contains tumor cells

Interpreting these images and results enables the physicians to determine whether a tumor is present, but biopsy (microscopic examination of tumor tissue) is the only way to identify its cell type.

Treatment

Patients with brain tumors are treated by multidisciplinary teams of highly skilled specialists whose decisions are based on test results; tumor size, position, and growth pattern; the patient's history and current medical status; and the patient's wishes.

Surgery

Surgery is the treatment of choice for accessible brain tumors that can be removed without causing serious neurological damage. A craniotomy, the procedure performed most often, allow surgeons to remove as much of the tumor as possible and send a specimen to the laboratory for microscopic analysis. The operation also creates an entry channel for **chemotherapy** drugs and forms of radiation that are implanted in the brain.

Prior to surgery, patients are often given **corticosteroids** and other medications to reduce swelling of brain tissue and anticonvulsants to prevent or control seizures. Preoperative radiation treatments may also be administered to reduce tumor size.

Patients whose benign brain tumors can be completely removed may not require any additional postoperative treatment, however, periodic physical and neurologic examinations and CT or MRI scans are usually recommended to determine whether the tumor has returned. Surgeons cannot be absolutely sure that every bit of an infiltrating or metastasizing tumor has been removed and microscopic growth may still exist, so radiation and chemotherapy are used to eradicate malignant cells that may have escaped the scalpel.

If a tumor cannot be completely removed, debulking (removing a major portion of it) can alleviate symptoms, enhance the sense of well-being, and increase the effectiveness of other treatments.

Radiation therapy

External **radiotherapy** is generally delivered on an outpatient basis, and directs radiation to the tumor and the area around it. Implant radiation therapy involves placing radioactive material into channels made in the brain. Left in place permanently, or for a short time, these radioactive pellets, sometimes called seeds, release measured doses of radiation each day. Patients are usually hospitalized for observation during the several days the pellets are most active. Immediate family are encouraged to keep a distance or use protective gear, in some instances, during this period.

Stereotactic radiosurgery involves fitting the patient with a frame to stabilize the head, using imaging techniques to determine the exact location of tumor cells, and using a sophisticated instrument called a gamma knife to administer radiation precisely to that point.

Chemotherapy

One or more **anticancer drugs** may be taken by mouth or injected into a **blood** vessel, muscle, or the cerebrospinal fluid to kill malignant cells. Chemotherapy may be used in combination with radiation and surgery as part of initial treatment, or used alone to treat tumors that recur in the same place or in another part of the body. When a young child has a brain tumor, chemotherapy is often used to eliminate or delay the need for radiation.

Other treatments

If a brain tumor cannot be eradicated, treatment is designed to make the patient as comfortable as possible and preserve as much neurologic function as possible. The patient's physician may prescribe **analgesics** to relieve pain, anticancer drugs to limit tumor growth, anticonvulsants to control seizures, and steroids to reduce swelling of brain tissue.

KEY TERMS

Central nervous system (CNS)—The division of the nervous system that consists of the brain and spinal cord.

Cerebrospinal fluid (CSF)—Clear lymph-like liquid that fills brain cavities and protects the brain and spinal cord.

Craniotomy—Surgical procedure in which part of the skull is removed (then replaced) to allow access to the brain.

Gamma knife—High-dose radiation treatment for intracranial tumors.

Intracranial—Located within or on the surface of the brain; within the cranium (skull).

Malignant—A cancerous or life-threatening tumor.

Melanoma—A particularly deadly type of skin cancer that develops in the melanocytes, or skin-pigmenting cells.

Metastasis—Spread of disease, particularly cancer, from one part of the body to another.

Potential therapies

Researchers are exploring ways to empower chemotherapy drugs to penetrate the blood-brain barrier (which protects the CNS by separating the brain from blood circulating throughout the body), and attack cancer cells that have infiltrated tissue inside it. The goal is to target these drugs to certain types of cells or cell-growth mediators, keeping healthy brain tissue unaffected.

Researchers also are investigating:

- less-invasive surgical procedures
- methods of incorporating chemotherapy drugs into tumor cells to reduce the need for radiation
- laboratory techniques that enable physicians to select the chemotherapy drugs most likely to kill particular types of tumors
- gene therapy in which genetically engineered material is transported to tumor cells by viruses that infect tumor cells and convert them to normal cells, stop their growth, or kill them

Alternative therapies have not been demonstrated to cure brain tumors and should never be substituted for conventional therapy. However, complementary therapies (used with, not instead of, standard treatments) may

help some patients cope with the **stress** of illness and side effects of their treatment. Among these are biofeedback training, massage, **meditation**, and botanical and homeopathic treatments.

Biofeedback can teach patients to influence and control **heart** rate, muscle tension, and other stress-related body functions. Some patients claim that guided imagery (visualization) helps them feel healthier and more in control of their disease.

Massage, meditation, guided imagery, and reflexology help some patients relax; while **yoga** is said to soothe the body, spirit, and mind while reducing the other effects of stress. **Hydrotherapy** uses ice, liquid, and steam to improve circulation and relieve pain. Body work and **therapeutic touch** may help relieve pain and other symptoms.

Some patients and practitioners incorporate botanical therapies, homeopathic treatment, traditional Chinese medicine treatments, changes in diet, and use of dietary supplements as complementary therapies.

Health care team roles

Brain tumor diagnosis and treatment involves a multidisciplinary team of health care professionals. In addition to primary care physicians, such as a family practitioner or an internist, the treatment team may include a neurologist, neurosurgeon, pathologist, radiologist, as well as clinical specialists and **advanced practice nurses**, physical and occupational therapists, radiologic and laboratory technicians, and dietitians and nutritionists. Social workers and case managers help with arrangements for home-care treatment or interim facility care.

Patient education

Before, during and after treatment, nurses and allied health professionals should inform and educate patients and families about the risks and complications of any planned diagnostic test, intervention or treatment. It is important to realize that in order for **informed consent** to be valid, the surgeon or other physician must be the one to offer initial information on the pros and cons of therapies. Patients and families should be taught about some of the common side effects of treatment including weight loss, malnutrition, increased risk of **infection**, pain, fatigue, and depression.

Occupational therapists can teach patients and families new ways to approach daily tasks. Physical therapists, **physical therapy** assistants, and speech therapists can help patients who have difficulty keeping their balance, expressing their thoughts, speaking, or swallowing. Children may need special tutors and counseling before

and after returning to school. For patients who have incurable brain tumors, hospice care can provide a supportive environment and specially trained health professionals to help patients manage pain and remain comfortable, whether at home or in a treatment facility.

Prognosis

The patient's prognosis depends on the location of the tumor and its cell type. A patient whose tumor is discovered early and removed completely may make a full recovery, but the surgery itself may harm or destroy normal brain tissue. This can result in additional problems, such as seizures, weakness, personality changes, or thought, speech, and coordination difficulties. Although these postoperative problems may initially be more severe than the symptoms produced by the tumor, they usually diminish or disappear over time.

Consequences of radiation therapy

Cells killed by radiation can cluster in the brain, resembling tumors. These dead-cell clusters can cause headaches, seizures, and memory loss. Children treated with radiation may lose some of their eyesight and develop learning problems. Radiation damage to the pituitary gland can hinder normal growth and development.

Consequences of chemotherapy

Some anticancer drugs may cause kidney damage and other temporary or permanent dysfunction, such as tingling in the fingers and ringing in the ears.

Inoperable tumors

Brain tumors that cannot be removed may cause irreversible brain damage and death.

Prevention

Since the causes of primary brain tumors have not been determined conclusively, there is no known way to prevent them. The best way to prevent secondary or metastatic brain tumors is to reduce risk factors such as:

- poor **nutrition** and a low-fiber diet; since these contribute to development of intestinal cancers
- smoking, which can cause lung cancer
- excessive alcohol consumption, which is associated with **liver cancer**
- excessive exposure to the sun, which can cause melanoma

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ORGANIZATIONS

- American Brain Tumor Association. 2770 River Road, Des Plaines, IL 60018. (847) 827-9918.
<<http://www.abta.org>>.
- Brain Tumor Foundation for Children, Inc. 2231 Perimeter Park Drive, Suite 9, Atlanta, GA 30341. (404) 454-5554.
- Brain Tumor Information Services. Box 405, Room J341, University of Chicago Hospitals, 5841 S. Maryland Avenue, Chicago, IL 60637. (312) 684-1400.
- MedHelp International. 6300 N. Wickham, Suite 130, Box 188, Melbourne, FL 32940. (407) 253-9048.
<<http://www.medhlp.netusa.net>>.
- National Brain Tumor Foundation. 785 Market Street, #1600, San Francisco, CA 94103.
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Barbara Wexler

Breast biopsy

Definition

A breast biopsy is the removal of breast tissue for examination under a **microscope** by a pathologist. This can be accomplished surgically (excisional biopsy), or by withdrawing tissue through a needle (aspiration biopsy).

Purpose

A biopsy is recommended when a significant abnormality is found which cannot be identified conclusively by imaging studies. The abnormality in question might be a finding on breast self-examination, on routine physical or gynecological examination, or on a mammogram. Signs of concern in addition to palpable lumps include:

- severe breast **pain**
- changes in the size of a breast or the nipple
- changes in the shape of the breast or nipple
- pitting, dimpling or redness of the breast skin.
- nipple redness, irritation or inversion of the nipple which is new
- changes in the pattern of veins visible on the surface of the breast
- some types of nipple discharge

If imaging studies are not decisive, the differentiation of **cancer** from a benign breast condition must be determined using a biopsy. However, in pre-menopausal women, it may be appropriate to follow a lump by physical exam for one to two menstrual cycles before considering biopsy.

Precautions

Physical exam is not sufficient for evaluating significant breast abnormalities. About 30% of abnormalities thought to be benign by physical exam turn out to be cancerous, and 60% of those thought to be malignant prove to be benign.

The type of biopsy recommended should be considered carefully. The best approach will depend upon whether the area can be felt, how well it can be seen on mammogram or ultrasound, and how suspicious it feels or appears. Specialized equipment is needed for different types of biopsy, and availability may vary. Generally, needle biopsy is less invasive and much less expensive than surgical biopsy. It is appropriate for most, but not all situations. However, some surgeons feel that it is less accurate.

Description

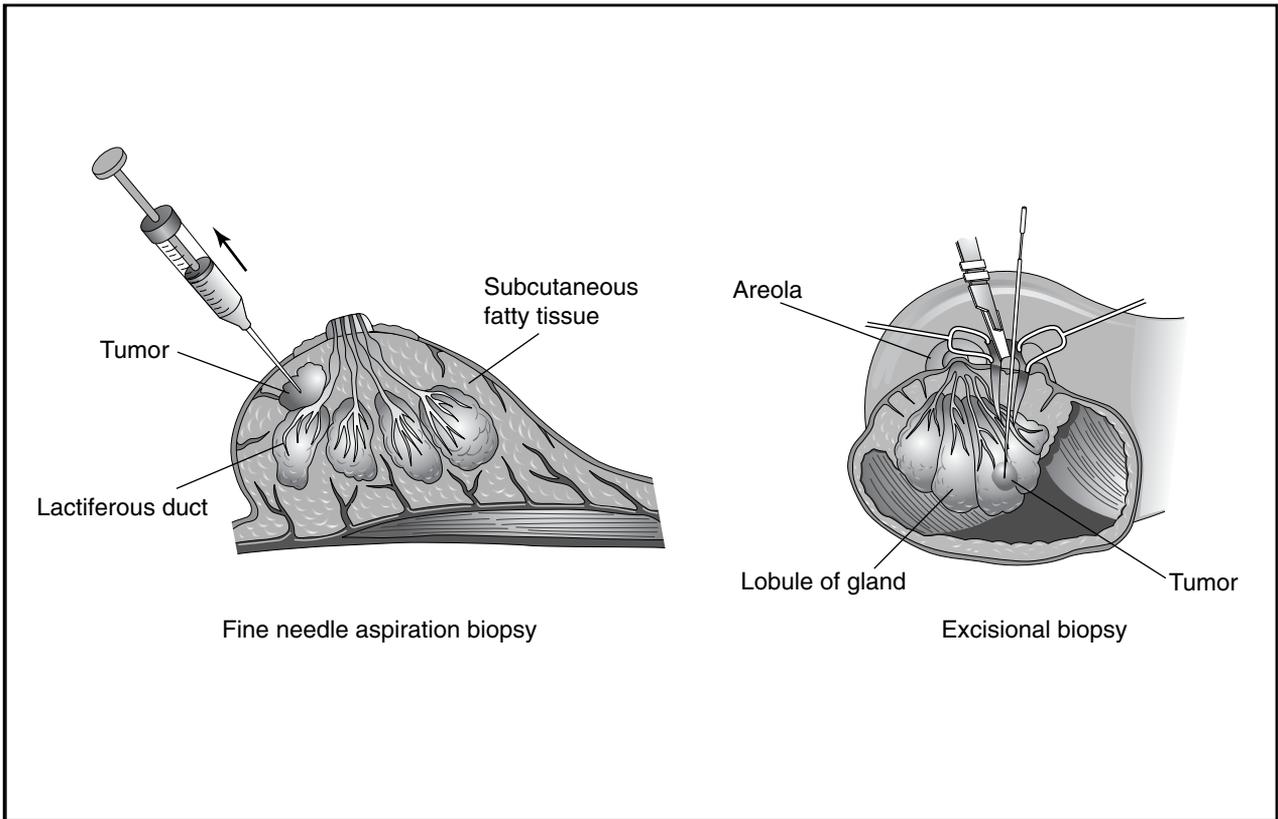
The least invasive of biopsy procedures is the needle biopsy. A needle biopsy removes part of the suspicious area for examination. There are two types, aspiration biopsy using a fine needle, and large core needle biopsy. Either of these may be called a percutaneous needle biopsy. Percutaneous refers to a procedure done through the skin.

A fine needle aspiration (FNA) biopsy uses a very thin needle to withdraw fluid and cells that can be studied. It can be performed in a doctor's office, clinic, or hospital. Local anesthetic may be used, but is sometimes withheld, as the injection may be more painful than the biopsy needle. The area to place the needle may be located by touch. No specialized equipment is needed. This procedure is simple and inexpensive, but FNA biopsies also have the highest rate of false negative results (i.e., no cancer is found in the sample, but cancer is present at the biopsy site). FNA is very useful for biopsy of lumps suspicious for being benign cysts by physical exam and/or ultrasound. If the contents of the cyst can be completely aspirated, prove to be non-bloody fluid, and the cyst does not recur, no further biopsy is needed.

A large core needle biopsy uses a larger diameter cutting-type needle to remove small pieces of tissue, about the size of a grain of rice. It can be performed in a clinic or hospital that has the appropriate facilities. Local anesthetic is routinely used.

Ultrasound is used to guide needle placement for some lesions. The patient lies on her back or side. After the area is numbed, a sterile gel is applied. The physician places a transducer, an instrument about the size of an electric shaver, over the skin. This produces an image from the reflection of sound waves. A special needle, usually in a spring loaded device, is used to obtain the tissue. The procedure is observed on a monitor as it is happening.

If the suspicious area is seen best with x ray, a stereotactic device is used. This means that x rays are taken from several angles. This information is input into a computer, which analyzes the data and produces an image that is used to guide the needle to the correct site. The patient may be sitting up, or she may be lying on her **stomach**, with her breast positioned through an opening in the table. The breast is held firmly but comfortably between a plastic paddle and a metal plate, similar to those used for mammograms. Several samples will be taken because a growth might have both benign and malignant areas in it. X rays may be taken before, during, and after the tissue is drawn into the needle, to confirm that the correct spot is biopsied. This procedure may also



A fine needle aspiration biopsy uses a very thin needle to withdraw fluid and cells from the breast to be examined. An excisional biopsy is a surgical procedure in which the entire area of concern and some surrounding tissue is removed for analysis. (Illustration by Electronic Illustrators Group.)

be referred to as a stereotactic core biopsy, or a mammotomy. Stereotactic needle biopsies are just as successful as the mammographically guided open biopsy discussed below.

There are two types of surgical breast biopsy considered here, excisional and incisional. An excisional biopsy is a surgical procedure, where the entire area of concern and some surrounding tissue is removed. It is usually done as an outpatient procedure in a hospital or free-standing surgery center. The patient may be awake, and is sometimes given a sedative. The area to be operated on is numbed with local anesthetic. Infrequently, **general anesthesia** is used. An excisional biopsy itself usually takes under one hour. The total amount of time spent at the facility depends on the type of anesthesia used, whether a needle localization was done (see below), and the extent of the surgery.

If a mass is very large, an incisional biopsy may be performed. In this case only a portion of the area is removed and sent for analysis. The procedure is the same as an excisional biopsy in other respects.

If the abnormality is not palpable, a needle localization must be done before the actual surgery. After local anesthetic is administered, a fine wire is placed in the area of concern. Either mammogram or ultrasound guidance is used to place the tip of the wire in the lesion. The patient is awake and usually sitting up. The surgeon then proceeds with an open biopsy, and removes the wire from the target tissue. A mammogram of the specimen is then taken to assure the abnormality intended has been sufficiently biopsied.

Preparation

No food restrictions are necessary for needle biopsy; however, it may be advisable to eat lightly before the procedure. This is especially important if the patient will be lying on her stomach for a stereotactic biopsy. A surgical breast biopsy may require the patient to have nothing to eat or drink for a period of time before the operation. This will typically be from midnight the night before, if general anesthesia is planned.

KEY TERMS

Biopsy—Removal of a sample of tissue, organ, or gland for microscopic examination.

Aftercare

The skin opening for a needle biopsy is minimal. It may be closed with thin, clear tape, called a Steri-strip, or covered with a small gauze bandage. The patient can return to her usual routine immediately after the biopsy. Strenuous activity or heavy lifting is not recommended for 24 hours. Any bandages can be removed one or two days after the biopsy.

After a surgical biopsy, the incision will be closed with stitches, and covered with a bandage. The bandage can usually be removed in one or two days. Stitches are taken out approximately one week afterward. Depending on the extent of the operation, normal activities can be resumed in approximately one to three days. Vigorous **exercise** may be limited for one to three weeks.

Complications

Bleeding or bruising after the procedure can result in soreness that should disappear within two days. **Infection** is always a possibility when the skin is broken, although this rarely occurs. Redness, swelling, significant drainage or severe pain at the biopsy site indicates a possible infection. Another possible consequence of a breast biopsy is a hematoma. This is a pocket of **blood** at the biopsy site. It is usually absorbed naturally by the body. If it is very large and uncomfortable, it may need to be drained. A surgical breast biopsy may produce a visible scar on the breast. Sometimes this may make future mammograms harder to interpret accurately.

Results

A normal pathology report indicates no malignancy is present. The tissue sample may be further classified as a benign solid tumor of the breast (fibroadenoma) or fibrous connective tissue with tiny cysts (fibrocystic change). Studies have demonstrated that approximately 80% of all breast biopsies result in a benign pathology report. An abnormal pathology report indicates a cancer is present. If a fine needle aspiration biopsy was performed, the pathologist has viewed individual cells under a microscope to see if they appear cancerous. Large core needle biopsy and surgical biopsy will be able to give

more information. This includes the type of cancer, whether it has invaded surrounding tissue, and how likely it is to spread quickly. There are some conditions which are not malignant but indicate high risk for future development of **breast cancer**. If these are identified, more frequent monitoring of the area may be recommended.

Health care team roles

Needle and surgical biopsies are performed by a physician. Radiologic technicians may be involved in many of the procedures described above, such as obtaining mammograms and needle localizations. Nursing staff may assist in surgical biopsies, and monitor patients in the recovery area after procedures. Physician assistants and nurse practitioners may explain the procedure and possible outcomes to the patient. Histology technicians prepare the biopsied tissue by fixation, thin-sectioning, and staining. A pathologist performs the microscopic evaluation of the cells.

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ORGANIZATIONS

American Cancer Society. 1599 Clifton Rd. NE, Atlanta, GA 30329-4251. 800-ACS-2345 (800-227-2345). <<http://www.cancer.org>>.

National Cancer Institute. National Institutes of Health. 5000 Rockville Pike, Bethesda, MD 20892. NCI/Cancer Information Service (CIS) 800-4-CANCER (800-422-6237). <<http://cancernet.nci.nih.gov>>.

Erika J. Norris

Breast cancer

Definition

Breast **cancer** is the abnormal growth and uncontrolled division of cells in the breast. Cancer cells can invade and destroy surrounding tissue, and may metastasize.

size (spread) throughout the body via **blood** or lymph fluid to other parts of the body.

Description

Breast cancer is a leading cause of morbidity (illness) and mortality (death) for women. It is the second most common cause of cancer death among American women; every year, about 180,000 women are diagnosed with the disease.

Every woman is at risk for breast cancer. If a woman lives to age 85, there is one chance in nine that she will develop the condition sometime during the rest of her life. Age is an established risk factor; the risk of developing the disease increases with advancing age. The breast cancer risk of a 25-year-old woman is only one out of 19,608; by age 45, it is one in 93. More than 75% of all breast cancers are detected in women over age 50.

Causes and symptoms

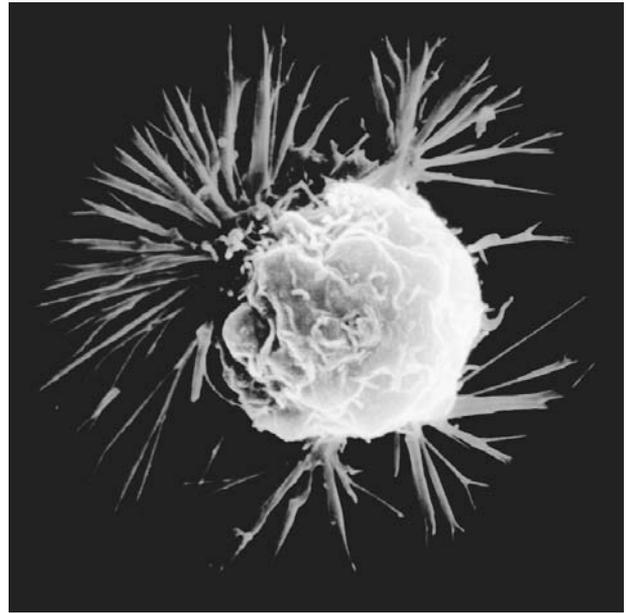
There are a number of risk factors for the development of breast cancer, including:

- family history of breast cancer in first-degree relatives (mother, sister, or daughter)
- early onset of menstruation and late menopause
- reproductive history (women who never had children or have children late in life and women who have never breastfed have increased risk)
- history of abnormal breast biopsies

More than 75% of all breast cancers are diagnosed in women without a family history or other major risk factor for the disease. Inherited gene alterations also place women at risk for developing breast cancer at younger ages. About 20% of cases occur in families with a history of breast cancer. A breast cancer gene was discovered in 1994, however, only about 5% of breast cancers are believed to be related to the gene.

Some studies suggest that high fat diets, **obesity**, radiation exposure, or alcohol consumption contribute to the risk profile. Researchers have found that for certain women, hormone replacement therapy may contribute to the development of breast cancer. While one or more risk factors may boost a woman's chances of developing breast cancer, the interplay of factors is complex.

Not all lumps detected in the breast are malignant (cancerous). Many are benign and may be related to other breast diseases such as fibrocystic breast disease and require no treatment or simply the removal of the lump. All women should be taught to perform regular, monthly breast self-examinations (BSE) to detect any



A breast cancer cell. (Phototake NYC. Reproduced by permission.)

changes in breast tissue. Health professionals should also encourage women to schedule a screening **mammography**, which is a breast x ray that will detect cysts or tumors too small to be found during self-examination.

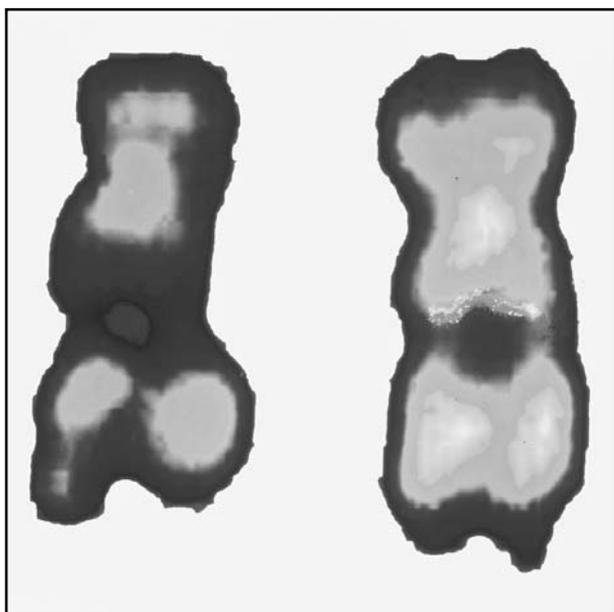
Changes in the breast that may be a sign of breast cancer include:

- lump or thickening in breast or armpit
- changes in a nipple (thickening, pulling in, bleeding, or discharge)
- dimpled or reddened skin over the breast
- change in breast size or shape
- abnormality on a mammogram

Diagnosis

More than 90% of all breast cancers are detected by mammography. The American Cancer Society guidelines recommend screening mammograms every one to two years for women between 40 and 49, and every year after age 50. Women with a family history of breast cancer will be advised to have a mammogram every year at an earlier age.

Typically, mammography screening includes two views of each breast, one from above, and one from the side. Generally, the radiology technician examines the images immediately to make sure no further x rays are needed, or to decide whether an ultrasound may be required.



Magnification of chromosome 17 pair, which carries the breast and ovarian cancer gene. (Custom Medical Stock Photo. Reproduced by permission.)

If an irregularity is detected, such as a mass, changes from earlier mammograms, abnormalities of the skin, or enlargement of the lymph nodes, further testing may be recommended. Diagnostic testing may include ultrasound of the breast, a biopsy, or needle sampling, or consultation with a breast surgeon.

Biopsy of the breast is a removal of breast tissue for examination by a pathologist. An excisional biopsy is a surgical procedure in which the entire lump area and a margin of surrounding tissue are removed for examination. If the mass is very large, an incisional biopsy is performed to remove a portion of the suspicious area. Needle biopsy may be performed using two different methods. An aspiration needle biopsy uses a very fine needle to withdraw cells and fluid from the mass for analysis. A large core needle biopsy uses a larger diameter needle to remove small pieces of tissue from the mass that can be analyzed. These analyses determine whether the mass is benign or cancerous and whether further treatment is required.

To determine if the cancer has metastasized, physicians remove some axillary (underarm) lymph nodes to examine them for the presence of cancer cells. Lymph node dissection, the procedure that determines whether cancer cells are in the lymph nodes, is part of the process of staging (classifying the extent) the cancer. Breast cancer is rated from Stage 0 to Stage IV. The staging process uses an array diagnostic information to describe the extent of disease and includes:

- Stage 1: The cancer is no larger than 0.8 in (2 cm) and no cancer cells are found in the lymph nodes.
- Stage 2: The cancer is no larger than 0.8 in (2 cm) and has spread to the lymph nodes, or is larger than 0.8 in (2 cm), but has not spread to the lymph nodes.
- Stage 3A: The tumor is larger than 2 in (5 cm) and has spread to the lymph nodes, or is smaller than 2 in (5 cm), but has spread to the lymph nodes, which have blended together.
- Stage 3B: Cancer has spread to tissues near the breast or to internal mammary lymph nodes.
- Stage 4: Cancer has spread to skin and lymph nodes near the collarbone or to other organs of the body.

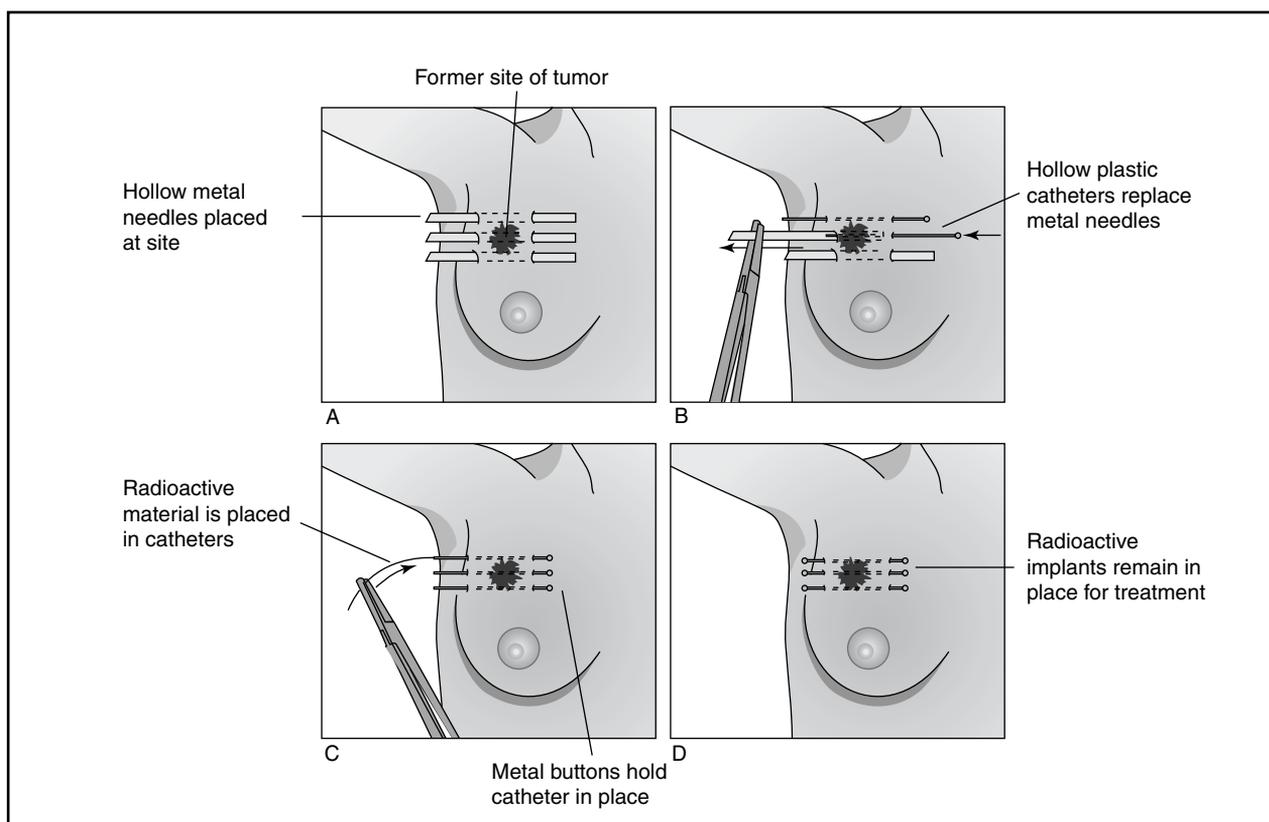
Treatment

Early detection is associated with the best clinical outcomes. Treatment options include surgery with or without **chemotherapy**, or surgery with or without radiation. Sometimes, all treatment modalities may be used in the same patient. Breast cancer is treated locally to eliminate tumor cells from the breast by surgery and radiation, and systemically to destroy cancer cells that have traveled to other parts of the body. Systemic therapy includes the use of chemotherapy and hormonal treatments to reduce the amount of estrogen circulating in the blood.

Lumpectomy is a surgical treatment for newly diagnosed patients with breast cancer. Lumpectomy is considered breast-conserving surgery because only the malignant tumor and a surrounding margin of normal breast tissue are removed. Lymph nodes in the armpit (axilla) may also be removed. This procedure is called lymph node dissection.

It is estimated that at least 50% of women with breast cancer are good candidates for a lymph node dissection. The location, size, and type of tumor are of primary importance when considering breast cancer surgery options. The size of the breast is another factor the surgeon considers when recommending surgery. The patient's psychological outlook, as well as her lifestyle and preferences, should also be taken into account when treatment decisions are made. If the tumor is less than about 1.5 in (4 cm) or there is little risk of recurrence, the patient and physician may opt for lumpectomy, followed by radiation therapy.

Many studies have compared the survival rates of women who have had mastectomy (removal of a breast) with those who have undergone lumpectomy and radiation therapy. The data clearly demonstrate that for women with comparable stages of breast cancer, survival rates are equal between the two groups.



Brachytherapy may be used for treatment of breast cancer. (Delmar Publishers, Inc. Reproduced by permission.)

In some instances, women with later stage breast cancer may be able to have lumpectomy. Chemotherapy may be administered before surgery to decrease tumor size and the chance of metastasis in selected cases.

If the tumor is larger, a total (or simple) mastectomy may be recommended. If the cancer has spread to the chest muscles, a radical mastectomy may be the best treatment option.

In a lumpectomy, the surgeon removes:

- the lump
- a margin of the tissue around the lump or mass
- some of the lymph nodes under the arm (to determine whether the cancer has metastasized)

A new technique that may eliminate the need for removing many axillary lymph nodes is being tested. The term sentinel node biopsy is most frequently used to refer to this method. It is based on the idea that the condition of the first lymph node in the network, which drains the affected area, can predict whether the cancer may have spread to the rest of the nodes. If this first, or sentinel, node is cancer-free, it is thought there is no need to look further. Many patients with early-stage breast cancers

may be spared the risks and complications of axillary node dissection as the use of the sentinel node biopsy continues to increase.

Even if no cancer is found in the nodes, radiation always follows lumpectomy, and treatment may include chemotherapy. Some studies suggest that following lumpectomy, a combination of chemotherapy and radiation offers the best chance of long-term survival.

In a modified radical mastectomy, the doctor removes:

- the entire breast
- axillary lymph nodes
- the lining over the chest muscle, but not the muscles themselves

Today, radical mastectomy is rarely performed, but when necessary, the surgeon removes:

- the entire breast
- the chest muscles
- all of the lymph nodes under the arm

Mastectomy may be combined with breast reconstruction, either during the surgical procedure, postopera-

KEY TERMS

Adjuvant therapy—Treatment involving radiation, chemotherapy, hormone therapy, or a combination of all three.

Aspiration biopsy—The removal of cells in fluid or tissue from a mass or cyst using a needle for microscopic examination and diagnosis.

Benign—Not malignant, non-cancerous.

Biopsy—Surgical removal and testing of tissue to determine if it is malignant.

Estrogen-receptor assay—A test to see if a breast cancer needs estrogen to grow.

Hormone therapy—Treating breast cancer by changing the hormone balance of the body, instead of by using cell-killing drugs.

Lumpectomy—Surgical procedure in which only the cancerous tumor is removed, together with a margin of normal tissue.

Malignant—Cancerous.

Mammography—X-ray imaging of the breast that can often detect lesions in the tissue too small or too deep to be felt.

Mastectomy—Surgical removal of breast(s).

Progestin—A type of hormone used to treat some types of breast cancer.

tively or months later. During surgery, if cancer cells are detected in the lymph nodes, more extensive surgery may be indicated. If the cancer has spread to the nodes, then radiation, chemotherapy, hormone therapy, or a combination of all three will be recommended after surgery. These post-surgical treatments are referred to as adjuvant therapy.

Radiation

Once the cancer has been surgically removed, the oncologist, a specialist in cancer medicine, may recommend radiation to destroy any remaining breast cancer cells. Radiation stops cancer cells from dividing. It works especially well on fast-growing tumors. Unfortunately, it also stops some types of healthy cells from dividing. Healthy cells that divide quickly, such as those of the skin and hair, are most affected. This is why radiation can cause fatigue, skin problems, and alopecia (hair loss).

Chemotherapy

Breast cancer surgery may be followed by chemotherapy, even when it is diagnosed in the earliest stages. Chemotherapy is administered either orally or by intravenous injection. It is usually administered in cycles: anticancer agents are given, followed by a period of time for recovery. Treatment time ranges from four to nine months.

There may be significant side effects with some types of chemotherapy, including nausea and vomiting, temporary hair loss, mouth or vaginal sores, fatigue, weakened **immune system**, and **infertility**. Advances in chemotherapy, especially regimens for early breast cancer, use medications that cause fewer side effects.

Hormone therapy

The growth of some breast cancer cells may be slowed by the antiestrogen drug tamoxifen. Administered orally, tamoxifen travels throughout the bloodstream, affecting all cells in the body. Treatment with tamoxifen continues at least two years, and often as long as five years. Research suggests that tamoxifen may lower the risk of breast cancer recurrence by between 25–35%. Side effects of tamoxifen may include a slightly higher risk of endometrial cancer (cancer of the lining of the uterus). The risk increases if the drug is taken for more than five years. Other side effects include menopause-like symptoms such as weight gain, hot flashes, and mood swings.

Other possible hormone treatments include the use of progestins, estrogens, and androgens. In rare cases, the surgeon may suggest oophorectomy (surgical removal of the ovaries) in pre-menopausal women as a way of eliminating the main source of circulating estrogen, which can boost the growth of some breast tumors.

Stem cell treatment

Stem cell treatment may be used to treat advanced breast cancer. Treatment involves removing stem cells from the patient's bone marrow or blood, and administering very high doses of chemotherapy or radiation to kill cancer cells. Since these high doses of chemotherapy also kill healthy white blood cells, patients are left extremely vulnerable to **infection**. When the stem cells are replaced, they restore the body's ability to combat infection.

Prognosis

The prognosis for breast cancer depends on the type and stage of cancer. Most patients can return to a normal lifestyle within a month or so after surgery. Arm, shoulder, and chest strengthening exercises can help patients

regain strength and flexibility, and avoid lymphedema (swelling resulting from fluid retention).

Despite significant advances in early detection, imaging, and treatment, in 1999, more than 43,000 women in the United States died from breast cancer. There is a five-year survival rate of 97% for women with localized breast cancer, but that drops to 77% for women with cancer that has spread to the axillary lymph nodes, and to 22% for those with distant metastases, such as metastases to **liver, lungs**, bone, or **brain**.

Because of the emotional upset caused by the diagnosis and treatment of breast cancer, counseling or participation in a support group program may benefit some patients. Indeed, many women have found a peer group of breast cancer survivors to be invaluable.

Health care team roles

Patients with breast cancer are usually cared for by a multidisciplinary team of health professionals. The patient's family physician or primary care physician collaborates with specialists such as surgeons and oncologists. Radiologic technicians perform mammograms, x rays, and other imaging studies, and nurses and laboratory technicians may obtain samples of blood, urine, and other laboratory tests.

Before and after any surgical procedures, including biopsies, nurses provide preparatory education to help patients and families. Depending on the tumor stage and treatment plan, patients may also benefit from rehabilitation therapy with physical therapists, nutritional counseling from dietitians, and counseling from social workers or other mental health professionals.

Patient education

It is vitally important for health professionals to instruct and encourage women to perform regular, monthly breast self-examination (BSE). Physicians, nurses, and health educators should use every patient encounter to reinforce the value and importance of BSE.

Prevention

Today, there is no single, proven strategy to prevent breast cancer. For the majority of women at average risk of developing breast cancer, a healthy lifestyle, maintenance of ideal body weight, and regular aerobic **exercise** provide the best known defenses against disease.

Genetic testing enables identification of women with a genetic predisposition to develop breast cancer. Inherited gene alterations, specifically BRCA1 and BRCA2, place women at risk for developing breast cancer at younger ages.

Researchers cannot, however, predict if and when women with genetic predisposition will develop the disease.

Surveillance of women with BRCA1 or BRCA2 mutations includes monthly self-examinations beginning in the late teens, followed by an annual mammography and biannual clinical breast exams, beginning at age 25 to 35. Women with a family history of premenopausal breast cancer are advised to receive clinical breast exams annually and a mammography every one to two years, beginning at age 35.

Traditional medical options for breast cancer prevention among women deemed at highest risk include pharmaceutical intervention—chemoprevention with anti-estrogens such as tamoxifen and raloxifene—and prophylactic mastectomy and oophorectomy. The prophylactic (preventive) surgeries are controversial and, to date, there is insufficient data to determine their efficacy. Many high-risk women choose surveillance, an approach that does not prevent breast cancer, but aims to identify it early, when it is most amenable to treatment.

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Porter, Margit Esser. *Hope Is Contagious: The Breast Cancer Treatment Survival Handbook*. New York: Simon & Schuster, 1997.

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American Cancer Society. (800) ACS-2345. <<http://www.cancer.org>>.

Cancer Care, Inc. (800) 813-HOPE. <<http://www.cancercareinc.org>>.

Cancer Information Service of the NCI. (800) 4-CANCER. <<http://wwwwic.nci.nih.gov>>.

National Alliance of Breast Cancer Organizations. 9 East 37th St., 10th Floor, New York, NY 10016. (888) 80-NABCO.

National Coalition for Cancer Survivorship. 1010 Wayne Ave., 5th Floor, Silver Spring, MD 20910. (301) 650-8868.

National Women's Health Resource Center. 2425 L St. NW, 3rd Floor, Washington, DC 20037. (202) 293-6045.

OTHER

Centers for Disease Control. <<http://www.cdc.gov>>.

Community Breast Health Project at Stanford. <<http://www-med.Stanford.EDU:80/CBHP>>.

The National Cancer Institute. <<http://www.nci.nih.gov>>.

Barbara Wexler

Breast infection *see* **Mastitis**

Breast radiography *see* **Mammography**

Breast x ray *see* **Mammography**

Breastfeeding *see* **Lactation**

Breastfeeding consulting *see* **Lactation consulting**

Breathing, regulation of

Definition

The regulation of breathing is the result of a complex interaction involving a system of sensors, a respiratory control center, and an effector system to carry out its commands to the muscles and organs involved in breathing.

Description

In the body, cells obtain their energy by combining oxygen with various nutrients, producing carbon dioxide as a waste product. Thus, they need a constant supply of oxygen and also need to have the carbon dioxide removed. This is accomplished by breathing, also known as respiration or ventilation, terms used by physiologists to mean the inhaling and exhaling of air.

Breathing is spontaneously initiated in the **central nervous system** and is performed by the body's respiratory system. The overall purpose of this system is to allow the body to inhale the oxygen-containing air, and to exhale the harmful carbon dioxide produced by the metabolic reactions.

Air contains 21% oxygen as a component gas. Air is inhaled into the body through the mouth and nose. It then travels past the throat and voice box (larynx), through the windpipe (trachea), which divides into two main air passages leading to the right and left **lungs**. The two passages divide again in the lungs into smaller branches (bronchi) that separate into even smaller ones (bronchioles or alveolar ducts) much like a tree branches out. These air passages contain little air sacs at their ends called alveoli. There are approximately 150 million alveoli in the human lungs. They have very thin walls that release the oxygen into the **blood**, receiving in exchange its carbon dioxide,

which is then exhaled out of the lungs through the same path leading back to the nose and mouth.

Breathing is an automatic process triggered in a complex area of the **brain** called the brain stem, a part of the brain that connects with the **spinal cord** and its nerves. The brain stem contains the involuntary respiratory control center. This means that breathing is more a reflex activity than an activity based on will, meaning that it happens without our having to think about it or decide that it should occur. Breathing is in fact such a strong reflex that it is very hard to willfully stop breathing for any length of time.

Function

The brain stem respiratory control center regulates breathing with the help of nerves, muscles and special sensors called chemoreceptors. Chemoreceptors are specialized cells that can detect chemical substances in the body and pass that information to nerves that are part of the central nervous system for relay to the respiratory control center. In this way, breathing is constantly monitored and adjusted to maintain appropriate pH and partial pressure of oxygen in the arterial blood, that is the blood coming from the **heart** and that contains the highest levels of oxygen for distribution in the body. The regulation of breathing is a homeostatic control mechanism, meaning that it seeks to maintain the stability of the body's internal environment via negative feedback mechanisms. For example, high levels of carbon dioxide in the body automatically trigger quicker and deeper breathing, which in turn decreases the level of carbon dioxide by increasing the intake of oxygen.

The respiratory control center is the central controlling area for breathing. It receives information from other parts of the body and produces an automatic coordinated response. The response is a reaction that triggers the various organs and muscles involved in breathing and located in different parts of the body to act together. It is located in the lower part of the brain stem, called the medulla oblongata, a scoop-shaped structure connected with the spinal cord. The medulla contains special breathing nerve cells (neurones). One type are the inspiratory neurones, which are active during inhaling and inactive during exhaling. The other type are the expiratory neurones, which are active during exhaling and inactive during inhaling. These two groups of neurones generate an automatic cycle of inhaling and exhaling. This automatic cycle can be modified or even temporarily stopped, depending on the information received by the respiratory control center from a variety of origins, such as **reflexes** from the lungs and airways, informa-

tion from the chemoreceptors, and commands from other areas of the brain.

The major centers providing the information required by the respiratory control center to regulate breathing are the following:

- **Central chemoreceptors.** The central chemoreceptors are located at the bottom of the fourth ventricle (region of the brain stem) and they respond to the acidity—or pH—of the cerebrospinal fluid (CSF), the fluid that bathes the brain and spinal cord. The acidity of any fluid is measured by the pH; this value is related to the number of hydrogen ions present in the fluid. The normal pH of the body is 7.4; values higher than this represent alkaline conditions in the body, meaning a lower amount of hydrogen ions, and values of pH less than 7.4 represent acidic conditions, meaning a higher amount of hydrogen ions. Thus, when the acidity of the CSF changes, the messages sent by the central chemoreceptors to the respiratory control center then have an effect on breathing.
- **Peripheral arterial chemoreceptors.** There are two types of peripheral chemoreceptors: the carotid bodies and the aortic bodies. They are small pieces of tissue containing chemoreceptors that respond to the amounts of oxygen and carbon dioxide in arterial blood. The carotid bodies are located where the common carotid artery divides into the two carotid arteries on both sides of the neck. The aortic bodies are located on the aorta, the body's largest blood vessel, which starts from the heart. The information from the carotid bodies is carried along the ninth cranial nerve and the information from the aortic body is passed along the tenth cranial nerve to the respiratory control center. The information from the carotid bodies is believed to affect the immediate regulation of breathing, breath by breath, by the respiratory control center.
- **Brain.** Breathing can also be voluntary, that is influenced by other parts of the brain, especially the cerebral cortex, the part of the brain where thought processes reside and are responsible for willful action. We can all consciously breathe more deeply and more rapidly (hyperventilation), as for example, before starting heavy **exercise**. Strong emotions can also result in hyperventilation.
- **Lung.** There are various receptors located in the lung that can also affect breathing. For example, a type of receptor in the bronchi respond to irritating inhaled substances and cause coughing, breath holding, and sneezing. Other receptors located in the flexible tissues of the lung and the chest wall are sensitive to stretch. The exact role played by these receptors in the regulation of breathing is not fully understood, but they are

thought to be responsible for various reflexes that have been discovered in laboratory studies performed on animals. These are stretch reflexes that occur when the lung and chest wall are distended so as to prevent further inhaling. Also, when the air volume is low in the lungs, then there are opposite reflexes.

After receiving information, the respiratory control center needs a pathway to send its regulatory messages. This is done by special nerves, called efferent nerves. They leave the respiratory control center and pass down the spinal cord to the diaphragm, and to the muscles located between the ribs (intercostal muscles) and to other muscles located in the neck and used to breathe. The diaphragm is a thin, sheet-like muscle located at the bottom of the chest cavity below the lungs and heart, and it is the most important muscle involved in breathing. When a person inhales, the diaphragm contracts and moves downward, thus stretching the cavity that contains the lungs (thorax or thoracic cavity), while the intercostal muscles contract and widen the thoracic cavity, which results in air filling the lungs through suction. When a person exhales, the diaphragm and intercostal muscles relax, which decreases the size of the thoracic cavity and forces air out of the lungs. During normal breathing, inhaling is an active muscular process. Exhaling is passive and relies on the natural elasticity of the tissues to deflate the lung.

Role in human health

Breathing is an essential activity of the body, required to maintain life. If it is stopped, death quickly follows. Thus, the regulation of breathing is also essential, meaning that any disruption of this function will affect the respiratory ability of the body, with consequences depending on the extent of the impairment.

Common diseases and disorders

If the rate of oxygen intake and of carbon dioxide elimination is not matched by delivery of the first and removal of the second, an imbalance occurs that may result in respiratory abnormalities associated with serious diseases such as **pneumonia** (inflammation of the lungs), **emphysema** (excessive and abnormal accumulation of air in the lungs resulting from a reduction of the area of the lung membranes), **heart failure**, anemia (lack of red blood cells in the blood, resulting in insufficient oxygen), and **asthma** (narrowing of the bronchi). The following conditions are the result of such imbalances:

- **Hypoxia.** Also known as anoxia. It means “without oxygen” and is used to describe a condition of insufficient oxygen being provided to the cells of the body.

KEY TERMS

Acidity—Refers to a compound that is acid or sour. When dissolved in water, acids yield hydrogen ions.

Brain stem—Lowest part of the brain that connects with the spinal cord. It is a complicated neural center with several neuronal pathways between the cerebrum, spinal cord, cerebellum, and motor and sensory functions of the head and neck. It consists of the medulla oblongata, the part responsible for cardiac and respiratory control, the midbrain, which is involved in basic, involuntary body functions, and the pons, where some cranial nerves originate.

Bronchi—Air passages in the lungs.

Central nervous system (CNS)—In humans, the CNS consists of the brain, the cranial nerves and the spinal cord.

Cerebrospinal fluid (CSF)—A clear fluid that contains small quantities of sugar (glucose) and protein. The CSF fills the brain and the central canal of the spinal cord and its normal pH is 7.4. Any change from this value is detected by chemoreceptors.

Chemoreceptors—Specialized cells that can detect chemical substances in the body and relay that information to the central nervous system. The substances detected may be external, such as when an individual smells or tastes something or they can be internal, such as the oxygen or carbon dioxide present in the blood.

Cranial nerve—In humans, there are 12 cranial nerves. They are connected to the brain stem and basically control the head as well as help regulate the organs of the thoracic and abdominal cavities.

Diaphragm—Thin, sheet-like muscle located below the lungs and heart at the bottom of the chest cavity and that separates it from the abdomen. The diaphragm is a breathing muscle, it allows air to get in and out of the lungs by moving up and down. When the diaphragm moves down, a person breathes in. When the diaphragm moves up, the person breathes out.

Homeostasis—Stability of the body's internal environment, achieved by a system of integrated control systems activated by feedback systems. For example, high levels of carbon dioxide in the CSF triggers stronger ventilation in the lungs which in turn decreases the level of carbon dioxide by increasing the intake of oxygen.

Involuntary activity—Activity that is not under the influence or control of the will.

Lungs—Large pair of respiratory—or breathing—organs located in the chest. The lungs bring the oxygen present in the inhaled air into the blood and remove toxic carbon dioxide from the blood.

Metabolism—The sum of all the physical and biochemical processes occurring in the body to produce what is required to maintain life. This includes the transformation of nutrients into energy and the use of energy by the body.

Peripheral chemoreceptors—Chemoreceptors not located in the brain stem. There are two types: the aortic bodies located in the aorta, the largest artery in the body and the carotid bodies located in the carotid arteries that pass on either side of the neck, carrying oxygenated blood from the aorta to the brain.

pH—A measure of the acidity of a solution, or of its hydrogen ion concentration. In the human body, the solution can be the blood or the CSF. The normal pH of body fluids is 7.4.

Reflex—Action or movement of the body that is the sum of involuntary activity.

Respiration—In humans, breathing, meaning the inhaling of oxygen-containing air and the exhaling of carbon dioxide-containing air. It can also refer to the exchange of oxygen and carbon dioxide in the blood. The term respiration has yet another meaning in biochemistry, where it refers to the complex chemical reactions occurring in the body, called oxidation reactions, by which chemical substances transfer electrons and convert energy into forms required to maintain life.

Respiratory system—The organs that are involved in breathing: the nose, the throat, the larynx, the trachea, the bronchi and the lungs.

Trachea—The windpipe, a tube made of fiber and cartilage that connects the voice box (larynx) to the bronchi.

Ventilation—Air entering an exiting the body. Pulmonary ventilation refers to the exchange of air between the lungs and the ambient air and alveoli ventilation refers to the exchange of oxygen and carbon dioxide with the blood.

- Hypoxic hypoxia. This condition is characterized by an inadequate supply of oxygen to the arterial blood and abnormally low partial pressure of oxygen in the arteries. **Cyanosis** (blueness of the skin and membranes) is a major symptom, due to lower levels of hemoglobin, the protein that carries oxygen in the blood.
- Stagnant hypoxia. This is failure to transport oxygen to the tissues and is due to a slow blood flow, as can occur with heart failure.
- Anemic hypoxia. In anemic hypoxia, the partial pressure of oxygen in the arteries is normal, but the oxygen content of the arterial blood is lower than normal.
- Hypercapnia. This means an excess of carbon dioxide.
- Acidosis. Increase of the amount of hydrogen ion (acidity) in the blood and CSF, leading to respiratory acidosis. It occurs when the lungs are not ventilating properly and results in excessive amounts of carbon dioxide in the blood. Non-functional carotid bodies have been shown to cause acidosis.
- Alkalosis. Loss of hydrogen ion in the blood and CSF, leading to respiratory alkalosis, meaning excessive loss of carbon dioxide from the body. An alkaline CSF inhibits the respiratory control center.

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Monique Laberge, Ph.D.

Breech birth

Definition

In a breech birth, the presenting part of the fetus, or the part that enters the woman's birth canal first, is the buttocks or leg(s).

Description

In almost 97% of vaginal births, the head is the part of the baby to be born first (i.e., vertex presentation). During a woman's **pregnancy**, the fetus moves freely inside the uterus, cushioned by the amniotic fluid. At 20 weeks' gestation, the midway point in the pregnancy, about 24% of fetuses are in a breech position. By 34 weeks, only about 7% are in a breech position. As the pregnancy progresses towards term (37–42 weeks), the growing fetus has less room in which to turn around, and usually remains more in an inverted (head down) position. However, in about 3–4% of births, the buttocks or feet present first.

There are three types of breech presentations:

- Complete breech, in which the buttocks present first, the baby's thighs are tight against the abdomen, the legs are crossed, and the feet are flexed. In this position, the fetus is curled up tightly in a ball.
- Frank breech, in which the knees are straight (i.e., not bent), and the legs are held tightly against the abdomen and head. This breech position comes closest to filling the pelvic inlet, as would the fetus's head.
- Footling breech, in which one or both legs enter the birth canal first. The fetus appears to be standing in an upright position.

Risks

Risks of a vaginal breech delivery include:

- Prolapse of the umbilical cord. This is especially true in a footling presentation, where the feet and legs are small and provide room for the umbilical cord to slip alongside and into the birth canal. Any pressure on the cord compresses the sides of the cord, decreasing **blood** flow and oxygen to the fetus. This may result in anoxia.
- Entrapment of the head. This occurs when the body of the neonate passes through the cervix, but the head, which is the largest part of the body, cannot fit through the cervical opening. This may occur because the cervix was incompletely dilated at the time of the birth of the baby, or when the head is larger than the pelvic opening.
- Trauma to the head or neck of the neonate during delivery. This could result in permanent **brain** damage or **paralysis** of the infant.
- Trauma to the spine or an arm resulting in fracture of a bone.
- Meconium aspiration. The breech position may cause an early rupture of the amniotic fluid membranes, and meconium (the infant's first stool) may be released. If the neonate breathes in any of the meconium, he or she

risks obstruction of the airway by the meconium, and pneumonia.

- Dysfunctional labor. Because of the fetal breech position, the labor can be drawn out, exhausting the mother, and diminishing her ability to push as the time of delivery approaches.
- Higher level of perinatal morbidity and mortality.

Accurate imaging of the fetus *in utero* has decreased the number of breech births by alerting obstetricians and midwives to this presentation prior to the time of delivery. A technique called external version may be used to encourage the fetus to rotate into a vertex position. This technique will be described below, under “Treatment.” However, as the practice of external version has increased, practitioners have had less experience delivering a breech baby vaginally. A successful vaginal delivery of a breech presentation depends to a great extent on the skill and experience of the practitioner.

Twins present a special challenge, and will take one of several possible birth positions:

- Vertex-vertex. In this, the safest of positions for delivery, the twins both present in the vertex, or head down position. It occurs in about 40–45% of twin births.
- Vertex-breech or breech-vertex. This position offers the most efficient use of the uterine space, but is not the best presentation for delivery. Vertex-breech and vertex-transverse positions occur in about 35–40% of twin births. Breech-vertex positioning occurs in about 15–20% of births.
- Breech-breech presentation occurs in about 15–20% of twin births, and almost always results in cesarian-section birth.

If the second twin entering the birth canal is the larger, there will be a concern that he or she may become stuck because the smaller, first twin did not adequately enlarge the cervical opening. Twins are often born prematurely, and are smaller than full-term infant. The more premature the infant, the greater the chance it will have a smaller body-to-head proportion than the full-term infant. This creates a greater hazard for breech birth, because the small body can come through a less-dilated cervix, and there is a greater chance that the head will get trapped. Accurate imaging of twin positions will play a major role in determining the safest delivery method. An external version of the second twin may be proposed. Version of the first twin is unlikely, as the procedure poses a threat to both twins.

Causes and symptoms

The cause of a particular breech presentation may not be understood about 80% of the time. However, causes of breech presentation may include:

- an inability of the fetus to have full movement inside the uterus
- the position of the placenta, such as a low-lying **placenta previa**, and a short umbilical cord
- decreased muscle tone of the fetus
- a congenital disorder of the fetus, especially neuromuscular in nature
- a space-related problem for the fetus, such as with uterine fibroids
- fetal anomaly, such as hydrocephalus
- uterine structural anomaly, such as a septum trapping the fetus in a breech position
- gestation of less than 40 weeks
- multiple gestation
- hydramnios, in which excess amniotic fluid is produced and the fetus has too much room in which to move

Diagnosis

There are three primary ways in which a breech position is discovered, including imaging, position of the fetal heartbeat, and external palpation on the mother’s abdomen.

Imaging. There are a variety of imaging technologies, varying in safety, cost, and ease of access. **Magnetic resonance imaging (MRI)** is very accurate, but is extremely expensive, not as readily available, and would rarely provide more information than an ultrasound to justify its use. Ultrasound is the most widely used method of imaging during pregnancy, as it uses sound waves instead of radiation, is available in most health care centers, and is cost efficient. Ultrasound is considered safe to use at all stages in pregnancy.

Leopold’s maneuvers consist of a series of four external palpations of the mother’s abdomen to determine fetal position in the uterus. The fetal head is hard and can move separately from the rest of the body. The buttocks feel soft and move with the body. As the time for delivery draws near, a vaginal examination may be required, however, as Leopold’s maneuvers can sometimes be misleading. In a vaginal examination, the baby’s fontanelles are palpated.

Treatment

When dealing with a breech presentation, there are three choices for delivery: attempt to rotate the fetus into a vertex presentation prior to delivery; attempt a trial of vaginal delivery in the breech position; or deliver by cesarian section. Some hospitals may not have the mother attempt a vaginal delivery and instead opt for cesarian section.

The preferred mode of delivery is a vaginal birth with the fetus in vertex presentation. Attempts are therefore made to rotate the fetus from a breech into a vertex position. One method has been to have the mother assume different positions (e.g., knee-chest) in the hope that this would cause the fetus to move into a more favorable position. Research studies have not shown this to be very successful, although periodic anecdotal accounts of success have been reported. In the November 11, 1998 issue of the *Journal of the American Medical Association*, researchers reported on the use of traditional Chinese medicine to cause the fetus to rotate. In this study, moxa, a combustible Chinese herb, was used over a two-week period to stimulate an acupuncture point on the toe. Stimulation of this point is believed to increase fetal activity, during which the fetus then moves into the vertex position. After two weeks of treatment with moxa, 75% of the 130 fetuses studied rotated into the vertex position, while only 48% of the control (no intervention, just routine obstetrical care) fetuses rotated. However, the results of this study has not been replicated.

A more traditional and more commonly used treatment within Western medical standards is external version. In external version, the fetus is rotated manually by the physician, who exerts pressure on the mother's abdomen to cause the fetus to somersault into the vertex position. Medication may be given to the mother to relax the uterine muscles prior to the procedure. The vertex position allows the fetus more mobility and decreases the chance of uterine contractions, which lead to early labor. Before attempting version, however, an ultrasound is performed to confirm the position of the fetus. The timing of version is important. Done too early, the fetus may rotate back into a breech position if too much space is still available. Performed at 35-37 weeks' gestation, the success rate has shown to be up to 65%. In approximately 1-2% of cases, complications arise following version, leading to the need for immediate delivery via cesarian section.

Version should always be done in a hospital, where there are facilities for immediate cesarian delivery available in the cases of cord compression or **placental abruption**. Some research has indicated that giving the mother an epidural for the version procedure increases its

success rate. The version can be accomplished by two health care professionals. Mineral oil may be applied to the mother's abdomen so that the obstetrician's hands can smoothly slide over the surface. The fetal **heart** rate should be monitored closely for any signs of fetal distress, and should be continued for about an hour after the procedure to assure fetal stability. Mothers who are Rh-negative may be given Rh immune globulin, which would prevent incompatibility should fetal-to-mother transfusion occur during the version. About 90% of babies turned by version will remain in this position for delivery.

Version has risks and is contraindicated in the following situations:

- uterine structural anomalies
- third-trimester bleeding
- hydramnios, excess amniotic fluid production
- nuchal cord, or the cord around the baby's neck, (not always seen on ultrasound)
- previous uterine surgery, such as cesarian section, that has weakened the uterine walls
- cephalopelvic disproportion (CPD), a condition in which the baby's head is too big for the mother's pelvic inlet, as evidenced on ultrasound or other imaging tools

When a vaginal breech birth is attempted, the pace of the delivery is very important. Fetal heart rate and uterine contractions need to be closely monitored. During a vertex vaginal delivery, the head is molded coming down the birth canal, and the labor process slows the pace of the delivery. In a breech vaginal birth, the smaller body may slip more quickly through the canal. If the head becomes caught, fetal anoxia (lack of oxygen) can occur. The head does not mold during a rapid breech birth, and if the neonate is allowed to deliver quickly, perhaps due to a detected prolapsed cord, the rapid change in pressure can result in intracranial hemorrhage. To assist the breech delivery, the mother may be asked to assume a squatting position, as this increases the birth canal volume by about 28%. (This position is not popular in the United States.) Forceps may be used to protect the neonate's neck and head from trauma and to assist in the delivery. If the vaginal birth attempt causes fetal distress, an emergency cesarian delivery may be required.

In a cesarian birth, an incision is made through the mother's abdominal wall into the uterus. The amniotic fluid membranes are broken and the neonate is extracted. A vertical incision in the uterus along the mother's abdominal midline is called a classical cut. This provides the fastest access to the infant and may be chosen in the event of an emergency delivery. The fetus can be removed from the uterus in minutes. If a woman has had

KEY TERMS

Cephalopelvic disproportion—When the fetus' head is larger than the mother's pelvic inlet.

Nuchal cord—The term used when the umbilical cord is looped around the fetus' neck in utero.

Presentation—Presentation refers to that part of the fetus' body that enters into the birth canal first.

Prolapsed umbilical cord—When the cord falls into the birth canal, and may even hang out of the mother's vagina. This can cause compression of the cord and lead to decreased oxygen and blood flow to the fetus.

Transverse—In the transverse position, the fetus lies sideways against the birth canal, with a shoulder or arm possibly entering the canal.

the classical uterine incision, she will not be allowed to attempt to deliver vaginally in the future, because the uterine wall rupture can during the next labor. When time permits, the preferred incision is a transverse one, just above the pubic bone. This incision is sometimes referred to as a bikini cut. Healing time is decreased and may allow a woman to successfully deliver vaginally in the future.

Prognosis

About half the attempts of a vaginal breech delivery will result in a cesarian birth. Discovery of breech presentation prior to the time of delivery allows attempts to be made to rotate the fetus. If these attempts prove unsuccessful, a cesarian birth can then be scheduled. A scheduled cesarian allows the mother and her partner to be informed and participate, to some degree, in the process. Anesthesia can be chosen that allows the mother to be awake during the birth of her child. If emergency cesarian delivery is required, the mother will be given a **general anesthesia** to shorten the time required to extract the fetus in distress. If complications do not occur, the prognosis is excellent.

Health care team roles

During a breech birth more nursing personnel may be needed to assist the obstetrician and provide support for the mother. A neonate that has been in a breech position *in utero* may maintain an unusual position for a few days after birth. An explanation by the nurse can greatly reduce the mother's concern that there is something wrong with her baby.

Prevention

None of the known causes of breech presentation mentioned above are preventable, and in many breech presentations, there is no known cause. However, while it is not possible to prevent this presentation, attempts such as version are made to prevent a breech delivery, or to minimize its inherent risks.

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Esther Csapo Rastegari, R.N., B.S.N., Ed.M.

Bridges see **Dental crowns, inlays, and bridges**

Bronchoscopy

Definition

Bronchoscopy is a procedure in which a hollow, flexible tube is inserted into the airways (nose or mouth). The bronchoscope is inserted through the nose (or mouth) provides a view of the tracheobronchial tree and can be used to collect bronchial and/or lung secretions. Tissue biopsy may also be performed via the bronchoscope.

Purpose

During a bronchoscopy, the physician can visually examine the lower airways, including the larynx, trachea, bronchi, and bronchioles. The procedure is used to examine the mucosal surface of the airways for abnormalities that might be associated with a variety of lung diseases. Its use may be diagnostic or therapeutic.

Bronchoscopy may be used to examine and help diagnose:

- diseases of the lung, such as **cancer** or tuberculosis
- a congenital deformity of the **lungs**
- a suspected tumor, obstruction, secretion, bleeding or foreign body in the airways
- airway abnormalities, such as tracheal stenoses
- a persistent cough, or hemoptysis, a cough that includes **blood** in the sputum

Bronchoscopy may be used for the following therapeutic purposes:

- to remove a foreign body in the lungs
- to remove excessive secretions

Bronchoscopy can also be used to collect the following specimens:

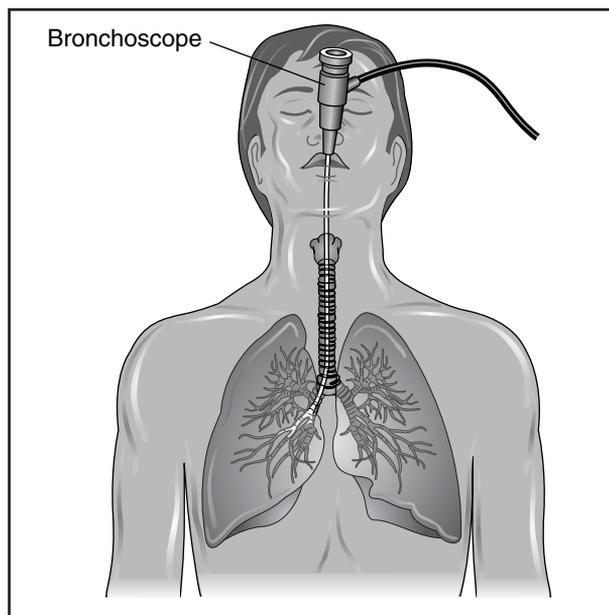
- sputum
- tissue samples from the bronchi or bronchioles
- cells collected from washing the lining of the bronchi or bronchioles

If the purpose of the bronchoscopy is to take tissue samples or biopsy, a forceps or bronchial brush are used to obtain cells. Alternatively, if the purpose is to identify an infectious agent, a bronchoalveolar lavage can be used to gather fluid for culture purposes. If any foreign matter is found in the airways, it can be removed as well.

The instrument used in bronchoscopy, a bronchoscope, is a slender flexible tube that uses fiberoptic technology (very fine filaments that can bend and carry light). There are two types of bronchoscopes, a standard tube which is more rigid and a fiberoptic tube which is more flexible. The rigid instrument doesn't bend, doesn't see as far down into the lungs as the flexible one, and may carry a greater risk of causing injury to nearby structures. Because it can cause more discomfort than the flexible bronchoscope, it requires stronger anesthesia. However, it is useful for taking large samples of tissue and for removing **foreign bodies** from the airways.

Precautions

If the patient has severe **respiratory failure** and cannot breathe adequately on his or her own, the patient should be placed on a ventilator prior to bronchoscopy. It may not be appropriate to perform bronchoscopy on patients who have congestive **heart failure** or have experienced a recent **heart** attack. All patients must be constantly monitored while undergoing a bronchoscopy so that any abnormal reactions can be dealt with immediately.



Bronchoscopy is a procedure in which a hollow, flexible tube is inserted into the airways, allowing the physician to visually examine the lower airways, including the larynx, trachea, bronchi, and bronchioles. It can also be used to collect specimens for bacteriological culture to diagnose infectious diseases such as tuberculosis. (Illustration by Electronic Illustrators Group.)

Description

The procedure is ideally performed in an endoscopy room, but may be performed at the bedside. Follow institutional procedures for preoperative medications. The patient is placed in a supine position or sits upright. A pulmonologist trained to perform a bronchoscopy will spray anesthesia into the patient's mouth or nose. When the anesthetic has taken effect, the bronchoscope will be put into the patient's mouth or nose and passed into the throat. While the bronchoscope is moving down the throat, additional anesthesia is put into the bronchoscope to anesthetize the lower airways. The physician observes the trachea, bronchi, and the mucosal lining of these passageways looking for any abnormalities that may be present.

Alternative procedures

Depending upon the purpose of the bronchoscopy, alternatives may include a **chest x ray** or a computed tomography (CT) scan. If the purpose is to obtain biopsy specimens, one option is to perform surgery, which carries greater risks. Another option is percutaneous biopsy guided by CT.

Preparation

The patient should fast for six to twelve hours prior to the procedure and refrain from drinking any liquids the day of the procedure. Smokers should refrain from smoking for 24 hours prior to the procedure. The bronchoscopy itself takes about 45-60 minutes. Prior to the bronchoscopy, several tests will be done, including chest x ray and blood work. Sometimes a bronchoscopy is done under **general anesthesia**, in which case the patient will have an intravenous (i.v.) line in the arm. More commonly, the procedure is performed under **local anesthesia**, which is sprayed into the nose or mouth. This is necessary to inhibit the gag reflex. A sedative may be given. It is important that the patient understands that at no time will the airway be blocked and that oxygen can be supplied through the bronchoscope. A signed consent form is necessary for this procedure.

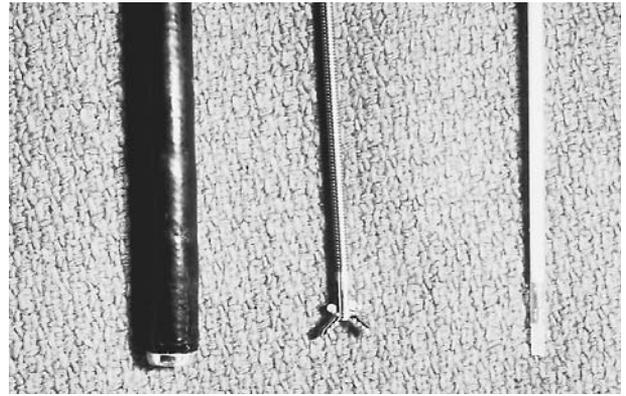
Aftercare

After the bronchoscopy, the **vital signs** (heart rate, **blood pressure**, and breathing) are monitored. Sometimes patients have an abnormal reaction to anesthesia. Any sputum should be collected in an emesis basin so that it can be examined for the presence of blood. If a biopsy was taken, the patient should not cough or clear the throat as this might dislodge any blood clot that has formed and cause bleeding. No food or drink should be consumed for about two hours after the procedure or until the anesthesia wears off. There is a significant risk for choking if anything (including water) is ingested before the anesthetic wears off, and the gag reflex has returned. To test if the gag reflex has returned, a spoon is placed on the back of the tongue for a few seconds with light pressure. If there is no gagging, the process is repeated after 15 minutes. No small or sharp objects are used to test this reflex. The gag reflex should return in one to two hours. Ice chips or clear liquids should be taken before the patient attempts to eat solid food.

The patient should be instructed that after the anesthetic wears off the throat may be irritated for several days.

Patients should notify their health care provider if they develop any of these symptoms:

- hemoptysis (coughing up blood)
- shortness of breath, wheezing or any trouble breathing
- chest **pain**
- fever, with or without breathing problems



Instruments used in bronchoscopy procedures. (Custom Medical Stock Photo. Reproduced by permission.)

Complications

Minor side effects arise from the bronchoscope causing abrasion of the lining of the airways. This results in some swelling and inflammation, as well as hoarseness caused from abrading the vocal cords. If this abrasion is more serious, it can lead to respiratory difficulty or bleeding of the lining of the airways. A more serious risk involved in having a bronchoscopy performed is the occurrence of a pneumothorax, due to puncturing of the lungs, which allows air to escape into the space between the lung and the chest wall. These risks are greater with the use of a rigid bronchoscope than with a fiberoptic bronchoscope. If a rigid tube is used, there is also a risk of chipped teeth. The risk of transmitting infectious disease from one patient to another by the bronchoscope is also present. There is potential for **infection** from endoscopes inadequately reprocessed by an automated **endoscope** reprocessing (AER) system. The Centers for Disease Control (CDC) reported apparent patient-to-patient transmission of infections following bronchoscopic procedures that used bronchoscopes that were inadequately reprocessed by AERs. Investigation of the incidents revealed inconsistencies between the reprocessing instructions provided by the manufacturer of the bronchoscope and the manufacturer of the AER; or that the bronchoscopes were inadequately reprocessed.

Results

Normal tracheal appearance consists of smooth muscle with C-shaped rings of cartilage at regular intervals. The trachea and the bronchi are lined with a mucous membrane.

Abnormal bronchoscopy findings include deformity in the bronchial wall, such as inflammation, stenosis or compression of the trachea, neoplasm, and foreign bod-

KEY TERMS

Anesthesia—A drug used which causes loss of sensation. It is used to lessen the pain of surgery and medical procedures.

Bronchi—The network of tubular passages that carry air to the lungs and allow air to be expelled from the lungs.

Bronchioles—Small airways extending from the bronchi into the lobes of the lungs.

Bronchoalveolar lavage—Washing cells from the air sacs at the end of the bronchioles.

Emesis basin—A basin used to collect a patient's sputum or vomit.

Neoplasm—A new growth or tumor.

Trachea—The windpipe.

ies. Findings of swelling, or ulceration are abnormal. The bronchoscopy may also reveal the presence of atypical substances in the trachea and bronchi. If samples are taken, the results could indicate cancer, disease-causing agents or other lung disease. Other abnormalities include constriction or narrowing (stenosis), compression, dilation of vessels, or abnormal branching of the bronchi. Abnormal substances that might be found in the airways include blood, secretions, or mucous plugs. Any abnormalities are discussed with the patient.

Health care team roles

The test is usually performed by a pulmonologist, a physician specializing in diseases of the lungs. Nursing staff assist with providing education, monitoring the patient, and conducting tests, including checking blood pressure, pulse, and respiratory rate prior to the patient's discharge.

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American College of Chest Physicians. 3300 Dundee Road, Northbrook, IL 60062. (800) 343-2227.

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Maggie Boleyn, R.N., B.S.N.

Bruxism

Definition

Bruxism is a habitual grinding or clenching of the teeth. The behavior is usually unconscious, occurs most often during sleep, and is a reaction to periods of **stress** in the patient's life.

Description

Bruxers often unknowingly grind their teeth. Pencils, their fingernails, and the insides of their cheeks may be bitten. This habitual tooth gritting, grinding or clenching can lead to facial **pain** and tooth abrasion. Bruxism is common—as many as one in three people is a bruxer. The condition affects both adults and children. However, it often goes unrecognized until tooth damage is noticed by a dentist.

Causes and symptoms

Personality type may place a patient at risk for bruxism. People who are anxious, angry or stressed are more likely to succumb to the habitual grinding and clenching. Another cause of bruxism is an abnormal dental occlusion, which can cause the teeth to grind more easily due to their positioning. Clenching and grinding the teeth can cause jaw area tissue alterations.

Bruxism causes the teeth to wear and become flat at the tips. The teeth can become so severely worn that the dentin is exposed and sensitive. Bruxism can lead to temporomandibular joint pain and, as a result, the jaw might begin popping and clicking. Some bruxers have tongue indentations—another sign of bruxism.

KEY TERMS

Biofeedback—A training technique used to gain control over autonomic body functions.

Bruxers—People who grind and clench their teeth.

Dentin—The hard material of the main part of the tooth, situated beneath the enamel and contain the pulp.

Occlusion—Contact between the surfaces of the upper and lower teeth when the mouth is closed.

Temporomandibular joint—One of a pair of joints connecting the mandible in the lower jaw to the temporal bone in the skull.

Diagnosis

To diagnose bruxism, the dentist looks for signs of damage, such as chipped enamel, usual tooth wear and tear, radiographic bone changes, and sensitivity. Asking relevant questions can also help dentists make the diagnosis. The questions can include asking patients if their teeth or jaws hurt upon awakening in the morning and if they suffer from worry or stress. The dental exam helps to determine whether the grinding is caused by misaligned teeth or psychological forces.

Treatment

Often, treatment is aimed at getting bruxers to change their behavior. This might involve **relaxation** training and other stress management techniques. If relaxation doesn't suffice, dentists might recommend a plastic mouth appliance to relax the facial muscles and protect the teeth from the grinding and clenching. Another method of treatment is biofeedback. New treatments for bruxism, especially for nocturnal bruxers, are being studied. In some cases, psychological assessment or **psychotherapy** might be recommended.

Prognosis

Childhood grinding and clenching of the teeth are often outgrown by adolescence. By making an effort not to grind or clench their teeth, some people can address the problem successfully. Dental intervention to protect the teeth or correct misalign teeth, as well as attempts at stress and **anxiety** relief, often solve the problem.

Health care team roles

The first signs of bruxism, as well as its related problems, might be noticed by the dental hygienist during professional maintenance care; the patient may be referred to the dentist. Education of the patients about bruxism and options for treatment can be accomplished by the dental hygienist. If the patient comes to his or her primary health care provider complaining of jaw pain, the diagnosis may occur in the clinic or office setting. The patient would be referred to a dentist for a dental appliance.

Prevention

Bruxism precipitated by stress and anxiety can be avoided if patients treat their stress with proper management techniques.

Resources

ORGANIZATIONS

Academy of General Dentistry, 211 East Chicago Ave., Chicago, IL 600611. (312) 440-4800. <<http://www.agd.org>>.

American Dental Assistants Association, 208 North LaSalle Street, Suite 1320, Chicago, IL 60601-1225 (312) 541-1550 (March 15, 2001) <<http://www.dentalassistant.org>>.

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Lisette Hilton

BUN test see **Kidney function tests**

Burkitt's lymphoma see **Malignant lymphomas**

Burns

Definition

Burns are injuries to tissues caused by heat, friction, electricity, radiation, or chemicals.



A patient is treated for burn wounds. (Phototake. Reproduced by permission.)

Description

Burns are characterized by degree, based on the severity of the tissue damage. A first-degree burn causes redness and swelling in the outermost layers of the skin (epidermis). A second-degree burn involves redness, swelling, and blistering, and the damage may extend beneath the epidermis to deeper layers of skin (dermis). A third-degree burn, also called a full-thickness burn, destroys the entire depth of skin, causing significant scarring. Damage may also extend to the underlying fat, muscle, or bone.

The severity of a burn is also judged by the amount of body surface area (BSA) involved. Health care workers use the rule of nines to determine the percentage of BSA affected in persons more than nine years old: each arm with its hand is 9% of BSA; each leg with its foot is 18%; the front of the torso is 18%; the back of the torso, including the buttocks, is 18%; the head and neck are 9%; and the genital area (perineum) is 1%. This rule cannot be applied to a young child's body proportions, so BSA is estimated using the palm of the person's hand as a measure of 1% area.

The severity of a burn will determine not only the type of treatment, but also where the burned individual should receive treatment. Minor burns may be treated at home or in a doctor's office. These are defined as first- or second-degree burns that cover less than 15% of an adult's body or less than 10% of a child's body, or a third-degree burn of less than 2% BSA. Moderate burns should be treated at a hospital. These are defined as first- or second-degree burns that cover 15%–25% of an adult's body or 10%–20% of a child's body, or a third-degree burn on 2%–10% BSA. Critical, or major, burns are the most serious and should be treated in a specialized burn unit of a hospital. These are defined as first- or second-degree burns that cover more than 25% of an adult's body or more than 20% of a child's body, or a third-degree burn of more than 10% BSA. In addition, burns involving the hands, feet, face, eyes, ears, or genitals are considered critical. Other factors influence the level of treatment needed, including associated injuries such as bone **fractures** and smoke inhalation, presence of a chronic disease, or a history of being abused. Children and the elderly are more vulnerable to complications from burn injuries and require more intensive care.

Causes and symptoms

Burns may be caused by even a brief encounter with heat greater than 120°F (49°C). The source of this heat may be the sun (causing a sunburn), hot liquids, steam, fire, electricity, friction (causing rug burns and rope burns), and chemicals (causing a caustic burn upon contact).

Signs of a burn are localized redness, swelling, and **pain**. A severe burn will also blister. The skin may peel, appear white or charred, and feel numb. A burn may trigger a headache and **fever**. Extensive burns may induce **shock**, the symptoms of which are faintness, weakness, rapid pulse and breathing, pale and clammy skin, and bluish lips and fingernails.

Diagnosis

Physicians will diagnose a burn based upon visual examination, and will also ask the burned person or family members questions that help determine the best treatment. They may also check for smoke inhalation, **carbon monoxide poisoning**, cyanide **poisoning**, other event-related trauma, or, if suspected, further evidence of **child abuse**.

Treatment

Burn treatment consists of relieving pain, preventing **infection**, and maintaining body fluids, electrolytes, and calorie intake while the body heals. Treatment of chemical or electrical burns is slightly different from the treatment of thermal burns, but the objectives are the same.

Thermal burn treatment

The first act of thermal burn treatment is to stop the burning process. This may be accomplished by letting cool water run over the burned area or by soaking it in cool (not cold) water. Ice should never be applied to a burn. Cool (not cold) wet compresses may provide some pain relief when applied to small areas of first- and second-degree burns. Butter, shortening, or similar salve should never be applied to a burn since it prevents heat from escaping and drives the burning process deeper into the skin.

If a burn is minor, it may be gently cleaned with soap and water. Blisters should not be broken. If the skin of a burned area is unbroken, and it is not likely to be further irritated by pressure or friction, the burn should be left exposed to the air to promote healing. If the skin is broken or apt to be disturbed, the burned area should be coated lightly with an antibacterial ointment and covered with a sterile bandage. Aspirin, acetaminophen (for

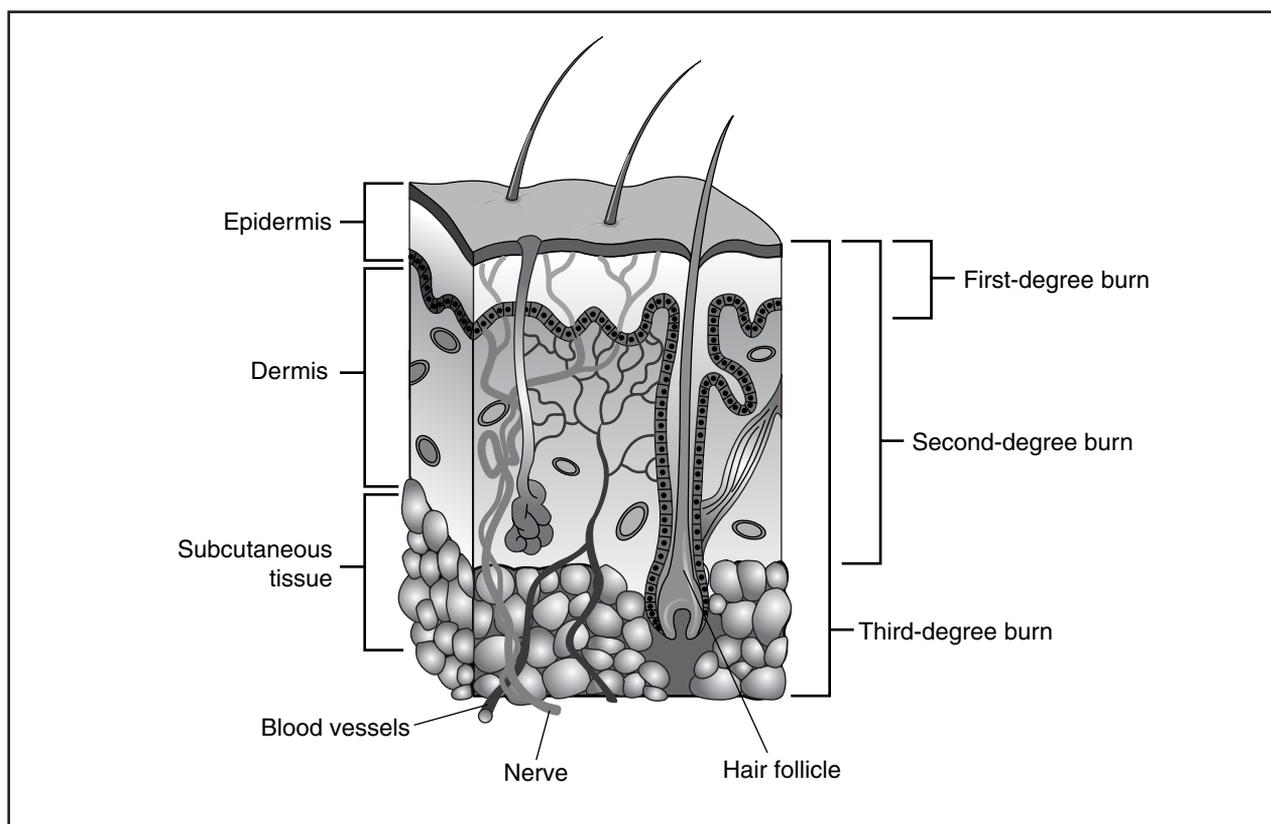
example, Tylenol), or ibuprofen (for example, Advil) may be taken to ease pain and relieve inflammation. Aspirin should not be given to persons under 18 years of age. A doctor should be consulted if any of these signs of infection appear:

- increased warmth, redness, pain, or swelling
- pus or similar drainage from the wound
- swollen lymph nodes
- red streaks spreading away from the burn.

In situations where a person has received moderate or critical burns, lifesaving measures take precedence over burn treatment, and emergency medical assistance must be called. A person with serious burns may stop breathing, and artificial respiration (also called mouth-to-mouth resuscitation or rescue breathing) should be immediately administered. Also, a person with burns covering more than 12% BSA is likely to go into shock. Shock may be prevented by laying the person down and elevating the feet about 12 in (30 cm). Burned arms and hands should also be raised higher than the person's **heart**.

In rescues, a blanket may be used to smother any flames as a person is removed from danger. A person whose clothing is on fire should stop, drop, and roll, or be assisted in lying flat on the ground and rolling to put out the fire. Afterwards, only burned clothing that comes off easily should be removed; any clothing embedded in the burn should not be disturbed. Removing any smoldering apparel and covering the person with a light, cool, wet cloth, such as a sheet but not a blanket or towel, will stop the burning process.

At the hospital, the staff will provide further medical treatment. A tube to aid breathing may be inserted if the burned person's airways or **lungs** have been damaged, as can happen during an explosion or a fire in an enclosed space. Also, because burns dramatically deplete the body of fluids, replacement fluids are administered intravenously. The burned person is also given **antibiotics** intravenously to prevent infection, and may also receive a tetanus shot, depending on an immunization history. Once the burned area is cleaned and treated with antibiotic cream or ointment, it is covered in sterile bandages, which should be changed two to three times a day. Surgical removal of dead tissue (debridement) also takes place. As burns heal, thick, taut scabs (eschar) form, which the doctor may have to cut to improve **blood** flow to the more elastic, healthy tissue beneath. The burned person will also undergo physical and **occupational therapy** to keep the burned areas from becoming inflexible and to minimize scarring.



There are three classifications of burns: first-degree, second-degree, and third-degree burns. (Illustration by Electronic Illustrators Group.)

In cases where the skin has been so damaged that it cannot properly heal, a skin graft is usually performed. A skin graft involves taking a piece of skin from an unburned portion of a burned person's body (autograft) and transplanting it to the burned area. When doctors cannot immediately use the person's own skin, a temporary graft is performed using the skin of a human donor (allograft), either alive or dead, or the skin of an animal (xenograft), usually that of a pig.

A burned person also may be placed in a hyperbaric chamber, if one is available. In a hyperbaric chamber (which can be a specialized room or enclosed space), the person is exposed to pure oxygen under high pressure, which can aid in healing. However, for this therapy to be effective, an injured person must be placed in a chamber within 24 hours of being burned.

Chemical burn treatment

Burns from liquid chemicals must be rinsed with cool water for at least 15 minutes to stop the burning process. Any burn to the eye must be similarly flushed with water. In cases of burns from dry chemicals such as

lime, the powder should be completely brushed away before the area is washed. Any clothing that may have absorbed the chemical should be removed. The burn should then be loosely covered with a sterile gauze pad and the person taken to a hospital for further treatment. A physician may be able to neutralize the offending chemical with another before treating the burn like a thermal burn of similar severity.

Electrical burn treatment

At the site of an accident, before electrical burns are treated, the power source must be disconnected if possible, and the person moved away from it to keep the individual giving aid from being electrocuted. Lifesaving measures again take priority over burn treatment, so breathing must be checked and assisted, if necessary. Electrical burns should be loosely covered with sterile gauze pads and the person taken to a hospital for further treatment.

Alternative treatment

In addition to the excellent treatment of burns provided by traditional medicine, some alternative

KEY TERMS

Debridement—The surgical removal of dead tissue.

Dermis—The basal layer of skin; it contains blood and lymphatic vessels, nerves, glands, and hair follicles.

Epidermis—The outer portion of skin, made up of four or five superficial layers.

Shock—An abnormal condition resulting from low blood volume due to hemorrhage or dehydration. Signs of shock include rapid pulse and breathing, and cool, moist, pale skin.

approaches may be helpful as well. (Major burns should always be treated by a medical practitioner.) The homeopathic remedies *Cantharis* and *Causticum* can assist in burn healing. A number of botanical remedies, applied topically, can also help burns heal. These include aloe (*Aloe barbadensis*), oil of St.-John's-wort (*Hypericum perforatum*), calendula (*Calendula officinalis*), comfrey (*Symphytum officinale*), and tea tree oil (*Melaleuca* spp.). Supplementing one's diet with **vitamin C**, **vitamin E**, and **zinc** also is beneficial for wound healing.

Prognosis

The prognosis is dependent upon the degree of a burn, the amount of body surface covered, whether critical body parts were affected, any additional injuries or complications like infection, and the promptness of medical treatment. Minor burns may heal in five to 10 days with no scarring. Moderate burns may heal in 10–14 days and may leave some scarring. Critical or major burns take more than 14 days to heal and will leave significant scarring. Scar tissue may limit mobility and functionality, but **physical therapy** may overcome these limitations. In some cases, additional surgery may be advisable to remove scar tissue and restore appearance.

Health care team roles

First aid is often administered at the scene of a burn. Paramedics may provide additional treatment and support as they transport a burned person to a hospital or burn center. Emergency physicians or surgeons provide care in a hospital setting. Family physicians may provide care for minor burns in their offices. Nurses provide supportive care. Physical therapists may provide therapy. Counselors, psychologists, or psychiatrists often provide

support after a serious burn occurs. Plastic surgeons may reconstruct severely burned areas of the body.

Prevention

Burns are commonly received in residential fires. Properly placed and working smoke detectors in combination with rapid evacuation plans will minimize a person's exposure to smoke and flames in the event of a fire. Children must be taught never to play with matches, lighters, fireworks, gasoline, or cleaning fluids.

Burns by scalding with hot water or other liquids may be prevented by setting the water heater thermostat no higher than 120°F (49°C), checking the temperature of bath water before getting into the tub, and turning pot handles on the stove out of the reach of children. Care should be used when removing covers from pans of steaming foods and when uncovering or opening foods heated in a microwave oven.

Thermal burns are often received from electrical appliances. Care should be exercised around stoves, space heaters, irons, and curling irons.

Sunburns may be avoided by the liberal use of a sunscreen containing either an opaque active ingredient, such as zinc oxide or titanium dioxide or a nonopaque active ingredient such as PABA (para-aminobenzoic acid) or benzophenone. Hats, loose clothing, and umbrellas also provide protection, especially between 10 A.M. and 3 P.M. when the most damaging ultraviolet rays are present in direct sunlight.

Electrical burns may be prevented by covering unused electrical outlets with safety plugs and keeping electrical cords away from infants and toddlers who might chew on them. Persons should also seek shelter indoors during a thunderstorm to avoid being struck by lightning.

Chemical burns may be prevented by wearing protective clothing, including gloves and eye shields. Chemical agents should always be used according to the manufacturer's instructions and properly stored when not in use.

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American Academy of Emergency Medicine. 611 East Wells Street, Milwaukee, WI 53202. (800) 884-2236. Fax: (414) 276-3349. <<http://www.aaem.org>>.

American Academy of Family Physicians. 11400 Tomahawk Creek Parkway, Leawood, KS 66211-2672. (913) 906-6000. <<http://www.aafp.org>>.

American Academy of Pediatrics. 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. Fax: (847) 434-8000. <<http://www.aap.org/default.htm>>.

American College of Surgeons. 633 North St. Clair Street, Chicago, IL 60611-32311. (312) 202-5000. Fax: (312) 202-5001. <<http://www.facs.org>>.

American Medical Association. 515 N. State Street, Chicago, IL 60610. (312) 464-5000. <<http://www.ama-assn.org>>.

International Shrine Headquarters, 2900 Rocky Point Dr., Tampa, FL 33607-1460, Phone: (813) 281-0300, <<http://www.shrinershq.org/index.html>>.

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Bursitis

Definition

Bursitis is the painful inflammation of the bursa, a padlike sac of fluid found in areas of the musculoskeletal system that are subject to friction, such as joints. Bursae cushion the movement between the bones, tendons, and muscles near the joints. Bursitis is most often caused by repetitive movement performed by individuals in the course of their occupations, activities of daily living, or recreational activities.

Description

There are more than 150 bursae in the human body. Usually bursae are present from birth, but they may form in response to repeated excessive pressure. Each sac contains a small amount of synovial fluid, a clear liquid that acts as a lubricant. Inflammation causes **pain** on movement. The most common site for bursitis is the subdeltoid (shoulder), but it also is seen in the olecranon (elbows), trochanteric (hips), knees, heels (Achilles), and toes. The affected area may be referred to as "frozen," because movement is so limited. In the knee there are four bursae, and all can become inflamed with overuse.

Causes and symptoms

The most common cause of bursitis is repeated physical activity using excessive force, but it may also flare up for no known reason. Bursitis may be caused by trauma, proximity to inflammatory disease such as rheumatoid arthritis and **gout**, and it is also associated with acute or chronic **infection**.

Pain and tenderness are common symptoms. If the affected joint is close to the skin, as with the shoulder, knee, elbow, or Achilles tendon, swelling and redness are seen and the area over the joint may feel warm to the touch. The bursae around the hip joint are deeper, and swelling is not obvious. Movement may be limited and is painful. In the shoulder, it may be difficult for the patient

KEY TERMS

Arthritis—The collective name for approximately 100 diseases that are collagen related and inflammatory in origin. The most common are osteoarthritis and rheumatoid arthritis.

Diabetes mellitus—A metabolic disease caused by a deficiency of insulin in type 1 diabetes. Insulin is essential to process carbohydrates in the body. In type 2 diabetes, development of resistance to existing insulin levels results in inadequate blood glucose control.

Gout—A hereditary metabolic disease that is a form of arthritis and causes inflammation in the joints of the distal extremities (the feet and hands). It is more common in men.

Inflammation—The reaction of tissue to injury, or the body's immune response to disease.

Kinesiology—The science or study of movement.

to raise the arm away from the side of the body. When the shoulder is affected, patients report difficulty with activities such as putting on clothes or combing their hair.

In acute bursitis, symptoms appear suddenly. With chronic bursitis, pain, tenderness, and limited movement flare up after **exercise** or strain.

Diagnosis

When a patient has pain in a joint, a careful **physical examination** is performed to determine which type of movement is affected and if there is any swelling. Bursitis will not show up on x rays, although sometimes **calcium** deposits in the joint are seen. If infection is suspected, aspiration of the bursa should be performed and the fluid sent to the laboratory for cell count, **gram stain** and culture. In most cases, the fluid will not be clear. It can be tested for the presence of **bacteria**, which indicate an infection, and crystals, which could indicate gout. In instances where the diagnosis is difficult, a local anesthetic is injected into the painful spot. If the discomfort stops temporarily, then bursitis is suspected.

Treatment

Conservative treatment of bursitis is usually effective. The application of heat, rest, and immobilization of the affected joint area is the first step. A sling may be used for a shoulder injury, and a cane is helpful for patients with hip problems. **Nonsteroidal anti-inflam-**

matory drugs (NSAIDs) like aspirin, ibuprofen, and naproxen, obtained without a prescription, may relieve pain and inflammation. Once the pain decreases, mild to moderate exercise of the affected area may begin. If muscles proximal (near) to the affected joint have become weak or stiff because of the disease or prolonged immobility, exercises to build strength and improve movement are prescribed. A physician or physical therapist prescribes an effective exercise regimen.

If the bursitis is related to an inflammatory condition such as arthritis or gout, then management of the underlying disease is necessary to control the bursitis.

When bursitis does not respond to conservative treatment, an injection into the joint of a long-acting corticosteroid preparation, such as prednisone, may offer the patient immediate and lasting relief. The corticosteroid, which acts to reduce inflammation, is mixed with a local anesthetic and works on the joint within minutes. Usually one injection is all that is needed. It is important that the patient does not overuse the joint too soon because the pain has gone. A gradual build up to normal use is necessary.

Surgery to remove the damaged bursa may be performed in extreme cases.

If bursitis is caused by an infection, then additional treatment is needed. Septic bursitis may be caused by the presence of *Staphylococcus aureus*. This is confirmed by examining a sample of the fluid in the bursa and sending it for culture. Septic bursitis requires treatment with **antibiotics** specifically for the infection, and these antibiotics may be taken by mouth, injected into a muscle, or administered intravenously. The bursa must be drained by needle aspiration two or three times during the first week of treatment. When a patient has such a serious infection, there may be underlying causes such as previously undetected diabetes, or compromised **immune system** defense function, a byproduct of several diseases and some medications, e.g. **chemotherapy**.

Alternative treatments take into consideration the role of diet in bursitis. Dietary changes and vitamin supplements may be helpful. The use of herbs, **homeopathy**, aromatherapy, and **hydrotherapy** may help to relieve symptoms. Ginger has been used to reduce inflammation. Acupuncture has been shown to be effective treatment for hip and shoulder pain caused by bursitis and other conditions. Other therapies that deal effectively with musculoskeletal problems may also be helpful, such as osteopathy, massage, chiropractic, and applied kinesiology.

Health care team roles

The diagnosis of bursitis is usually made by the primary care physician or mid-level practitioner (physician assistant or nurse practitioner). Laboratory technologists are involved in determining whether infection is present in joint fluid and radiology technologists perform radiographic or imaging studies. Nurses, physical therapists, **physical therapy** assistants, and exercise physiologists offer patients instruction about movements to strengthen the muscles surrounding joints and ways to prevent future injuries. For bursitis of the elbow or wrist, an occupational therapist may supervise recovery.

Prognosis

Bursitis usually responds well to treatment, but it may develop into a chronic condition if the underlying cause is not corrected.

Prevention

Aggravating factors should be eliminated if possible, to prevent recurrent bursitis. Over exercising or the repetition of a movement that triggers the condition should be avoided. Regular exercises designed to strengthen the muscles around the joint will also help. When engaging in repetitive tasks, patients should be

advised to take frequent breaks and alternate activities using different parts of the body. To cushion the joints, it is advisable to use cushioned chairs when sitting and foam kneeling pads for the knees. Leaning on the elbows, and kneeling or sitting on a hard surface for a long period of time should be avoided. Avoiding high heels can help female patients avoid bursitis in the heel, and patients should be counseled to replace running shoes as soon as the alignment of the old ones deteriorates with wear.

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Barbara Wexler

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C

C-reactive protein tests *see* **Cardiac marker tests**

CAD *see* **Coronary artery disease**

Caffeine

Description

Caffeine is a drug that stimulates the **central nervous system** (CNS). Caffeine is found naturally in coffee, kola seed kernels or nuts (*Cola nitida*), and a variety of teas. Other foods and beverages, such as chocolate and soft drinks, also contain caffeine, and the drug can be purchased in over-the-counter tablet and capsule form (No Doz, Overtime, Pep-Back, Quick-Pep, Caffedrine, and Vivarin). Some prescription **pain** relievers, medicines for migraine headaches, and **antihistamines** also contain caffeine.

General use

Caffeine makes people more alert, less drowsy, and improves coordination. Combined with certain pain relievers or medicines for treating **migraine headache**, caffeine makes those drugs work more quickly and effectively. Caffeine alone can also help relieve headaches. Antihistamines are sometimes combined with caffeine to counteract the drowsiness caused by those drugs. Caffeine is also sometimes used to treat other conditions, including breathing problems in newborns and in young babies after surgery.

Preparations

Kola can be prepared in decoction or tincture form. To prepare a decoction, mix 1-2 tsp of powdered kola nut in a cup of water. After bringing the water to a boil, sim-

mer the decoction on low heat for 10-15 minutes. Tinctures of kola nut can be purchased at many health food stores or mail order suppliers. A tincture is an herbal preparation made by diluting the herb in alcohol, glycerin, or vinegar. Dosage of kola tincture varies by formula and the symptoms or illness it is supposed to treat, but an average recommended dosage might be 1-4 ml three times daily. Powdered kola nut and kola tinctures should be stored in airtight containers away from direct light to maintain potency.

For over-the-counter caffeine preparations, adults and children age 12 years and older should take 100-200 mg no more than every three to four hours. In timed-release form, the dose is 200-250 mg once a day. Timed-release forms should not be taken less than six hours before bedtime. Caffeine pills or tablets are typically not recommended for children under 12 years of age.

Precautions

If caffeine is administered in a kola preparation, kola should always be obtained from a reputable source that observes stringent quality control procedures and industry-accepted good manufacturing practices. Consumers should look for the designations “U.S.P.” (U.S. Pharmacopeia) or “NF” (National Formulary) on kola nut labeling. Herbal preparations prepared under USP or NF guidelines meet nationally recognized strength, quality, purity, packaging, and labeling standards as recommended by the United States Food and Drug Administration (FDA).

Avoid taking too much caffeine when it is being taken as an over-the-counter drug. Consider how much caffeine is being taken in from coffee, tea, chocolate, soft drinks, and other foods that contain caffeine. Check with a pharmacist or healthcare professional to find out how much caffeine is safe to use.

Caffeine cannot replace sleep and should not be used regularly to stay awake as the drug can lead to more serious **sleep disorders**, like insomnia.

KEY TERMS

Arrhythmia—Abnormal heart rhythm.

Central nervous system (CNS)—The brain, spinal cord, and nerves throughout the body.

Decoction—An herbal extract produced by mixing an herb in cold water, bringing the mixture to a boil, and letting it simmer to evaporate the excess water. The decoction is then strained and drunk hot or cold. Decoctions are usually chosen over infusion when the botanical or herb in question is a root, seed, or berry.

Palpitation—Rapid, forceful, throbbing, or fluttering heartbeat.

Tinctures—A liquid extract of an herb prepared by steeping the herb in an alcohol and water mixture. Tinctures can also be prepared using vinegar or glycerin, instead of alcohol.

Withdrawal symptoms—A group of physical or mental symptoms that may occur when a person suddenly stops using a drug to which he or she has become dependent.

People who use large amounts of caffeine over long periods build up a tolerance to it. When that happens, they have to use more and more caffeine to get the same effects. Heavy caffeine use can also lead to dependence. If an individual stops using caffeine abruptly, withdrawal symptoms may occur, including headache, fatigue, drowsiness, yawning, irritability, restlessness, vomiting, or runny nose. These symptoms can go on for long as a week.

If taken too close to bedtime, caffeine can interfere with sleep. Even if it does not prevent a person from falling asleep, it may disturb sleep during the night.

The notion that caffeine helps people sober up after drinking too much alcohol is a myth. In fact, using caffeine and alcohol together is not a good idea. The combination can lead to an upset **stomach**, nausea, and vomiting.

Older people may be more sensitive to caffeine and thus more likely to have certain side effects, such as irritability, nervousness, **anxiety**, and sleep problems.

Allergies

Anyone with **allergies** to foods, dyes, preservatives, or to the compounds aminophylline, dyphylline, oxi-phylline, theobromine, or theophylline should check with a physician before using caffeine. Anyone who has ever

had an unusual reaction to caffeine should also check with a physician before using it again.

Pregnancy

Caffeine can pass from a pregnant woman's body into the developing fetus. Although there is no evidence that caffeine causes birth defects in people, it does cause such effects in laboratory animals given very large doses (equal to human doses of 12-24 cups of coffee a day). In humans, evidence exists that doses of more than 300 mg of caffeine a day (about the amount of caffeine in two to three cups of coffee) may cause **miscarriage** or problems with the baby's **heart** rhythm. Women who take more than 300 mg of caffeine a day during **pregnancy** are also more likely to have babies with low birth weights. Any woman who is pregnant or planning to become pregnant should check with her physician before using caffeine.

Breastfeeding

Caffeine passes into breast milk and can affect the nursing baby. Nursing babies whose mothers use 600 mg or more of caffeine a day may be irritable and have trouble sleeping. Women who are breast-feeding should check with their physicians before using caffeine.

Other medical conditions

Caffeine may cause problems for people with these medical conditions:

- peptic ulcer
- heart arrhythmias or palpitations
- heart disease or recent heart attack (within a few weeks)
- high **blood pressure**
- liver disease
- insomnia (trouble sleeping)
- anxiety or panic attacks
- agoraphobia (fear of being in open places)
- premenstrual syndrome (PMS)

Side effects

At recommended doses, caffeine can cause restlessness, irritability, nervousness, shakiness, headache, light-headedness, sleeplessness, nausea, vomiting, and upset stomach. At higher than recommended doses, caffeine can cause excitement, agitation, anxiety, confusion, a sensation of light flashing before the eyes, unusual sensitivity to touch, unusual sensitivity of other senses, ringing in the ears, frequent urination, muscle twitches or

tremors, heart arrhythmias, rapid heartbeat, flushing, and convulsions.

Interactions

Using caffeine with certain other drugs may interfere with the effects of the drugs or cause unwanted—and possibly serious—side effects. Certain drugs interfere with the breakdown of caffeine in the body. These include oral contraceptives that contain estrogen, the antiarrhythmia drug mexiletine (Mexitol), the ulcer drug cimetidine (Tagamet), and the drug disulfiram (Antabuse), used to treat **alcoholism**.

Caffeine interferes with drugs that regulate heart rhythm, such as quinidine and propranolol (Inderal). Caffeine may also interfere with the body's absorption of **iron**. Anyone who takes iron supplements should take them at least an hour before or two hours after using caffeine.

Serious side effects are possible when caffeine is combined with certain drugs. For example, taking caffeine with the decongestant phenylpropanolamine can raise **blood** pressure. Very serious heart problems may occur if caffeine and monoamine oxidase inhibitors (MAO) are taken together. These drugs are used to treat **Parkinson's disease**, depression, and other psychiatric conditions. Consult with a pharmacist or physician about which drugs can interact with caffeine.

Because caffeine stimulates the nervous system, anyone taking other **central nervous system stimulants** should be careful about using caffeine.

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Office of Dietary Supplements. National Institutes of Health. Building 31, Room 1B25, 31 Center Drive, MSC 2086, Bethesda, MD 20892-2086. (301) 435-2920. Fax: (301) 480-1845. <<http://odp.od.nih.gov/ods/>> (Includes on-line access to International Bibliographic Information on Dietary Supplements (IBIDS), a database of published, international scientific literature on dietary supplements and botanicals).

Paula Ford-Martin

Caisson disease see **Decompression sickness**

Calcium

Description

As the most plentiful mineral in the body, calcium plays a key role in the development and maintenance of bones and teeth. Calcium enables the contraction of muscles, including the function of the body's most important muscle, the **heart**. It is also essential for normal **blood** clotting, proper nerve impulse transmission, and the appropriate support of connective tissue.

Almost every segment of the population—women, children, teenagers, men, unborn babies, and the elderly—benefit from calcium in their daily diet. The mineral is an important dietary supplement for those who are undergoing significant periods of bone growth, such as in childhood, and during **pregnancy** and breastfeeding.

Calcium is an effective weapon for the aging population as they combat **osteoporosis**. A condition that simply means “porous bones,” osteoporosis attacks bones when they are their most vulnerable. As the body ages, bones lose more calcium, and it becomes vital to supplement the diet with calcium in order to encourage bone growth and prevent or slow down the process of osteoporosis.

General use

While the body relies on the presence of calcium for many of its everyday functions, the number of reasons why the mineral should be supplemented in the diet are numerous. Calcium is beneficial to everyone, but research has shown that women may benefit more than others. A study in the October 1999 issue of the journal *Obstetrics & Gynecology* found that pregnant women who do not get enough calcium in their diet can increase the bone mineral content of their fetus by about 15% by taking 1,300 mg of a calcium supplement per day during their second and third trimesters. For those women who already consume enough calcium, the additional supplements do not have this effect. Additional research shows that calcium deficiencies lead to preeclampsia during pregnancy, causing high **blood pressure**, swelling, and weight gain greater than one pound per day. The risk of preeclampsia developing lowers by 45–75% for women who receive calcium supplementation.

Premenstrual syndrome (PMS) is another condition women face that may be alleviated by the use of calcium supplements. Researchers at the National Institute of Mental Health (NIMH) concluded that those women who took 1,200 mg of calcium per day reduced their overall PMS symptoms by more than 50%. In the study, calcium supplementation led to the reduction of psychological

PMS symptoms (such as mood swings) by 45%, food cravings by 54%, and bloating and water retention by 36%.

A 1999 study reported that researchers have found that increasing the amount of daily calcium consumed by women may reduce their risk of stroke. Those women in the Nurses' Health Study who took more than 400 mg of calcium daily were at the lowest risk for a stroke, while those who consumed more than 600 mg each day did not have an increased benefit. Researchers believe that the risk of stroke is reduced by calcium from decreased cholesterol levels, or by stopping the formation of blood clots that cause strokes.

For elderly postmenopausal women, the prevention of osteoporosis becomes critical. In order to maintain bone mass during this time, a study conducted in 1999 concluded that a low-dose hormone replacement therapy (HRT) combined with calcium and **vitamin D** supplementation is an effective therapeutic option for prevention of osteoporosis. Estriol, which is used in HRT, appears to be helpful in controlling menopausal symptoms. Results from research regarding this use of estriol on bone density have been contradictory, according to the *Alternative Medicine Review*, with the results showing the most effectiveness coming from Japanese studies.

Calcium alone is frequently prescribed with estrogen at the beginning of **menopause** to treat or prevent osteoporosis. This therapy is recommended to guard against the increased loss of calcium in the bones due to increasing age. As bones lose more calcium they become dense and more brittle, and more vulnerable to the attack of osteoporosis. This condition is most common in people over 70, and in women after menopause, where it may increase the risk of broken hips, ribs, and pelvis, and the weakening of other bones. Increased physical **exercise** is also important for bone strengthening.

Calcium has also been shown to be beneficial to the colon. Among those people taking calcium supplements, research points to a modest reduction in the recurrence of polyps in their colons. Colon polyps are benign tumors that often turn cancerous. Researchers think that calcium binds to carcinogens, preventing abnormal cell growth.

Stemming from its active role in building bone density throughout the body, calcium may prove particularly beneficial for strengthening of the jawbone. Dental researchers at the State University of New York at Buffalo report that calcium supplementation may prevent periodontal disease as it builds a strong jawbone. Periodontal, or gum, disease is an **infection** caused by **bacteria** that deposits in pockets between the teeth and gums, and is the leading cause of tooth loss in the United States. As the infection progresses, the jawbone that

holds a tooth in place is eventually destroyed, causing the tooth to loosen and fall out. The researchers contend that calcium's overall bone-building role would equal a stronger jawbone that would better fight off gum disease.

While supplements of calcium can be found in many forms, research has shown a promising benefit if it is obtained from dairy foods, rather than supplements or leafy greens—calcium in the form of dairy may actually prevent weight gain. Those in the study who consumed at least 1,000 mg of calcium a day (equaling about 3 cups, or 750 ml of skim milk), gained six to seven fewer pounds over two years than those with low-calcium diets. Researchers of Purdue University speculate that calcium probably prevents weight gain by increasing the breakdown of body fat and decreasing its formation. It is important to note, however, that dairy products should be consumed in moderation, as other research conducted has indicated that dairy is not necessarily a good, absorbable calcium source.

Calcium is proving essential to those children around the world who are struck by rickets. Rickets is a deficiency condition in children that effects developing cartilage and newly formed bone throughout the body causing deformities. Often thought to be a result of the inadequate intake of vitamin D from dietary sources or lack of exposure to sunlight, research reported in 2000 has found that children with rickets respond well to calcium supplementation. While rickets is rare in the United States and Europe, it remains a problem in many parts of the world. Researchers conclude that effective treatment for the condition is calcium supplementation alone, or in combination with vitamin D. Osteomalacia, or the adult form of rickets, also responds to calcium supplementation.

Preparations

Calcium may be supplemented in the diet in a variety of ways. A numerous amount of foods are rich in calcium, including dairy products (such as milk, yogurt, and cheese) and leafy green vegetables like turnip greens, broccoli, kale, and collards. Canned salmon, sardines, shrimp, and tofu are also high in calcium. More foods are being fortified with calcium, making it easier to ensure the proper amount of the mineral is consumed. Calcium-fortified foods range from cranberry juice cocktail, cereal and waffles, to orange juice and flour. With almost every segment of the population consuming too little calcium, researchers recommend calcium-fortified foods to increase daily calcium intake.

While the types of food calcium may be obtained from continues to increase, most people still lack enough of the essential mineral. For those who are not getting enough calcium from foods, supplements are an accept-

able alternative. The chemical form of calcium supplements come in five varieties: carbonate, citrate, lactate, phosphate, chelate, and citrate malate. The supplements are available as tablets, syrup, or suspension form. Calcium supplements should be stored at room temperature and away from moisture and sunlight. It should not be stored in the bathroom, and the liquid forms should not be frozen.

Experts state that calcium is best absorbed from the citrate malate form, or the type of calcium found in some juices, but they recommend calcium carbonate for the overall amount of calcium it offers and its affordability. Calcium carbonate can be found in **antacids**, and it is absorbed better when taken with meals. Food slows down the time it takes substances to travel through the gut, giving the calcium more time to be absorbed. Absorption is key for the proper functioning of calcium. Sufficient levels of vitamin D and hydrochloric acid in the **stomach**, and the presence of other **minerals**, such as magnesium and phosphorous are essential for quick absorption.

The body may also be better able to absorb calcium when taken along with ingredients extracted from chicory root. Research indicates that raftilin inulin and raftilose oligofructose, both extracts from chicory root, are dietary fibers that are not digested in the stomach or the **small intestine**. Instead, they are fermented by Bifidobacteria in the colon—beneficially leading to increased calcium absorption throughout the body, with emphasis on bone tissue. Additionally, oligofructose improves the texture and mouthfeel while improving taste and fruit flavors in low-fat yogurts. Inulin is used for fat replacement and fiber enrichment of reduced-fat and fat-free sour cream and whipped topping.

There are many ways to ensure calcium is part of a daily diet, but it is important that the recommended daily allowance (RDA), or appropriate dosage of the mineral be followed. The RDA of calcium for adults is 800 mg; pregnant women and young adults should be certain their intake equals 1,200 mg per day. Adults over 50 should increase their intake to 1,000 mg per day with supplements that include vitamin D.

Calcium supplements may be taken with a large glass of water during or after a meal. Tablets in chewable form must be chewed thoroughly before swallowing, and effervescent tablets should be diluted in cold water or juice before taking. It is recommended that other medications be taken two hours after any calcium supplement. The simultaneous intake of calcium may interfere with the absorption of other drugs. Do not take more than 500 mg of calcium at one time for the best absorption of the mineral.

Precautions

When adding calcium supplements to the diet, it is recommended that it not be taken within one to two hours of eating bran, or whole grain cereals or breads. Large amounts of alcohol or **caffeine** containing beverages or tobacco should be avoided. Large amounts of calcium, phosphates, magnesium, or vitamin D in medication or dietary supplements should not be taken unless directed by a physician. Those with **diarrhea**, stomach trouble, parathyroid disease, sarcoidosis, or **kidney stones** should consult with their physician before taking calcium.

Side effects

Calcium is typically well tolerated by those who add it to their diets, but if the mineral is taken in high levels it can cause several side effects, including: nausea, vomiting, loss of appetite, constipation, stomach **pain**, thirst, dry mouth, increased urination, and weakness. While these side effects are rare, it is even more unlikely to experience the life-threatening symptoms of an irregular or very slow heart beat. If these dangerous symptoms appear while taking calcium, use of the mineral should be discontinued and emergency treatment should be sought. An **overdose** of a calcium supplement may lead to confusion, irregular heartbeat, depression, bone pain, or **coma**.

Interactions

It is important that all over-the-counter (OTC) or prescription medications are reviewed with a physician before beginning calcium supplement.

According to the *Complete Guide to Prescription & Nonprescription Drugs*, 1999 Edition, by H. Winter Griffith, the following are some of the drugs that may cause possible interactions if taken with calcium:

- alendronate
- anticoagulants
- calcitonin
- calcium-containing medicines
- chlorpromazine
- oral contraceptives
- corticosteroids
- digitalis preparations
- diuretics, thiazide
- estrogens
- etidronate

KEY TERMS

Carcinogen—Any substance or agent that produces or instigates cancer.

Preeclampsia—A toxemia of pregnancy that causes increasing hypertension, headaches, and swelling of the lower extremities.

Sarcoidosis—A disease of unknown etiology which causes widespread lesions that may affect any organ or tissue of the body.

Stroke—A hemorrhage into the brain, formation of a clot in an artery, or rupture of an artery that causes sudden loss of consciousness, followed by paralysis.

- iron supplements
- meperidine
- mexiletine
- nalidixic acid
- nicardipine
- nimodipine
- oxyphenbutazone
- para-aminosalicylic acid (PAS)
- penicillins
- pentobarbital
- phenylbutazone
- phenytoin
- pseudoephedrine
- quinidine
- salicylates

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Food and Drug Administration, Office of Consumer Affairs, HFE-88, Rockville, MD 20857.

Beth Kapes

Calcium carbonate *see* **Antacids**

Calorie-modified diet *see* **Diet therapy**

Cancer

Definition

Cancer is characterized by uncontrolled growth of cells in the body and the ability of these malignant cells to spread (metastasize) to distant sites within the body. If the spread is not controlled, cancer can result in death. Cancer is not just one disease but a group of almost one hundred different types of malignant diseases.

Description

Cancer, by definition, is a disease of the genes. A gene is a small part of DNA, which is the instruction manual of the cell. Genes hold the instructions to make **proteins**, which carry out many of the body's functions. It is these proteins that allow the human body to carry out all the processes that permit people to breathe, think, move, etc.

Throughout people's lives the cells in their bodies grow, divide, and replace themselves. Many genes produce proteins that are involved in controlling the processes of cell growth and division. An alteration (mutation) to the DNA molecule can disrupt some of the genes on the DNA molecule and produce faulty proteins. This causes a cell to lose restraint on growth. The abnormal cell begins to divide uncontrollably and eventually forms a

new growth known as a tumor or neoplasm (medical terms for cancer meaning new growth). In a healthy body the **immune system** can recognize neoplastic (abnormal) cells and destroy them before they get a chance to divide. Even so, some mutant cells may escape immune detection and survive to develop into cancerous growths.

Tumors are divided into two general categories: benign or malignant. A benign tumor is slow growing and does not spread or invade surrounding tissue. Once it is removed it doesn't usually recur. A malignant tumor, on the other hand, invades surrounding tissue and can spread to other parts of the body. Malignant tumors can be removed; however, if the cancer cells have spread to the surrounding tissues, the tumor is likely to recur.

A majority of cancers are caused by changes in the cell's DNA that are due to the environment. Environmental factors that are responsible for causing the initial mutation in the DNA are called carcinogens. Internal factors can cause cancer as well. Certain hormones have been shown to have an effect the growth or control of a particular cell line. Hormones are substances made by one organ and passed through the bloodstream to perform a function in another organ.

While there is scientific evidence that both environmental and genetic factors play a role in most cancers, approximately 5–10% of all cancers are classified as hereditary (genetic). This means a faulty gene that leads to a cancer is passed from parent to child. This poses a greater risk for that particular type of cancer in certain descendants of the family. However, having a cancer-causing gene does not necessarily mean that person will automatically get cancer. Rather, it means that person is predisposed to a type of cancer, or more likely to get this cancer when compared to the general population. Cancers known to have a hereditary tendency in some cases include **breast cancer**, colon cancer, ovarian cancer, skin cancer, and **prostate cancer**.

Aside from genes, certain inherited physiological traits can contribute to cancers. For example, inheriting fair skin makes a person more likely to develop skin cancer, but only if they also have prolonged exposure to intensive sunlight.

There are many different types of cancers. Some of the most common types include:

- **Carcinomas**. These cancers arise in the epithelium (layers of cells in the skin covering the body's surface and lining the internal organs and various glands). About 80% of human cancers fall into this category. Carcinomas can be subdivided into two subtypes: adenocarcinomas, which are cancers that develop in an organ or a gland; and squamous cell carcinomas, cancers that originate in the skin.

- **Melanomas**. This form also originates in the skin, usually in the pigment cells (melanocytes), and can quickly metastasize to internal organs.
- **Sarcomas**. Cancers of the supporting tissues of the body, such as bone, muscle, cartilage, and fat.
- **Leukemias**. Cancers of the **blood** or blood-forming organs.
- **Lymphomas**. Cancer of the **lymphatic system**, the network of vessels and nodes that acts as a filtration system, distributing nutrients to blood and tissue and preventing **bacteria** and other foreign substances from entering the bloodstream.
- **Gliomas**. Cancers of nerve tissue.

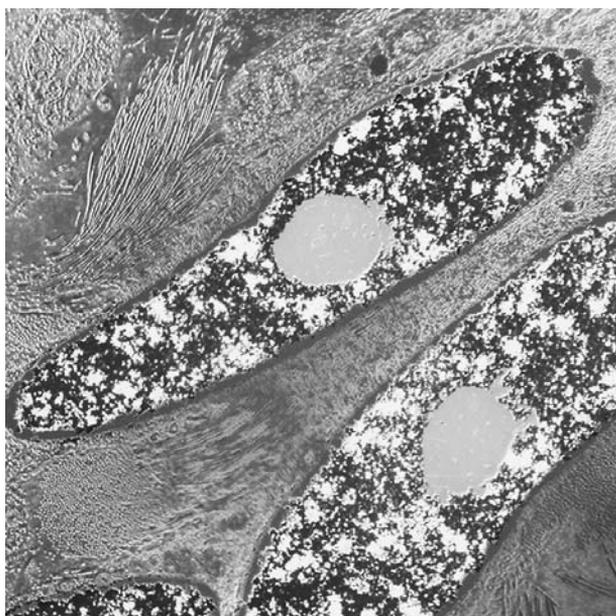
The most common cancers are skin cancer, **lung cancer**, colon and rectal (colorectal) cancer, breast cancer (in women), and prostate cancer (in men). In addition, cancer of the **kidneys**, ovaries, uterus, **pancreas**, bladder, and blood and lymph-node cancer (leukemias and lymphomas) are also included among the 12 major cancers that affect most Americans.

Almost every tissue can give rise to cells that cause cancer and each of these cancers is very different in its symptoms and prognosis. However, there are basic and similar genetic processes that lead to tumor growth in the human body. Genes are responsible for producing proteins that regulate cell growth and division. When these genes do not function properly, the proteins are abnormal and cells can grow uncontrollably. This results in the formation of a tumor. As more genetic mutations (changes) occur in this tumor, it becomes more life-threatening and has a greater chance of spreading to other parts of the body.

Three classes of genes appear to play a role in the development of cancer:

- Proto-oncogenes encourage and promote the normal growth and division of cells. When they are defective, they become oncogenes. Oncogenes are overactive proto-oncogenes that cause excessive cell multiplication that can lead to tumors.
- Tumor suppressor genes act as brakes on cell growth. They prevent cells from multiplying uncontrollably. If these genes are defective there is no control over cell growth and tumors can result.
- DNA repair genes ensure that each strand of DNA is correctly copied during **cell division**. When these genes do not function properly, the replicated DNA is likely to have errors. This causes defects in other genes and can lead to tumor formation in some cases.

Approximately 5–10% of cancers have a hereditary component. In these cancers a child does not inherit can-



A transmission electron micrograph (TEM) of two spindle cell nuclei from a human sarcoma. Sarcomas are cancers of the connective tissue (bone, nerves, smooth muscle).

(Photograph by Dr. Brian Eyden, Photo Researchers, Inc. Reproduced by permission.)

cer from the parents. Rather, a predisposition to cancer is inherited. For example, a faulty tumor suppressor gene may be inherited. This gene is not able to control cell growth but the corresponding gene inherited from the other parent is still functional. Cell growth is under control. However, as a child grows up, radiation, pollution, or any other environmental factor could change the functional gene, making it defective as well. Now, neither of these tumor suppressor genes are functioning, and it is likely that a tumor will develop. Defects in proto-oncogenes and DNA repair genes can be inherited, as well, leaving a person more vulnerable to cancer than the general population.

Some cancers seem to run in families. In these cancers there is no specific gene responsible for the clustering of cancer in a family. However, a particular type of cancer may be seen more often than in the general population. It is suggested that this is due to a combination of genetic and environmental factors.

Cancer kills one out of every four Americans. As of 2001 it was the second leading cause of death in the United States, surpassed only by **heart** disease. More than 1.2 million new cases of cancer are diagnosed every year in the United States. The National Cancer Institute estimates that approximately 8.4 million Americans alive in 2001 had a history of cancer. Some of these people were cured while others were still affected with the disease and possibly undergoing treatment.

Anyone is at risk for developing cancer. Since the occurrence of cancer increases as a person ages, most cases are seen in adults middle-aged or older. Nearly 80% of cancers are diagnosed in people 55 years of age and older.

Lifetime risk is the term used to refer to the probability that an individual will develop cancer over the course of his or her lifetime. In the United States men have a one-in-two lifetime risk of developing cancer. For women, the risk is one in three. Overall, African Americans are more likely to develop cancer than Caucasians and are 33% more likely to die of cancer than Caucasians.

The major risk factors for cancer are tobacco, alcohol, diet, sexual and reproductive behavior, infectious agents, family history, occupation, environment, and pollution.

Tobacco

Eighty-to-ninety percent of lung cancer cases occur in smokers. Smoking has also been shown to be a contributory factor in cancers of mouth, pharynx, larynx, esophagus, pancreas, uterine cervix, kidney, and bladder. Smoking accounts for at least 30% of all cancer deaths. Scientists have shown that inhaling secondhand smoke (passive smoking) can increase one's risk of developing cancer.

Alcohol

Excessive consumption of alcohol is a risk factor in certain cancers such as **liver** and breast cancer. Alcohol, in combination with tobacco, significantly increases the chances that an individual will develop mouth, pharynx, larynx, and esophageal cancers. The combined effect of tobacco and alcohol is greater than the sum of their individual effects. This is called synergy.

Diet and physical activity

One-third of all cancer deaths are due to a poor adult diet. High-fat diets have been associated with cancers of the colon and rectum, prostate, endometrium, and possibly breast. Consumption of meat, especially red meat, has been associated with increased cancer at various sites such as the colon and prostate. Additionally, a high-calorie diet and low level of physical activity can lead to **obesity**, which increases the risk for cancer at various sites including the breast, colon and rectum, prostate, kidney, and endometrium.

Sexual and reproductive behavior

The human papilloma virus, a sexually transmitted disease, has been shown to cause cancer of the cervix.

Having many sexual partners and becoming sexually active early has been shown to increase one's chances of contracting this disease and, therefore, developing cervical cancer. In addition, it has also been shown that women who do not have children or those who have children late in life have an increased risk for both ovarian and breast cancer.

Hormone replacement therapy

As women go through **menopause**, a physician may recommend hormone replacement therapy. This involves taking female hormones (called estrogen and progesterone) to control certain symptoms such as hot flashes and vaginal dryness that occur during this time of a woman's life. Taking estrogen alone can increase the risk for uterine cancer. However, progesterone is often prescribed at the same time to counteract the cancerous effects of estrogen. There is a questionable relationship between hormone replacement therapy and breast cancer as well. As of 2001, this relationship was not fully understood.

Family history

Certain cancers tend to occur more commonly among members of a family. Much of the time this seems to happen by chance, or is due to a common family habit such as cigarette smoking or extended sun exposure. However, certain cancers can occur in excess in some families due to a genetic predisposition that is passed from generation to generation. For example, if the BRCA1 gene is defective in a family, members of that family may have an increased risk to develop breast, colon, ovarian, or prostate cancer. Other defective genes can make persons susceptible to other types of cancer. Therefore, inheriting particular genes can increase a person's chance of developing cancer.

Occupational hazards

There is ample evidence that occupational hazards account for 4% of all cancer deaths. For example, asbestos workers have an increased incidence of lung cancer. Similarly, bladder cancer is associated with dye, rubber, and gas workers; skin and lung cancer with people who are smelters, gold miners and arsenic workers; leukemia is seen more frequently in people who work with glue and varnish; **liver cancer** is more prevalent in PVC manufacturers; and lung, bone, and bone marrow cancer is associated with radiologists and uranium miners.

Environment

High-frequency radiation has been shown to cause human cancer. Ultraviolet radiation from the sun

accounts for a majority of melanoma cases. Other sources of radiation are x rays, radioactive substances, and rays that enter the earth's atmosphere from outer space. Virtually any part of the body can be affected by these types of radiation, especially bone marrow and the **thyroid gland**.

Additionally, being exposed to substances such as certain chemicals, metals, or pesticides, can increase the risk of cancer. Asbestos is an example of a well-known carcinogen, increasing the risk for lung cancer. This risk is increased even further for a smoker who is exposed to asbestos over a period of time.

Causes and symptoms

Cancer is a progressive disease and goes through several stages. Each stage can produce a number of symptoms. Unfortunately, many types of cancer do not display any obvious symptoms or cause **pain** until the disease has progressed to an advanced stage. Early signs of cancer are often subtle and are easily mistaken for signs of other less-dangerous diseases.

Despite the fact that there are several hundred different types of cancers producing very different symptoms, the American Cancer Society (ACS) has established the following seven symptoms as possible warning signals of cancer:

- changes in the size, color, or shape of a wart or a mole
- a sore that does not heal
- persistent cough, hoarseness, or sore throat
- a lump or thickening in the breast or elsewhere
- unusual bleeding or discharge
- chronic indigestion or difficulty in swallowing
- any change in bowel or bladder habits

Other diseases can produce similar symptoms. However, it is important to have these symptoms checked as soon as possible, especially if they linger. The earlier a cancer is diagnosed and treated, the better the chance of it being cured. Many cancers, for example breast cancer, may not have any early symptoms. Therefore, it is important to undergo routine screening tests, such as breast self-exams and mammograms.

Diagnosis

If a person has symptoms of cancer, a physician will begin with a complete medical history and a thorough **physical examination**. The doctor will examine different parts of the body in order to identify any variations from the normal size, feel, and texture of the organ or tis-

sue. In addition to the physical exam, the doctor may order various tests.

Laboratory tests on blood and urine are often used to obtain information about a person's health. If cancer is suspected, a special test can be done that measures the amount of certain substances, called tumor markers, in the blood, urine, or particular tissues. These proteins are released from some types of cancer cells. Thus, the levels of these substances may be abnormal when certain cancers are present. However, laboratory tests alone cannot be used to make a definitive diagnosis of cancer. Blood tests are generally more useful in monitoring the effectiveness of the treatment or in following the course of the disease and detecting any signs of recurrence.

A doctor may look for tumors by examining images of areas inside the body. The most common way to obtain these images is by using x rays. Other techniques used to examine the insides of the body include computed tomography (CT scan), **magnetic resonance imaging** (MRI), and ultrasonography.

The most definitive diagnostic test is a biopsy. In this technique a piece of tissue is surgically removed for examination under a **microscope**. A biopsy provides information about the cellular nature of an abnormality: the stage it has reached, the aggressiveness of the cancer, and the extent of its spread. Further analysis of the tissue obtained by biopsy defines the cause of the abnormality. Since a biopsy provides the most accurate analysis, it is considered the gold standard of diagnostic tests for cancer.

Regular screening examinations conducted by healthcare professionals can result in the early detection of various types of cancer. Early detection means treatment is more likely to succeed. For example, the ACS recommends an annual mammogram (x ray of the breast) for women over the age of 40 years, to screen for breast cancer. It also recommends a **sigmoidoscopy**, in which a thin, lighted tube with a tiny camera is used to view the inside of the colon, every five years for people over the age of 50. This technique can assess the presence of **colorectal cancer**. Self-examinations for cancers of the breast, testes, mouth, and skin can also help in detecting tumors before the symptoms become serious.

Evolutions in molecular biology and the genetics of cancer have led to the development of several tests designed to assess one's risk of getting certain types of cancer. **Genetic testing** involves looking closely at certain genes that have been linked to particular cancers. As of 2001 there were many limitations to genetic testing. Tests could be uninformative and to a very small proportion of individuals tested. Additionally, concerns exist about insurance coverage and employment discrimination for someone who has an increased risk for cancer. As

of 2001 these tests were reserved only for very specific individuals. A hereditary cancer clinic can help assess who may benefit from this type of testing.

Treatment

The aim of cancer treatment is to remove all or as much of the tumor as possible and to prevent the recurrence or spread of the primary tumor. While devising a treatment plan for cancer, the likelihood of curing the cancer must be weighed against the side effects of the treatment. If the cancer is aggressive and a cure is not possible, then treatment should be aimed at relieving the symptoms and controlling the cancer for as long as possible.

Cancer treatment can take many different forms, and it is always tailored to an individual. The decision on which type of treatment is the most appropriate depends upon the type and location of the cancer and the extent to which it has already spread. A physician will also consider an affected person's age, sex, general health status, and personal treatment preferences. Treatment can be local, meaning that it affects cancer cells in the tumor and the surrounding area only. Surgery and radiation are local treatments. Treatment can also be systemic, meaning that the treatment travels through the bloodstream and affects cancer and other cells throughout the entire body. **Chemotherapy**, immunotherapy, and hormone therapy are examples of systemic treatments.

Surgery

Surgery can be used for many purposes:

- **Treatment.** Treatment of cancer by surgery involves removal of the tumor to cure the disease. This is typically done when the cancer is localized to a discrete area. Along with the cancer, some of the surrounding tissue is also removed to ensure that no cancer cells remain in the area. Since cancer usually spreads via the lymphatic system, lymph nodes near the tumor site may be removed for examination.
- **Prevention.** Preventive or prophylactic surgery involves removal of an abnormal-looking area that is likely to become malignant over time. For example, 40% of people with a colon disease called ulcerative colitis ultimately die of colon cancer. Rather than live with the fear of developing colon cancer, these people may choose to have their colons removed in order to reduce their risk of colorectal cancer.
- **Diagnosis.** The most definitive tool for diagnosing cancer is a biopsy. Sometimes a biopsy can be performed by inserting a needle through the skin and aspirating a small amount of fluid or tissue. At other times the only way to obtain a tissue sample is through surgery.

- **Cytoreductive surgery.** This is a surgical procedure in which the surgeon removes as much of the cancer as possible. The remaining cancer cells are then treated with radiation therapy, chemotherapy, or both.
- **Palliative surgery.** This type of surgery is intended to relieve cancer symptoms or slow the progression of disease. It is not designed to cure the cancer. For example, if the tumor is very large or has spread to many places in the body, removing the entire tumor may not be an option. However, by decreasing the size of the tumor, pain may be alleviated. This is known as debulking surgery.

Radiation therapy

Radiation uses high-energy rays to kill cancer cells. This technique may be used instead of surgery. It also may be utilized before surgery to shrink a tumor or after surgery to destroy any remaining cancer cells.

Radiation can be either external or internal. In the external form, the radiation comes from a machine that aims the rays at the tumor. In internal radiation (also known as brachytherapy), radioactive material is sealed in needles, seeds, or wires and placed directly in or near the tumor. Radiation may lead to various side effects, such as fatigue, hair loss, and a susceptibility to infections. However, these side effects can usually be controlled.

Chemotherapy

Chemotherapy is the use of drugs to kill cancer cells. The entire body is exposed to the drugs (systemic therapy) in an effort to destroy the hard-to-detect cancer cells that have spread and are circulating in the body. The cancer cells are affected more dramatically than normal cells because they are rapidly dividing. Chemotherapeutic drugs can be injected into a vein, the muscle, or the skin, or they may be taken by mouth.

When chemotherapy is used before surgery, it is known as primary, or neoadjuvant chemotherapy. Its purpose is usually to reduce the size of the tumor. The more common use of chemotherapy is in adjuvant therapy. In this technique, chemotherapy is given after surgery to destroy any remaining cancer cells and to help prevent cancer from recurring. Chemotherapy can also be used in conjunction with radiation.

Side effects of chemotherapy vary but can include susceptibility to infections, fatigue, poor appetite, weight loss, nausea, **diarrhea**, and hair loss. Decreased fertility can be a long-term side effect in some instances.

Bone marrow failure is a complication of chemotherapy. When high-dose chemotherapy is utilized, bone

Recommendations for cancer screening

Procedure	Frequency
Chest x ray	Not recommended on a routine basis
Sputum cytology	Not recommended on a routine basis
Fecal occult blood testing (FOBT) or sigmoidoscopy	Yearly after age 50
Papanicolaou (Pap) smear	Every 3 years from onset of sexual activity to age 65
Mammography alone or mammography and breast physical examination	Every 1–2 years at ages 50–69; starting at ages 40–49 may be recommended if high-risk

SOURCE: U.S. Preventative Services Task Force, Dept. of Health and Human Services.

marrow failure is anticipated. Bone marrow transplantation (BMT) or peripheral stem cell transplantation (PSCT) are techniques used to treat this complication. Both techniques provide healthy stem cells for an affected person. Stem cells are immature cells that mature into blood cells. Transplanted stem cells replace the patient's stem cells that have been damaged or destroyed by chemotherapy or radiation. This procedure allows an individual to undergo very aggressive treatment for cancer. Those who receive BMT or PSCT have an increased risk of **infection**, bleeding, and other side effects due to the chemotherapy and radiation. Graft-versus-host disease may also occur. This complication develops when the donated marrow reacts against the recipient's tissues. It can occur any time after the transplant. Drugs may be given to reduce the risk of graft-versus-host disease and to treat the problem if it occurs.

Immunotherapy

Immunotherapy, also called biological therapy, is the use of treatments that promote or support the body's immune system response to cancer. The side effects of immunotherapy are variable but include flu-like symptoms, weakness, loss of appetite, and skin rash. These symptoms will subside after the treatment is completed.

Hormone therapy

Hormone therapy is used to fight certain cancers that depend on hormones for their growth. Drugs can be used to block the production of hormones or change the way they work. Additionally, organs that produce hormones may be removed. As a result of this therapy, the growth of the tumor slows and survival may be extended for several months or years.

COMMON PATHOGENS AND THE CANCERS ASSOCIATED WITH THEM	
<i>Causative Agent</i>	<i>Type Of Cancer</i>
Viruses	
Papillomaviruses	Cancer of the cervix
Hepatitis B virus	Liver cancer
Hepatitis C virus	Liver cancer
Epstein-Barr virus	Burkitt's lymphoma
Cancers of the upper pharynx	Hodgkin's lymphoma, Non-Hodgkin's lymphoma, Gastric cancers
Human immunodeficiency virus (HIV)	Kaposi's sarcoma Lymphoma
Bacteria	
<i>Helicobacter pylori</i>	Stomach cancer Lymphomas

(Illustration by Standley Publishing. Courtesy of Gale Group.)

Alternative and complementary therapies

There are certain cancer therapies that have not been scientifically tested and approved. If these unproven treatments are used instead of the standard therapy, this is known as alternative therapy. If they are used along with standard therapy, this is known as complementary therapy. Alternative therapy is considered dangerous because some of these unproven treatments might have life-threatening side effects. Additionally, persons who use alternative therapy may lose the opportunity to benefit from standard, proven therapy. However, some complementary therapies may help to relieve symptoms of cancer, decrease the magnitude of side effects from treatment, or improve a patient's sense of well being. The American Cancer Society recommends that anyone considering alternative or complementary therapy consult a health care team before doing so.

Palliative care

Palliative care, which focuses on the terminally ill, is an extremely important aspect of care. Its goal is to prevent and relieve pain and suffering through symptom management, and addresses not only the physical, but the practical, emotional, and spiritual needs of patients, their families, and caregivers. By viewing dying as a natural process, palliative care helps facilitate what can be termed a "good" death, free from suffering and stress. Many patients and their families are unaware that suffer-

ing at the end of life is no longer necessary. Health care professionals can relieve a patient and their loved ones of much **anxiety** by informing them that appropriate symptom management is readily available.

Hospice care

Hospice care is the environment in which palliative care is given to terminally ill patients. Hospice care can be provided either at home, or in a home-like facility called a hospice. Hospice care focuses on providing the best possible palliative care for the patient until the patient dies.

Prognosis

Most cancers are curable if detected and treated in their early stages. The prognosis for a person with cancer is affected by many factors, particularly the type of cancer and stage of the cancer, the extent to which it has metastasized, and its aggressiveness. In addition, a person's age, general health status, and effectiveness of the treatment being pursued are important factors.

To help predict the outcome of cancer and the likelihood of recovery from the disease, five-year survival rates are used. In the United States, as of 2001, the five-year survival rate for all cancers combined was 59%. This means that 59% of people with cancer are expected to be alive five years after they are diagnosed. These people may be free of cancer, or they may be undergoing treatment. It is important to note that, while this statistic can give some information about the average survival of people with cancer in a given population, it cannot be used to predict the course of cancer for an individual. No two people are exactly alike. The five-year survival rate does not account for differences in detection methods, types of treatments, additional illnesses, and personal behavior of the individual.

Health care team roles

Family physicians, internists, gynecologists, or pediatricians generally make an initial diagnosis of cancer. Other physicians, notable radiologists, and oncologists provide chemotherapeutic and radiologic treatment. Nurses provide emotional and educational support, **home care**, home hospice care, and case management. Counselors and psychologists may provide emotional support to patients and their families. Epidemiologists collect and maintain data related to cancer.

Prevention

According to experts from leading universities in the United States, a person can reduce the chances of getting cancer by following these guidelines:

- eating plenty of fruits and vegetables
- exercising vigorously for at least 20 minutes every day
- avoiding excessive weight gain
- avoiding tobacco (including second hand smoke)
- decreasing or avoiding consumption of animal **fats** and red meats
- avoiding excessive amounts of alcohol
- avoiding the midday sun (between 11 A.M. and 3 P.M.) when the sun's rays are the strongest
- avoiding risky sexual practices
- avoiding known carcinogens in the environment or work place

Certain drugs being used for treatment can also be suitable for prevention. For example, tamoxifen (Nolvadex) has been very effective against recurrence of breast cancer and is now thought to be helpful in the prevention of breast cancer. Similarly, retinoids derived from **vitamin A** are being tested for their ability to slow the progression of, or prevent, head and neck cancers.

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KEY TERMS

Benign—A growth that does not spread to other parts of the body. Recovery is favorable with treatment.

Biopsy—The surgical removal and microscopic examination of living tissue for diagnostic purposes.

Bone marrow—Spongy material that fills the inner cavities of the bones. The progenitors of all the blood cells are produced in this bone marrow.

Carcinogen—Any substance capable of causing cancer by mutating a cell's DNA.

Chemotherapy—Treatment with anticancer drugs.

Epithelium—Layer of cells covering the body's surface and lining the internal organs and various glands.

Hormone therapy—Treatment of cancer by changing the hormonal environment, such as testosterone and estrogen.

Immunotherapy—Treatment of cancer by stimulating the body's immune system.

Malignant—A general term for cells that can break loose from an original tumor, invade, and then destroy other tissues and organs.

Metastasis—The spread of cancer from one part of the body to another.

Radiation therapy—Treatment using high-energy radiation from x-ray machines, cobalt, radium, or other sources.

Sore—An open wound or a bruise or lesion on the skin.

Tumor—An abnormal growth resulting from a cell that lost its normal growth control restraints and started multiplying uncontrollably.

X rays—High energy radiation used in high doses, either to diagnose or treat disease.

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American College of Occupational and Environmental Medicine. 55 West Seegers Road, Arlington Heights, IL 60005. (708) 228-6850. <<http://www.acoem.org>>.

American College of Radiology. 1891 Preston White Drive, Reston, VA 20191. (703) 648-8900.<<http://www.acr.org>>.

American College of Surgeons. 633 North St. Clair Street, Chicago, IL 60611-32311. (312) 202-5000. <<http://www.facs.org/>>.

American Lung Association. 1740 Broadway, New York, NY 10019.(212)-315-8700. <<http://www.lungusa.org/diseases/lungtb.html>>.

American Melanoma Foundation. 3914 Murphy Canyon Road, Suite A132, San Diego, CA 92123. (858) 277-4426. <<http://www.melanomafoundation.org/homepage.html>>.

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Cancer chemotherapy drugs see **Anticancer drugs**

Cancer therapy, supportive

Definition

Supportive **cancer** therapy is the use of medications to prevent or counteract the unwanted side effects of cancer treatment.

Purpose

Along with their beneficial effects, many cancer treatments cause uncomfortable and sometimes harmful side effects. Three of the most common untoward effects of cancer treatment are nausea and vomiting, destruction of red and white **blood** cells in bone marrow that results in anemia and neutropenia, and **pain**. Fortunately, several drugs have been developed that specifically target these adverse reactions.

Precautions

The patient should be questioned as to medications being taken, and if adverse reactions have ever occurred. Any **allergies** to foods, dyes, preservatives, or other substances should also be assessed.

Description

Various medications are available for use in supportive cancer therapy. Their use is dependent upon several factors, including the particular treatment the patient is undergoing and the severity of symptoms.

Nausea and vomiting

The prevention and control of nausea and vomiting are extremely important for patients receiving cancer treatment. Unrelieved nausea and vomiting may lead to nutritional deficiencies, **dehydration**, electrolyte imbalances, and a general deterioration of the patient's mental and physical status. The drugs used to treat nausea and vomiting are known as antiemetics. Each falls into one of several categories.

PHENOTHIAZINES. The drugs within this category that are most commonly used as antiemetics include prochlorperazine (Compazine) and promethazine (Phenergan). These drugs can be given orally, intramuscularly, intravenously, and rectally. The most common side effects include extrapyramidal reactions, and sedation. There may be a significant drop in **blood pressure** if the medication is given too rapidly via the intravenous route.

DOPAMINE 2 ANTAGONISTS. Metoclopramide (Reglan) is the most widely used drug for nausea and

vomiting in this category. It may be given either orally or intravenously. Like phenothiazines, it may lead to extrapyramidal reactions. Metoclopramide increases the pressure in the lower esophageal sphincter and increases the rate of gastric emptying, which may be an important factor in its antiemetic effect.

5-HT₃ ANTAGONISTS. Three medications within this category are available in the United States: ondansetron (Zofran), granisetron (Kytril), and dolasetron (Anzemet). They are thought to work by blocking some actions of serotonin. These drugs may be given orally or intravenously. The most common side effects are headache (which can be treated with mild **analgesics**), constipation or **diarrhea**, dry mouth, fatigue and weakness, and dizziness.

In general, 5-HT₃ antagonists are more effective than other antiemetics. However, their effectiveness is improved when they are given in combination with **corticosteroids**.

CORTICOSTEROIDS. Steroids like dexamethasone (Decadron) and methylprednisolone (Prednisone) are occasionally used alone in treating mild to moderate nausea, but more frequently are used in combination with other antiemetic drugs. They may be given orally, intramuscularly, and intravenously. It is not known exactly how corticosteroids work in treating nausea and vomiting, but they may affect prostaglandin activity in the **brain**. In the short-term, steroids may not only relieve nausea, but may also produce a sense of well being and an increased appetite in the patient. Long-term use is usually avoided, as it may cause suppression of the **immune system**, muscle weakness, hyperglycemia, lethargy, weight gain, and mood changes.

CANNABINOIDS. A great deal of interest has been shown in using **marijuana** to treat nausea and vomiting in cancer patients. However, because of both societal and legal restrictions, cannabinoids are usually not among the first drugs selected to treat nausea and vomiting. Two forms of marijuana have been used: marijuana cigarettes and a medicine taken by mouth containing the active chemical component of marijuana. Dronabinol (Marinol) is a synthetic form of the active ingredient in marijuana that is given orally. It makes some people feel drowsy, dizzy, lightheaded, or “high,” with a sense of well being. It takes longer to work than smoked marijuana and may be difficult for patients with nausea and vomiting to keep down. The active ingredients of marijuana are more quickly absorbed from smoking marijuana cigarettes. However, since many patients are unable to tolerate smoking and each marijuana cigarette may vary in its potency, research is being conducted into other ways to

effectively administer marijuana, such as inhalers, nasal sprays, and skin patches.

Patients considering using marijuana to control nausea and vomiting should be encouraged to fully discuss this option with their health care professional. A careful consideration of both the legal and medical issues is important.

BENZODIAZEPINES. Benzodiazepines such as Lorazepam (Ativan) and Alprazolam (Xanax) are valuable tools in the prevention and treatment of nausea and vomiting when given in combination with other antiemetics. They are especially useful in preventing anticipatory nausea and vomiting. The adverse effects of benzodiazepines include lowered blood pressure, sedation, altered perception, and dependence.

Anemia and neutropenia

Anemia and neutropenia are two potentially very serious complications of cancer treatment. Hematopoietic agents and colony stimulating factors help combat these complications by stimulating the bone marrow to produce new cells.

HEMATOPOIETIC AGENTS. A weakened bone marrow occurring as a result of cancer treatment or certain cancers can lead to low erythropoietin levels. Erythropoietin is a hormone produced by the **kidneys** and **liver** in response to low blood oxygen levels or anemia. It stimulates the bone marrow to make new red blood cells. Synthetically made versions of human erythropoietin called epoetin (Procrit, Epogen) can perform the same function.

Epoetin, which is injected, is usually well tolerated by patients. Some side effects may include high blood pressure, tachycardia, minor allergies, **edema**, diarrhea, and **iron** deficiency. Patients taking this medication need to have adequate iron levels in the body. The physician may prescribe iron supplements along with Epoetin. Occasionally Epoetin may cause a flu-like reaction that shows up about one or two hours after an injection. Normally the symptoms will go away within 12 hours. Another possible side effect is bone pain, which may be treated with mild analgesics.

COLONY STIMULATING FACTORS. While **chemotherapy** is in the process of destroying cancer cells, it can also damage cells in the bone marrow, where in addition to other types, white blood cells are produced. White blood cells help to defend the body against infections, so a decreased number is associated with an increased risk for **infection**. The numbers of white blood cells usually drop to their nadir, or lowest value, around 10-14 days after the end of chemotherapy treatment. Normally it takes around

KEY TERMS

Antiemetics—Medications used to alleviate nausea and vomiting.

Extrapyramidal reactions—Muscular rigidity, tremors, and altered gait brought on by certain medications. Also called drug-induced parkinsonism.

Neutropenia—The presence of an abnormally small level of neutrophils in the blood, usually less than 1500-2000 per microliter. Patients with low levels of neutrophils are at high risk for infections.

three to four weeks for the white blood cell count to recover. In order to speed up this process, drugs called colony stimulating factors can be given that can help the bone marrow to produce new white blood cells. Examples of colony stimulating factors are G-CSF (Filgrastim, Neupogen) and GM-CSF (Sargramostim, Leukine). Both are given by injection daily for around seven to 14 days. The patient or caregiver is often taught how to administer the injections.

Colony stimulating factors commonly cause mild bone pain, normally in the pelvis or lower back. This occurs around the same time that the white blood cells come back in the bone marrow. This symptom can be treated with mild analgesics. Other common side effects include headache, skin rash, muscle or joint pain, and itching.

Pain

Approximately 60%-90% of cancer will need some type of pain-relieving therapy, depending on the type and severity of their cancer. For example, cancers of the abdomen can cause intense pain while lymphomas often never cause pain. Supportive cancer therapy for pain can be vitally important. Pain causes suffering and can lead to depression and anger. There are many causes of cancer pain, including:

- Chemotherapeutic drugs may poison nerves in addition to tumors. For example, cisplatin, carboplatin and other cancer drugs can cause peripheral neuropathy, such as burning in the hands and feet.
- Radiation therapy can produce neuropathic pain by scarring nerves (fibrosis) or cause painful skin reactions.
- Tumor spread can cause neuropathic pain, for example, when spinal tumors pinch or press nerves.

- Cancers and various complications can cause somatic pain, such as obstructions in the intestine or urinary tract.
- Surgery can cause both somatic and neuropathic pain.

There are a variety of treatments for cancer pain, depending on its severity. Aspirin, acetaminophen (Tylenol), and other **nonsteroidal anti-inflammatory drugs** (NSAIDs) are often used for mild pain. Moderate pain treatments include codeine, Percocet, Percodan, hydrocodone (Vicodin), and propoxyphene (Darvon). Demerol, Dilaudid, and morphine are some of the drugs used to treat severe pain. These medications have various side effects, some of them potentially serious.

Preparation

The patient should be instructed on the particular medication being administered or prescribed, including the dosage, times of administration, expected side effects, and any potentially adverse reactions. Patients receiving colony stimulating factors may need to be instructed on **subcutaneous injection** technique.

Aftercare

The health care professional should assess the patient's response to the medication administered and if any side effects have occurred.

Complications

As with many medications, serious complications, though usually rare, can and do occur. A physician should be notified quickly if any of the following occur.

Phenothiazines

If **sore throat** and **fever**, unusual bleeding or bruising, or an increase in weakness occur, the physician should be notified. Seizures, severe drowsiness, facial flushing, hallucinations, muscle spasms, trembling and jerking movements may all be symptoms of an **overdose**.

Dolasetron, granisetron, and ondansetron

The physician should be notified immediately if any of the following occur: shortness of breath or other breathing difficulties, chest pain, skin rash, **hives** or itching, and fever. Prompt notification should also take place if patients taking dolasetron experience hematuria, anuria or dysuria; or swelling of the face, feet or legs.

Dronabinol

Dronabinol may worsen some medical conditions, including high blood pressure, **heart** disease, **bipolar**

disorder, and **schizophrenia**. Any new symptoms suggestive of these conditions should be reported to the doctor. A variety of other side effects and possible signs of overdose should also be reported immediately, including tachycardia, difficulty urinating, slurred speech, mood changes, confusion and forgetfulness, sensory changes, and hallucinations.

Epoetin

Certain side effects should be brought to a physician's attention as soon as possible, including headache, visual disturbances, elevated blood pressure readings, tachycardia, edema, and weight gain. The physician should be notified immediately if the patient taking epoetin experiences chest pain or seizures.

Colony stimulating factors

Colony stimulating factors increase the risk of infection because of lowered white blood cell counts. Therefore, any signs of infection, including fever and chills, should be reported to the physician as soon as possible. Other symptoms that should be reported promptly include redness or pain at an injection site; chest pain; tachycardia; difficulty breathing and/or wheezing; and edema.

Results

The goal of antiemetic administration in supportive cancer therapy is relief of nausea and vomiting. For those receiving epoetin or either of the colony stimulating factors, normalized blood cell counts and prevention of infections are the desired results.

Health care team roles

Medications used in the supportive care of cancer patients are ordered by the physician. Some states may allow **advanced practice nurses** to prescribe. The pharmacist is responsible for dispensing the drugs. The nurse plays an important role in both **administering medication**, assessing the response of the patient, and teaching the patient about all aspects of the drug being given.

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Carbohydrates

Definition

Carbohydrates are compounds that consist of carbon, hydrogen, and oxygen, linked together by energy-containing bonds. There are two types of carbohydrates: complex and simple. The complex carbohydrates, such as starch and fiber, are classified as polysaccharides. Simple carbohydrates are known as sugars and they are classified as mono- or disaccharides, depending on the number of sugars present. Monosaccharides consist of only one sugar; disaccharides have two sugar molecules bonded together.

Purpose

In the digestive tract, carbohydrates are broken down into the monosaccharide glucose, which provides energy for the body's cells and tissues. Glucose is the body's primary source of fuel.

Precautions

A common concern among consumers is that a high intake of carbohydrate-rich foods will cause weight gain. Consuming too much of *any* particular food can cause an increase in weight, but eating a balanced diet with plenty of fruits, vegetables, and grains will help promote weight

KEY TERMS

Diabetes—A condition characterized by inadequate use of insulin preventing a person from controlling blood sugar levels.

Fructose—Monosaccharide known as fruit sugar.

Galactose—Monosaccharide known as milk sugar.

Glucose—Monosaccharide used for energy; also known as blood sugar.

Lactose—Disaccharide known as milk sugar.

Low-density lipoprotein cholesterol (LDL)—Lipoproteins containing a large amount of cholesterol; transport lipids to other tissues in the body.

Maltose—Disaccharide known as malt sugar.

Sucrose—Disaccharide commonly known as table sugar.

Polysaccharides—Long chains of glucose units linked together.

management. General guidelines recommend that about 55 to 60% of daily calories come from carbohydrates.

Description

Carbohydrates are either simple or complex. Both have four calories per gram, and both are further reduced by the body to glucose, but complex carbohydrates, which undergo most of their digestion in the **large intestine**, take longer to digest. Carbohydrates come almost exclusively from plants, vegetables, and grains. Milk is the only animal-based product that contains a significant amount of carbohydrate.

Simple carbohydrates include the single sugars, or *monosaccharides*, and the double sugars, or *disaccharides*. The monosaccharides include glucose, fructose, and galactose. Disaccharides include lactose, which is made of glucose and galactose; maltose, made of two glucose units; and sucrose, made of glucose and fructose. Monosaccharides can be absorbed directly into the bloodstream, but disaccharides need to be broken down into their monosaccharide components before they can be absorbed.

When food is consumed, the digestion of carbohydrates begins in the mouth, where an enzyme in saliva breaks down starch molecules into the disaccharide maltose. The food then moves into the **stomach** where it mixes with the stomach's acid and other juices. In the **small**

intestine, starch is further broken down into disaccharides and small polysaccharides by an enzyme released from the **pancreas**. Cells lining the small intestine then secrete an enzyme that further splits these disaccharides and polysaccharides into monosaccharides. The cells lining the small intestine can absorb these monosaccharides, which are then taken to the **liver**. The liver converts fructose and galactose to glucose. If there is an excess of fructose or galactose, it may also be converted to fat. Lastly, the glucose is transported to the body's cells by the circulatory system, where it can be used for energy.

When there is an excess of glucose, the muscle and liver cells often convert it to glycogen, which is the storage form of glucose. The muscles store two thirds of the body's glycogen solely for themselves, and the liver stores the other one third, which can be used by the **brain** or other organs. When **blood** glucose levels decline, the body breaks down some of its glycogen stores, and uses the glucose for energy. If blood glucose levels are too high, the excess glucose is taken to the liver where it is converted to glycogen and stored for future use.

Fiber

One of the complex carbohydrates, fiber, is a polysaccharide in which the bonds holding it together cannot be digested by humans. Fiber can be either water-soluble or water-insoluble. Even though these compounds cannot be digested by humans, they serve several important functions. The main function of insoluble fiber is to bind bile acids, which reduces fat and cholesterol absorption. Sources of insoluble fiber include wheat bran, whole grains, and brown rice. Soluble fiber, which helps decrease low-density lipoprotein (LDL) cholesterol, can be found in barley, fruit, legumes, and oats.

Fiber is an extremely important part of the diet. It aids in weight control by displacing calorie-dense **fats** in the diet. Fiber also absorbs water and slows the movement of food through the digestive tract, promoting a feeling of fullness. Recommended intakes of fiber should be about 27 to 40 grams per day.

The food guide pyramid was designed by health professionals to help consumers make nutritious food choices. The bottom and largest portion of the pyramid represents the bread, cereal, rice, and pasta group, and it is recommended that a healthy diet includes six to 11 servings from this food group daily. Three to five servings from the vegetable group and two to four servings from the fruit group are also recommended. These amounts will provide sufficient carbohydrates (including fiber) in the diet.

Complications

When carbohydrate intake is low, there is insufficient glucose production, which then causes the body to use its protein for energy. This ultimately prevents the body's protein from performing its more important functions, such as maintaining the body's **immune system**.

Without carbohydrate, the body also goes into a state of ketosis, in which by-products of fat breakdown, called *ketones*, accumulate in the blood. This causes a shift in the **acid-base balance** of the blood, which can be fatal.

Insulin

Diabetes is a disease in which the body cannot metabolize carbohydrates, and either doesn't make or doesn't respond to insulin, a hormone secreted by the pancreas that is used to transport glucose to the body's cells. In individuals with type 1 diabetes, the pancreas fails to produce insulin, thus causing blood glucose levels to remain the same after meals. This condition is known as hyperglycemia. These individuals must receive daily injections of insulin to control their blood glucose levels. In type 2 diabetes, there may be sufficient insulin, but the body's cells may be resistant to it. Once again, this causes blood glucose levels to rise. Type 2 diabetes can be treated through oral medication and proper diet, although the need for insulin injections may develop later on.

Health care team roles

Registered dietitians and nutritionists are the professionals most qualified to educate individuals on the role of carbohydrates in a healthy diet, as well as the complications associated with low-carbohydrate intakes. Medical doctors and nursing professionals also play an important role in treating carbohydrate-related conditions such as diabetes, while dietitians serve to make recommendations concerning the nutritional needs of these individuals.

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Lisa M. Gourley

Carbon monoxide poisoning

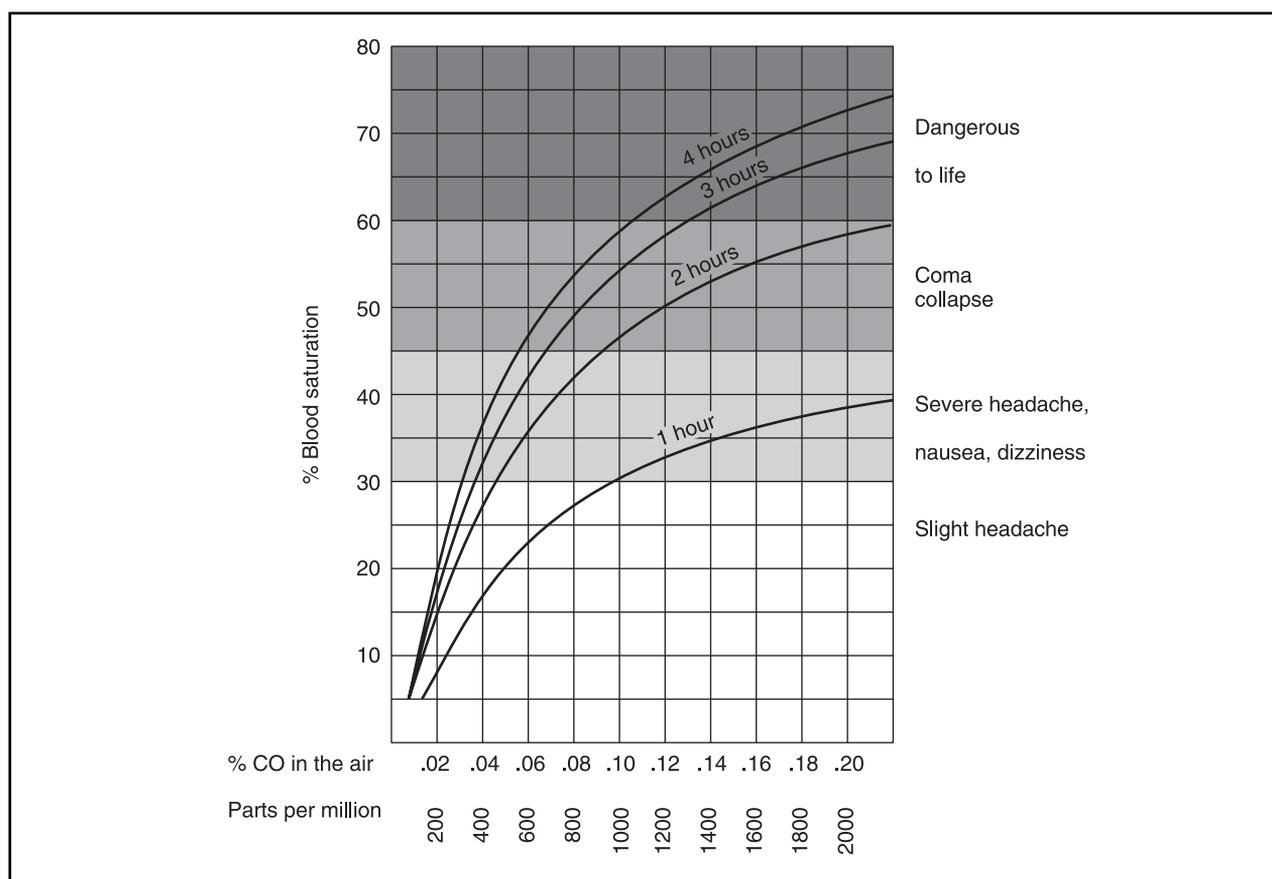
Definition

Carbon monoxide (CO) **poisoning** occurs when carbon monoxide gas is inhaled. CO is a colorless, odorless, highly poisonous gas that is produced by incomplete combustion of fossil fuels. It is found in automobile exhaust fumes, faulty stoves and heating systems, fires, and cigarette smoke. Other sources include wood-burning stoves, kerosene heaters, improperly ventilated water heaters and gas stoves, and blocked or poorly maintained fireplace chimney flues. CO interferes with the ability of the **blood** to carry oxygen. The result is headache, nausea, convulsions, and finally death by asphyxiation.

Description

Carbon monoxide, sometimes called coal gas, has been known to be a toxic substance since the third century B.C. It was used for executions and suicides in early Rome. Today it is the leading cause of accidental poisoning in the United States. According to the *Journal of the American Medical Association*, 1,500 Americans die each year from accidental exposure to CO, and another 2,300 from intentional exposure (suicide). An additional 10,000 people seek medical attention and recover after exposure to CO.

Anyone who is exposed to CO will become sick, and the entire body is involved in CO poisoning. A developing fetus can be poisoned if a pregnant woman breathes CO gas. Infants, people with **heart** or lung disease, or those with anemia may be more seriously affected than otherwise healthy adults. People, such as underground-parking garage attendants, who are exposed to car exhausts in a confined area, are more likely to be poi-



Carbon monoxide, effects under exposure. (Graph by Hans & Cassidy. Reproduced by permission.)

soned by CO. Firefighters also have an elevated occupational risk of inhaling CO.

Causes and symptoms

Normally when a person breathes fresh air into the **lungs**, the oxygen in the air binds with a molecule called hemoglobin (Hb) that is found in red blood cells. This allows oxygen to be moved from the lungs to every part of the body. When the oxygen/hemoglobin complex reaches a muscle where it is needed, the oxygen is released. Because the oxygen binding process is reversible, hemoglobin can be used repeatedly to pick up oxygen and move it throughout the body. After oxygen is released, carbon dioxide binds to hemoglobin and is transported back to the lungs.

Inhaling carbon monoxide gas interferes with this oxygen-transport system. In the lungs, CO competes with oxygen to bind with a hemoglobin molecule. Hemoglobin and CO bind more than 200 times more readily than do Hb and oxygen. The hemoglobin holds on to the CO much more tightly, forming a complex called carboxyhemoglobin (COHb). As a person breathes CO-

contaminated air, more and more oxygen transportation sites on the hemoglobin molecules become blocked by CO. Gradually, there are fewer and fewer sites available for oxygen. This creates a condition called carboxyhemoglobinemia. All cells need oxygen to live. When they do not get enough oxygen, cellular **metabolism** is disrupted and eventually cells begin to die.

The symptoms of CO poisoning and the speed with which molecules of carboxyhemoglobin appear depend on the concentration of CO in the air and the rate and efficiency with which a person breathes. Heavy smokers may live with up to 9% of their hemoglobin already bound to CO, which they regularly inhale in cigarette smoke. This makes them much more susceptible to environmental CO. The Occupational Safety and Health Administration (OSHA) has established a maximum permissible environmental exposure level of 50 parts per million (ppm) of CO over eight hours.

With exposure to 200 ppm for two to three hours, a person begins to experience headache, fatigue, nausea, and dizziness. These symptoms correspond to 15–25% COHb in the blood. When the concentration of COHb

reaches 50% or more, death follows in a very short time. Emergency room physicians usually have the most experience diagnosing and treating CO poisoning, though occupational and environmental health professionals may also see multiple cases.

The symptoms of CO poisoning in order of increasing severity include:

- headache
- shortness of breath (dyspnea)
- dizziness
- fatigue
- mental confusion and difficulty thinking (disorientation)
- loss of fine hand-eye coordination
- nausea and vomiting
- rapid heart rate (tachycardia)
- hallucinations
- inability to accurately execute voluntary movements
- collapse
- lowered body temperature (hypothermia)
- coma (unconsciousness)
- convulsions (seizures)
- seriously low **blood pressure** (critical hypotension)
- cardiac and respiratory failure
- death

In some cases, the skin, nose, mucous membranes, or nails of a person with CO poisoning are cherry red or bright pink. Because the color change doesn't always occur, it is an unreliable symptom on which to base a diagnosis.

Although most CO poisoning is acute (sudden), it is possible to suffer from chronic CO poisoning. This condition exists when a person is exposed to low levels of the gas over a period of days or months. Symptoms are often vague and include (in order of frequency) fatigue, headache, dizziness, sleep disturbances, cardiac symptoms, apathy, nausea, and **memory** disturbances. Little is known about chronic CO poisoning, and it is often misdiagnosed.

Diagnosis

The main reason to suspect CO poisoning is evidence that fuel is being burned in a confined area, for example, a car running inside a closed garage, a charcoal grill burning indoors, or an unvented kerosene heater in a workshop. Under these circumstances, one or more persons suffering from the symptoms listed above,

strongly suggests CO poisoning. In the absence of some concrete reason to suspect CO poisoning, the disorder is often misdiagnosed as **migraine headache**, stroke, psychiatric illness, **food poisoning**, alcohol poisoning, or heart disease.

Confirmation of CO poisoning comes from a carboxyhemoglobin test. This blood test measures the amount of CO bound to hemoglobin in the body. Blood is drawn as soon after suspected exposure to CO as possible.

Other tests that are useful in determining the extent of CO poisoning include measurement of other arterial **blood gases** and pH; a **complete blood count**; measurement of other blood components such as sodium, potassium, bicarbonate, urea nitrogen, and lactic acid; an electrocardiogram (ECG); and a **chest x ray**.

Treatment

The most immediate treatment for CO poisoning is to remove a person from the source of carbon monoxide gas and expose the individual to fresh air. If breathing has stopped or there is no pulse, **cardiopulmonary resuscitation (CPR)** should be started. Depending on the severity of the poisoning, 100% oxygen may be given with a tight fitting mask over an airway as soon as it is available.

Taken with other symptoms of CO poisoning, COHb levels over 25% in otherwise healthy individuals, over 15% in patients with a history of heart or lung disease, and over 10% in pregnant women usually indicate the need for hospitalization. In the hospital, fluids and electrolytes are given to correct any chemical imbalances that may have arisen from the breakdown of cellular metabolism.

In severe cases of CO poisoning, patients are given hyperbaric **oxygen therapy**. This treatment involves placing a person in a special chamber where he or she breathes 100% oxygen at a pressure of more than one atmosphere (the normal pressure the atmosphere exerts at sea level). The increased pressure forces more oxygen into the blood. Hyperbaric facilities are specialized, and are usually available only at larger hospitals or regional trauma centers.

Prognosis

The speed and degree of recovery from CO poisoning depends on the duration and concentration of exposure to the gas. The half-life of CO in normal room air is four to five hours. This means that, in four to five hours, half of the CO bound to hemoglobin will be replaced with oxygen. At normal atmospheric pressures, but breathing 100% oxygen, the half-life for the elimination of CO from the body is 50–70 minutes. In hyperbaric

KEY TERMS

Carboxyhemoglobin (COHb)—Hemoglobin that is bound to carbon monoxide instead of oxygen.

Carboxyhemoglobinemia—A condition characterized by blood saturated with carboxyhemoglobin molecules.

Hemoglobin (Hb)—A molecule of red blood cells that normally binds to oxygen to transport it to cells, where it is required for life.

Hypothermia—Development of a subnormal body temperature, usually less than 96°F (37°C).

pH—A measurement of the acidity or alkalinity of a fluid. A neutral fluid, neither acid nor alkali, has a pH of 7.0.

therapy, at three atmospheres of pressure, the half-life is reduced to 20–25 minutes.

Although the symptoms of CO poisoning may subside in a few hours, some people may show residual memory problems, fatigue, confusion, and mood changes for two to four weeks after their exposure to the gas.

Health care team roles

Trained persons may initiate **first aid** and CPR. **Emergency medical technicians** or paramedics may continue such treatment and initiate oxygen therapy while transporting a patient to a hospital. A physician provides treatment in the emergency department. A physician also supervises treatment in a hyperbaric chamber. A therapist may provide counseling after recovery from CO exposure.

Prevention

Carbon monoxide poisoning is preventable. Particular care should be paid to situations where fuel is burned in a confined area, or where heating equipment is old and in need of replacement. Portable and permanently installed carbon monoxide detectors that sound a warning similar to smoke detectors are available for under \$50. Specific actions that will prevent CO poisoning include:

- Stop smoking. Smokers have less tolerance to environmental CO.
- Have heating systems and appliances installed by a qualified contractor to ensure they are properly vented and meet local building codes.

- Inspect and properly maintain heating systems, chimneys, and appliances.
- Do not use a gas oven or stove to heat the home.
- Do not burn charcoal indoors.
- Make sure there is good ventilation if using a kerosene heater indoors.
- Do not leave cars or trucks running inside a garage.
- Keep car windows rolled up when stuck in heavy traffic, especially when inside a tunnel.

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- American Academy of Emergency Medicine, 611 East Wells Street, Milwaukee, WI 53202. (800) 884-2236. Fax: (414) 276-3349. <www.aem.org>.
- American Association for Respiratory Care, 11030 Ables Lane, Dallas, TX 75229. <www.aarc.org>.
- American Association of Nurse Anesthetists, 222 S. Prosper Avenue, Park Ridge, IL 60068. Tel: 847-692-7050. <www.aana.com>.
- American Lung Association, 1740 Broadway, NY, NY 10019. (212)-315-8700.

<www.lungusa.org/diseases/lungtb.html>. info@lungusa.org.

OTHER

Chimney Safety Institute of America.

<www.csia.org/home/cohazard.html>.

National Institute of Occupational Safety and Health.

<www.cdc.gov/niosh/carbon2.html>.

U.S. Environmental Protection Agency.

<www.epa.gov/iaq/pubs/coftsht.html>.

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Carbuncle see **Boils**

Carcinoembryonic antigen test see **Tumor marker tests**

Cardiac blood pool scan see **Multiple-gated acquisition (MUGA) scan**

Cardiac catheterization

Definition

Cardiac catheterization (also called **heart** catheterization) is a diagnostic and occasionally therapeutic procedure that allows a comprehensive examination of the heart and surrounding **blood vessels**. It enables the physician to take angiograms, record **blood** flow, calculate cardiac output and vascular resistance, perform an endomyocardial biopsy, and evaluate the heart's electrical activity. Cardiac catheterization is performed by inserting one or more catheters (thin flexible tubes) through a peripheral blood vessel in the arm (antecubital artery or vein) or leg (femoral artery or vein) under x-ray guidance.

Purpose

Cardiac catheterization is most commonly performed to examine the coronary arteries, because heart attacks, angina, sudden death, and **heart failure** most often originate from disease in these arteries. **Coronary artery disease** is the first-ranked cause of death for both men and women in the United States. Cardiac catheterization with coronary **angiography** is recommended in patients with angina (especially unstable angina); suspected coronary artery disease; suspected silent ischemia and a family history of heart attack; ischemic cardiac myopathy; congestive heart failure; congenital heart disease; and pericardial disease. Catheterization is



Doctors at work during a cardiac catheterization procedure. With the patient under a local anesthetic, the catheter is inserted into an artery in the thigh, then guided to the coronary arteries. A dye is then released, revealing blockages. (Photograph by Simon Fraser, Photo Researchers, Inc. Reproduced by permission.)

also recommended for patients with suspected valvular disease, including aortic stenosis or regurgitation and mitral stenosis or regurgitation. In addition, the procedure may be performed after acute **myocardial infarction**; before major noncardiac surgery in patients at high risk for cardiac problems; before cardiac surgery in patients at risk for coronary artery disease; and before such interventional technologies and procedures as stents and percutaneous transluminal coronary **angioplasty** (PTCA).

Cardiac catheterization may reveal the presence of other conditions, including enlargement of the left ventricle; ventricular aneurysms (abnormal dilation of a blood vessel); narrowing of the aortic valve; insufficiency of the aortic or mitral valve; and septal defects that allow an abnormal flow of blood from one side of the heart to the other.

Symptoms and diagnoses that may be associated with the above conditions and may lead to cardiac catheterization include:

- chest **pain** characterized by prolonged heavy pressure or a squeezing pain
- abnormal results from a treadmill **stress** test
- myocardial infarction (heart attack)
- congenital heart defects
- valvular disease

Left- and right-side catheterization

Cardiac catheterization can be performed on either side of the heart to evaluate different functions. Testing the right side of the heart allows the physician to evaluate tricuspid and pulmonary valve function, in addition to measuring blood pressures and collecting blood samples from the right atrium, right ventricle, and pulmonary artery. Catheterization of the left side of the heart is performed to test the blood flow in the coronary arteries as well as the level of function of the mitral and aortic valves and left ventricle. The physician can assess the adequacy of blood supply through the coronary arteries, blood pressures, and blood flow throughout the chambers of the heart, collect blood samples, and take x rays of the heart's ventricles or arteries.

Coronary angiography

Coronary angiography, which is also known as coronary arteriography, is an imaging technique that involves injecting a dye into the vascular system to outline the heart and coronary vessels. Angiography allows the visualization of any blockages, narrowing, or abnormalities in the coronary arteries. If these signs are visible, the cardiologist may assess the patient's readiness for coronary bypass surgery, or a less invasive approach such as dilation of a narrowed blood vessel by surgery or the use of a balloon (angioplasty). Because some interventions may be performed during cardiac catheterization, the procedure is considered therapeutic as well as diagnostic.

Outpatient catheterization

Cardiac catheterization is usually performed in a specially designed cardiac catheterization suite in a hospital, so that any procedural complications may be handled rapidly and effectively. Cardiac catheterization may also be performed on patients presenting to the emergency department with chest pain or chest injuries. The procedure may be performed on an outpatient basis, depending on the patient's pre- and post-catheterization

condition. As of 2000, however, the American Heart Association (AHA) and the American College of Cardiology (ACC) issued a joint statement denying approval of the use of separate cardiac catheterization laboratories that are not part of a hospital, on the grounds that a small number of patients having the procedure on an outpatient basis will have unexpected reactions or complications.

Precautions

Contraindications

Cardiac catheterization is categorized as an invasive procedure that involves the heart, its valves, and coronary arteries, in addition to a large artery in the arm or leg. Cardiac catheterization is contraindicated for patients with the following conditions:

- A bleeding disorder, or anticoagulation treatment with Coumadin (sodium warfarin). These may affect bleeding and clotting during the catheterization procedure.
- Renal insufficiency or poor kidney functioning (especially in diabetic patients), which may worsen following angiography.
- Severe uncontrolled hypertension.
- Severe peripheral vascular disease that limits access to the arteries.
- Untreated active infections, severe anemia, electrolyte imbalances, or coexisting illnesses that may affect recovery or survival.
- Endocarditis (an inflammatory **infection** of the heart's lining that often affects the valves).

Radiation hazards

Cardiac catheterization involves radiation exposure for staff members as well as the patient. The patient's dose of radiation is minimized by using lead shielding in the form of blankets or pads over certain body parts and by choosing the appropriate dose during fluoroscopy. Staff members' exposure to radiation is monitored by the wearing of radiation badges that detect exposure and lead aprons that shield the body. The radiographic/fluoroscopic system may be equipped with movable lead shields that do not interfere with access to the patient and are placed between staff members and the source of radiation during the procedure.

Description

More than 1.5 million cardiac catheterizations are performed every year in the United States, primarily to diagnose or monitor heart disease.

Cardiac anatomy

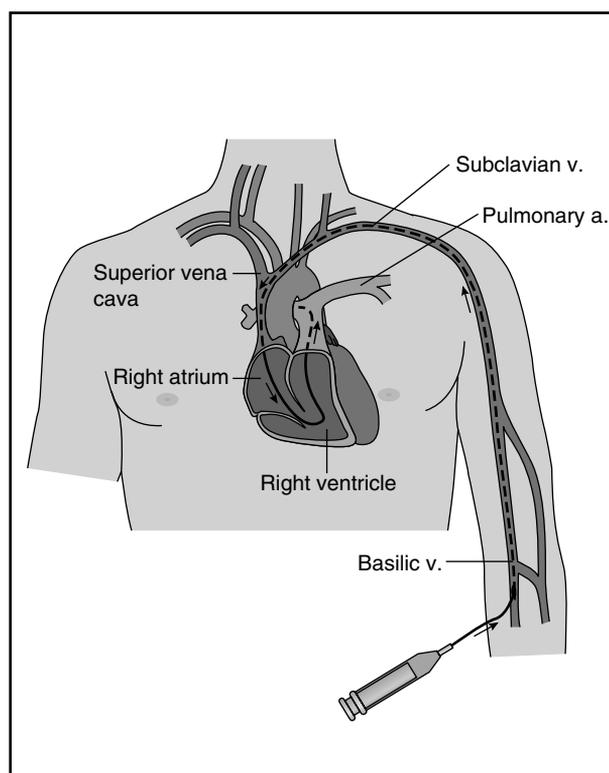
The heart consists of four chambers separated by valves. The right side of the heart, which consists of the right atrium (upper chamber; sometimes called the right auricle) and the right ventricle (lower chamber), pumps blood to the **lungs**. The left side of the heart, which consists of the left atrium (or auricle) and the left ventricle, simultaneously pumps blood to the rest of the body. The right and left coronary arteries, which are the first vessels to branch off from the aorta, supply blood to the heart. The left anterior descending coronary artery supplies the front of the heart; the left circumflex coronary artery wraps around and supplies the left side and the back of the heart; and the right coronary artery supplies the back of the heart. There is, however, a considerable amount of variation in the anatomy of the coronary arteries.

Catheterization procedure

The patient lies on a table on his or her back during the catheterization procedure, connected to monitoring equipment, including an **electrocardiography** device. The insertion site is numbed with a local anesthetic, and access to the vein or artery is obtained using a needle. A sheath, a rubber tube that facilitates insertion of catheters and infusion of drugs, is placed in the puncture site. Under fluoroscopic guidance, a guidewire, which is a thin wire that guides the catheter insertion, is threaded through a brachial or femoral artery and up to the heart. The catheter, a flexible or preshaped tube approximately 32–43 inches (80–110 cm) long, is then inserted over the wire and threaded to the heart. The patient may experience pressure as the catheter is threaded into the heart. The contrast agent or dye used for imaging is then injected so that the physician can view the heart and surrounding vessels. The patient may experience a hot flushed feeling or slight nausea following injection of the contrast medium. Depending on the type of catheterization (left- or right-heart) and the area being imaged, different catheters with various shapes and ends are used.

The radiographic/fluoroscopic system has an x-ray subsystem and video system with viewing monitors that allow the physician to view the procedure in real time using fluoroscopy as well as taking still x rays for documentation purposes. Most newer systems use a digital angiography system that allows images to be recorded, manipulated, and stored digitally on a computer.

The procedure usually lasts about two or three hours. If further intervention is necessary, an angioplasty, stent implantation, or other procedure can be performed. At the end of the catheterization, the catheter and sheath are removed, and the puncture site is closed using a sealing device or manual compression to stop the bleeding. One



Cardiac catheterization procedure. (Delmar Publishers, Inc. Reproduced by permission.)

commonly used sealing device is called Perclose, which allows the doctor to sew up the hole in the groin. Two other devices called AngioSeal and VasoSeal use collagen seals to close the holes in the femoral artery.

Preparation

Before undergoing cardiac catheterization, the patient may have had other noninvasive diagnostic tests, including an electrocardiogram (ECG), **echocardiography**, computed tomography (CT), **magnetic resonance imaging** (MRI), laboratory studies (e.g., blood work), and/or nuclear medicine cardiac imaging. The results of these noninvasive tests may have indicated a need for cardiac catheterization to confirm a suspected cardiac condition, further define the severity of a previously diagnosed condition, or establish the need for an interventional procedure (e.g., cardiac surgery).

Patients should give the physician or nurse a complete list of their regular medications, including aspirin and **nonsteroidal anti-inflammatory drugs** (NSAIDs), because they can affect blood clotting. Diabetics who are taking either metformin or insulin to control their diabetes should inform the physician, as these drugs may

Cardiac monitoring pressures and volumes

Pressure	Normal values
Aortic artery pressure (routine blood pressure)	90–140/60–90 mm Hg
Central venous pressure	2–14 cm H ₂
End-diastolic left ventricular pressure	4–12 mm Hg
Pulmonary wedge pressure	Left atrial: 6–15 mm Hg
Pulmonary artery pressure	15–28/5–16 mm Hg
Systolic left ventricle pressure	90–140 mm Hg
Volumes	
Cardiac index (CI)	2.8–4.2 L/min/m ² for a patient with 1.5m ² of body surface area
Cardiac output (CO)	3–6 L/min
Ejection fraction (EF)	0.67±0.07
End-diastolic volume (EDV)	50–90ml/m ²
End-systolic volume (ESV)	25 ml/m ²
Stroke volume (SV)	45±12 ml/m ²

SOURCE: Pagana, K.D. and T.J. Pagana. *Mosby's Diagnostic and Laboratory Test Reference*. 3rd ed. St. Louis: Mosby, 1997.

need to have their dosages changed before the procedure. Patients should also notify staff members of any **allergies** to shellfish containing iodine, iodine itself, or the dyes commonly used as contrast agents before cardiac catheterization.

Because cardiac catheterization is considered surgery, the patient will be instructed to fast for at least six hours prior to the procedure. A mild sedative may be administered about an hour before the procedure to help the patient relax. If the catheter is to be inserted through the groin, the area around the patient's groin will be shaved and cleansed with an antiseptic solution.

Aftercare

While cardiac catheterization may be performed on an outpatient basis, the patient requires close monitoring following the procedure; he or she may remain in the hospital for up to 24 hours. The patient will be instructed to rest in bed for at least eight hours immediately after the test. If the catheter was inserted into a vein or artery in the leg or groin area, the leg will be kept extended for four to six hours. If a vein or artery in the arm was used to insert the catheter, the arm will need to remain extended for a minimum of three hours.

Most doctors advise patients to avoid heavy lifting or vigorous **exercise** for several days after cardiac catheterization. Those whose occupation involves a high level of physical activity should ask the doctor when they can safely return to work. In most cases, a hard ridge will form over the incision site that diminishes as the site heals. A bluish discoloration under the skin often occurs

at the point of insertion but usually fades within two weeks. The incision site may bleed during the first 24 hours following surgery. The patient may apply pressure to the site with a clean tissue or cloth for 10–15 minutes to stop the bleeding.

The patient should be instructed to call the doctor *at once* if tenderness, **fever**, shaking, or chills develop, which may indicate an infection. Other symptoms requiring medical attention include severe pain or discoloration in the leg, which may indicate that a blood vessel was damaged.

Complications

As with all invasive procedures, cardiac catheterization involves some risks. The most serious complications include stroke, myocardial infarction, and death resulting from clotting or rupture in one of the coronary or cerebral vessels. Other complications include cardiac arrhythmias, pericardial tamponade, vessel injury, and renal failure. The most common complications resulting from cardiac catheterization are vascular-related, including external bleeding at the arterial puncture site, hematomas, and pseudoaneurysms.

The patient may be given anticoagulant medications to lower the risk of developing an arterial blood clot (thrombosis) or of blood clots forming and traveling through the body (embolization).

The risk of complications from cardiac catheterization is higher in patients over the age of 60; those who have severe heart failure; or those with advanced valvular disease.

Allergic reactions related to the contrast agent (dye) and anesthetics may occur in some patients during cardiac catheterization. Allergic reactions may range from minor **hives** and swelling to severe **shock**. Patients with allergies to seafood or penicillin are at a higher risk of allergic reaction; giving **antihistamines** prior to the procedure may reduce the occurrence of allergic reactions to contrast agents.

Results

Normal findings from a cardiac catheterization will indicate no abnormalities in the size or configuration of the heart chamber, the motion or thickness of its walls, the direction of blood flow, or motion of the valves. Smooth and regular outlines on the x ray indicate normal structure of the coronary arteries.

The measurement of intracardiac pressures, or the pressure in the heart's chambers and vessels, is an essential part of the catheterization procedure. Pressure readings that are higher than normal are significant for a

KEY TERMS

Aneurysm—An abnormal dilatation of a blood vessel, usually an artery. It may be caused by a congenital defect or weakness in the vessel's wall.

Angiography—A procedure that allows x-ray examination of the heart and coronary arteries following injection of a radiopaque substance (often referred to as a dye or contrast agent).

Angioplasty—A procedure in which a balloon catheter is used to mechanically dilate the affected area of a diseased artery and enlarge the constricted or narrowed segment. It is an alternative to vascular surgery.

Aortic valve—The valve between the heart's left ventricle and ascending aorta that prevents regurgitation of blood back into the left ventricle.

Arrhythmia—A variation in the normal rhythm of the heartbeat.

Catheter—A flexible or preshaped curved tube, usually made of plastic, used to evacuate fluids from or inject fluids into the body. In cardiac catheterization, a long, fine catheter is inserted through a blood vessel directly into the chambers of the heart.

Computed tomography (CT)—A diagnostic imaging procedure that uses x rays to produce cross-sectional images of the anatomy. It may be performed prior to cardiac catheterization.

Coronary bypass surgery—A surgical procedure that places a shunt to allow blood to travel from the aorta to a branch of the coronary artery at a point below an obstruction.

Echocardiography—An ultrasound examination of the heart that may be performed prior to cardiac catheterization.

Fluoroscopy—A diagnostic imaging procedure that uses x-rays and contrast agents to visualize anatomy and motion in real time.

Hematoma—An accumulation of clotted blood that may occur in the tissue around the catheter insertion site following cardiac catheterization.

Ischemia—A localized deficiency in the blood supply, usually caused either by vasoconstriction or by obstacles to the arterial blood flow.

Magnetic resonance imaging (MRI)—A diagnostic imaging procedure that uses a magnetic field to produce anatomical images. It may be performed prior to cardiac catheterization.

Mitral valve—The bicuspid valve that lies between the left atrium and left ventricle of the heart. "Bicuspid" means that the valve has two flaps.

Percutaneous transluminal coronary angioplasty (PTCA)—A cardiac intervention in which an artery blocked by plaque is dilated, using a balloon catheter to flatten the plaque and open the vessel. It is also called balloon angioplasty.

Pericardial tamponade—The collection of blood in the sac surrounding the heart that causes compression. Tamponade is a possible complication of cardiac catheterization.

Pseudoaneurysm—A dilation of a blood vessel that resembles an aneurysm. Pseudoaneurysms may occur as a complication of cardiac catheterization.

Pulmonary valve—The heart valve that separates the right ventricle and the opening into the pulmonary artery.

Septum—The muscular wall that separates the two sides of the heart. An opening in the septum that allows blood to flow from one side to the other is called a septal defect.

Shunt—A passageway (or an artificially created passageway) that diverts blood flow from one main route to another.

Stent—A small tubelike device made of stainless steel or other material, used to hold open a blocked artery.

Tricuspid valve—The right atrioventricular valve of the heart. It has three flaps, whereas the mitral valve has only two.

patient's overall diagnosis. Pressure readings that are lower, other than those resulting from shock, are usually not significant.

The ejection fraction is also determined by performing a cardiac catheterization. The ejection fraction is a

comparison of the quantity of blood ejected from the heart's left ventricle during its contraction phase with the quantity of blood remaining at the end of the left ventricle's relaxation phase. The cardiologist will look for a normal ejection fraction reading of 60–70%.

Abnormal results are obtained by viewing the still and live motion x rays during cardiac catheterization for evidence of coronary artery disease, poor heart function, disease of the heart valves, and septal defects.

The most prominent sign of coronary artery disease is narrowing or blockage (stenosis) in the coronary arteries, with narrowing greater than 50% considered significant. A clear indication for intervention by angioplasty or surgery is a finding of significant narrowing of the left main coronary artery and/or blockage or severe narrowing in the high left anterior descending coronary artery.

A finding of impaired wall motion is an additional indicator of coronary artery disease, an aneurysm, an enlarged heart, or a congenital heart problem. Using an ejection fraction test that measures wall motion, cardiologists regard an ejection fraction reading under 35% as increasing the risk of complications while also decreasing the possibility of a successful long- or short-term outcome from surgery.

Detecting the difference in pressure above and below the heart valve can verify the presence of valvular disease. The greater the narrowing, the higher the difference in pressure.

To confirm the presence of septal defects, measurements are taken of the oxygen content on both the left and right sides of the heart. The right heart pumps unoxygenated blood to the lungs, and the left heart pumps blood containing oxygen from the lungs to the rest of the body. Elevated oxygen levels on the right side indicate the presence of a left-to-right atrial or ventricular shunt. Low oxygen levels on the left side indicate the presence of a right-to-left shunt.

Health care team roles

A cardiac catheterization team consists of a physician (e.g., interventional cardiologist), a nurse, a circulating nurse, and a radiologic technologist. Nurses assist the physician and monitor the patient during the procedure. Because clinical laboratory equipment may be used during the procedure to monitor certain parameters (e.g., **blood coagulation** time), nursing or other staff should be familiar with the operation of laboratory devices used in the cardiac catheterization suite. The radiologic technologist assists the physician with the operation of the x-ray and fluoroscopy equipment during the procedure and oversees any image processing, printing, and/or storage needs. The radiologic technologist may work with a medical physicist to monitor radiation safety protocols for the patient and staff.

Resources

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ORGANIZATIONS

American College of Cardiology. Heart House, 9111 Old Georgetown Road, Bethesda, MD 20814-1699. (800) 253-4636. <<http://www.acc.org>>.

American Heart Association National Center. 7272 Greenville Avenue, Dallas, TX 75231. (800) AHA-USA1. <<http://www.americanheart.org>>.

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Cardiac cycle

Definition

The cardiac cycle is the sequence of events that occur when the **heart** beats. The cycle has two main phases: diastole, when the heart ventricles are relaxed, and systole, when the ventricles contract. One cardiac cycle is defined as the contraction of the two atria followed by contraction of the two ventricles.

Description

The heart is a muscular organ that works as a pumping system. It takes in **blood** with reduced levels of oxy-

gen from the veins (deoxygenated blood), and delivers it to the **lungs** for oxygenation. When it receives the oxygenated blood back from the lungs, it pumps the blood back into the arteries to be distributed throughout the body.

The heart is divided into four hollow chambers, two on the left and two on the right. The right chambers are the right atrium and the right ventricle. They receive blood from the veins. The left chambers are the left atrium and the left ventricle. They receive blood from the pulmonary circulation, and the left ventricle forces blood into the systemic circulation.

In a cardiac cycle, blood enters the right atrium of the heart from the superior and inferior vena cavae, and flows across the tricuspid valve into the right ventricle. From the right ventricle the blood flows into the pulmonary artery, which is separated from the ventricle by the pulmonary valve. After oxygenation in the lungs, blood returns to the heart via four pulmonary veins that enter the left atrium. From the left atrium, blood flows across the mitral valve and into the left ventricle. From the left ventricle blood is ejected across the aortic valve into the aorta. Together, the mitral and tricuspid valves are known as the atrioventricular valves and the aortic and pulmonary valves as the semilunar valves.

From a mechanical point of view, the cardiac cycle is due to blood movement occurring as a result of pressure differences within the chambers of the heart. In order for blood to flow through a blood vessel or across and heart valve, there must be a force acting on the blood. This force is provided by the difference in **blood pressure** (a pressure gradient) across these structures by the contractions of the heart. Each heart beat, or cardiac cycle, is divided into two phases of contraction and relaxation, stimulated by electrical impulses from the sinoatrial node (SA node), a patch of tissue in the heart that sets the rate of contractions. It contracts itself and then sends nerve impulse to the atria. The time during which ventricular contraction occurs is called systole. The time between ventricular contractions, during which ventricular filling occurs, is called diastole (also known as the relaxation phase).

In early diastole, the ventricles relax, the semilunar valves close, the atrioventricular valves open and the ventricles fill with blood. In mid diastole, the atria and ventricles are relaxed, the semilunar valves are closed, the atrioventricular valves are open, and the ventricles keep filling with blood. In late diastole, the SA node sends an electrical impulse to the atria, which causes the atria to contract and the ventricles to fill with more blood. The electrical signal that causes contraction moves from the atria toward the ventricles. Before it

does, though, it reaches the atrioventricular node (AV node). The AV node delays the signal so that the ventricle can contract all at once rather than a little bit at a time.

Prior to systole, the electrical signal passes from the AV node down the AV bundle, also known as the bundle of His, to the Purkinje fibers. The fibers allow the fast spread of the electrical signal to all parts of the ventricles, and the electrical signal causes the ventricles to contract. Systole begins with the closure of the atrioventricular valves. During systole, the ventricles contract, the semilunar valves open, and blood is pumped from the ventricles to the aorta.

Blood pressure is highest during systole, and lowest during diastole. It has two components, the systolic and diastolic pressure. Normal systolic pressure for an adult is 120 mm Hg, and normal diastolic pressure is 80 mm Hg. These values are commonly recorded as 120/80.

The normal heart beats at a rate of about 72 beats per minute (with a range of 60-100 beats per minute), but can vary with normal daily activity.

The cardiac cycle produces well-known sounds that can be clearly heard with a **stethoscope**. The first heart sound is associated with closure of the atrioventricular valves and signals the start of ventricular systole. The second heart sound is associated with the closure of the semilunar valves and indicates the start of ventricular diastole. A third heart sound is due to the rapid phase of ventricular filling, and a fourth heart sound is due to atrial systole. The two last sounds are usually not loud enough to hear, so neither of them is heard under normal exam procedures.

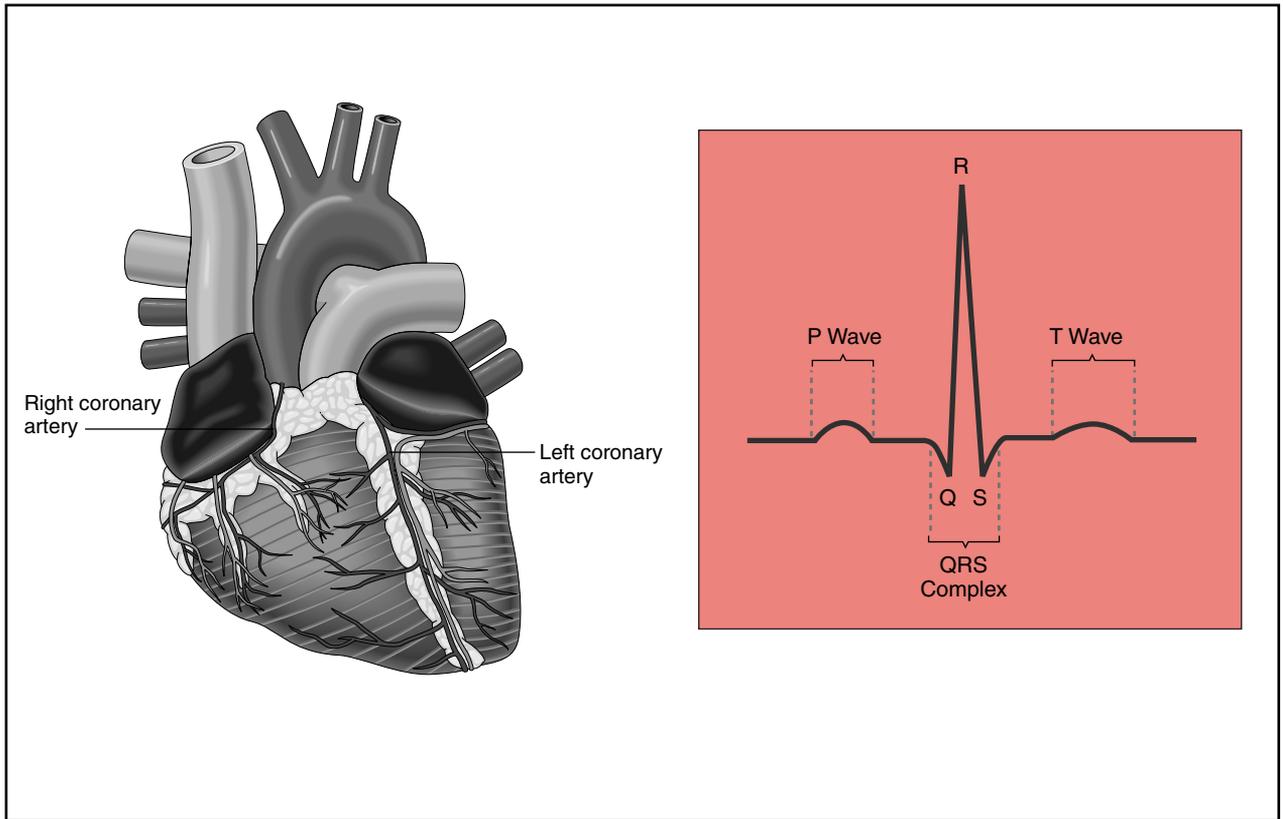
Role in human health

The role of the cardiac cycle is essential to maintain life, as the heart distributes the oxygen-carrying blood required for the functioning of the body.

Common diseases and disorders

Although diseases of the valves are common, and other cardiac disorders can also disrupt normal blood flow, they do not cause an abnormal cardiac cycle per se. Since the normal sequence of events occurs, even though it's impaired, it is considered a normal cardiac cycle (but not a normal heart beat). Most of the common abnormalities in the cardiac cycle are caused by disturbances in electrical conduction of the heart.

Disturbances in the electrical cycle are known as arrhythmias. However, two types of disturbances, sinus tachycardia and sinus bradycardia, do not affect the sequence of events, because they speed up (tachycardia)



The heartbeat is controlled by electric impulses. To the right is a schematic representation of these impulses. (Delmar Publishers, Inc. Reproduced by permission.)

or slow down (bradycardia) the beating of the heart. The other arrhythmias have one of two origins. They can be caused by a lack of normal electrical conduction. For example, a lack of electrical signaling from the sinoatrial node can lead to the placement of an exogenous pacemaker (something that causes the heart to beat other than the sinoatrial node). The other cause of arrhythmias is abnormally strong ectopic (in the wrong place) electrical activity. For example, premature atrial contractions can be caused by excessive electrical activity somewhere in the atrium other than the sinoatrial node. Some arrhythmias may be a combination of the two.

Cardiac cycle disturbances can be complex, but can be dissected by an electrocardiogram (EKG or ECG). They can be caused by a wide variety of problems, including, but not limited to, coronary heart disease, damage to the heart muscle secondary to a heart attack, genetic heart defects, valvular disease of the heart, and medications. Following is a list of common arrhythmias.

Atrial arrhythmias:

- paroxysmal atrial tachycardia
- multifocal atrial tachycardia

- atrial fibrillation
- atrial flutter

Ventricular arrhythmias:

- premature ventricular contractions (PVCs)
- ventricular tachycardia
- ventricular fibrillation

Arrhythmias arising because of abnormalities in the AV node, Purkinje fibers, or bundle of His:

- nodal rhythm
- first degree block
- second degree block
- third degree block
- bundle branch block

Resources

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KEY TERMS

Aorta—The largest artery of the body that originates from the left ventricle of the heart, arches over the heart to the left, and descends just in front of the spinal column. The aorta divides into three arteries: the brachiocephalic artery (that supplies blood to the brain and head), the left carotid artery, and the left subclavian artery.

Aortic valve—The heart valve that divides the left ventricle and the aorta. Blood from the left ventricle is ejected across the aortic valve into the aorta for further distribution. It opens during contraction of the left ventricle and closes afterwards to prevent the backward flow of blood from the aorta.

Arterial blood pressure—The ejection of blood into the aorta by the left ventricle results in the characteristic aortic pressure pulse. The maximum of the aortic pressure pulse is called the systolic pressure and the lowest pressure in the aorta is called the diastolic pressure.

Arterial pulse pressure—The arterial pulse pressure is the difference between the systolic and diastolic arterial pressures.

Artery—Blood vessel that carries blood away from the heart for distribution throughout the body.

Atrioventricular node (AV node)—Nodal tissue located on the right side of the partition that divides the atria, near the bottom of the right atrium. It delays impulses from the SA node, thus allowing the atria to empty themselves.

Atrioventricular valves—Heart valves located between the atria and the ventricles. They are the mitral valve and the tricuspid valve.

Diastole—The time in between ventricular contractions during which ventricular filling occurs. Also called the relaxation phase.

Diastolic pulse pressure—The pressure exerted on the walls of the arteries during diastole. A normal value ranges around 90 mmHg.

Heart—In humans, the heart is divided into four chambers: the right atrium and ventricle and the left atrium and ventricle. Blood flows from the veins into the right atrium, then to the right ventricle and into the lungs for oxygenation, from where it is returned to the left atrium, then to the left ventricle for distribution to the body via arteries.

Mitral valve—The heart valve that divides the left atrium and the left ventricles. It opens during con-

traction of the left atrium to allow blood flow into the left ventricle and closes to prevent the backward flow of blood to the left atrium.

Oxygenation—The process of adding oxygen to something. Oxygen is added to the blood in the lungs. Oxygen contained in the inhaled air is delivered to the blood, where the oxygen binds to a protein called hemoglobin (which functions as an oxygen-carrier).

Pulmonary artery—Short blood vessel that carries deoxygenated blood from the heart to the lungs.

Pulmonary vein—One of four blood vessels that carry oxygenated blood from the lungs to the heart.

Pulmonary valve—The heart valve that divides the right ventricle from the pulmonary artery.

Semilunar valves—Heart valves shaped like a half-moon that located between the aorta and the left ventricle and between the pulmonary artery and the right ventricle. They are the aortic valve and the pulmonary valve.

Sinoatrial node (SA node)—Also called the pacemaker of the heart. It consists of nodal tissue located in the upper wall of the right atrium. It controls the rate of contraction of the heart by generating nerve impulses that travel throughout the heart wall causing both atria to contract.

Systole—The time during which ventricular contraction occurs.

Systolic pulse pressure—The pressure exerted on the walls of the arteries during the contraction of the heart. A normal value ranges around 150 mmHg.

Tricuspid valve—The heart valve, named for its three cusps, that divides the right atrium from the right ventricle. Blood flows from the right atrium, across the tricuspid valve, and into the right ventricle. When closed, it prevents the blood from flowing back into the right atrium.

Vein—Blood vessel that returns blood to the heart from the body. All the veins from the body converge into two major veins that lead to the right atrium of the heart. These veins are the superior vena cava and the inferior vena cava. The pulmonary vein carries the blood from the right ventricle of the heart into the lungs.

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Monique Laberge, PhD

Cardiac exercise stress testing see **Stress test**

Cardiac mapping see **Electrophysiology study of the heart**

Cardiac marker tests

Definition

Cardiac marker tests identify **blood** analytes associated with **myocardial infarction** (MI), commonly known as a **heart** attack.

Purpose

Cardiac markers help physicians to assess acute coronary syndromes and to identify and manage high-risk patients. Creatine kinase-MB (CK-MB), myoglobin, homocysteine, C-reactive protein (CRP), troponin T (cTnT), and troponin I (cTnI) are all used for assessment of the suspected acute myocardial infarction. CK-MB, cTnT, and cTnI may also be used to identify and manage high-risk patients.

Precautions

C-reactive protein results may be affected by the use of oral contraceptives, NSAIDs, steroids, salicylates, intrauterine devices (IUDs), and overnight sample refrigeration. Homocysteine levels may be affected by smoking, diabetes, and coffee.

Description

Creatine kinase (CK)

Creatine kinase is an enzyme responsible for transferring a phosphate group from ATP to creatine. It is composed of M and/or B subunits that form CK-MM, CK-MB, and CK-BB isoenzymes. Total CK (the activity of the MM, MB, and BB isoenzymes) is not myocardial-specific. However, the MB isoenzyme (also called CK-2) comprises about 40% of the CK activity in cardiac muscle and 2% or less of the activity in most muscle groups and other tissues. In the proper clinical setting, MB is both a sensitive and specific marker for myocardial infarction. MB usually becomes abnormal three to four hours after an MI, peaks in 10 to 24 hours, and returns to normal within 72 hours. However, an elevated serum MB may occur in people with severe skeletal muscle damage (such as in **muscular dystrophy** or a crush injury) and renal failure. In such cases, the CK index (MB divided by total CK) is very helpful. If the index is under 4%, a nonmyocardial cause of a high MB should be suspected. C-MB is considered the benchmark for cardiac markers of myocardial injury. Measurement of CK-MB may be performed via electrophoresis or immunoassays; the latter demonstrates better analytical sensitivity and better precision.

CK-MB isoforms can be used to determine whether thrombolytic therapy (such as treatment with tissue plasminogen activator to dissolve a blood clot in the coronary artery) has succeeded. MB isoforms are different molecular forms of MB found in the circulation. When MB is released into the blood, the terminal lysine of the M subunit is removed by an enzyme in the plasma. This results in a molecule with faster electrophoretic mobility, called CK-2₁. This is the prevalent form of MB in the blood. The slower form, designated CK-2₂, is the unmodified cardiac form of MB. After successful thrombolytic therapy, the unmodified form of MB is rapidly flushed into the blood, causing it to become the dominant isoform.

Myoglobin

Myoglobin is a protein found in both skeletal and myocardial muscle. It is released rapidly after tissue injury and may be elevated as early as one hour after myocardial injury, though it may also be elevated due to skeletal muscle trauma. However, if myoglobin values do not rise within three to four hours after a person shows acute symptoms, it is highly unlikely that he or she had an MI. There are several measurement methods available, including fluorometric, nephelometric, and turbidimetric assays; plus immunochromatography-based tests designed for qualitative, point-of-care testing.

Troponin T and troponin I

Troponin C, I, and T are **proteins** that form the thin filaments of muscle fibers and regulate the movement of contractile proteins in muscle tissue. Skeletal and cardiac forms are structurally distinct, and antibodies can be produced that react only with the cardiac forms of troponin I and troponin T.

Cardiac troponin T (cTnT) and cardiac troponin I (cTnI) are the newest additions to the list of cardiac markers. Troponins are specific to heart muscle. They have enabled the development of assays that can detect heart muscle injury with great sensitivity and specificity. While these markers have been used mainly to aid in the diagnosis of chest-pain patients with nondiagnostic electrocardiograms, they are also used as prognostic indicators of a MI. According to the American Heart Association, "Several studies have identified a measurable relationship between cardiac troponin levels and long-term outcome after an episode of chest discomfort. They suggest that these tests may be particularly useful to evaluate levels of risk. In other words, it's possible that the results of a troponin test could be used to identify people at either low risk or high risk for later, serious heart problems."

Several commercially available quantitative immunoassays are available for the measurement of cTnI and cTnT. There is also a qualitative cTnI test, targeted at bedside testing.

C-reactive protein (CRP)

CRP is a protein found in serum or plasma at elevated levels during a inflammatory processes. The protein can be measured via a variety of methods, including EIA or ELISA, for the quantitative or semiquantitative determination of C-reactive protein in human serum, particle agglutination tests that provide semiquantitative results, and laser and rate nephelometry tests that measure antigen-antibody complexes by light dispersion.

CRP binds to the C polysaccharide of the capsule of *Streptococcus pneumoniae*. It is a sensitive marker of acute and chronic inflammation and **infection**, and in such cases is increased several hundred-fold. Several recent studies have demonstrated that CRP levels are useful in predicting the risk for a thrombotic event. These studies suggest that a high-sensitivity assay for CRP be used that is capable of measuring the very low level normally found in serum (0.1 to 2.5 mg/L). Heart patients who have persistent CRP levels between 4 and 10 mg/L, with clinical evidence of low-grade inflammation, should be considered to be at increased risk for thrombosis. People can be stratified into four groups of increased risk based upon the quartile in which their CRP levels fall.

Homocysteine

Homocysteine is an amino acid. According to the American Heart Association, studies have shown that too much homocysteine in the blood is related to a higher risk of coronary heart disease, stroke, and peripheral vascular disease; and that it may also have an effect on atherosclerosis. High levels of homocysteine are the result of inheritance or dietary excess and have been implicated in vascular-wall injury. One immunoassay is available for it. It is believed that laboratory testing for plasma homocysteine levels can improve the assessment of risk, particularly in patients with a personal or family history of cardiovascular disease, but in whom the well-established risk factors (smoking, high blood cholesterol, high **blood pressure**, physical inactivity, **obesity**, and diabetes) do not exist. Homocysteine levels are obtained via high-performance chromatography with electrochemical detection.

Preparation

These assays require a sample of blood, which is typically obtained via a standard venipuncture procedure. Homocysteine tests require the patient to fast. Homocysteine is stable only in separated refrigerated or frozen plasma for 48 hours.

Aftercare

Discomfort or bruising may occur at the puncture site, or the person may feel dizzy or faint. Applying pressure to the puncture site until the bleeding stops reduces bruising. Warm packs to the puncture site relieve discomfort.

Complications

There are no complications associated with these tests.

Results

Normal results vary, based on the laboratory and method used. Unless otherwise specified, the following information is from the American College of Cardiology and the American Heart Association.

- Total CK: Reference value is 38 to 174 units/L for men and 96 to 140 units/L for women. The values begin to rise within four to six hours and peak at 24 hours. Values return to normal within three to four days.
- CK-MB: Reference value is 10 to 13 units/L. The values begin to rise within three to four hours and peak at 10 to 24 hours. Values return to normal within two to four days.

KEY TERMS

Cardiac marker—A substance in the blood that rises following a myocardial infarction.

Diagnostic window—A cardiac marker's timeline for rising, peaking, and returning to normal after a heart attack.

Myocardial infarction (MI)—Commonly known as a heart attack, a myocardial infarction is an episode in which some of the heart's blood supply is severely cut off or restricted, causing the heart muscle to suffer and die from lack of oxygen.

Myoglobin—A protein that holds oxygen in heart and skeletal muscle. It rises after damage to either of these muscle types.

- Troponin T: Reference value is less than 0.1 ng/mL. The values begin to rise within two to four hours and peak at 10 to 24 hours. Values return to normal within five to 14 days.
- Troponin I: Reference value is less than 1.5 ng/mL. The values begin to rise within two to four hours and peak at 10 to 24 hours. Values return to normal within five to 10 days.
- CK-MB isoforms: Reference value is a ratio of 1.5 or greater. The values begin to rise within two to four hours and peak at six to 12 hours. Values return to normal within 12 to 24 hours.
- Myoglobin: Reference value is less than 110 ng/mL. The values begin to rise within one to two hours and peak at four to eight hours. Values return to normal within 12 to 24 hours.
- Homocysteine: The normal fasting level for plasma is five to 15 micromol/L. Moderate, intermediate, and severe hyperhomocysteinemia refer to concentrations between 16 and 30, between 31 and 100, and less than 100 micromol/L, respectively.
- C-reactive protein: According to the U.S. Food and Drug Administration, in healthy people, reference values are below 5 mg/dL; in various diseases, this threshold is often exceeded within four to eight hours after an acute inflammatory event, with CRP values reaching approximately 20 to 500 mg/dL.

Health care team roles

Cardiac marker tests are usually performed by clinical laboratory scientists, medical technologists, or clinical laboratory technicians.

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Cardiac monitor

Definition

The cardiac monitor is a device that shows the heart's electrical activity as a wave pattern on a monitor. It is a bedside monitor.

Purpose

The cardiac monitor continuously shows the cardiac rhythm and sends the electrocardiogram (EKG) tracing to a main monitor in the nursing station. Most commonly used in emergency rooms and critical care areas, cardiac monitoring allows for continual observation of several patients. Aside from monitoring cardiac patients, continuous monitoring is useful for observation of postoperative patients, patients with severe electrolyte imbalances, and other unstable patients. Continuous cardiac monitoring allows for prompt identification and initiation of treatment for cardiac arrhythmias and other conditions.

Precautions

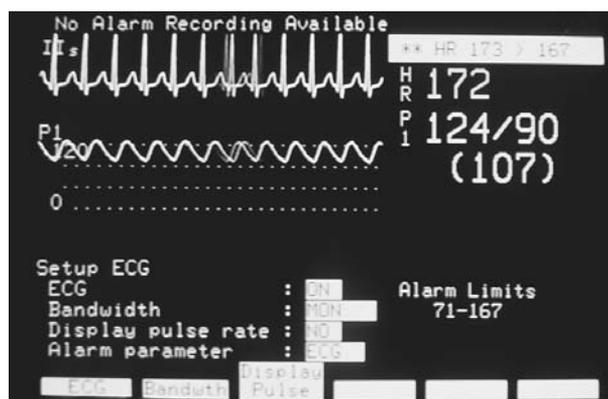
The American Heart Association warns of potential interference between some **pacemakers** and cardiac monitors. Minute ventilation rate-adaptive pacemakers can occasionally interact with certain cardiac monitoring and diagnostic equipment, causing the pacemakers to pace at their maximum-programmed rate. Minute ventilation is sensed in rate-adaptive pacemakers by technology known as bioelectric impedance measurement (BIM). Many medical devices in addition to pacemakers use this technology. When one of these devices is used on a patient with an active, minute ventilation rate-adaptive pacemaker, the pacemaker can erroneously interpret the mixture of BIM signals created in the patient, resulting in an elevated pacing rate. Cardiac monitors, echocardiograph equipment, apnea monitors, respiration monitors, and external defibrillators are common devices that may use BIM technology.

Description

The monitor provides a visual display of the patient's heart rhythm, which is particularly useful information during heart attacks, when patients can develop lethal cardiac arrhythmias. The monitor sounds an alarm if the patient's heart rate goes above or below a predetermined number. An automatic **blood pressure** cuff and a **pulse oximeter**, which measures the oxygen saturation in the **blood**, are also included with some monitors.

Equipment required for continuous cardiac monitoring includes:

- cardiac monitor
- monitor cable
- leadwires
- electrodes
- dry washcloth or gauze pad
- alcohol sponges



Cardiac monitors display vital information for patients in the intensive care unit. (Photograph by Hank Morgan. Science Source/Photo Researchers. Reproduced by permission.)

Preparation

All electrical equipment and outlets are grounded to avoid electrical shock and artifact (electrical activity caused by interference). The nurse should plug in the monitor, turn on power, and connect the cable if not already attached. He or she should connect the lead wires to the proper position and ensure that color-coded wires match the color-coded cable. If the device is not color coded, the right arm (RA) wire should be attached to the RA outlet, the left arm (LA) wire attached to the LA outlet, and so forth. The nurse should open the electrode package, and attach an electrode to each lead wire. The hands should be washed and the procedure should be explained to the patient. Privacy should be ensured for the patient, and the patient should be clean and dry to prevent electrical shock.

Next, the chest should be exposed and the sites selected for electrode placement. Using the rough patch on the electrode, a dry washcloth, or gauze pad, each site should be rubbed briskly until it reddens, but care should be taken not to damage or break the skin. Dead skin cells are removed in this manner, thereby promoting better electrical conduction. Patients who are extremely hairy may need to be shaved prior to application of the electrodes. An alcohol pad is used to clean the sites in patients with oily skin. Areas should dry completely to promote good adhesion. Alcohol should not become trapped beneath the electrode, as this can lead to skin breakdown. In addition to oily skin, diaphoretic skin can cause interference in the recording. To minimize this interference, the electrode site should be rubbed with a dry 4x4 gauze pad before application. The backing of the electrode should be removed, and the gel inspected. If the electrode

KEY TERMS

Amyloidosis—A metabolic disorder, characterized by starch-like formation in tissue structures.

Artifact—Extra electrical activity typically caused by interference.

Cardiomyopathies—Diseases of the heart muscle. Usually refers to a disease of obscure etiology.

Electrodes—Adhesive pads which are placed on the skin and attached to the leads.

Lead—Color coded wires that connect the electrode to the monitor cable.

QRST complex—The combined waves of an electrocardiogram for monitoring the heart.

has dried out, which can happen if the electrode package is opened before immediate use, it should be discarded and another used. The nurse should apply one electrode to each site, press one side of the electrode against the skin, and pull gently. Then, the opposite side of the electrode should be pressed against the skin. The nurse should press two fingers on the electrode in a circular pattern to affix the gel and stabilize the electrode, then repeat for each electrode. *To avoid potential artifact, do not place the electrodes on bony prominences or hairy areas.*

Aftercare

After placing all electrodes, the nurse should observe the monitor and evaluate the quality of the tracing, making size and tracing position adjustments as needed. He or she should confirm that the monitor is detecting each heartbeat by taking an apical pulse and comparing the pulse to the digital display. The upper and lower alarm limits should be set according to institutional policy, and the alarm activated. A rhythm strip should be recorded for the medical record, and labeled with patient name, room number, date, time, and interpretation of the strip.

Complications

There is a potential for skin breakdown at the electrode placement site. The patient may be allergic to the adhesive used, or the electrode may have been left on the skin too long. The electrodes should be removed and new electrodes applied, using hypoallergenic electrodes if necessary.

Results

A normal cardiac tracing shows a regular rate and rhythm with no deviations in the QRST complex (the combined waves of an electrocardiogram). Abnormal results may include bradycardia, or tachycardia, accompanied by the alarm. Q waves (the short initial downward stroke of the QRST complex) are abnormal, and may or may not signal an infarction.

Some causes of noninfarction Q waves are:

- ventricular hypertrophy
- ventricular preexcitation (Wolf-Parkinson-White syndrome)
- cardiomyopathies
- pulmonary embolism
- incomplete left bundle branch block

Causes of changes in ST Segment (part of the EKG between the QRS complex and the T wave) and T Wave (deflection in an EKG that represents electrical activity of the ventricular repolarization) include:

- aberrant conduction
- amyloidosis
- bundle branch block
- cardiomyopathy
- cocaine vasospasm
- electrolyte disturbances
- intracranial hemorrhage
- myocardial metastases
- myocarditis
- paced rhythm
- pancreatitis or acute abdomen
- pericarditis
- physical training
- Prinzmetal's angina
- pulmonary embolism
- tachycardia
- ventricular aneurysm
- ventricular hypertrophy
- ventricular rhythms
- Wolff-Parkinson-White syndrome

Alarm signals are abnormal and must be investigated. A false high alarm rate may be caused by skeletal muscle activity or by the monitor incorrectly interpreting large T waves as a QRS complex, which would double the true heart rate. The electrodes should be repositioned

as needed to ensure that the electrode is not over a major muscle mass and that QRS complex is larger than the T wave. A false low alarm rate may be due to patient movement, or poor contact between electrodes and skin. Electrodes should be reapplied as needed. Artifact is a common abnormal finding, and may be caused by improperly placed electrodes, patient movement, static electricity, seizures, **anxiety**, or chills. The position of electrodes should be checked and static-causing bed linen changed. The cables should not have exposed connectors.

Health care team roles

Cardiac monitoring is usually ordered by a physician. A nurse practitioner or physician assistant can place the electrodes on the patient's body. A nurse provides ongoing care during the monitoring, assesses patient to determine hemodynamic effects of rhythms, and intervenes for dysrhythmias as appropriate. The nurse also instructs the patient and family about the cardiac monitor's use.

Resources

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The American College of Cardiology. Heart House, 9111 Old Georgetown Road, Bethesda, MD 20814-1699. (800) 253-4636. <<http://www.acc.org/>>.

American Heart Association. 7272 Greenville Ave., Dallas TX 75231-4596. (800) 242-1793. <<http://www.amhrt.org/>>.

Applied Biometrics. P.O. Box 3170, Burnsville, MN 55337. (952) 890-1123.

OTHER

Advanced Cardiac Monitoring: Ventricular Ectopy vs. Aberrancy. Videotape. RamEx, Inc.

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Cardiac rehabilitation

Definition

Cardiac rehabilitation is a multi-disciplinary treatment and secondary prevention program for patients with various cardiac disorders, including recovery from **heart attack** and bypass surgery, which includes **exercise**, education, counseling, and lifestyle changes to help the patient return to previous levels of health and functioning and prevent recurrence of cardiac problems.

Purpose

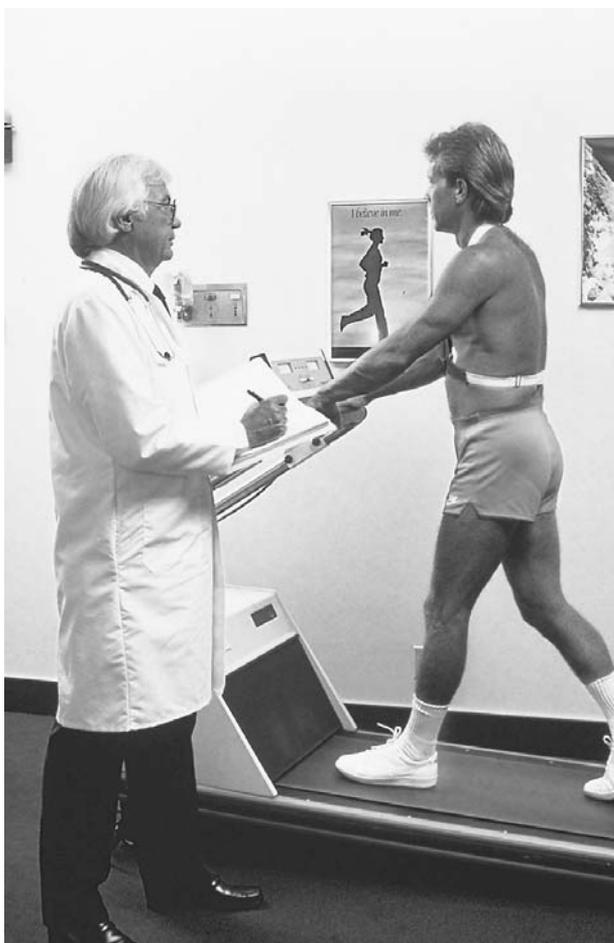
The purpose of cardiac rehabilitation is to provide comprehensive, multifaceted treatment, education, and secondary prevention for cardiac patients and individuals with heart disease risk factors, in order to aid recovery and prevent recurrence of heart problems. Cardiac rehabilitation programs can improve quality of life, help patients return to their previous level of functioning in work and daily life, increase fitness, facilitate heart-healthy behavior changes and management of risk factors, and reduce costs by decreasing frequency and expense of hospital stays.

Precautions

Exercise, or certain kinds of exercise, may be contraindicated in the presence of some medical conditions. Conditions included are acute **heart failure**, angina at rest, second or third degree heart block, excessively low or high **blood pressure**, orthopedic problems, continued ischemia, aortic stenosis or mitral valve disease, or other health conditions in addition to the cardiac disorder. Exercise might also need to be discontinued if certain problems or symptoms such as the following occur: failure of monitoring equipment, lightheadedness, confusion, nausea, angina that occurs while exercising, excessive rise in **blood pressure**, or unusual heart rate. In addition, certain precautions may be taken before any cardiac patient begins an exercise program or session. Some of these include recording heart rate, blood pressure, and cardiac rhythm at each supervised session, and educating the patient in how to prepare for the exercises (proper breathing, dressing appropriately, avoiding smoking, etc.). Any preexisting medical conditions should also be taken into consideration when planning exercise treatments.

Description

Cardiac rehabilitation is a comprehensive, multidisciplinary approach to treatment and secondary preven-



This 40-year-old male works out on a treadmill, monitored by his physician, following heart surgery. (Custom Medical Stock Photo. Reproduced by permission.)

tion for patients with various forms of cardiac disorders, such as post **myocardial infarction** (heart attack), bypass surgery, chronic stable angina pectoris, and heart transplant. It involves a cardiac rehabilitation team, which can be comprised of primary care and specialty physicians, nurses, physical therapists, exercise physiologists, occupational therapists, mental health professionals and dieticians. The physician may choose to participate in various roles, or refer patients to physical therapists and other practitioners or hospital departments.

A specially qualified physical therapist or RN may provide or direct cardiac rehabilitation services. At least one member of the **physical therapy** department or other team of practitioners in charge should be ACLS (Advanced Cardiac Life Support) certified, and a cardiopulmonary specialist should be included. The ACLS certification, which can be obtained during a one-day training course provided by the American Heart

Association, is a level higher than **CPR**, and allows the practitioner to perform intubation and use a defibrillator.

Cardiac rehabilitation can be broken into three phases. Phase I, inpatient treatment in a hospital, can begin as early as 24 hours after a cardiovascular event. Phase II, outpatient treatment, can take place at the hospital, in a community center, in a medical center, or at the patient's home or place of employment. Phase III, referred to as the secondary prevention or maintenance phase, is performed more independently by the patient, with the goal of maintaining benefits and preventing further cardiac problems. An individual patient may participate in cardiac rehabilitation for a few weeks, six months, or longer. Many programs are conducted in groups, but the exercise prescription and other facets of treatment are individually designed to meet the specific medical needs and preferences of each patient.

The main components of a cardiac rehabilitation program are exercise, education, counseling, and behavior modification. Physical therapists may play a large part in the exercise component, as well as some aspects of **patient education**. Some of the goals of exercise are to restore or improve fitness, increase exercise tolerance and functional capacity, regain levels of functioning equivalent to those prior to the disease or surgery, and improve confidence and mood. Exercise and education by a physical therapist or other qualified practitioner can also help the patient manage and improve other risk factors and associated conditions such as diabetes, **obesity**, high blood **lipids** (fats), and **stress**. Inactivity itself is now recognized as a coronary risk factor, and thus exercise is an essential part of treatment for many reasons. A physical therapist may also be especially appropriate for work with cardiac patients who also have musculoskeletal problems. For example, bypass recipients may have problems with mobility of the shoulder or other joints.

The other components of the rehabilitation program may include education about the heart condition and its risk factors, counseling for psychological aspects of heart disease, stress management, vocational or occupational counseling, and guidance in adopting healthier behaviors. Some of the lifestyle or behavioral changes encouraged include smoking cessation and a lower fat diet, and management of other controllable coronary disease risk factors such as smoking, high blood pressure, high cholesterol, obesity, stress, and a sedentary lifestyle.

Many economic and medical benefits have been associated with cardiac rehabilitation, including decreased disability and improved functional capacity, less likelihood of mortality and recurrent morbidity, and decreased medical costs. Another benefit is that the use of electrocardiograph and other forms of objective and sub-

jective assessment in ongoing supervised rehabilitation can lead to detection of problems and adjustments in the patient's treatment. Reasons for cost effectiveness of this form of treatment include reduction in disability and health care costs, fewer re-hospitalizations, and improved productivity. Despite these benefits, only about 11-38% of qualified candidates generally participate. Although many insurance companies cover all or part of a cardiac rehabilitation program, coverage is not available to all patients, and may be limited in terms of length of treatment or conditions covered.

Preparation

A cardiac rehabilitation program is usually prescribed and overseen by a physician, and generally begins in the hospital, under the direction of appropriate hospital departments, and after exercise testing and other preparatory procedures have been administered. An EKG will likely be given before the rehabilitation program begins, and then be used as an ongoing monitoring method by the physical therapist or other rehabilitation team members.

Aftercare

The patient may continue with a maintenance or secondary prevention program, and should maintain the healthy habits they have gained, including regular exercise to maintain improved fitness and associated physical and psychological benefits.

Complications

Patients are closely monitored for any exercise-related health complications, and the rehabilitation team is equipped to detect and manage possible emergencies. Cardiac rehabilitation is a safe treatment option, and serious problems are rare.

Results

Participation in a cardiac rehabilitation program can help the heart patient return to physical and emotional/social well-being and be able to function in their lives and work as near as possible to their pre-illness level of functioning. In fact, their overall quality of life and health may be improved. Patients also learn new ways of taking care of their health so that recurrence of illness or symptoms and re-hospitalization are minimized, and deterioration of existing conditions is less likely.

KEY TERMS

Electrocardiogram (EKG/ECG)—A test that records electrical activity of the heart. It may be used to detect a heart attack, because injured cardiac muscle causes abnormal conduction of electrical impulses.

Ischemia—Shortage of blood supply to a body tissue or organ (to the heart in the case of cardiac ischemia), which can cause tissue death. Cardiac ischemia can lead to heart attack or abnormal cardiac rhythms.

Myocardial infarction (MI)—The medical term for a heart attack. When cardiac ischemia, narrowing of a coronary artery or arteries, decreases blood supply to the heart muscle (myocardium), it can cause muscle tissue death (infarction).

Secondary prevention—The prevention of a recurrence of illness, such as another heart attack.

Health care team roles

After a prescription is made by the primary care physician or cardiac specialist, various health care professionals are involved in the program, including a physical therapist or exercise physiologist, nurses, an occupational therapist, dietician, and mental health professional. A nurse specializing in cardiac rehabilitation, exercise physiologist or physical therapist, or physical therapy department may manage the patient's rehabilitation program, in consultation with a physician.

Resources

ORGANIZATIONS

Agency for Health Care Policy and Research (AHCPR).

“Cardiac Rehabilitation: Exercise Training and Education, Counseling, and Behavioral Interventions” and “Recovering from Heart Problems Through Cardiac Rehabilitation” (patient guide). These can be obtained by writing or calling: Cardiac Rehabilitation. AHCPR Publications Clearinghouse. P.O. Box 8547. Silver Spring, MD 20907. (800) 358-9295.

American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR). 7600 Terrace Avenue, Suite 203. Middleton, WI 53562. (608) 831-6989.
<<http://www.aacvpr.org/>>.

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OTHER

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Diane Fanucchi, B.A., C.M.T.

Cardiogenic shock *see* **Shock**

Cardiopulmonary resuscitation (CPR)

Definition

Cardiopulmonary resuscitation (CPR) is a procedure to support and maintain breathing and circulation on a person who has stopped breathing (respiratory arrest) and/or whose **heart** has stopped (cardiac arrest).

Purpose

CPR is performed to restore and maintain breathing and circulation and to provide oxygen and **blood** flow to the heart, **brain**, and other vital organs. It should be performed if a person is unconscious and not breathing. Respiratory and cardiac arrest can be caused by allergic reactions, an ineffective heartbeat, a heart attack, asphyxiation, breathing passages that are blocked, choking, drowning, drug reactions or overdoses, electric shock, exposure to cold, severe shock, or trauma. CPR can be performed on infants, children, and adults by trained bystanders or healthcare professionals. It should always be performed by the person on the scene who is most experienced in CPR.

Precautions

CPR should never be performed on a healthy person, since it can cause serious injury to a beating heart.

Description

CPR is part of the emergency cardiac care system designed to save lives. Many deaths can be prevented by prompt recognition of the medical situation and notification of the emergency medical system (EMS). This should be followed by early CPR, defibrillation (which delivers a brief electric shock to the heart in an attempt to

get the heart to beat normally), and advanced cardiac life support measures.

CPR must be performed within four to six minutes of the time that breathing stopped in order to prevent brain damage or death. It is a two-part procedure that involves rescue breathing and external chest compressions. To provide oxygen to the person's **lungs**, the rescuer administers mouth-to-mouth breaths, then helps circulate the blood through the heart to vital organs by external chest compressions. Mouth-to-mouth breathing and external chest compression should be performed together, but if the rescuer isn't strong enough to do both, the external chest compressions should be done alone. Some bystanders are reluctant to initiate CPR because of the possible transmission of infectious disease during mouth-to-mouth breathing or their inexperience with CPR. External chest compressions alone have been found to have similar results when compared to mouth-to-mouth breathing and external chest compressions combined. External chest compressions, as well as CPR that is performed inexpertly, are more effective than no resuscitation attempt.

When performed by a bystander, CPR is designed to support and maintain breathing and circulation until emergency medical personnel arrive and take over. When performed by healthcare personnel, it is used in conjunction with other basic and advanced life support measures.

According to the American Heart Association, early CPR and defibrillation combined with early advanced emergency care can increase survival rates for people with a type of abnormal heart beat called ventricular fibrillation by as much as 40%. CPR by bystanders may prolong life during deadly ventricular fibrillation, giving emergency medical service personnel time to arrive.

It must be appreciated, however, that most CPR attempts are not ultimately successful in restoring the victim to a good quality of life. Often, there is brain damage even if the heart starts beating again. CPR is therefore not generally recommended for the chronically or terminally ill or frail elderly. For these people, it is traumatic and not a peaceful end of life.

CPR has been practiced for more than 40 years. Each year, it helps save thousands of lives in the United States. More than five million Americans receive training in CPR through the American Heart Association and the American Red Cross courses annually. In addition to courses taught by instructors, the American Heart Association also has an interactive video called *Learning System*, which is available at more than 500 healthcare institutions. Both organizations teach CPR the same way, but use different terms. They recommend that family members or other people who live with patients at risk of

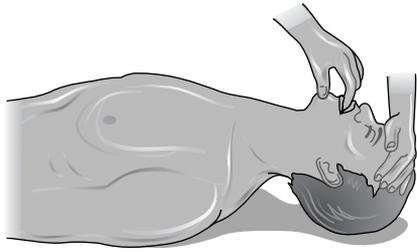


Figure A

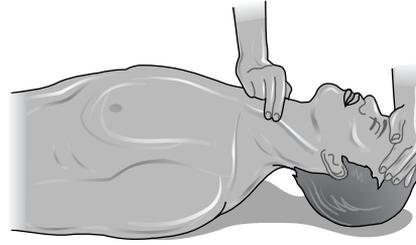


Figure D

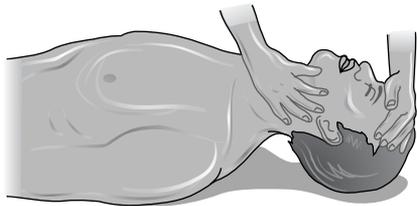


Figure B



Figure E



Figure C



Figure F

CPR in basic life support. Figure A: The victim should be flat on his back and his mouth should be checked for debris. Figure B: If the victim is unconscious, open airway, lift neck, and tilt head back. Figure C: If victim is not breathing, begin artificial breathing with four quick full breaths. Figure D: Check for carotid pulse. Figure E: If pulse is absent, begin artificial circulation by depressing sternum. Figure F: Mouth-to-mouth resuscitation of an infant. (Illustration by Electronic Illustrators Group.)

respiratory or cardiac arrest be trained in CPR. A handheld device called CPR Prompt is available to walk people trained in CPR through the procedure, using American Heart Association guidelines.

In 2000, focus groups from the American Heart Association and the American Red Cross joined forces with international councils in order to create a consistent, single description of resuscitation guidelines. These guidelines have been released and many changes in CPR have been instituted. These changes replace the recommendations from their publications in 1992.

Performing CPR

The basic procedure for CPR is the same for adults, infants, and children, with a few modifications for infants and children to account for their smaller size.

PERFORMING CPR ON AN ADULT. In most cases, the first step is to call the emergency medical system for help by telephoning 911. There are exceptions to calling for help first. The new concept of “phone fast” is being recommended for trauma victims, water submersion victims, and medication/drug overdoses. CPR should be started immediately on these types of victims because the rate of survival increases with early rescue efforts. To start CPR, use the following steps:

- The rescuer opens the person’s airway by placing the head face up, with the forehead tilted back and the chin lifted. The rescuer checks again for breathing (three to five seconds), then begins rescue breathing (mouth-to-mouth artificial respiration). He pinches the person’s nostrils shut while holding the chin in the other hand. The rescuer places his mouth against the person’s mouth with the lips making a tight seal, then gently exhales for about one to one and a half seconds. The rescuer breaks away for an instant and then repeats. The person’s head is repositioned after each mouth-to-mouth breath.
- After two breaths, the rescuer checks for indications of blood circulation (regular respiratory inhalations, vomiting, or any attempt to move). If the rescuer is a health care professional, the person’s pulse is checked by moving the hand that was under the person’s chin to the artery in the neck (carotid artery). If the person shows no signs of circulating blood, the rescuer continues rescue breathing until help arrives or the person begins breathing spontaneously. If the person is breathing, the rescuer turns the person onto his or her side.
- If there is no heartbeat, the rescuer performs chest compressions. The rescuer kneels next to the person, placing the heel of one hand in the spot on the lower chest where the two halves of the rib cage come together. The

rescuer puts his other hand on top of the one on the chest and interlocks the fingers. He straightens his arms, leans forward to position the shoulders directly above the hands on the person’s chest, and presses down, using only the palms, so that the person’s breastbone sinks in about 1½-2 in (4-5 cm). The rescuer releases without removing the hands, then repeats about 15 times in 10-15 seconds.

- The rescuer tilts the person’s head and returns to rescue breathing for one or two quick breaths. Then he alternates breathing and heart presses for one minute, and checks for any signs of blood circulation. If the rescuer finds signs of a heartbeat and breathing, CPR is stopped. If the person is breathing but has no pulse the heart presses are continued; if the person has a pulse but is not breathing, rescue breathing is continued. The number of heart presses has recently increased to 15 heart presses to two breaths for single or double rescuer CPR. The recommended number of heart presses is at least 100 a minute. The rationale for this increase relates to establishing adequate heart and brain circulation.
- For children over the age of eight, the rescuer performs CPR the same as on an adult.

PERFORMING CPR ON AN INFANT OR CHILD UNDER THE AGE OF EIGHT. The procedures outlined above are followed with these differences:

- The rescuer administers CPR for one minute, then calls for help.
- The rescuer makes a seal around the infant/child’s mouth (and nose with infants) to give gentle breaths. The rescuer delivers 20 rescue breaths per minute, taking 1½-2 seconds for each breath.
- Chest compressions are given with only one hand for a child and with two or three fingers for an infant. The breastbone is depressed only 1-1½ in (2.5-3.75 cm) for a child and ½-1 in (1-2.5 cm) for an infant, the rescuer gives at least 100 chest compressions per minute.

New developments in CPR

The use of the automated external defibrillator (AED) has saved many lives and is now considered part of the CPR chain of survival. The AED is a machine that is attached to the unresponsive victim, analyzes the heart rhythm and has the ability to shock the victim with electricity. The AED has two pads that have to be placed on the victim’s right upper chest wall and the left lower chest wall. Most cardiac arrest victims have a heart rhythm called ventricular fibrillation and the only way to correct this deadly heartbeat is with electricity. Some airports, airplanes, and shopping malls have automated external

defibrillators onsite with user-friendly instructions, and survival rates in these places have increased significantly.

Preparation

If a person suddenly becomes unconscious, the rescuer should call out for help from other bystanders, and then determine if the person is responsive by shaking him or her gently on the shoulder and asking, loudly, if they are OK. Upon receiving no answer, the rescuer should call the emergency medical system with the exception of the “phone fast” victims. The rescuer should check to see whether the person is breathing by kneeling near the person’s shoulders, looking at the person’s chest, and placing his cheek next to the person’s mouth. The rescuer should look for signs of breathing in the chest and abdomen, and listen and feel for signs of breathing through the person’s lips. If no signs of breathing are present after three to five seconds, CPR should be started.

Aftercare

Emergency medical care is always necessary after successful CPR. Once the person’s breathing and heart-beat have been restored, the rescuer should make him or her comfortable and stay there until emergency medical personnel arrive. The rescuer can continue to reassure the person that help is coming and talk positively until the professionals arrive and take over.

Complications

CPR can cause injury to the person’s ribs, **liver**, lungs, and heart. But these risks must be accepted if CPR is necessary to save the person’s life. As health care professionals, many complications will be apparent in the acute care setting. Medical and nursing management of these complications will be addressed by prioritizing the most traumatic or deadly first.

Health care team roles

CPR and basic life support are important skills to have for anyone in the health care field. Recognition of the need to initiate CPR and the activation of proper resuscitation can save many lives. The international, universal mnemonic used to prompt health care professionals with the basics of CPR quickly is ABCD. This mnemonic stands for:

- Airway: Is the person’s airway open?
- Breathing: Is the person breathing?



Emergency team treating heart attack patient. (Custom Medical Stock Photo. Reproduced by permission.)

- Circulation: Does the person have a pulse (health care professional)? Does the person have any signs of blood circulation (layperson)?
- Defibrillation: Where is the defibrillator (AED)?

Legally, health care professionals coming to a person’s aid in an emergency situation are covered under the federal Good Samaritan Law. Protection under this law requires that the situation be an emergency, that no monetary compensation for the treatment provided, and that the care provided has to be done “in good faith.” In most states, health care professionals have no mandatory obligation to help in an emergency situation, but this law is in place to protect those who do from liability.

Patient education

All health care professionals should emphasize the importance of laypeople in their communities being trained in CPR. Classes are offered through the American Heart Association and the American Red Cross. Many

KEY TERMS

Automated external defibrillator (AED)—A device that analyzes a person's heartbeat and can automatically deliver an electric shock if needed.

Cardiopulmonary—Relating to the heart and the lungs.

Defibrillation—A procedure to stop the type of irregular heart beat called ventricular fibrillation, usually by using electric shock.

Resuscitation—Bringing a person back to life after an apparent death.

Ventricular fibrillation—An irregular heartbeat where the heart beats very fast but ineffectively. Ventricular fibrillation is fatal if not quickly corrected.

hospitals and local health departments have classes available for the public.

Training

CPR training is recommended every two years, and most health care institutions require their workers to obtain certification in Basic Cardiac Life Support (BCLS), which covers CPR. Studies have been done on the differences between video aided/practice training and lecture training. Video and practice training has been found to be the most effective.

Resources

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Lori Beck

Cardiovascular system

Definition

The cardiovascular system includes the **heart** and the **blood vessels** and is responsible for the transport of **blood** throughout the body.

Description

The main components of the cardiovascular system are the heart, arteries, arterioles, capillaries, venules, and veins. Adults have approximately 60,000 miles (96,000 km) of blood vessels. By moving blood throughout this network of vessels, the cardiovascular system supplies all cells of the body with oxygen and nutrients and removes carbon dioxide and other waste products.

The heart

The heart is the focal point of the cardiovascular system. It supplies the driving force for the movement of blood. The heart functions as a pump, actively forcing blood out of its chambers and passively relaxing to allow the next quantity of blood to enter. On refilling, the blood does not get actively sucked into the heart, but moves into the chambers due to the underlying pressure of the cardiovascular system as a whole.

The heart is cone-shaped, pointing down and to the left, and is located left of center of the chest between the **lungs**. The organ is made of three types of tissue: the myocardium (middle layer), the epicardium (outer layer), and the endocardium (thin inner layer). A fluid-filled sac called the pericardium surrounds the heart, helping to reduce friction during contraction. When the myocardium applies force on the blood by contracting, the cells of the tissue become short and thick. The contraction phase of the myocardium is called systole. This is followed by relaxation of the cells, where they become thinner and longer. The relaxation phase is called diastole.

The heart functions as a double pump, with both the right and left heart having a structure to receive blood and a structure to pump the blood. The blood-receiving structures are called the atria and the blood-pumping structures are called the ventricles. During a heartbeat, the two atria contract together, moving the blood from the atria to the ventricles. Then, while the two atria relax and refill, the two ventricles contract, moving the blood out of the heart. This system means that blood leaves the heart in pulsed waves.

The right atrium and ventricle pump blood from the heart to the lungs using a subset of the blood vessels called the pulmonary circulation system. The blood trav-

els to the lungs where it gives off waste carbon dioxide and receives oxygen, then returns to the left side of the heart to be pumped to the rest of the tissues and organs of the body. The blood vessels that carry blood to the body are called the systemic circulation system. In a healthy heart, blood does not pass directly between the left and right sides of the heart. The two atria are separated by a wall known as the atrial septum, and the wall separating the two ventricles is known as the ventricular septum.

Valves within the heart ensure that the blood travels in the right direction. On the right side of the heart, the tricuspid valve allows blood to travel only from the right atrium to the right ventricle. The mitral valve performs the same function on the left side of the heart. As the blood leaves the right ventricle to go to the lungs, the pulmonary valve controls the direction of the blood flow, while the aortic valve functions between the right ventricle and the aorta, the largest artery.

During diastole, when the ventricles relax, the mitral and tricuspid valves open, allowing blood to flow into the ventricles. At the same time, the aortic and pulmonary valves are closed to prevent reentry of the blood that had been pumped from the heart. During systole, when the ventricles contract, the mitral and tricuspid valves close to prevent backflow, and the aortic and pulmonary valves open to allow the blood to leave the heart. There are no valves at the atrial inputs, part of what ensures consistent blood inflow into the ventricles.

The heart works on an electrical conduction system, as the cells contract in response to electrical signals. All cells of the heart can contract spontaneously, with the beginning of the heartbeat dependent on the cells with the most rapid innate rate. These cells are located in the sinoatrial (SA) node of the heart, sometimes called the heart's natural pacemaker. The electrical signal moves from the SA node to the atrium, in a cluster of conducting cells called the atrio-ventricular (AV) node. The slowing of the signal at this point allows the atria to contract slightly before the ventricles, giving the ventricles more time to fill before they contract. The signal passes on to the electrical network of the ventricles, called the His-Purkinje system, which causes the ventricles to contract. The electrical workings of the heart can be visualized using an **electrocardiography unit**.

Overall, heart rate is controlled by signals from the autonomous nervous system to the SA node. The **autonomic nervous system** automatically controls the heart rate as well as many other functions of the body including breathing, **blood pressure**, and excretion. The system is extremely flexible and can double the heart rate in as fast as three to five seconds.

The arteries and arterioles

Blood leaving the heart from either the left or right ventricle enter a network of vessels called the arteries. Arteries are highly elastic vessels, having flexible fibers in their structure and a relatively thick layer of smooth muscle. Larger arteries have three layers—the inner (intima), the middle (media), and the outer (adventitia). Blood flows through the central opening, known as the lumen, which is lined with endothelial cells. The layers of the blood vessels interact to exert major control over blood pressure and where the blood flows. The adventitia contains the nervous control and blood vessels for the arteries, the media contains smooth muscles, and the endothelial layer of the intima is important for sensing environmental changes.

The aorta, the largest artery, branches directly off the left ventricle, and is especially elastic because of the addition of cardiac muscle cells in the area where it branches off the heart. The elastic qualities of arteries are important so that they can expand to receive the blood volume under high pressure, and contract to continue forcing the blood into the rest of the circulatory system. The elasticity of the arteries is a significant component of the blood pressure during diastole, when the ventricles of the heart relax.

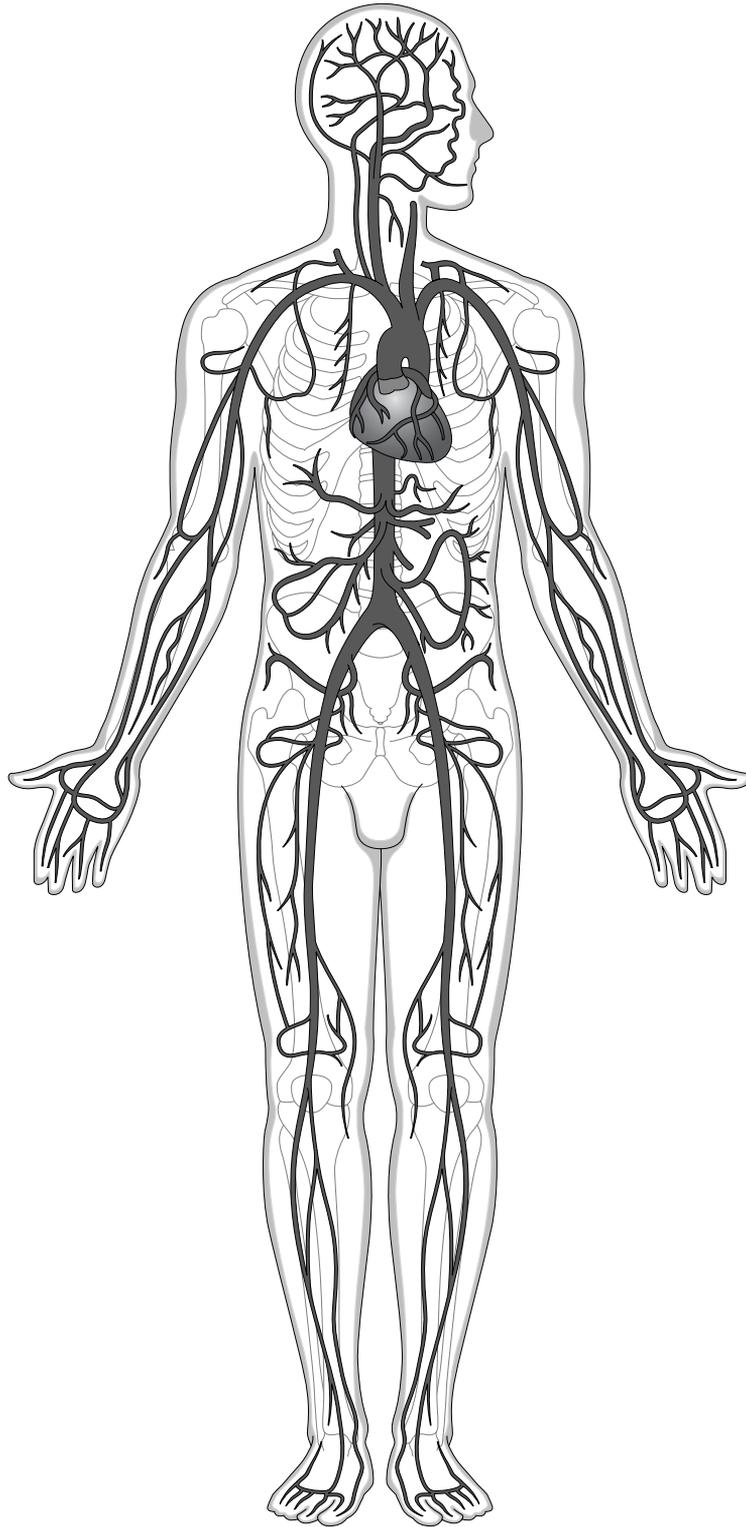
From the left ventricle the coronary arteries, which supply blood to the heart itself, emerge from the aorta. Then the aorta makes a large U-turn in the chest, eventually becoming the abdominal artery. Major branches to the head (carotid arteries), arms (axillary arteries), and legs (femoral arteries) come off this one vessel. The flow of blood in the arteries is pulsile, increasing and decreasing with each heartbeat, about 70 times per minute. The flow of blood in the branch arteries accounts for the pulse that can be felt in the wrists and neck.

The other major artery, the pulmonary artery, carries blood from the right ventricle to the lungs. Although the systemic arteries carry oxygenated blood, the arteries of the pulmonary system carry deoxygenated blood to the lungs. A vessel is called an artery because it carries blood away from the heart, not because the blood it carries contains oxygen.

As arteries move away from the heart, they branch into smaller vessels called arterioles. Arterioles are structurally similar to arteries and play an important role in directing blood to the parts of the body needing it most, such as muscles under stress.

The veins and the venules

The major veins of the body are collectively called the *venae cavae*. The superior vena cava takes in blood



The heart and major veins and arteries of the cardiovascular system. (Courtesy of Gale Group.)

from the arms through the axillary veins, from the head through the jugular veins, and from the heart through the coronary veins. The inferior vena cava collects the blood from the legs from the femoral veins and from the abdomen from the hepatic, portal, and renal veins, among others. Both the superior and inferior venae cavae empty into the right atrium.

The pulmonary vein brings blood oxygenated in the lungs back to the left atrium, so it can be pumped to cells throughout the body. As with arteries, veins are not so named because the vessel carries deoxygenated blood, but by their role in bringing blood back to the heart.

Veins have the same three structural layers as arteries but the layers contain less elastic tissue and muscle components, making the walls thinner and six to ten times more expandable. The blood pressure in veins is lower than in the arteries, so to keep the blood flowing to the heart there are one-way valves that prevent backflow. Additionally, the action of the muscles in the legs help to return the blood to the heart, a mechanism called the venous pump.

As veins move farther from the heart they branch into smaller structures known as venules. The venules end in very thin blood vessels known as the capillaries.

The capillaries

The arteries and the veins are connected by the vessel web of the capillaries. The lumen of these vessels is very small, to the extent that blood cells must line up single file to pass through the thinnest of them. Capillary walls are also very thin, allowing the passage of gases and nutrients between the blood cells and the cells of the body.

The exact role of the capillaries varies depending on the part of the body in which they are located. The capillaries of the pulmonary circulation are found in the air sacs of the lungs, called alveoli, and it is there that the exchange of oxygen into the blood and carbon dioxide out of the blood occurs. In the **kidneys**, the capillaries in the organ's tubules are the point where waste products are taken out of the blood to be excreted in the urine. The capillaries of the intestine are the location where nutrients from digested food are absorbed into the bloodstream. Capillaries serving the muscles bring in oxygen and nutrients and take away carbon dioxide and waste products.

Function

For reference, at any particular point in time, about 9% of the body's blood is located in the pulmonary circulation and about 7% is in the heart's circulation. The

remaining 84% is located in the systemic circulation, with 64% in the veins, 13% in the arteries, and 7% in the arterioles and capillaries. The greater percentage in the veins is due to the less elastic nature of the vessels and the tendency of the blood to pool there.

As the pulmonary circulation has a relatively smaller network of vessels when compared to the systemic circulation, the right side of the heart doesn't have to work as hard as the left side to move the blood. Accordingly, the left side of the heart is larger and more muscular. The passive-filling nature of the heart keeps the unequal balance in blood volume between the pulmonary and systemic circulation. Without active filling, the physical differences between the systemic and pulmonary capillaries such as relative size of the vessel bed and relative elasticity determine the blood distribution. If the heart was a different kind of pump, cardiac characteristics, such as rate or stroke volume (amount of blood pumped by one contraction of the left ventricle) would govern the relative volumes.

One way to visualize the function of the cardiovascular system is to follow the movement of one blood cell throughout the body. The path can begin at the left ventricle, where an oxygenated blood cell is pumped out by contraction of the myocardium, through the aortic valve into the aorta. The cell follows the curve into the abdominal artery and into the axillary artery into the arm. The artery subdivides into smaller and smaller branches, small enough to be called arterioles. Blood is needed at a muscle in the arm, so the arterioles are open to keep a large quantity of blood flowing in that direction. The blood cell continues through smaller vessels until it is in a capillary bed next to a muscle cell.

There the cell gives up its oxygen cargo, takes up carbon dioxide waste produced by the muscle, and begins the journey back to the heart. Travelling through the capillaries to the venules and then into the axillary vein, the cell goes into the superior vena cava and into the right atrium. The right atrium contracts, and the cell moves through the tricuspid valve into the right ventricle. On the next systole, the cell rushes out of the right ventricle, through the pulmonary valve into the pulmonary artery to the lungs. The branches of vessels grow smaller and smaller, until the cell is in the capillaries of the alveoli where it releases the carbon dioxide to the lung space to be exhaled, and picks up another load of oxygen.

Travelling back to the heart through the veins of the pulmonary circulation system, the cell enters the left atrium through the pulmonary vein. When the atrium contracts, the cell goes through the mitral valve into the left ventricle, having made one cycle through the cardiovascular system. In this way, the cardiovascular system sup-

plies all the cells of the body with oxygen and nutrients and carries away carbon dioxide and other wastes.

Role in human health

It is difficult to overestimate the role the cardiovascular system plays in human health, with literally every cell of every tissue dependent on its function for survival. The cardiovascular system is the way the body transports things to and from the body's cells. Oxygen, nutrients, and hormones are carried from the point these substances are made or brought into the body to the cells for their use. Cellular wastes are transported from the cells to the lungs, kidneys, or **liver** to be broken down or removed from the body. The circulatory system is also one of the transport systems (along with the lymph) for the immune cells responsible for protecting the body from disease.

Changes in the functioning of the circulatory system have far reaching effects. A defect of the circulatory system, heart disease, is the number one cause of death in humans. Some of the common names and medical terms for the symptoms of a malfunctioning cardiovascular system include

- chest **pain** (angina pectoris)
- shortness of breath (dyspnea)
- general tiredness (fatigue)
- swelling (edema)
- loss of consciousness (syncope)
- light-headedness (presyncope)
- palpitations (arrhythmia or extrasystoles)
- limb pain or tiredness (claudication)
- abnormal skin color (pallor, **cyanosis**, erythema, necrosis)
- sores on skin (ulceration)
- collapse (**shock**)
- sudden changes in **vision**, strength, coordination, speech, or sensation

Common diseases and disorders

Diagnosing cardiovascular disease can be complicated because often more than one cardiovascular problem exists at the same time in the same person. Symptoms of one problem can mask symptoms of another. Sometimes the multiple problems have a common cause or one cardiovascular problem can be causing another. This can make diagnosis and treatment a difficult task.

High blood pressure

The most common cardiovascular disease is high blood pressure (**hypertension**), affecting one in four Americans (one in three black Americans). Blood pressure is measured in millimeters of mercury, based on how high the pressure in the arteries can raise a column of mercury above baseline using a blood pressure cuff. With a generally accepted normal of systolic to diastolic of 120/80, the disease is categorized into three stages. The systolic measurement, the diastolic measurement, or both can be elevated with hypertension.

Stage 1 disease is present with systolic measurements of 5.12–5.47 in (130–139 mm) Hg, stage 2 with 6.29–7.04 in (160–179 mm) Hg, and stage 3 with 7.08 in (180 mm) Hg or higher. For diastolic measurements, stage 1 occurs from 3.54–3.89 in (90 to 99 mm) Hg, stage 2 with 3.93–4.29 in (100 to 109 mm) Hg, and stage 3 with measurements above 4.33 in (110 mm) Hg. Treatment decisions for hypertension take into account not only the measured blood pressure, but also the presence of other cardiovascular disease, hereditary risk factors, evidence of damage to internal organs, and lifestyle (**stress**, diet, **exercise**).

Primary hypertension is associated with a persistent increase in resistance of blood flow in the arterioles, the smaller branches off the arteries. The precise cause is unknown.

Heart disease

Some specific diseases of the heart include cardiomyopathy, congenital heart disease, heart valve defects, myocardial infarction (heart attack), problems of the pericardium, and arrhythmias. If any of these diseases cause the heart to lose its ability to pump blood effectively, the patient is said to have **heart failure**. Because poor pumping ability often results in an accumulation of fluid in the tissues and lungs, it is often called congestive heart failure.

Cardiomyopathy is a disease of the heart muscle with multiple causes and is the number one reason people undergo heart transplants. Categorized by the type of muscle damage, there are three general types of cardiomyopathy: dilated, hypertrophic, and restrictive. Dilated cardiomyopathy refers to the enlargement of the heart that is a response to the overall myocardial weakness. Many problems can cause dilated cardiomyopathy, including viral infections, excessive alcohol intake, and myocarditis (inflammation of the heart).

Hypertrophic cardiomyopathy is an abnormal overgrowth of the heart muscle. An inherited disease, the overgrown muscle blocks the movement of blood both

into and out of the heart. The most common cause triggering hypertrophic cardiomyopathy is hypertension. Restrictive cardiomyopathy is due to a stiffening of the heart muscle that prevents it from fully relaxing during diastole. This problem is a symptom of other diseases such as hemochromatosis (a defect in **iron** use by the body) or amyloidosis (overproduction of antibodies by the bone marrow that cannot be broken down).

Congenital heart disease is caused by defects of the heart present at birth. Defects can be relatively mild and asymptomatic to severe and life-threatening. Some more common problems are abnormally formed blood vessels that block blood flow, malformed heart valves, incorrect connections between arteries, veins, and the heart, or defects in the atrial or ventricular septa. The most common congenital heart defect is a combination of four problems called the tetralogy of Fallot. With this problem the ventricular septum is incomplete, there is an obstruction to blood flow beneath the pulmonary artery, the aorta is shifted rightward, and the right ventricular wall is thickened.

Any of the hearts valves can obstruct blood flow if they are too stiff (stenosis) or don't close properly and allow blood to leak (regurgitation). Valve problems can cause congestive heart failure or heart enlargement, which can lead to angina or heart arrhythmias. Causes of valve disease include congenital defects, **calcium** deposits, and infections, such as **endocarditis** (a bacterial **infection** of the endocardium, the lining of the heart). Severe valve problems can be treated by removal of the diseased valve and replacement with an artificial valve.

A **myocardial infarction** (heart attack) is death of heart tissue due to the sudden lack of blood flow from the coronary arteries. Doctors believe the most common cause of the blockage is a blood clot that formed at a rupture of an atherosclerotic plaque that has broken loose. The results of the heart attack are dependent on the amount of heart tissue that is damaged. With less than 10% of the heart affected, there is a reduction in the ability of the heart to pump blood, but a normal lifestyle can often be maintained. At 25%, enlargement of the heart and heart failure is a common result. If 40% or more of the heart is damaged, shock or death usually occurs.

Pericarditis is inflammation of the pericardium, usually caused by a viral infection. Although this disease can cause sharp, piercing chest pain, it is usually self-limiting and ordinarily does not lead to further problems. Pericardial effusion is a collection of fluid around the heart in the pericardial sac. If the fluid amount is great enough, it can reduce the heart's ability to expand and receive blood, reducing its efficiency. This condition is known as cardiac tamponade. A final condition of the pericardium is pericardial constriction, an abnormal inflexibility of the

pericardial membrane. Some types of pericarditis often result in this problem. If the inflexible membrane causes heart failure, it can be removed surgically.

Arrhythmias are abnormal heartbeats. Very broadly, arrhythmias can be classified into four different types: conduction system abnormalities, abnormally slow, abnormally fast, and irregular. Conduction system abnormalities are seen using **electrocardiography** units and do not directly cause an outwardly altered heartbeat. An example is some heart blocks, where the electrical signal adopts alternative paths in the heart to avoid nonconductive tissue.

Slow heartbeat (bradycardia) is the most common cause for the implantation of a pacemaker and can be caused by problems with the autonomic nervous system, the SA node, or the conduction system. Abnormally fast heartbeats (tachycardia) can be atrial flutter, the presence of an extra, abnormal pathway for electrical conduction in the heart, or ventricular tachycardia (V tach). Some common irregular heartbeats include extra beats (extrasystoles) and atrial fibrillation, where the atria stop having effective contractions and beat chaotically at several hundred times per minute.

Arterial disease

Some diseases of the arteries include atherosclerosis, arterial thrombosis, aneurysm, and arteritis. The most common cause of heart attacks, **coronary artery disease** is the blockage of one or more of the vessels that supply blood to the heart. The arteries can be obstructed by a blood clot (thrombosis), atherosclerosis, or a coronary spasm. These problems can be treated with drugs that dissolve the clot or surgical procedures that remove or circumvent the blockages, such as coronary **angioplasty** or bypass surgery.

Atherosclerosis is caused by the degradation of the lining of the arteries (endothelium) and the resultant plaque, a build-up of platelets, cholesterol, and other substances such as calcium that forms at the site. Atherosclerosis occurs to some extent in everyone and can occur in any of the body's arteries. Depending on the location, the disease can lead to other cardiovascular problems such as heart attack, leg pain, stroke, and aneurysm. Arterial thrombosis is another way that arteries can be blocked, but in this case an abnormal blood clot, called an embolus, is responsible. This condition presents with very similar symptoms to atherosclerosis. If it occurs in a coronary artery, it can cause heart attacks.

An aneurysm is an abnormally widened area of an artery. A common site for this problem is in the abdominal aorta and it is usually caused by atherosclerosis. Aneurysms can be surgically treated if detected before rupture. A final disease of the arteries is arteritis, an

KEY TERMS

Adventitia—The outer layer of the arteries containing nerves and blood vessels.

Diastole—Phase of the heartbeat where the ventricles relax and fill with blood.

Endocardium—The thin, innermost layer of the heart which is infected with endocarditis.

Epicardium—The outermost layer of the heart.

Intima—The innermost layer of the arteries containing a layer of endothelial cells that are damaged with atherosclerosis.

Media—The middle layer of arteries containing the smooth muscle.

Myocardium—The middle, working layer of the heart containing the heart muscle cells.

Pulsile—Movement in waves, a characteristic of the blood when leaving the heart and in the circulation.

Regurgitation—A defect of the heart valves that interferes with its ability to close completely, allowing blood to leak in the direction opposite of circulation.

Septum—A physical divider between chambers, found between the atria and the ventricles.

Stenosis—A stiffening of the heart valves, which narrows its opening and can interfere with function.

Systole—Phase of the heartbeat where the ventricles contract and force blood from the heart.

inflammation of the arteries. This problem is usually a part of another general disease, such as Takayasu's disease, temporal arteritis, Buerger's disease, and polyarteritis nodosa.

Venous disease

Some diseases of the veins include venous thrombosis, thrombophlebitis, pulmonary embolism, and **varicose veins**. Blockages in the veins are not usually caused by atherosclerosis, but by blood clots or venous thrombi. Venous thrombosis and the resulting inflammation, thrombophlebitis, can occur in superficial veins, usually a relatively minor problem, or in deep veins, a more serious condition where the threat of the clot breaking off and traveling to the heart or lungs is present.

These conditions are generally treated with blood-thinning drugs. If the clot does travel and get lodged in the lungs the condition is called a pulmonary embolism. This is a serious problem that often requires hospitalization. If blood-thinning drugs do not resolve the problem, surgical removal of the clot can be necessary.

Varicose veins refer to a condition where the veins become abnormally dilated and most commonly appear as soft bluish bulges in the legs. Caused by elevated pressure in the veins and the resulting damage to the valves within the vessels, varicose veins, unless severe, are a cosmetic problem. They can be treated with surgery, injections (sclerotherapy), or lasers.

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Caries see **Dental caries**

Carpal tunnel syndrome

Definition

Carpal tunnel syndrome is a common disorder caused by compression at the wrist of the median nerve supplying the hand, causing numbness and tingling.

Description

The carpal tunnel is an area in the wrist where the bones and ligaments create a small passageway for the median nerve. The median nerve is responsible for both sensation and movement in the hand, in particular the thumb and first three fingers. When the median nerve is compressed, an individual's hand will feel as if it has "gone to sleep." Persistent pressure causes **pain** that may manifest as a burning or tingling sensation in the fingers (acroparesthesia). Reduced motor ability in the hand and wrist may gradually develop as well.

Women between the ages of 30 and 60 have the highest rates of carpal tunnel syndrome; they are two to five times as likely as men to develop the disorder. It is the most frequently occurring nerve compression found in the upper part of the body, and is a very significant cause of missed work days. Research has shown that the prevalence of carpal tunnel syndrome in the general population ranges from 2.1 to 4%. At least 200,000 carpal tunnel release surgical interventions are performed every year in the United States, and is the most frequently performed surgery on the hand. The costs associated with the procedure are at least \$1 billion each year. The cost to employers is also substantial because of the significant loss of work time associated with the condition.

Causes and symptoms

Compression of the median nerve in the wrist can occur during a number of different conditions, particularly those conditions which lead to changes in fluid accumulation throughout the body. Because the area of the wrist through which the median nerve passes is very narrow, any swelling in the area will lead to pressure on the median nerve. This pressure will ultimately interfere with the nerve's ability to function normally. **Pregnancy, obesity**, arthritis, certain thyroid conditions, diabetes, and certain pituitary abnormalities all predispose individuals to carpal tunnel syndrome. Other conditions which increase the risk for carpal tunnel syndrome include the presence of organic lesions, tumors, congenital malformations, and various injuries to the arm and wrist (including **fractures**, sprains, and dislocations). A type of carpal tunnel syndrome that is transmitted by hereditary means has also been found. Furthermore, activities which cause an individual to repeatedly bend the wrist inward toward the forearm can predispose to carpal tunnel syndrome. Certain jobs that require repeated strong wrist motions carry a relatively high risk of precipitating carpal tunnel syndrome. Injuries of this type are referred to as "repetitive motion" injuries, and are more frequent among people

working at computer keyboards or cash registers, factory workers, and some musicians.

Symptoms of carpal tunnel syndrome include numbness, burning, tingling, and a prickly pin-like sensation over the palmar surface of the hand, and into the thumb, forefinger, middle finger, and half of the ring finger. Some individuals notice a shooting pain going from the wrist up the arm, or down into the hand and fingers. This pain can radiate into the shoulder, neck, and chest regions, in some cases. Although pain is generally increased during repetitive movement, it is typically greatest during the night. With continued median nerve compression, an individual may begin to experience muscle weakness, making it difficult to open jars and hold objects with the affected hand. Eventually, the muscles of the hand served by the median nerve may begin to grow noticeably smaller (atrophy), especially the fleshy part of the thumb. Untreated, carpal tunnel syndrome may eventually result in permanent weakness, loss of sensation, and even **paralysis** of the thumb and fingers of the affected hand. Noticeable differences in strength and sensory perception can develop between the affected hand and the unaffected hand.

Diagnosis

The diagnosis of carpal tunnel syndrome is made in part by checking to see whether pain or paresthesia (Phalen's sign) can be brought on by holding his or her hand in position with wrist bent for about a minute. X-rays are often taken to rule out the possibility of a tumor causing pressure on the median nerve. A health practitioner examining a patient suspected of having carpal tunnel syndrome will perform a variety of simple tests to measure muscle strength and sensation in the affected hand and arm. The practitioner will likely test for Tinel's sign (tingling or shock-like pain) by tapping the surface of the wrist over the median nerve to try to produce symptoms. A similar test known as the carpal compression test, where the thumb is placed over the patient's carpal tunnel for 30 seconds, may also be performed.

Further testing might include electromyographic or nerve conduction velocity testing to determine the exact severity of nerve damage. These tests involve stimulating the median nerve with electricity and measuring the resulting speed and strength of the muscle response, as well as recording speed of nerve transmission across the carpal tunnel. A variety of conditions need to be ruled out to confirm the diagnosis of carpal tunnel syndrome. These include **osteoarthritis**, **blood** vessel compression or occlusion, other nerve compression conditions, and tendinitis.

Treatment

Carpal tunnel syndrome is initially treated with splints, which support the wrist and prevent it from flexing inward into the position that exacerbates median nerve compression. Nurses and physical therapists often instruct the patient on how to use these splints or braces. Some people get significant relief by wearing such splints at night while sleeping, whereas others will need to wear the splints all day, especially if they are performing jobs which stress the wrist. If possible, the patient should avoid the repetitive action that may have precipitated the condition initially. Elevation of the affected arm may help some patients. Nurses often provide information on how to minimize strain on the carpal tunnel during daily activities. Physical therapists and nurses can provide information on various exercises, which may help with the symptoms associated with carpal tunnel syndrome. There is some evidence that vitamin B₆ can help symptoms in some patients who have less serious symptoms, although this treatment is currently considered controversial and should be considered an alternative form of medicine. Acetaminophen, ibuprofen, or other **nonsteroidal anti-inflammatory drugs** may be prescribed to decrease pain and swelling. The clinician or pharmacist can provide advice on how to most effectively use these drugs to minimize carpal tunnel symptoms. When carpal tunnel syndrome is more advanced, injection of steroids into the wrist to decrease inflammation may be necessary. This must be carefully performed to avoid damaging the median nerve. Some patients may benefit from receiving low doses of oral **corticosteroids**.

The most severe cases of carpal tunnel syndrome may require surgery to decrease the compression of the median nerve and restore its normal function. Such a repair involves cutting the ligament that crosses the wrist, thus allowing the median nerve more room and decreasing compression. This surgery is done almost exclusively on an outpatient basis and is often performed under **local anesthesia**. Careful injection of numbing medicines (local anesthesia) or nerve blocks (the injection of anesthetics directly into the nerve) create sufficient numbness to allow the surgery to be performed painlessly, without the risks associated with **general anesthesia**. Nurses provide information on what the patient should do postoperatively. Recovery from this type of surgery is usually quick and without complications. The return of muscle strength in the affected limb occurs gradually in most patients. However, when the muscle has severely atrophied in advanced cases, complete restoration of previous muscle strength is not likely. A less-invasive surgical technique using an **endo-**

scope has been developed for this procedure and is being used to a small extent.

Health care team roles

The x-ray technologist will perform the radiography that will help the practitioner determine whether a tumor or injury has occurred in the lower arm of the patient. An x ray of the neck and upper back region of the patient can help rule out any degenerative condition of the spine that could produce some of these symptoms. Likewise, an imaging technologist performing **magnetic resonance imaging (MRI)** could help the practitioner find abnormalities in the lower arm and hand all the way up to the upper back and neck regions of the spine. Nurses can be involved at many points of the diagnostic and therapeutic process. They may assist in the initial physical diagnostic procedures performed by a physician.

Patient education

Physical therapists can design exercises that improve posture and strengthen certain muscle groups in order to alleviate or prevent carpal tunnel strain. These therapists often design rehabilitation programs for patients who have undergone carpal tunnel release surgery. These programs have the goal of restoring muscle strength to the weakened muscles of the lower arm and hand.

Nurses may provide instruction about maintaining good posture and performing exercises that reduce strain on the carpal tunnel in patients that are at the beginning stages of carpal tunnel syndrome. They may also instruct the patient on how to wear a splint or a brace and assist the practitioner in the process of steroid injection into the carpal tunnel. Nurses assist in the carpal tunnel release surgery and in the ensuing recovery process. They also play an important role in the postoperative period by providing instructions about arm elevation and other issues, such as the use of splints. Occupational therapists can play a significant role in the prevention of carpal tunnel syndrome by providing information on good posture techniques and ergonomics while working.

Prognosis

There is a wide range of outcomes in patients with carpal tunnel syndrome. A few patients have spontaneous remission of symptoms. However, most patients need to undergo some form of therapy. Continued pressure on the median nerve puts an individual at risk for permanent disability in the affected hand. Most people are able to control the symptoms of carpal tunnel syndrome using conservative methods, such as splinting and anti-inflammatory agents. Steroid injections often produce only tem-

porary improvement in symptoms. Most of these individuals have a recurrence of symptoms. Many women develop carpal tunnel syndrome in the third trimester of pregnancy, but symptoms usually disappear after the baby is born. Symptoms often reappear in later pregnancies in these women. Because symptoms generally resolve at the end of the pregnancy, surgery is not recommended in these women. In patients who do require surgery, about 95% will have complete cessation of symptoms.

Prevention

Prevention is generally aimed at becoming aware of the repetitive motions which put the wrist into a bent position. People who must work long hours at a computer keyboard, for example, may need to take advantage of recent advances in ergonomics, which position the keyboard and computer components in ways that increase efficiency and decrease stress. An interruption in the repetitive movement once an hour throughout the day may help prevent and reduce symptoms. Early use of a splint may also be helpful for people whose jobs increase the risk of carpal tunnel syndrome. Splints may also improve sleeping posture and prevent or reduce carpal tunnel symptoms.

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KEY TERMS

Carpal tunnel—A passageway in the wrist, created by the bones and ligaments of the wrist, through which the median nerve passes.

Corticosteroids—Any one of several hormonal substances obtained from the adrenal gland cortex and which are classified according to biological activity.

Endoscope—A device made of a tube and an optical system for observing the inside of the body.

Electromyography—A type of test in which a nerve's function is tested by stimulating a nerve with electricity, and then measuring the speed and strength of the corresponding muscle's response.

Median nerve—A nerve which runs through the wrist and into the hand. It provides sensation and some movement to the hand, the thumb, the index finger, the middle finger, and half of the ring finger.

Osteoarthritis—A chronic disease that involves the joints and which is characterized by damaged cartilage, bone overgrowth, spur formation, and reduced function.

Tendinitis—Inflammation of a tendon.

ORGANIZATIONS

- Association for Repetitive Motion Syndromes, P.O. Box 471973, Aurora, CO 80047-1973. 1-303-369-0803. <<http://www.certifiedpst.com>>.
- National Institutes of Arthritis and Musculoskeletal and Skin Diseases, National Institutes of Health, Bldg. 31, Rm. 4C05, Bethesda, MD 20892-2350. 1-877-226-4267. <<http://www.nih.gov>>.

Mark Alan Mitchell

Cast care

Definition

A cast is a rigid dressing used to immobilize a fractured bone or soft tissue injury. It is made of strips impregnated with plaster or fiberglass material. The injured area is first covered with a layer of padding made of cotton or synthetic materials to protect the skin from

irritation. The plaster or fiberglass strips are then dipped in water and applied over the padding to form the cast.

Purpose

In general, casts are applied to injured limbs to support and protect the bones and soft tissue. The cast helps to reduce the **pain**, swelling, and muscle spasms following the injury. If the bone is broken, the cast holds the fractured bone ends in correct alignment during the healing process. A cast, because of its rigid properties, will also provide protection from further injury. Body casts are used to prevent movement of the vertebrae of the back and may be used after a traumatic injury to the spine or a surgical repair of the vertebrae.

Precautions

For health professionals

Wet casts must be handled carefully, using only the palms of the hands, because a wet cast can be dented or compressed if handled too much after application. Dents or compression of the cast can cause pressure or irritation to the skin beneath the dressing, which may develop sores or ulcers.

Patients in a hip cast or body cast should be repositioned every two hours during the first 24 hours to allow even drying of the cast and every two hours when awake thereafter to avoid developing pressure sores on the skin.

For patients

The use of crutches may be recommended for patients with a leg cast or a sling for patients with an arm cast for use during the first 24–48 hours. Patients should be instructed to rest and keep the affected limb elevated on a pillow as much as possible during the first 24 hours.

Description

Materials

Of the two types of materials used for the hard supportive layer of casts, fiberglass has the advantages of being lighter, longer-wearing, and better able to “breathe” than plaster. Fiberglass is less trouble for the patient, because plaster casts are more likely to lose their shape if they become wet than fiberglass casts. It is also easier for x rays to penetrate fiberglass than plaster casts. Plaster, on the other hand, is less expensive and is easier to mold or shape to the body. A plaster cast will harden in 15–30 minutes but takes 24–48 hours to dry completely. A fiberglass cast will dry faster, in 15–30

minutes, but the force of the patient’s full body weight may cause the cast to crack in the first 24 hours after application.

Application

Casts are usually applied by physicians or orthopedic technicians, with the assistance of other health professionals. If the bone is broken, the physician will first place the fractured bone into alignment. Stockinette cut to size is applied to the limb and then cast padding (cotton batting) is wrapped around the extremity. The physician dips the casting material in water, squeezes out excess water, and then applies it wet over the cast padding to form the cast. After applying the cast, the physician will roll the stockinette over the edges of the cast to provide smooth edges at the top, bottom and any openings on the cast. The patient’s toes and fingertips are not covered by the cast. The cast is then usually placed on pillows elevated above the patient’s **heart** level for 15–20 minutes to dry.

Preparation

A health professional will assist the patient in removing any clothing that will be difficult to pull over the cast later. The patient is positioned with the affected extremity resting on a pillow. The skin around the affected area is gently cleansed and thoroughly dried. The patient may be given medication for pain as directed by the physician. After the cast has been applied, extra pillows are placed under the cast to elevate it. The patient should be kept warm and comfortable while the cast is drying. It is helpful to explain to the patient that the cast will feel warm at first but then cool and damp as the material dries.

Aftercare

Aftercare includes measuring the patient for crutches or a sling as appropriate. In addition, patients should be given aftercare instructions as follows:

- The cast should be kept dry. Water weakens plaster casts and may cause skin irritation beneath the cast. The patient should use two layers of plastic to keep the cast dry while bathing or showering.
- To decrease swelling and pain in the first 24–48 hours, the patient should place crushed ice in a plastic bag, covered with a pillow case or towel, on the cast over the injury every 15 minutes per hour while awake.
- Dirt, sand, or powder should be kept away from the inside of the cast. Cast boots can be purchased to cover the foot area of a leg cast.

- Padding should not be pulled out of the cast. In addition, the patient should not stick coat hangers, knitting needles, or similar items inside the cast in order to scratch itchy skin.
- The patient should not break off or trim the edges of the cast without consulting the physician.
- The cast should be inspected regularly. If it develops cracks or soft spots, the physician should be notified.
- The patient should never attempt to remove the cast. The physician will remove the cast at the appropriate time with a special saw that cuts through the casting material but will not damage skin.

Complications

Compartment syndrome

A serious complication that can occur after cast application is known as compartment syndrome. This is a rare phenomenon that occurs when a cast is too tight. As the affected limb swells, the cast acts as a closed compartment, tightly compressing the nerves and **blood vessels**. Compartment syndrome can cause permanent nerve damage or loss of limb due to decreased circulation and oxygen to the tissue. Patients should be instructed to call the physician *at once* if any of the following signs or symptoms appear:

- increased pain combined with the feeling that the cast is too tight
- numbness and tingling in the hand or foot
- burning and stinging sensations
- excessive swelling in the part of the limb below the cast
- inability to actively move the toes or fingers

Compromised healing

Another complication of cast application is that the injury may not heal properly. In some cases the bone endings are set incorrectly, producing a deformity; or do not unite at all. Either may require surgical correction. Delayed union of the bone endings may occur in elderly or malnourished patients; their casts may need to remain in place for a longer period of time.

Results

Cast application is an effective treatment for a fractured bone, serious soft tissue injury or surgical joint repair. Casts generally remain in place until bone healing occurs (four to six weeks). The physician will order x rays to monitor bone healing. X rays can be done through the cast. As bone healing occurs and the limb strengthens,

KEY TERMS

Compartment syndrome—A potentially serious complication of cast application, caused by pressure of the cast on the nerves and blood vessels in the injured limb.

the physician may replace the initial cast with a shorter one or a splinted cast that can be removed for bathing. When the cast is removed, the patient's skin will appear dry and the muscles of the limb may be slightly wasted. Skin care with moisturizers and special exercises to regain muscle strength or to relieve joint stiffness may be ordered by the physician.

Health care team roles

Cast application is usually performed by a physician but may be performed by a specially trained orthopaedic technician under the direction of the physician. The licensed nurse will assess the inpatient patient in a medical setting with a newly casted limb for the first 24–48 hours after cast application. In the outpatient setting, the licensed nurse will observe the patient for the first hour after cast application and instruct the patient and patients family about cast care, signs and symptoms of complications and the importance of follow-up visits with the physician for routine reassessment and cast removal.

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CAT scan *see* **CT scans**

Cataracts

Definition

The lens of the eye is normally transparent. A cataract is a condition in which the lens of the eye becomes cloudy or opaque. This cloudiness can impair **vision** and may lead to eventual blindness.

Description

The human eye has several parts. The outer layer of the eyeball consists of a transparent dome-shaped cornea and an opaque, white sclera. The cornea and sclera help protect the eye. The next layer includes the iris, pupil, and ciliary body. The iris is the colored part of the eye and the pupil is the small, dark, round hole in the center of the iris. The pupil is primarily responsible for allowing light into the eye. The ciliary body contains muscles that help the eye focus. The lens, which lies behind the pupil and iris, is covered by a cellophane-like capsule. It is normally transparent, elliptical in shape, and somewhat elastic. Due to this elasticity, the lens can focus on both near and far objects. The lens is attached to the ciliary body by fibers (zonules of Zinn). Muscles in the ciliary body act on the zonules, which then change the shape of the lens. This process is called accommodation—the lens focuses images to help make vision clear. As people age, the lens hardens and changes shape less easily. As a result, accommodation becomes more difficult, making it harder to see things up close. This normal aging condition, called **presbyopia**, generally occurs around age 40 and continues until about age 65. Individuals with this condition generally need reading glasses.

The lens is made up of approximately 35% protein and 65% water. As people age, degenerative changes in the lens's **proteins** occur. Changes in the proteins, water content, enzymes, and other chemicals are some of the reasons for the formation of a cataract.

The major areas of the lens are the nucleus, the cortex, and the capsule. The nucleus is in the center of the lens, the cortex surrounds the nucleus, and the capsule is the outer layer. Opacities can occur in any area of the lens, and cataracts can be classified according to their location (nuclear, cortical, or posterior subcapsular cataracts). The density and location of the cataract determines the amount of vision affected. If the cataract forms in the area of the lens directly behind the pupil, vision may be significantly impaired. A cataract that occurs on the outer edges or side of the lens causes less visual impairment.

Cataracts in the elderly are so common that they are thought to be a normal part of aging. Cataracts affect about 50% of individuals between the ages of 52-64, while at least 70% of those 70 and older are affected. Cataracts associated with aging (senile or age-related cataracts) are usually bilateral (occur in both eyes) with asymmetric progression (different rates of progression). Initially, cataracts may not affect vision. If the cataract remains small or at the periphery of the lens, the visual changes may be minor.

Cataracts are much less common in younger people. Congenital cataracts are rare in newborns. When they do occur, they may be due to genetic defects or an **infection** or disease in the mother during **pregnancy**. Traumatic cataracts may develop after a foreign body or trauma injures the lens or the eye. Systemic illnesses, such as diabetes, also may result in cataracts. Cataracts can occur secondary to other eye diseases—for example, uveitis or **glaucoma**. Such cataracts are called complicated cataracts. Toxic cataracts result from chemical toxicity, such as steroid use. Cataracts also can result from exposure to the sun's ultraviolet (UV) rays.

Causes and symptoms

Recent studies have investigated the effect of **nutrition** on cataract formation. The results have been mixed, with some studies finding that there is a connection between nutrition and cataract formation and other studies finding none. Much interest has been focused on the use of antioxidant supplements as a protection against cataracts. Antioxidants, such as **vitamins** A, C, E, and beta-carotene, help the body neutralize oxygen-free radicals.

Smoking and alcohol intake, however, have been implicated in cataract formation, as have the use of oral corticosteroids and antihypertensive agents. Some studies have determined that a diet high in fat increases the likelihood of cataract formation, while an increase in foods rich in antioxidants reduces the incidence. More research is needed to determine the precise role played by diet, smoking, alcohol consumption, and antioxidants in the formation of cataracts.

Some unrelated physical conditions, such as **diabetes mellitus**, also may contribute to cataracts. Eye injuries and sun exposure also are causative factors.

There are several common symptoms of cataracts:

- gradual, painless onset of blurry, filmy, or fuzzy vision
- poor central vision
- frequent changes in eyeglass prescriptions
- changes in color vision

- increased glare from lights, especially oncoming headlights when driving at night
- “second sight” improvement in near vision (no longer needing reading glasses)
- poor vision in sunlight
- presence of a milky whiteness in the pupil as the cataract progresses

Diagnosis

Ophthalmologists and optometrists detect and monitor cataract growth and prescribe prescription lenses for visual deficits. Ophthalmologists perform cataract extraction.

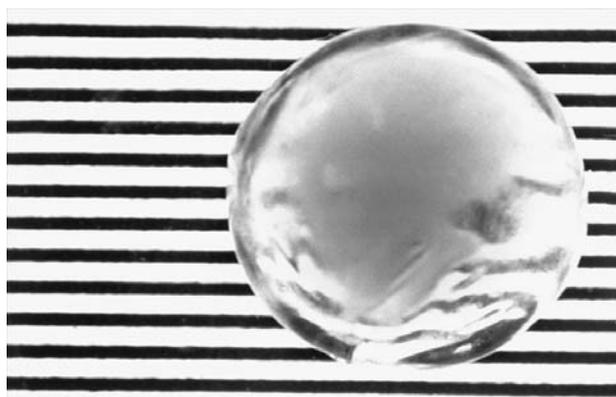
Cataract diagnosis begins with a complete eye exam. The ophthalmic assistant, technician, or nurse gathers information to determine the progression of the vision loss. It is unusual for cataracts to cause rapid vision loss, but sometimes patients believe the vision problem is acute because vision in the better eye has only recently been compromised. Patient history includes a review of refractive history, previous ocular disease, amblyopia, eye surgery, and trauma. Ophthalmic personnel also question patients about difficulties driving, reading, and performing daily activities, and record any medication the patient currently uses.

The ocular exam determines the severity of the cataract and assesses other factors that might contribute to the potential for good vision after surgery. The exam includes measurement of visual acuity under both low and high illumination, biomicroscopy with pupillary dilation, stereoscopic fundus examination with pupillary dilation, assessment of ocular motility and binocularity, visual fields, evaluation of pupillary responses, refraction, and measurement of intraocular pressure (IOP).

Treatment

No treatment may be necessary for cataracts that cause no symptoms or that cause only minor visual changes. It is important for an ophthalmologist or optometrist to continue to monitor and assess the cataract during regular office visits. Increased strength in prescription eyeglasses or **contact lenses** may be diagnostic and beneficial.

Cataract surgery—the only option for patients whose cataracts interfere with vision to the extent that their daily activities are affected—is the most frequently performed surgery in the United States. It generally improves vision in more than 90% of patients. Most cataracts are removed before the lens is completely opaque or mature. This is done to minimize the impact of



A dense cataract on the lens of an eye. (Photograph by Margaret Cubberly, Phototake NYC. Reproduced by

the cataract on the patient’s daily life and also to decrease the risk of other eye complications. Sometimes cataracts need to be removed so the surgeon can examine the back of the eye more carefully. This is important in patients with diseases that may affect the eye. If cataracts are present in both eyes, surgery is performed on one eye at a time. The first eye heals before the second cataract is removed, sometimes as soon as the following week. A final eyeglass prescription is usually given about four to six weeks after surgery. Patients will still need reading glasses. The overall health of the patient must be considered in making the decision to have undergo cataract surgery. However, age alone need not preclude effective surgical treatment of cataracts, and people in their 90s can have successful return of vision after cataract surgery.

Surgery to remove cataracts is generally an outpatient procedure. A local anesthetic is used, and some newer techniques take only minutes to complete. Removal of the cloudy lens can be accomplished with one of the three types of cataract surgery available:

- **Extracapsular cataract extraction.** In this type of cataract extraction, the lens and the front portion of the capsule are removed. The back part of the capsule remains in place.
- **Extracapsular cataract extraction by phacoemulsification.** This type of extracapsular extraction requires only a very small incision, resulting in faster healing. Ultrasonic vibration is applied to the lens to break it up into very small pieces, and the ophthalmologist then aspirates the pieces out of the eye with suction. As of 2001, this is the most commonly performed type of cataract surgery.
- **Intracapsular cataract extraction.** The lens and the entire capsule are removed. This method carries an increased risk for detachment of the retina and swelling after surgery, and, as a result, it is rarely used.

KEY TERMS

Glaucoma—Disease of the eye characterized by increased pressure of the fluid inside the eye. Untreated, glaucoma can lead to blindness.

Ultraviolet radiation (UV)—Invisible light rays that may be responsible for sunburns, skin cancers, and cataract formation.

Uveitis—Inflammation of the uvea. The uvea is a continuous layer of tissue which consists of the iris, the ciliary body, and the choroid. The uvea lies between the retina and sclera.

A replacement lens is inserted at the time of the surgery. A plastic artificial lens called an intraocular lens (IOL) is placed in the remaining posterior lens capsule of the eye. When the intracapsular extraction method is used, an IOL may be clipped onto the iris. Contact lenses and cataract glasses (aphakic lenses) are prescribed if an IOL cannot be inserted due to complications. A folding IOL is used with the phacoemulsification procedure to allow it to pass through the small incision.

Antibiotic drops to prevent infection and steroids to reduce inflammation are prescribed after surgery. An eye shield or glasses protect the eye from injury while it heals. During the night, an eye shield is worn. The patient returns to the doctor the day after surgery for assessment, with several follow-up visits over the next two months to monitor the healing process. Return visits at three and six months are optional.

Prognosis

The cataract extraction success rate is very high with a good prognosis. A visual acuity of 20/40 or better is expected as a result of cataract extraction. If an extracapsular cataract extraction was performed, a secondary cataract may develop in the remaining back portion of the capsule. This can occur one to two years after surgery. YAG capsulotomy is most often used for this type of cataract. YAG stands for yttrium aluminum garnet, the name of the laser used for this procedure. This is a painless outpatient procedure and requires no incision. The laser beam makes a small opening in the remaining back part of the capsule, allowing light through.

Complications occur in a very small percentage (3-5%) of surgical cataract extractions. Possible complications include infections, corneal **edema** (swelling), diplopia, bleeding, retinal detachment, iris prolapse or vitreous in the wound, intraocular lens dislocation, and

the onset of glaucoma. Some problems may occur one to two days, or even several weeks, after surgery. Follow-up examinations should check the patient for haziness or redness in the eye, decrease in vision, nausea, and **pain**.

Health care team roles

Skilled ophthalmic technicians and assistants record the patient history and perform many of the preliminary tests. Depending on skill level, these ophthalmic assistants may perform measurement of visual acuity under both low and high illumination, biomicroscopy with pupillary dilation, assessment of ocular motility and binocularity, visual fields, evaluation of pupillary responses to rule out afferent pupillary defects, refraction, and measurement of intraocular pressure (IOP).

Before the surgery, nurses and assistants also prepare the operating room (OR). Many ophthalmologists now have their own ambulatory surgery centers (ASCs) where skilled technicians and ophthalmic nurses play a critical role in preparing the OR and patients for the surgery. Ophthalmic nurses also assist the ophthalmologist during surgery and discuss outcomes with patients post-operatively.

Patient education

When a cataract is found, the patient should be informed, even if surgery is not immediately indicated. The optometrist or ophthalmologist should discuss the different treatment options, as well as the risks and benefits of surgery with the patient.

Prevention

The eyes should be protected from UV radiation by wearing glasses with a special coating. Dark lenses alone are not sufficient, but the lenses must be coated to filter out UV light (specifically, UV-A and UV-B). Antioxidants also may help prevent cataracts by reducing free radicals that can damage lens proteins. A healthy diet rich in sources of antioxidants, including citrus fruits, sweet potatoes, carrots, green leafy vegetables, and/or vitamin supplements, may be beneficial. When taking certain medications, such as steroids, more frequent eye exams may be necessary. Patients should also be told not to smoke.

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American Optometric Association. 243 North Lindbergh Blvd., St. Louis, MO 63141. (314) 991-4100. <<http://www.aoanet.org>>.

The Lighthouse. 111 East 59th Street, New York, NY 10022. (800) 334-5497. <<http://www.lighthouse.org>>.

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Mary Bekker

Catecholamines tests see **Adrenomedullary hormone tests**

Catheterization, female

Definition

Urinary catheterization is the insertion of a catheter through the urethra into the urinary bladder for withdrawal of urine. Straight catheters are used for intermittent withdrawals; indwelling (Foley) catheters are inserted and retained in the bladder for continuous drainage of urine into a closed system.

Purpose

Intermittent catheterization is used for the following reasons:

- To obtain a sterile urine specimen for diagnostic evaluation; to empty bladder content when the patient is unable to void (urinate) due to urinary retention, bladder distention, and obstruction, or to measure residual urine after urination.
- To instill medication for a localized therapeutic effect and to instill contrast material (dye) into the bladder through the urethral catheter for cystourethralgraphy (x ray of the bladder and urethra).
- To empty the bladder for increased space in the pelvic cavity to protect the bladder during labor and delivery and during pelvic and abdominal surgery.
- To strictly monitor the urinary output and **fluid balance** of critically ill patients.

Indwelling catheterization is:

- Indicated as palliative care for terminally ill or severely impaired incontinent patients, for whom bed and clothing changes are uncomfortable, and as a way to manage skin ulceration caused or exacerbated by incontinence.
- Used to maintain a continuous out flow of urine for patients undergoing surgical procedures that cause a delay in bladder sensation, and for persons with chronic neurological disorders that cause **paralysis** or loss of sensation in the perineal area.
- Indicated for urologic surgery, bladder outlet obstruction, and for patients with an initial episode of acute urinary retention to allow the bladder to regain its tone.

Precautions

Because the urinary tract is normally a sterile system, catheterization presents the risk of causing a urinary tract **infection** (UTI). The catheterization procedure must be sterile and the catheter must be free from **bacteria**.

Urinary catheterization aids or replaces the body's normal ability to urinate. Intermittent use of the procedure can stimulate normal bladder function, however frequent and continuous catheterization can lead to total dependency. Catheterization is invasive and has the potential of injuring the urethra and bladder, inviting urinary tract infections. Therefore aseptic techniques should be use in all catheter management activities.

The normal flow of urine from the **kidneys** through the ureters, bladder, urethra prevents the movement of bacteria up through the **urinary system**. The antibacterial properties of the bladder wall, urethra lining, and low urine pH also serve as protective barriers to urinary tract infections. Urinary tract infections occur when bacteria invade the protective barriers of one or more urinary structures.



A Foley catheter is left in place for continuous drainage of the bladder. (Custom Medical Stock Photo. Reproduced by permission.)

Infection control

Every attempt should be made to keep the urinary drainage system closed. Breaks in the system invite infections. Health care workers and patients should wash their hands before and after manipulation of the patient's catheter or collection system to control UTI. Cross-contamination is the most frequent cause of nosocomial (hospital acquired) catheter related infections. Good hand washing practices are the best prevention measure.

The extended portion of the catheter should be washed with a mild soap and warm water to keep it free of accumulated debris.

Frequent intermittent catheterization and long term use of indwelling catheterization predisposes the patient to UTI. Care should be taken to avoid trauma to the urinary meatus or urothelium (urinary lining) with catheters that are too large or inserted with insufficient use of lubricant. Patients with an indwelling catheter must be reassessed periodically to determine if alternative treatment will be more effective in treating the problem.

Description

The female urethral orifice is a vertical, slit-like or irregularly ovoid (egg shaped) opening, 4 or 5 mm in diameter, located between the clitoris and the vagina. The urinary meatus (opening) is concealed between the labia minora, which are the small folds of tissue that need to be separated in order to visualize the opening and insert the catheter. With proper positioning, good lighting and gloved hands, these anatomical landmarks can be identified. If necessary, provide perineal care to ensure a clean procedural environment.

Catheterization of the female patient is traditionally performed without the use of local anesthetic gel to facil-

itate catheter insertion. But since there are no lubricating glands in the female urethra (as found in the male urethra), the risk of trauma from a simple catheter insertion is more likely; therefore, ample supply of an anesthetic or antibacterial lubricant should be used.

Preparation

Health care practitioners performing the catheterization should have a good understanding of the anatomy and physiology of the urinary system, trained in antiseptic techniques and in catheter insertion and catheter care.

Determine the primary purpose for the catheterization and give the patient and/or caregiver a detail explanation. Patients requiring self-catheterization should be instructed and trained in the technique by a qualified health professional.

Sterile disposable catheterization sets are available in clinical settings and for home use. These sets contain most of the items needed for the procedure, such as antiseptic agent, perineal drapes, gloves, lubricant, specimen container, label, and tape. Anesthetic or antibacterial lubricant, catheter, and drainage system may need to be added. It is always wise to review the content of the pre-packaged catheterization set while assembling the materials.

Catheter choices

TYPES. Silastic catheters have been recommended for short-term catheterization after surgery because they are known to decrease incidence of urethritis. However, due to lower cost and acceptable outcomes, latex is the catheter of choice for long-term catheterization. Silastic catheters should be used for patients who are allergic to latex products.

There are also additional types of catheters:

- PTFE-coated latex Foley catheters
- hydrogel-coated latex Foley catheters
- pure silicone Foley catheters
- silicone-coated latex Foley catheter

SIZE. The diameter of the catheter is measured in millimeters. Authorities recommend the "narrowest and softest tube" that will serve the purpose. Rarely is a catheter larger than size 18 F required, and sizes 14 or 16 F are used more often. Catheters greater than size 16 F have been associated with patient discomfort and urine bypassing. A size 12 catheter has been successfully used in children and female patients with urinary restriction.

LENGTH. Female adult patients should be given the choice of a short, female length or a standard length catheter for urethral catheterization.

BALLOON SIZE. Select a catheter with a balloon-filling volume of 0.33 fl oz (10 ml) for routine drainage. Sterile water must always be used to inflate the balloon as other fluids may contain particles, which could block the inflation channel. Some indwelling catheters are manufactured pre-filled with 0.33 fl oz (10 ml) of sterile water, ready for balloon inflation after catheter insertion.

DRAINAGE SYSTEM. Review the design, capacity, and emptying mechanism of the variety of urine drainage bags with the patient. Select the system that is most adaptable to the patient's lifestyle and her ability to manage the device independently. For women with normal bladder sensation, a catheter valve for intermittent drainage may be an acceptable option.

Procedure

The standard technique for catheter insertion is:

- Explain the procedure to the patient, position the patient and ensure privacy and good lighting.
- Wash hands, remove outer tray wrapper and put on sterile gloves before opening the sterile inner packet. Prepare a sterile field and place a specimen collection vessel between the patient's legs.
- Cleanse the labia according to established guidelines and identify the urethral meatus. If an anesthetic lubricating gel is used, instill approximately 0.16 fl oz (5 ml) of 2% lignocaine hydrochloride gel into the urethra or apply the gel to the meatus to achieve surface anesthesia within three to five minutes.
- Hold the catheter in the dominant hand and gently insert it into the urethral meatus; pass it slowly through the urethra and into the bladder. If the catheter is accidentally inserted into the vagina or the tip is contaminated, discard it and take new sterile catheter before proceeding.
- Once the urine starts to flow, collect the specimen and pass the catheter an additional 2 inches (5 cm) to ensure that the balloon is in the bladder before slowly inflating the balloon with 10 ml sterile water.

Aftercare

Patients using intermittent catheterization to manage incontinence may require a period of adjustment as they try to establish a catheterization schedule that is adequate for their normal fluid intake.

Antibiotics should not be prescribed as a preventative measure for patients at risk for urinary tract infections. Prophylactic use of antibacterial agents may lead to the development of drug-resistant bacteria. Patients

who practice intermittent self-catheterization can reduce their risks for UTI by using antiseptic techniques for insertion and catheter care.

Attach the indwelling catheter to the drainage system, slightly curve the tubing, and anchor it to prevent urethral traction. In women the catheter should be secured to the anteromedial thigh with non-allergenic adhesive.

Complications

Complications that are liable to occur include:

- Trauma and/or introduction of bacteria into the urinary system, leading to infection and, rarely, septicemia.
- Trauma to the urethra and/or bladder from incorrect insertion or removal of the catheter with the balloon inflated. Repeated trauma may cause scarring and/or stricture, or narrowing of the urethra.
- Bypassing of urine around the catheter. Inserting a smaller catheter size can minimize this problem.

Sexual activity and **menopause** can also compromise the sterility of the urinary tract. Irritation of the urethra during intercourse promotes the migration of perineal bacteria into the urethra and bladder, causing UTIs. Postmenopausal women may experience more UTIs than younger women. The presence of residual urine in the bladder secondary to incomplete voiding provides an ideal environment for bacterial growth.

Results

Urinary catheterization should be avoided whenever possible. Clean intermittent catheterization, when practical, is preferable to long-term catheterization.

Catheters should not be changed routinely. When each patient is monitored for indication of obstruction, infection, or complications before the catheter is changed, some patients require catheter changes weekly, and others may need a change in several weeks. Fewer catheter changes will reduce trauma to the urethra and reduce incidence of UTI.

Health care team roles

Observation

Before commencing with the catheterization, the nurse should observe the patient's general condition, palpate the pubic area to note gross distension. The patient should be monitored for indications of infections and encourage adequate fluid intake.

KEY TERMS

Catheterization—A procedure of inserting a catheter through the urethra into the bladder to remove urine.

Catheter—A tube for evacuating or injecting fluid.

Contaminate—To make an item unsterile or unclean by direct contact.

Foley catheter—A double channel retention catheter. One channel provides for the inflow and outflow of bladder fluid, the second (smaller) channel is used to fill a balloon that holds the catheter in the bladder.

Intermittent catheterization—Periodic catheterization to facilitate urine flow. The catheter is removed when the bladder is sufficiently empty.

Perineal area—The genital area between the vulva and anus in a woman.

Urinary incontinence—The inability to retain urine or control one's urine flow.

Urinary retention—The inability to void (urinate) to discharge urine.

Urethritis—Inflammation of the urinary bladder.

The nurse should seek medical advice if the catheter cannot be inserted easily, or if the patient complains of undue **pain** or bleeding other than that associated with minor trauma.

Patient education

The patient and/or caregiver should be taught to use **aseptic technique** for catheter care. Nursing interventions and **patient education** can make a difference in the incidence of urinary tract infections in the hospital and **nursing homes** and **home care** units.

The sexuality of the patient with an indwelling catheter for continuous urinary drainage is seldom considered. If a patient is sexually active, the practitioner must explain that intercourse can take place with the catheter in place. The patient or her partner can be taught to remove the catheter before, and replace it with a new one following intercourse.

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Catheterization, male

Definition

Urinary catheterization is the procedure of inserting a catheter through the urethra into the bladder to remove urine. Intermittent catheterization is performed for periodic relief of bladder distension; indwelling (Foley) catheters are inserted and retained in the bladder for continuous drainage of urine into a closed system.

Purpose

Intermittent catheterization is recommended to obtain a sterile urine specimen, to relieve urinary retention, for urologic surgery or surgery on contiguous structures, for critically ill patients requiring accurate measurement of intake and output, and for temporary obstruction of the bladder opening due to injury.

Indwelling catheterization is recommended for continuous drainage of urine when the bladder outlet obstruction can not be corrected by medical or surgical intervention; in cases of intractable skin ulceration caused or exacerbated by exposure to urine; and as palliative care for terminally ill or severely impaired incontinent patients.

Precautions

The urinary tract is normally a sterile system. The normal flow of urine from the **kidneys** through the ureters, bladder, and urethra prevents the migration of **bacteria** up through the **urinary system**. Antibacterial properties of the bladder wall, urethra, low pH of urine, and the prostatic fluid in men also inhibit bacteria growth. Urinary tract infections (UTI) usually result from bacterial invasion of the protective barriers of one or

more urinary structures. As a result, urinary catheterization should be avoided whenever possible. Precautions must be taken to keep the procedure sterile and the catheter free from bacteria. The extended portion of the catheter should be washed with a mild soap and warm water to keep it free of accumulated debris.

Frequent intermittent catheterization and long-term use of indwelling catheters predisposes the patient to UTI. Care should be taken to avoid trauma to the urinary meatus and urothelium (urinary lining) with catheters that are too large or inserted with an insufficient amount of lubricant. Further medical advice should be sought if the catheter cannot be inserted easily, or the patient complains of undue **pain** or bleeding other than that associated with minor trauma.

Every attempt should be made to keep the urinary drainage system closed. Breaks in the system invite infections. Health care workers and patients should wash their hands before and after manipulation of the patient's catheter or collection system to control UTI. Cross-contamination is the most frequent cause of nosocomial (hospital acquired) catheter related infections. Good hand washing practices are the best prevention measure. Patients with indwelling catheters should be re-evaluated periodically to determine if an alternative treatment method will be more effective.

Description

Intermittent catheterization is preferable to chronic indwelling catheterization in certain patients with bladder dysfunction. It has become the standard care for patients with **spinal cord** injuries. Elderly patients, following surgical repair of hip **fractures**, regain the ability to control urination more quickly on a program of intermittent catheterization every six to eight hours compared to the use of indwelling catheters.

Intermittent catheterization may be performed four or five times a day by the health care practitioner or caregiver. Patients who are interested in self-catheterization should be instructed and trained by a qualified health professional. This is also true for patients who require indwelling catheterization, as the procedure for insertion is similar to that for intermittent catheterization, with added responsibility of inflating the balloon.

Preparation

Health care practitioner performing the catheterization should have a good understanding of the male urinary system anatomy and physiology and should be trained in **aseptic technique**, catheter insertion technique, and catheter care.

Sterile disposable catheterization sets are available in clinical settings and for home use. These sets contain most of the items needed for the procedure, such as anti-septic agents, perineal drapes, gloves, lubricant, specimen container, label, and adhesive strips. Local anesthetic gel, antibacterial lubricant, catheter, and drainage system may need to be added. It is wise to check the content of the pre-packaged catheterization set when assembling materials and supplies.

Catheter choices

Silastic catheters have a decreased incidence of urethritis and are recommended for short-term and intermittent catheterization. Latex is the catheter of choice for long-term catheterization. Silastic catheters are recommended for patients who are allergic to latex products.

There are additional types of Foley catheters:

- PTFE-coated latex
- hydrogel-coated latex
- silicone-coated latex
- pure silicone

Select the smallest and softest catheter available. Catheters larger than 18 F are seldom used. Catheters size 14 or 16 F are used more frequently. A size 12 F catheter has been used successfully in catheterizing men with acute urinary retention. When indwelling catheters are required, select a catheter that can be inflated with 5 to 10 ml of sterile water.

Review the design, capacity, and emptying mechanism of a variety of urine drainage systems available. Select the system that is most adaptable to the patient's lifestyle and ability to manage the device independently. For patients with normal bladder sensation, a catheter valve for intermittent drainage may be an acceptable option.

Procedural precautions

Before starting the catheterization, observe the patient's general condition and palpate the suprapubic area to detect gross distension. The genital area should be washed with a mild soap and warm water and patted dry.

Phimosis is constriction of the prepuce (foreskin) so that it cannot be drawn back over the glans penis. This may make it difficult to identify the external urethral meatus. Care should be taken when catheterizing men with phimosis to avoid trauma from forced retraction of the prepuce or by incorrect positioning of the catheter.

The male urethra is longer than the female urethra and has two curves in it as it passes through the penis to the bladder, which makes catheter insertion more diffi-

cult. One curve can be straightened out by lifting the penis; the other curve is fixed. The penis should be held upright, at right angle to the patient's body when the catheter is inserted. The male urinary meatus is located at the end of the penis and is exposed by retracting the prepuce in uncircumcised patients. Men with a retracted penis can be even more difficult to catheterize. Gentle finger pressure on both sides of the penis will often cause the penis to emerge and extend from the body to facilitate the catheterization.

To perform the procedure:

- Position the patient in a horizontal recumbent position.
- Place the opened catheterization tray on the bedside stand in comfortable reaching distance.
- Retract the foreskin. Using an aseptic technique, clean the prepuce and insert anesthetic gel to anesthetize the glans penis and dilate the prepuce exposing the meatus. Anesthetic gel can then be introduced into the urethra and catheterization can commence.
- Use two or three aseptic swabs to clean the meatus with circular motion, beginning with the center of the opening and rotating outwards.
- Lubricate about 8 inches (20 cm) of the catheter.
- Hold the penis in the dominant hand and pull it upward and slightly backward to straighten the urethra.
- Gently insert the catheter with a smooth continuous motion until urine begins to flow. Do not force.
- Once the urine starts to flow, collect the specimen. Advance the catheter an additional 5 cm before inflating the balloon with 5 to 10 ml of sterile solution to hold the catheter in place.
- Connect the indwelling catheter to the drainage system. Put a slight curve in the catheter and anchor it to the upper outer thigh with hypoallergenic adhesive to prevent urethral traction.

Aftercare

Patients using intermittent catheterization as treatment of incontinence or retention will have a period of adjustment as they try to establish a catheterization schedule adequate for their normal fluid intake. The urinary drainage system should be kept closed. Breaks in the drainage unit may result in an **infection**. Avoiding cross-contamination is important in controlling catheter-related UTIs. Practitioners and caretakers should always wash their hands before and after handling a patient's catheter or urine collection unit.

The extended portion of the catheter should be washed with a mild soap and warm water to remove

accumulated debris. Patients with indwelling catheters should be re-evaluated periodically to determine if an alternative treatment method will be more effective.

Catheters should not be changed routinely. Each patient should be monitored for indication of obstruction or complications before changing the catheter. Some patients require catheter changes weekly, and others may need a change in several weeks.

In summary, the following guidelines are recommended for male catheterization:

- Catheterize the patient only when it is absolutely necessary.
- Secure the catheter properly.
- Maintain a closed sterile urine collection system and unobstructed urine flow.
- Avoid catheter irrigation unless it is needed to prevent or relieve bladder obstruction.
- Always use the smallest effective catheter.
- Do not change the catheter as an elective treatment option.
- Isolated minor episodes of UTI should not be treated with **antibiotics**. Antibiotic prophylaxis promotes emergence of drug-resistant bacteria.
- Provide continuing education in catheter care for practitioners and caretakers.

Complications

A few complications that may rise during the procedure are:

- urinary tract infections and catheter obstruction
- trauma and/or the introduction of bacteria into the urinary system, leading to infection and, rarely, septicemia
- trauma to the bladder, urethra, and meatus caused by incorrect insertion of the catheter or forceful removal with the bladder inflated by confused patients
- scarring, stricture and/or narrowing of the urethra due to repeated trauma
- urine bypass around the catheter (A smaller catheter size may minimize leakage.)
- leakage around the catheter due to forceful bladder spasms that overwhelm the catheter's drainage capacity

Results

Urinary catheterization aids or replaces the body's normal ability to urinate. Intermittent use of the procedure can stimulate normal bladder function. However frequent and continuous catheterization can lead to total

KEY TERMS

Bacteriuria—Bacteria in the urine (asymptomatic or symptomatic).

Foley catheter—A double channel retention catheter. One channel provides for the inflow and outflow of fluid; the second and smaller channel is used to fill a balloon that holds the catheter in the bladder.

Phimosis—Tightness of the foreskin, which cannot be drawn back from the glans penis.

Prepuce—A fold of cutaneous tissue over the glans penis.

Urinary catheterization—The insertion of a catheter through the urethra into a patient's bladder.

Urinary incontinence—The inability to retain urine or control one's urine flow.

Urinary retention—The inability to void (urinate) to discharge urine.

dependency. Practically every patient with chronic catheterization and frequent intermittent catheterization will develop bacteriuria. Some physicians do not recommend antibiotic therapy for asymptomatic bacteriuria. When symptomatic infections are treated in patients with indwelling catheters, the catheter is removed and a fresh urine specimen is obtained for culture to determine the source of the infection and direct the medical therapy.

Health care team roles

The physician orders the catheter and a **registered nurse** performs the procedure and provides **patient education**. Catheterization is a rather simple procedure, but female nurses are sometimes reluctant to perform urethral catheterization on male patients despite established patient care guidelines and advice on the male catheterization procedure. However, both intermittent and indwelling male catheterization is required to achieve optimum quality of life; therefore nurses should make the best possible practice and techniques available. Before commencing with the catheterization, the health care professional observes the patient's general condition, palpates the pubic area to note gross distension, monitors the patient for indications of infections, and encourages adequate fluid intake.

Patient education

The nurse usually teaches the patient and/or caregiver to use aseptic technique for catheter care. Nursing interventions and patient education can make a difference in the incidence of urinary tract infections in the hospital, **nursing homes**, and **home care** units.

The sexuality of the patient with an indwelling catheter for continuous urinary drainage is seldom considered. If a patient is sexually active, the patient or her partner can be taught to remove the catheter before intercourse, and replace it with a new one following intercourse.

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Cavities *see* **Dental caries**

CBC *see* **Complete blood count**

CD4 count *see* **AIDS tests**

Cell division

Definition

The process by which a cell distributes its genetic material (DNA) and cytoplasm to daughter cells.

Description

In higher organisms including humans, there are two types of cell division, mitosis and meiosis. Strictly speaking, mitosis and meiosis refer to division of the DNA and associated materials in the nucleus of the cell. In mitosis, the cells produced by division have exactly the same genetic information as the original cell, while in meiosis the cells produced by division have only half the genetic

information as the original cell. Both processes are accompanied by cytokinesis, the division of the cytoplasm.

Mitosis

Mitosis produces two daughter cells, each of which has the same genetic information as the parent cell. The entire process includes a series of precise steps to insure that the genetic material is accurately duplicated and distributed. The life of a cell is generally made up of two parts, interphase and mitosis. During interphase, DNA synthesis occurs. Since the process uses the original DNA as a template, the copy is exact (or nearly exact if mutations occur). After a pause, the cell then enters mitosis. Although the lifespan of a cell varies in length depending on the cell type, mitosis itself usually takes about one to two hours and involves four stages: prophase, metaphase, anaphase, and telophase.

PROPHASE. During prophase, the chromosomes, which contain the DNA, condense in length and become visible under a **microscope**. Humans have 23 chromosome pairs, for a total of 46 chromosomes. Since DNA duplication has already occurred, each of the 46 chromosomes at this stage is present in two copies referred to as sister chromatids. The two sister chromatids of a pair are attached to each other at a point called the centromere. As the chromosomes condense, the membrane surrounding the nucleus disappears, and fibers appear, which come together to form a spindle within the cell. The spindle has two opposite poles and a mid-section, the equatorial plate.

METAPHASE. At the beginning of metaphase, the chromosomes line up individually on the equatorial plate. Fibers emanating from the poles of the spindle attach to the centromeres of the sister chromatids. One member of each pair of sister chromatids is attached to a spindle fiber that radiates from one pole, and the other is attached to a fiber that radiates from the opposite pole.

ANAPHASE. After all chromosomes (92 sister chromatids in 46 pairs) have aligned on the equatorial plane of the spindle, the centromere of each chromosome splits, and the fibers begin to contract. One sister chromatid of each pair is pulled to one pole of the spindle and the other is pulled to the opposite pole.

TELOPHASE. Separate membranes form around the chromosome sets at each pole to form two nuclei. The chromosomes elongate and the spindle disappears. Cytokinesis then occurs, resulting in two daughter cells each with 46 chromosomes and roughly half the cytoplasm of the parent cell.

Function and role in human health

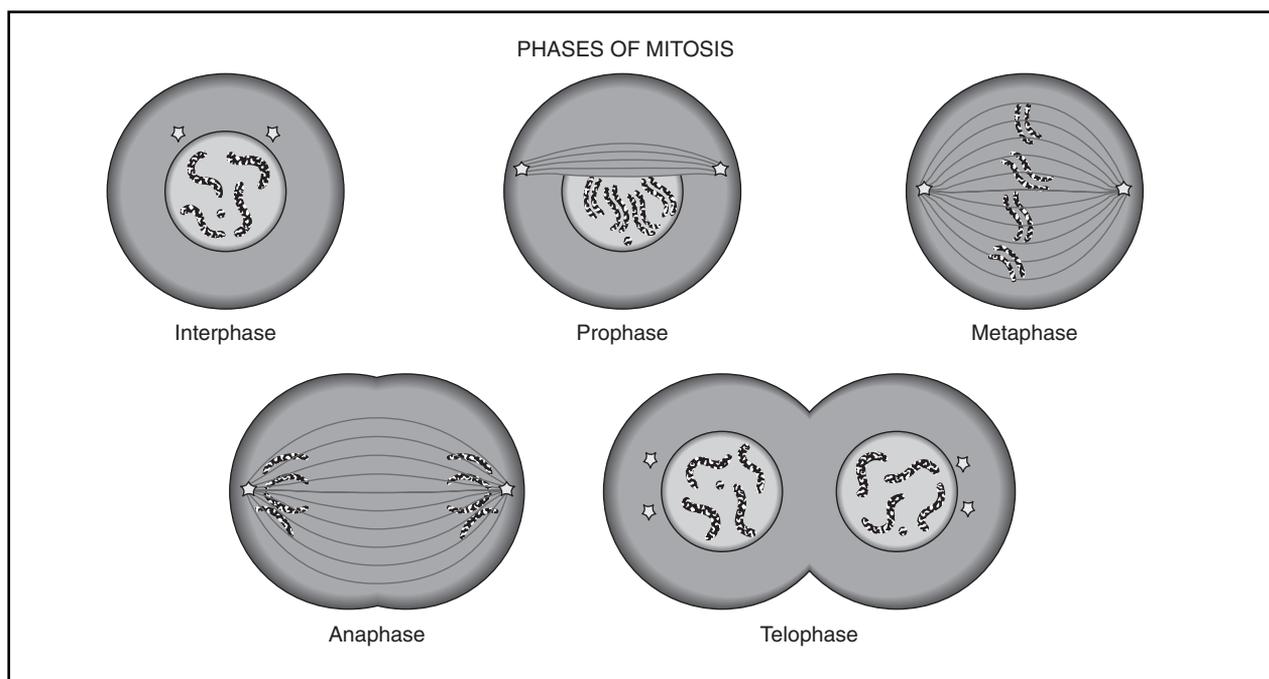
Mitosis is the process by which a single human zygote (fertilized egg cell) becomes a complex organism consisting of over 100 trillion cells. During the lifetime of an individual, mitosis continues. In some tissues such as epithelium (skin, mucous membranes), mitosis actively occurs to replace cells and repair damage. Other cell types such as nerve cells do not readily undergo mitosis after a certain point in development. Thus the capacity for mitosis is programmed into each cell type and is cell-specific. In addition, there are many molecules within the body that can influence cell division. Scientists are just beginning to learn about some of these and their possible roles in human health. For example, **cancer** occurs when the normal pattern of cell division within a tissue or organ is disrupted, and the cells begin to repeatedly undergo mitosis. Changes within the cell as well as external influences can play a part in disrupting the normal control of mitosis.

Meiosis

Meiosis is a special type of cell division that, in higher organisms, occurs only in cells of the ovaries or testes. Within these organs, cells destined to become eggs and sperm undergo meiosis in order to halve the amount of DNA that will be packaged into an egg or sperm. As with all the other cells in the body, these precursor cells are diploid; that is, they have the full complement of 46 chromosomes (23 pairs). Whereas mitosis creates two diploid cells from one existing diploid cell, meiosis results in eggs and sperm that have only one member of each pair of chromosome. Thus these cells, collectively known as germ cells, have only 23 chromosomes and are said to be haploid. At fertilization, the union of one egg and one sperm produces a diploid zygote (fertilized egg) with 46 chromosomes, half from the mother and half from the father. This zygote then begins the many mitotic divisions that will take it from a single cell to a complex, fully differentiated organism.

The steps in meiosis are similar in many ways to those in mitosis, but there are several important differences. One obvious distinction is that, unlike mitosis which includes only one division of the nucleus and cytoplasm, meiosis is actually composed of two divisions, meiosis I and meiosis II. As in a mitotic division, DNA duplication occurs during interphase before meiosis so that the cells begin meiosis I with double the diploid amount of DNA (92 sister chromatids).

MEIOSIS I PROPHASE. Prophase of meiosis I (prophase I) includes several significant features. As the chromosomes condense, chromosome pairing occurs. This is an important phenomenon that occurs only during



Phases of mitosis. (Gale Research.)

meiosis. Higher organisms receive half of their genetic material from their mother and half from their father; that is, one set of chromosomes is maternal in origin and the other set is paternal. During interphase of a cell cycle, as well as during mitotic divisions, these various chromosomes from the maternal and paternal sets do not associate in pairs. Pairing only occurs in prophase of meiosis I. This pairing brings the same chromosome from the mother and father together in close association. This pairing is essential for the important step that happens next.

A process of crossing over occurs between the maternal and paternal member of each chromosome pair. These crossover points, which can be seen through the microscope, are the places where maternal and paternal chromosomes have exchanged sections of genetic material in a process known as recombination. This essential step occurs during meiosis and serves to recombine the genetic material an individual received from their mother and father. That individual can then pass on new combinations of the genes from their parents to their offspring. This greatly increases the possible combinations of genetic traits and helps create diversity in the offspring. At the end of prophase, recombination is complete and the chromosome pairs, still attached at their cross-over points, move to the equatorial plate of the spindle that is beginning to form.

In females the process of meiosis begins while the individual herself is still an embryo. The eggs within that early embryo complete prophase I up to a certain point

and then go into an arrested state. Eggs only begin to be released from that arrest many years later after a woman has reached **puberty**. Each month as one egg is ovulated (released from the ovary), meiosis resumes.

MEIOSIS I METAPHASE. During metaphase I, the 23 chromosome pairs line up on the equatorial plate of the spindle with one member of each pair attached by a spindle fiber to one pole and the other member attached to the other pole. At this point the two members of a pair (each of which is itself composed of a pair of sister chromatids) are being held together only at the anchor points created by the cross-overs. When all chromosome pairs are properly aligned on the equatorial plate of the spindle, the anchors release and anaphase I begins.

MEIOSIS I ANAPHASE. During this stage, the two members of a chromosome pair travel to opposite spindle poles. Unlike anaphase of mitosis, the centromeres do not separate. Thus, each chromosome at a pole is composed of a pair of sister chromatids attached at their centromeres. An important point to understand is that the pairs of chromosomes do not line up on the spindle with all of the individual's mother's chromosomes pointing toward one pole and the father's pointing to the other. The alignment is random, so the function of meiosis I is similar to the shuffling of a deck of cards before dealing a hand. The half set of 23 chromosomes that collects at one spindle pole during anaphase will have chromosomes, and thus genetic information, from both the individual's mother and father. This is another way in which

KEY TERMS

Amniocentesis—A procedure performed around the fourth month of pregnancy in which a needle is inserted through a woman's abdomen into her uterus to draw out a small sample of the amniotic fluid from around the baby. Fetal cells in the fluid can be used to check the chromosome make-up of the baby.

Chorionic villus sampling (CVS)—A procedure used for prenatal diagnosis at eight to 10 weeks gestation. Under ultrasound guidance a needle is inserted either through the mother's vagina or abdominal wall and a sample of cells is collected from around the early embryo. These cells can be used to study the chromosomes of the fetus.

Chromosomes—Structures in the nucleus of a cell that contain a thread of DNA containing the genetic information (genes). Humans have 46 chromosomes in 23 pairs.

Cytoplasm—The portion of the cell that surrounds the nucleus.

DNA—Deoxyribonucleic acid, the molecule that encodes the genes.

Genetic counselor—An individual, usually with an advanced degree and board certification, who specializes in assessing genetic risk and informing patients about these risks and the options for dealing with them.

Geneticist—A individual with an advanced degree (MS, MD, PhD) in genetics. Human geneticists and medical geneticists specialize in genetic issues pertaining to humans. Many geneticists are certified by specialty boards.

Nucleus—The membrane-bound body within a cell that contains the chromosomes.

meiosis increases diversity in the offspring. When the Austrian monk Gregor Mendel put forth his principles of heredity in 1865, the process of meiosis had not been discovered. However, scientists later came to realize that the inheritance pattern Mendel described for specific traits such as color and shape in the garden pea, were due to the events of the first meiotic division.

MEIOSIS I TELOPHASE. At the poles, a separate nuclear membrane forms around each haploid chromosome set and cytokinesis occurs, resulting into two daughter cells. In females, cytokinesis produces one large cell with the bulk of the cytoplasm, and one very small

cell, the first polar body. The larger cell proceeds to meiosis II. In males, cytoplasmic division is equal and both cells enter meiosis II. Because meiosis I has reduced the diploid number of 46 chromosomes to 23, meiosis I is often referred to as the reduction division.

MEIOSIS II INTERPHASE. Unlike in mitosis, there is no further DNA duplication and interphase is brief.

MEIOSIS II PROPHASE. The nuclear membrane breaks down and a new spindle begins to form.

MEIOSIS II METAPHASE. The haploid set of 23 chromosomes, each consisting of a pair of sister chromatids, moves to the equatorial plate of the spindle. Fibers from the two poles attach at each centromere pair and exert tension to align the chromosomes.

MEIOSIS II ANAPHASE. The centromeres separate, and the sister chromatids are pulled to opposite poles. In this regard meiosis II is very similar to mitosis. In females, anaphase II is triggered by the sperm entering the recently ovulated egg.

MEIOSIS II TELOPHASE. The chromosomes begin to de-condense, a nuclear membrane forms around each set, and cytokinesis occurs. In sperm, cytokinesis is again equal and the result is the production of four haploid spermatids, which will go through a process of maturation to become sperm. In males, there is no arrest of meiosis and the entire meiotic process takes about 60 days. In females, meiosis II produces a small second polar body containing one set of chromosomes and a small amount of cytoplasm. The majority of the cytoplasm together with the other set of chromosomes comprises the ovum (mature egg). Since a sperm has already penetrated the envelope of the egg, all that remains is for the haploid chromosome sets from the egg and sperm to merge to produce the diploid zygote.

Common diseases and disorders

In humans, errors in chromosome division occur frequently during meiosis. Although these errors can take place either during the formation of the egg or the sperm, most errors occur during meiosis in the female for reasons that are not yet clearly understood. If mistakes occur during meiosis, eggs and sperm can be formed with either too many or too few chromosome. Fertilization then results in a fertilized egg than has less than or more than 46 chromosomes, a situation with major health consequences. For example, roughly 20% of all clinically recognized pregnancies result in **miscarriage**. Half of these are due to an extra or missing chromosome(s) in the developing embryo. Among live births, one in 150 infants has some type of chromosome abnormality. One of the more common is **Down syndrome**. Most cases of

Down syndrome are due to an error in meiosis that results in an extra chromosome (extra chromosome 21) being present in the fertilized egg. This condition is called trisomy 21. The individual who develops from this egg will have the clinical features of Down syndrome including mental retardation. Trisomy 21, as well as other similar chromosome errors, occurs more often in the pregnancies of women as they get older. For example, older women have a higher risk for miscarriages associated with chromosome errors. They also have a higher risk of giving birth to an infant with trisomy 21 Down syndrome or a similar chromosome abnormality. For this reason, women in their mid-30s or older are usually referred to a geneticist or genetic counselor to learn about prenatal testing options such as **amniocentesis** and **chorionic villus sampling** (CVS).

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Cell membranes

Definition

A cell membrane (also known as a plasma membrane) is a thin semifluid structure that separates the contents of a cell or organelle from its surroundings.

Description

The environment inside of a cell is drastically different from that of its surroundings. Outside the cell, water-soluble ions and molecules create a harsh and toxic environment. From this, the cell must selectively absorb nutrients that are essential to its growth and function. It

must also excrete toxic byproducts of its **metabolism**. The cell membrane subsequently has two major functions:

- It acts as a barrier, enclosing and protecting the components of a cell.
- It acts as a gate, controlling the flow of molecules in and out of the cell.

Higher-level cells known as eukaryotes contain specialized components, called organelles, that play dedicated roles in its growth and development. Each organelle is surrounded by a separate membrane whose function is similar to that of plasma membranes, but with a slightly different composition that enables the organelle to perform specific tasks.

Structure

Plasma and organelle membranes are composed primarily of **lipids** (fatty acids, sterols, or other water-insoluble molecules) and **proteins** (chains of amino acids). They differ in their proportion of lipids to proteins. For example, cell membranes of structures predominantly involved in energy production (e.g., the mitochondria) have a higher percentage of proteins, while membranes acting as insulators (e.g., the Schwann cell, which insulates some nerve fibers) have a higher proportion of lipids.

LIPIDS. A membrane is actually two layers of lipids that form a shell around the cell. This lipid bilayer is composed primarily of phospholipids (lipids containing one or more phosphate groups), each with a hydrophilic (water-soluble) “head” and a hydrophobic (water-insoluble) “tail.” The bilayer is the most stable configuration for phospholipids in a water environment, with the water-repelling tails sequestered in the middle of two layers of water-soluble heads. Thus the membrane forms a stable yet flexible configuration with a certain amount of fluidity: individual phospholipids can move rapidly across the surface of the membrane, and part to allow molecules soluble in organic media (e.g., other lipids, dissolved gases, etc.) to enter the cell.

PROTEINS. One type of protein can be loosely associated with the outside of the membrane; these are called extrinsic (or peripheral) proteins. Other proteins are tightly embedded in the membrane, and may extend from one side of the membrane to the other; these intrinsic or integral proteins are difficult to remove without destroying the membrane itself.

There are two general types of membrane proteins: transporters and receptors. Although some lipid-soluble molecules can permeate the cell membrane, many of the nutrients that a cell needs to function are too large to readily enter the cell. Transporters allow the cell to be

KEY TERMS

Active transport—Movement of a substance against its concentration gradient, from a low concentration to a high concentration.

Eukaryote—An organism whose cells contain a true nucleus bound by a membrane.

Extrinsic proteins—Proteins that are loosely associated with the outside of a plasma membrane; also known as peripheral proteins.

Hydrophilic—Having an affinity for water or for absorbing water.

Hydrophobic—Lacking an affinity for or resistant to water.

Intrinsic proteins—Proteins that are tightly embedded in a plasma membrane, and might extend from one side of the membrane to the other.

Ions—Atoms with positive or negative electric charge.

Lipid—A molecule of composed fatty acids, sterols, or other water-insoluble molecules.

Metabolism—The physical and chemical processes occurring within a cell that are necessary for life.

Organelle—A specialized compartment of a cell that performs specific functions, such as a mitochondrion, lysosome, or ribosome.

Passive transport—Movement of a substance across a membrane without the expenditure of metabolic energy.

Permeation—Movement of a substance through a permeable membrane from a region of high concentration to a region of low concentration.

Receptor—An extracellular structure capable of binding specific substances.

Transporter—A transmembrane protein that transports different substances across the membrane.

selective in which molecules it allows into its cytoplasm. Examples of transporters are channels, which facilitate free movement of molecules across the membranes, and pumps, which require a certain amount of energy in order to transport molecules. Transport proteins also exist in organelle membranes; transport channels have been shown to exist in the organelles of yeast cells and are essential to cell viability.

A cell must be able to communicate with its surroundings if it is going to adapt to changing conditions. Receptors are transmembrane proteins that detect signals from the extracellular environment and translate those signals into a cellular response. An example of a signal is the compound epinephrine (also known as adrenaline). Receptors specific to epinephrine detect its presence in the environment and bind to the molecule. This binding induces a cascade of events in the cell, resulting in increased production of glucose used as energy.

Function

The cell is constantly bombarded by ions and molecules of different type and size. While lipid-soluble molecules can pass readily through the membrane, water-soluble and larger particles require another mode of entry. The plasma membrane consequently has numerous means of importing or exporting substances:

- *Permeation* occurs when a substance moves through the membrane from a region of high concentration to a region of low concentration, a process called diffusion. Only lipid-soluble molecules and some small particles (e.g., biologically important gases such as oxygen and nitrogen) can readily permeate the cell membrane.
- *Passive transport* or facilitated diffusion occurs when water-soluble molecules and ions move through the membrane with the help of transporters (also called permeases).
- *Active transport* occurs when a substance is moved against its concentration gradient, from a low concentration to a high concentration. This process requires a higher amount of energy expended by the cell.

Role in human health

Thousands of **bacteria**, protozoa, and **fungi** cause human disease. These microbial cells also have membranes that are essential to their vitality. This vulnerability is a target of the human **immune system** and some types of drugs that fight microbial diseases. For example, the polymyxin class of **antibiotics** disrupts the cell membranes of bacteria such as *Pseudomonas aeruginosa* (causes respiratory tract, burn wound, ear, and eye infections). Compromising the cell membranes of such microorganisms effectively kills them.

Common diseases and disorders

Some human diseases the result of faulty membrane transport systems. An example would be type II (adult onset) **diabetes mellitus**. Excess glucose in the bloodstream, caused by eating a meal rich in **carbohydrates**,

is usually taken up by myocytes (muscle cells) and adipocytes (fat cells). The glucose transporter GluT4 is normally present in the cell membrane in small amounts. The presence of insulin (a hormone secreted by the **pancreas** in response to high glucose levels) causes more GluT4 transporters to be exposed, increasing uptake of glucose into the cell. In type II diabetes there is resistance to the metabolic effects of insulin, either at the cell membrane or in post-receptor signaling systems. This means that little glucose can be taken up by myocytes and adipocytes, and high **blood** glucose levels are the result.

Cystic fibrosis. a genetic disease, causes an abnormality in the mucus normally found in the **lungs**, resulting in increased bacterial infections and difficulty breathing. This is caused by a defective chloride and fluid transport that decreases the water content of the mucus and causes it to be excessively thick.

Other disorders of membrane transport include Giddelman's syndrome and Liddle's syndrome, which can cause either hypo- or **hypertension**. Membrane disorders are also important causes of water and electrolyte disturbances, disorders of neural transmission, and many other syndromes.

Hazardous substances such as tetrodotoxin (produced by the puffer fish), dendrotoxin (venom of the black mamba snake), and cobrotoxin (another snake venom) affect the function of different ion channels in **neurons**, blocking signals from the nervous system to muscles. The result may be **paralysis** and in some cases, death.

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Stephanie Islane Dionne

Central catheter maintenance

Definition

Central venous therapy involves placing a catheter into one of the patient's central veins, with the tip situated in the superior vena cava. Central catheter maintenance includes those actions performed by a nurse or other health care professional to keep the catheter functioning properly and to minimize any negative effects on the patient.

Purpose

There are a number of reasons for a patient to require a central catheter. Sometimes a person's peripheral venous access is inadequate for the type or duration of intravenous therapy planned. In other cases, a central line allows central venous pressure to be measured and monitored.

Precautions

Several factors should be considered when deciding which type of central catheter is appropriate for a patient. The duration of therapy and the types of medications ordered, the setting in which the client will receive intravenous therapy, and the client's activity level and lifestyle will all help to determine the catheter the patient has inserted.

Description

There are several types of central catheters, which are divided into two categories: nontunneled and tunneled. They are made from a variety of materials: Teflon, polyurethane, silicone, polyvinyl chloride, and a silicone/elastomer blend called silastic. Each type has advantages and disadvantages, and each type requires specific maintenance.

Nontunneled catheters are used primarily for short-term intravenous therapy, and when quick venous access is required to administer life-saving drugs or fluids. They may be inserted at the client's bedside by the physician. One type of nontunneled catheter is the peripherally

inserted central catheter (PICC). Specially trained nurses can insert the PICC, which is suitable for the administration of any intravenous therapy in any setting. Nontunneled central catheters are easily inserted, cost-effective, and easily removed. On the other hand, they can easily be dislodged by the patient's movements, require sterile dressing changes, and must be flushed by heparin when not used continually.

Tunneled central venous catheters include the Broviac, Hickman, and Groshong. These are made from either polyurethane or silicone and can be distinguished from each other by the inside gauge of lumen and the type of catheter tips. Each of these catheters has their advantages and disadvantages.

- *Broviac*: This is a smaller-bore catheter that is anchored to the chest wall so a patient's movement is not restricted. Its small lumen makes it suitable for children and the elderly. Its disadvantages are that it requires surgical insertion, tears and kinks easily, must be removed by a physician, and is difficult to repair. Because it has a smaller gauge, it is not suitable for many patients. It also requires routine flushing with saline and heparin to maintain its patency.
- *Hickman*: This catheter is also anchored to the chest wall, and it may have multiple lumens allowing multiple uses. However, it also requires surgical insertion, is difficult to repair, and the ports must be capped and clean at all times. Routine flushing is required for the Hickman with saline and heparin.
- *Groshong*: The Groshong has some of the same advantages as the Broviac and Hickman. In addition, because of its valve at the tip, the need for daily Heparin flushes is eliminated. Instead the line can be flushed weekly with 0.9% saline solution. The Groshong is also easy to repair, and generally requires less time and cost for maintenance than the Broviac or Hickman. It too has disadvantages, however. The Groshong tears and kinks easily and must be surgically inserted and removed by a physician.

In addition to flushing, all central catheters require routine sterile dressing changes. The frequency of with which the dressing must be changed depends upon whether the patient is hospitalized or in the home environment.

Another type of central catheter is an implanted port, which consists of a portal body, a septum, a reservoir, and a catheter. The port is inserted surgically into a subcutaneous pocket in the patient's trunk, and the catheter is then threaded into the central vascular system. The septum consists of a self-sealing silicone, which is accessed by the nurse using a special noncoring needle. One of its primary advantages is that it does not require frequent flushing when not in use, and since it is implanted

KEY TERMS

Central catheter—A catheter placed into a central vein for the purpose of administering drugs, fluids, nutrients, and blood products. It may also be used to withdraw blood for laboratory testing.

Noncoring needle—Also known as a Huber needle, this special type of needle has a hole on its side rather than at the tip, and may be either straight or angled. Its special shape slices rather than punctures in the septum, reducing the chance of leakage through the opening.

Patency—Degree of openness; once inserted, catheters can become clogged unless they are flushed with heparin and/or saline to keep them clear.

Urokinase—A kidney enzyme found in urine used to dissolve blood clots.

beneath the skin, it aids in maintaining the patient's body image.

Preparation

The patient should be told why a central catheter is being placed, what care it may require afterwards, and, if possible, should consent to the procedure before it is performed. Tunneled catheters are usually placed surgically by the physician. Prior to the procedure, a sedative is often ordered to relax the patient.

Aftercare

After the catheter is placed, the placement must be confirmed by x ray prior to use.

Complications

The two primary complications with central catheters are **infection** and occlusion. Infections can be decreased with strict sterile technique when changing dressings, and monitoring the patient closely for any signs of infection, including **fever**, redness or soreness at the site of insertion, and drainage from the insertion site.

Occlusions are the most common noninfectious complication seen with central venous access devices. Thrombotic, or **blood** clot, occlusions can be prevented with regular flushing using the proper technique. A positive-pressure technique prevents blood reflux after the

flushing. Some thrombotic occlusions may require flushing with an agent like urokinase.

Mechanical occlusions can also occur if the catheter develops a kink, or if the suture holding the catheter in place is too tight. In addition, if the catheter was positioned with the tip touching the vessel wall, a partial occlusion could result that would allow infusion, but not the aspiration of blood. These types of occlusions may require the replacement of the catheter.

Results

Ideally the central catheter will stay in place for as long as it is needed without complications developing. After it is no longer needed, the catheter is removed.

Health care team roles

With the exception of PICC lines, most central catheters are inserted by a physician. These lines are normally maintained and cared for by nurses.

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Central nervous system

Definition

The central nervous system (CNS) consists of the **brain** and **spinal cord**.

Description

Comprised of the brain and spinal cord, the CNS is central to the body as opposed to peripheral. It is responsible for unconscious and conscious body functions as well as intellectual functions that allow humans to think. The neuron is the basic nerve cell of the nervous system, however, the nervous system contains many types of

cells other than nerve cells. The nerve cell consists of a nucleus in a cell body, dendrites, and axons. The CNS is heavily guarded with protective features, however, this does not make it immune to disease and disorder. The CNS is cushioned with cerebrospinal fluid (CSF), protected by three layers of meninges, and protected from the body by the blood-brain barrier. The blood-brain barrier prevents harmful substances and disease-causing organisms from contaminating the bloodstream entering the CNS.

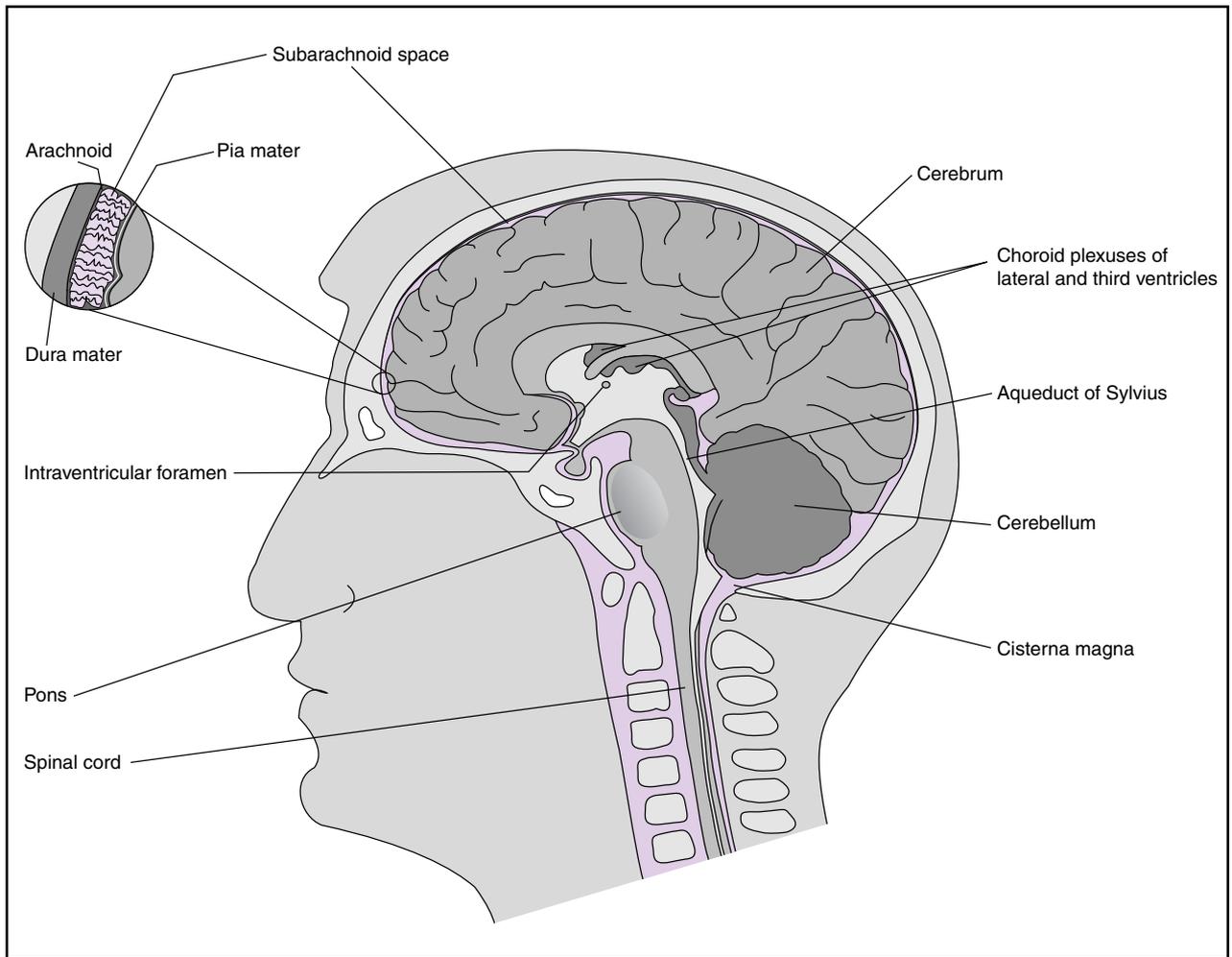
The **skull** (cranium) encloses the brain. Three main areas of the brain, the cerebrum, cerebellum, and brainstem, contain myelinated nerve fibers and white matter, in contrast to the cortex of the brain, the layer of gray matter. The cerebrum, the largest part of the brain containing the left and right hemispheres, controls conscious activities like motor functions. The cerebellum, located above the brainstem, communicates with other regions of the brain and spinal cord to control balance and coordination. The brainstem, the lowest part of the brain extending to the spinal cord, controls unconscious activities necessary for survival like breathing and **blood pressure**. The spinal cord is protected by the **vertebral column** from the cervical area to the sacrum. The spinal cord nerves relay sensory information to the brain and motor information to the body.

Function

The central nervous system (CNS) is a processing center that integrates sensory and motor activities via the brain and spinal cord. Nerves are like an electrical wire with an insulating sheath, called myelin, that facilitates the smooth, high-speed transmission of messages. Information in the nervous system is carried by brief electrical impulses that are conducted away from the body of the nerve cell along the axons. When impulses reach the tips of axons, information is transmitted to the next nerve cell in line, or to a muscle or organ. At the point of contact, or synapse, the information is carried across the gap between cells by neurotransmitters. The CNS has two-way communication. Nerve fibers either relay messages to the brain to communicate sensory stimuli, or they relay messages away from the brain to the body's tissues and organs. It is through the spinal cord that messages are sent back and forth to the brain. Spinal nerves in the spinal cord connect the message relay system to rest of the body

Role in human health

Many health care providers, neurologists, neurosurgeons, physiatrists, neuropsychologists, nurses, occupational therapists, speech language pathologists, physical



Major features of the brain and spinal cord, which comprise the central nervous system (CNS). (Delmar Publishers, Inc. Reproduced by permission.)

therapists, and vocational rehabilitation counselors play a role on the health care team and share in the responsibility of the neurologic patient. A combination of methods for assessing patients with neurologic diseases and disorders enables health care professionals to make informed treatment recommendations. These include neurologic and **physical examination**, laboratory tests such as lumbar puncture, brain-imaging scans such as MRI, neuropsychological testing, and nuclear medicine tests. Treating neurologic diseases and disorders requires active patient participation along with education and support from health care professionals. While **patient education** may be time-consuming, it is extremely important to the process of maintaining health and preventing disease.

Common diseases and disorders

There are hundreds of disabling neurological diseases and disorders that affect every age, race, and eth-

nicity. A few examples include developmental disorders (**cerebral palsy**), degenerative diseases (Parkinson's and **Alzheimer's disease**), metabolic diseases (Tay-Sachs disease), cerebrovascular diseases (stroke), autoimmune diseases (**multiple sclerosis**), and tumors (glioblastoma).

Alzheimer's disease

Alzheimer's disease (AD), a progressive, neurodegenerative disease, is the most common cause of **dementia** in later life. The course of the disease varies from person to person. Although the cause of AD is not yet known, researchers have found a familial tendency for AD. They have also implicated several possibilities including genetics, environmental factors, and biochemical changes in the brain caused by low levels of certain neurotransmitters. AD usually begins after age 65, however, it may have an early onset as early as age 40.

SYMPTOMS. The severity and progression of symptoms vary from person to person. Some of the early symptoms of AD, such as forgetfulness or loss of concentration, can easily be overlooked because they resemble signs of aging or could result from fatigue, depression, or the use of certain medications. Symptoms of AD include:

- **memory** loss, confusion, loss of concentration
- difficulty recognizing family and friends
- poor judgment, indifference
- changes in behavior and personality
- disorientation, wandering, sleep disturbance
- agitation, **anxiety**, depression

There is no specific test to confirm a diagnosis of AD. A combination of tools including brain imaging technologies, patient and family history, physical and neurological examination, and neuropsychological testing are utilized to definitively diagnose AD. There is no cure for AD and no clinically proven way to slow the progression of the disease. For some patients, medication may alleviate some of the symptoms. Treatments are intended to make the patient more comfortable.

Stroke

Stroke, also called cerebral vascular accident (CVA), occurs when the **blood** flow to part of the brain is disrupted. There are primarily two categories of stroke, ischemic and hemorrhagic. The most frequent cause of stroke is a blockage (ischemic) of a blood vessel in the brain. The blockage can have several causes but all with the same result, brain cell damage or death. Brain cells cannot survive without a blood supply of oxygen and nutrients. Blockage of blood flow in the brain can be caused by a clot in a blood vessel (thrombosis) of the brain, the movement of a clot from another part of the body (embolism) to the brain, or a severe narrowing of an artery in the brain (stenosis). In a hemorrhagic stroke, a blood vessel in the brain bursts, bleeding into the brain (intracerebral hemorrhage) or into the spaces surrounding the brain.

SYMPTOMS. The signs and symptoms of stroke depend on the areas of the brain affected and the functions they control. The right cerebral hemisphere controls the left side of the body and the left cerebral hemisphere controls the right side of the body. The symptoms of stroke may be:

- sudden numbness or weakness, especially on one side of the body
- sudden confusion, difficulty speaking, or understanding speech

- sudden difficulty seeing in one or both eyes
- sudden trouble walking
- sudden dizziness, loss of balance or coordination
- sudden severe headache
- paralysis, **pain**

Risk factors for stroke are either changeable or not. For example, a person cannot change their age or family history, but they can change behaviors, like smoking, that put them at risk for a stroke. Risk factors for stroke include:

- high blood pressure
- **heart** disease
- diabetes
- smoking
- heavy alcohol consumption
- drug abuse
- high blood cholesterol levels
- family history of stroke or TIA
- age over 55

According to the National Center for Health Statistics, stroke is the third leading cause of death in the United States. In order to improve this statistic, patients need prompt interventions. The public education campaign, “Know Stroke: Know the Signs. Act in Time,” promoted by the National Institute of Neurological Disorders and Stroke (NINDS) teaches people how to recognize the signs and symptoms of stroke and the importance of prompt medical treatment to improve recovery. Tissue plasminogen activator (t-PA), the first Food and Drug Administration (FDA) approved acute ischemic stroke treatment, needs to be given within a three-hour window of the onset of symptoms to dissolve the clot. Stroke is diagnosed by a neurological examination, blood tests, brain imaging scans, Doppler ultrasound, or arteriography.

Multiple sclerosis

Multiple sclerosis (MS) is a common neurological disease that occurs mainly in young adults. The course of the disease varies from person to person and is categorized by type. Relapsing-remitting MS (RRMS) has a course of acute attacks with full or partial recovery during remissions. Secondary progressive MS (SPMS) is initially relapsing-remitting and then becomes progressive. Primary progressive MS (PPMS) has a progressive course from the beginning of the disease with no remissions. Progressive-relapsing MS (PRMS) has a progres-

KEY TERMS

Antigen—A substance that stimulates the immune system to produce antibodies.

Autoimmune—The immune system sees self as a foreign antigen and attacks a part of the body.

Cerebrospinal fluid—Fluid surrounding and cushioning the brain and spinal cord.

Cognitive—Information processing functions carried out by the brain that include comprehension, memory, attention, planning, problem-solving, etc.

Dura mater—The outermost layer of meninges.

Exacerbation—The appearance of new symptoms or the aggravation of old symptoms.

Gene—Basic units of heredity in every cell that tell the cell how to put together different proteins.

Interferon—A naturally occurring immune system protein.

Lumbar puncture—A diagnostic procedure that uses a hollow needle to penetrate the spinal canal between the vertebrae to remove cerebrospinal fluid for analysis.

Meninges—Three layers of protective connective tissue covering the brain and spinal consisting of the pia mater, arachnoid, and dura mater.

Myelin—A protective coating made of fat and protein that insulates the nerve and enhances efficient nerve fiber conduction.

Neurotransmitter—A chemical that transmits a nerve impulse at the synapse.

sive course from the beginning with acute relapses, with or without full recovery.

MS is believed to be an autoimmune disease, where the **immune system** targets the myelin in the central nervous system. MS is the most common demyelinating disease. During an attack (exacerbation), inflammation occurs in the white matter of the central nervous system. This process is followed by destruction of myelin causing areas called plaques. Not only is the myelin damaged, but the attack may also damage or sever the nerve fibers underneath the myelin. The nerve cannot conduct or send a signal properly without the myelin sheath.

MS can be difficult to diagnose because there are other diseases with similar symptoms, and there is no specific test to confirm the diagnosis. A process of elimination may be done along with a combination of imaging

technologies such as MRI, CSF analysis, evoked potentials (EVP), medical history, and clinical examination.

SYMPTOMS. The symptoms of MS are unpredictable, can vary greatly from person to person, and come and go. The neurological symptoms of MS are the result of demyelination. Symptoms include:

- blurred, double **vision**, and blind spots
- numbness, tingling, and paresthesias (pins and needles)
- fatigue, dizziness, and vertigo
- difficulties with memory loss, concentration, and attention
- difficulty with coordination, balance, and gait
- muscle and nerve pain, muscle weakness, and tremors
- bladder and bowel problems

There are many conventional and alternative treatment therapies to alleviate the symptoms of MS, but there is no cure. However, four medications have been shown to slow down disease progression. The FDA approved Interferon beta 1b (Betaseron) in 1993, Interferon beta 1a (Avonex) in 1996, and glatiramer acetate (Copaxone) in 1996 for the treatment of RRMS. They were clinically shown to decrease the frequency and severity of attacks by approximately 30%. Mitoxantrone (Novantrone), a **chemotherapy** agent that suppresses immune function, was FDA approved in 2000 for the treatment of worsening RRMS and SPMS.

Research

Research in neuroscience and the development of new research techniques and technologies offer hope to the millions of patients and families affected by neurological diseases and disorders. Research into new treatments doesn't solve the problem, therefore, scientists are researching areas such as neurogenetics to discover how to prevent certain disorders. New treatment options and the possibility of cures can bring a sense of optimism to patients. However, the research process takes years before a treatment is available to the public. Only controlled clinical trials with human participants can determine if a treatment is safe and effective for patients.

Resources

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Alzheimer's Association. 919 N. Michigan Ave., Ste. 1100, Chicago IL 60611-1676. (800) 272-3900.

<<http://www.alz.org>>.

Alzheimer's Disease Education and Referral Center. PO Box 8250. Silver Spring, MD 20907-8250. (800) 438-4380.

<<http://www.alzheimers.org>>.

American Academy of Neurology. 1080 Montreal Ave., St. Paul, MN 55116. (651) 695-1940.

American Neurological Association. 5841 Cedar Lake Rd., Ste. 204, Minneapolis, MN 55416.

<<http://www.ana.org>>.

American Stroke Association. <<http://www.strokeassociation.org/Professional/pro.html>>.

Multiple Sclerosis Association of America. 706 Haddonfield Rd. Cherry Hill, NJ 08002. (800) 532-7667.

<<http://www.msaa.com>>.

National Institute of Neurological Disorders and Stroke. National Institutes of Health. Bethesda, MD 20892.

<<http://www.ninds.nih.gov>>.

National Multiple Sclerosis Society. 733 Third Ave., 6th Flr., New York NY 10017-3288. (800) 344-4867.

<<http://www.nmss.org>>.

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Central nervous system stimulants

Definition

Central nervous system (CNS) stimulants are medicines that speed up physical and mental processes.

Purpose

Central nervous system stimulants are used to treat conditions characterized by lack of adrenergic stimulation, including narcolepsy and neonatal apnea. Additionally, methylphenidate (Ritalin) and dextroamphetamine sulfate (Dexedrine) are used for their para-

doxical effect in attention deficit hyperactivity disorder (ADHD).

The anorexiant, benzphetamine (Didrex), diethylpropion (Tenuate), phendimetrazine (Bontril, Plegine), phentermine (Fastin, Ionamine), and sibutramine (Meridia) are CNS stimulants used for appetite reduction in severe **obesity**. Although these drugs are structurally similar to amphetamine, they cause less sensation of stimulation, and are less suited for use in conditions characterized by lack of adrenergic stimulation.

Phenylpropanolamine and ephedrine have been used both as diet aids and as vasoconstrictors.

Description

The majority of CNS stimulants are chemically similar to the neurohormone norepinephrine, and simulate the traditional "fight or flight" syndrome associated with sympathetic nervous system arousal. **Caffeine** is more closely related to the xanthines, such as theophylline. A small number of additional members of the CNS stimulant class do not fall into specific chemical groups.

Precautions

Amphetamines have a high potential for abuse. They should be used in weight reduction programs only when alternative therapies have been ineffective. Administration for prolonged periods may lead to drug dependence. These drugs are classified as schedule II under federal drug control regulations.

The amphetamines and their congeners are contraindicated in advanced arteriosclerosis, symptomatic cardiovascular disease, and moderate to severe **hypertension** and hyperthyroidism. They should not be used to treat patients with hypersensitivity or idiosyncrasy to the sympathomimetic amines, or with **glaucoma**, a history of agitated states, a history of drug abuse, or during the 14 days following administration of monoamine oxidase (MAO) inhibitors.

Methylphenidate may lower the seizure threshold.

Benzphetamine is category X during **pregnancy**. Diethylpropion is category B. Other anorexiant have not been rated; however their use during pregnancy does not appear to be advisable. Safety for use of anorexiant has not been evaluated.

Amphetamines are all category C during pregnancy. Breast feeding while receiving amphetamines is not recommended because the infant may experience withdrawal symptoms.

There have been reports that when used in children, methylphenidate and amphetamines may retard growth.

KEY TERMS

Agranulocytosis—An acute febrile condition marked by severe depression of the granulocyte-producing bone marrow, and by prostration, chills, swollen neck, and sore throat sometimes with local ulceration.

Anorexiant—A drug that suppresses appetite.

Anxiety—Worry or tension in response to real or imagined stress, danger, or dreaded situations. Physical reactions, such as fast pulse, sweating, trembling, fatigue, and weakness may accompany anxiety.

Attention-deficit hyperactivity disorder (ADHD)—A condition in which a person (usually a child) has an unusually high activity level and a short attention span. People with the disorder may act impulsively and may have learning and behavioral problems.

Central nervous system—The brain and spinal cord.

Depression—A mental condition in which people feel extremely sad and lose interest in life. People with depression may also have sleep problems and loss of appetite, and may have trouble in concentrating and carrying out everyday activities.

Leucopenia—A condition in which the number of leukocytes circulating in the blood is abnormally low and which is most commonly due to a decreased production of new cells in conjunction with various infectious diseases, as a reaction to various drugs or other chemicals.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies, or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies, or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

Withdrawal symptoms—A group of physical or mental symptoms that may occur when a person suddenly stops using a drug on which he or she has become dependent.

Although these reports have been questioned, it may be suggested that the drugs not be administered outside of school hours (because most children have behavior problems in school), in order to permit full stature to be attained.

The most common adverse effects of CNS stimulants are associated with their primary action. Typical responses include overstimulation, dizziness, restlessness, and similar reactions. Rarely, hematologic reactions, including leukopenia, agranulocytosis, and bone marrow depression have been reported. Lowering of the seizure threshold has been noted with most drugs in this class.

Withdrawal syndrome

Abrupt discontinuation following prolonged high dosage results in extreme fatigue, mental depression, and changes on the sleep EEG. This response is most evident with amphetamines, but may be observed with all CNS stimulants taken over a prolonged period of time.

Resources

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ORGANIZATIONS

Children and Adults with Attention Deficit Disorders (CH.A.D.D.). 499 N.W. 70th Avenue, Suite 109, Plantation, FL 33317. (305) 587-3700.

OTHER

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Facts about childhood hyperactivity. Pamphlet. National Institute of Child Health and Human Development, 1990.

Nancy Ross-Flanigan

Cerebral palsy

Definition

Cerebral palsy (CP) is the term used for a group of nonprogressive disorders of movement and posture

caused by abnormal development of, or damage to, motor control centers of the **brain** or, in some cases, hypoxemia (insufficient oxygen in the **blood**) during the birth process. CP is caused by events before, during, or after birth. The abnormalities of muscle control that define CP are often accompanied by other neurological and physical abnormalities.

Description

Voluntary movement (walking, grasping, chewing, etc.) is primarily accomplished using muscles that are attached to bones, known as the **skeletal muscles**. Control of the skeletal muscles originates in the cerebral cortex, the largest portion of the brain. Palsy means **paralysis**, but may also be used to describe uncontrolled muscle movement. Therefore, cerebral palsy encompasses any disorder of abnormal movement and paralysis caused by abnormal function of the cerebral cortex. However, CP does not include conditions due to progressive disease or degeneration of the brain. For this reason, CP is also referred to as static (nonprogressive) encephalopathy (disease of the brain). Also excluded from the definition of CP are any disorders of muscle control that arise in the muscles themselves or in the peripheral nervous system (nerves outside the brain and **spinal cord**).

CP is not a specific diagnosis but is more accurately considered a description of a broad but defined group of neurological and physical problems.

The symptoms of CP and their severity are quite variable. Persons with CP may have only minor difficulty with **fine motor skills**, such as grasping and manipulating items with their hands. A severe form of CP could involve significant muscle problems in all four limbs, mental retardation, seizures, and difficulties with **vision**, speech, and **hearing**.

Muscles that receive defective messages from the brain may be constantly contracted and tight (spastic), and the person with CP may exhibit involuntary writhing movements (athetosis) or have difficulty with voluntary movement (dyskinesia). There can also be a lack of balance and coordination with unsteady movements (ataxia). A combination of any of these problems may also occur. Spastic CP and mixed CP constitute the majority of cases. Effects on the muscles can range from mild weakness or partial paralysis (*paresis*), to complete loss of voluntary control of a muscle or group of muscles (*plegia*). CP is also designated by the number of limbs affected. For instance, affected muscles in one limb is called monoplegia, affected muscles in both arms or both legs is called diplegia, affected muscles in both limbs on one side of the body is called hemiplegia, and affected

muscles in all four limbs is called quadriplegia. Muscles of the trunk, neck, and head may be affected as well.

Approximately 500,000 children and adults in the United States have CP, and it is newly diagnosed in about 6,000 infants and young children each year. The incidence of CP has changed little since the 1960s and 1970s. Ironically, advances in medicine have decreased the incidence from some causes—Rh disease for example, but have increased its incidence from other causes—notably, prematurity and multiple pregnancies. (Medical advances have made it possible for more babies born prematurely or in multiple but underweight births to survive, thus allowing more time for CP to be recognized when it does occur.) No particular ethnic groups seem to be at higher risk for CP. However, people of disadvantaged background are at higher risk due to poorer access to adequate **prenatal care** and advanced medical services.

Causes and symptoms

CP can be caused by a number of different mechanisms at various times—from several weeks after conception, through birth, and into early childhood. For many years it was accepted that most cases of CP were due to brain injuries received during a traumatic birth, known as birth asphyxia. However, extensive research in 1980s showed that only 5–10% of CP could be attributed to birth trauma. Other possible causes include abnormal development of the brain, prenatal factors that directly or indirectly damage **neurons** in the developing brain, premature birth, and brain injuries that occur in the first few years of life.

Because CP has many causes, a discussion of the genetics of CP is complicated. A number of hereditary or genetic syndromes have signs and symptoms similar to CP, but usually also have problems not typical of CP. Put another way, some hereditary conditions mimic CP. Isolated CP, meaning CP that is not a part of some other syndrome or disorder, is usually not inherited.

It might be possible to group the causes of CP into those that are genetic and those that are nongenetic, but most would fall somewhere in between. Grouping causes into those that occur during **pregnancy** (prenatal), those that happen around the time of birth (perinatal), and those that occur after birth (postnatal), is preferable. CP related to premature birth and multiple pregnancies (twins, triplets, etc.) is somewhat different and considered separately.

Prenatal causes

Although much has been learned about human embryology in the latter part of the twentieth century, a

great deal remains unknown. Studying prenatal human development is difficult because the embryo and fetus develop in a closed environment, namely the mother's uterus. However, the relatively recent development of a number of prenatal tests provides a window on the process. Add to that more accurate and complete evaluations of newborns, especially those with problems, and a clearer picture of what can go wrong before birth is now possible.

The complicated process of brain development before birth is susceptible to many chance errors that can result in abnormalities of varying degrees. Some of these errors will result in structural anomalies of the brain, while others may cause undetectable, but significant, abnormalities among connections (sometimes referred to as wiring) in the cerebral cortex. An abnormality in structure or wiring is sometimes hereditary, but is most often due to chance, or a cause unknown at this time. Whether and how much genetics played a role in a particular brain abnormality depends to some degree on the type of anomaly and the form of CP it causes.

Just as a stroke can cause neurologic damage in an adult, so too can this type of event occur in the fetus. A burst blood vessel in the brain followed by uncontrolled bleeding (coagulopathy), known as intracerebral hemorrhage, could cause a fetal stroke. Alternatively, a cerebral blood vessel could be obstructed by a clot (embolism). Infants who later develop CP, along with their mothers, are more likely than other mother-infant pairs to test positive for factors that put them at increased risk for bleeding episodes or blood clots. Some coagulation disorders are strictly hereditary, but most have a more complicated basis.

A teratogen is any substance to which a pregnant woman is exposed that has the potential to harm an embryo or fetus. Links between a drug or other chemical exposure during pregnancy and a risk for CP are difficult to prove. However, any substance used by the pregnant woman that might affect fetal brain development, directly or indirectly, could increase the risk for CP. Furthermore, any substance used by the mother that increases the risk for premature delivery and low birth weight—such as alcohol, tobacco, or cocaine, among others—might indirectly increase the risk for CP.

The fetus receives all nutrients and oxygen from blood that circulates through the placenta. Therefore, anything that interferes with normal placental function might adversely affect development of the fetus, including the brain, or might increase the risk for premature delivery. Structural abnormalities of the placenta, premature detachment of the placenta from the uterine wall

(abruption), and placental infections (chorioamnionitis), are thought to pose some risk for CP.

Certain conditions in the mother during pregnancy might pose a risk to **fetal development** leading to CP. Women with autoimmune antithyroid or antiphospholipid (APA) antibodies are at slightly increased risk for CP in their children. A potentially important clue points toward high levels of cytokines in the maternal and fetal circulation as a possible risk for CP. Cytokines are **proteins** associated with inflammation, such as from **infection** or **autoimmune disorders**, and they may be toxic to neurons in the fetal brain. More research is needed to determine the exact relationship, if any, between high levels of cytokines during pregnancy and CP. A woman with high cytokine levels has some risk of developing the same complications in more than one pregnancy, slightly increasing the risk for more than one child with CP.

Serious physical trauma to the mother during pregnancy could result in direct trauma to the fetus as well. Injuries to the mother can compromise the availability of nutrients and oxygen to the developing fetal brain.

Perinatal causes

Birth asphyxia significant enough to result in CP is now uncommon in developed countries. Tight nuchal cord (umbilical cord around the baby's neck) and prolapsed cord (the cord presents through the birth canal before the baby and becomes kinked or buckled) are possible causes of birth asphyxia, as are bleeding and other complications associated with **placental abruption** and **placenta previa** (placenta lying over the cervix exit).

Infection in a mother is sometimes not passed to her fetus through the placenta but, rather, transmitted to the baby during delivery. Many of these infections are sexually transmitted diseases, such as gonorrhea, **syphilis**, and even **AIDS**. Any such infection that results in serious illness in the newborn has the potential to produce some neurological damage.

Postnatal causes

The remaining 15% of CP is due to neurologic injury sustained after birth. CP with a postnatal cause is sometimes referred to as acquired CP, but this is only accurate for those cases caused by infection or trauma.

Incompatibility between the Rh blood types of mother and child (mother Rh negative, baby Rh positive) can result in severe anemia in the baby (erythroblastosis fetalis). This occurs because the mother's blood develops antibodies to the infant's blood and attempts to destroy what it perceives as the "foreign" blood. This may lead to other complications, including severe **jaundice**, which



A physical therapist works with a child with cerebral palsy. (Lois Silver/Custom Medical Stock Photo. Reproduced by permission.)

can cause CP. Rh disease in the newborn is now rare in developed countries due to routine screening of maternal blood type and treatment of pregnancies at risk. The routine, effective treatment of jaundice due to other causes has also made it an infrequent cause of CP in developed countries. Rh blood type incompatibility poses a risk for recurrence of Rh disease with each pregnancy if treatment is not provided.

Serious infections that affect the brain directly, such as **meningitis** and encephalitis, may cause irreversible damage to the brain, leading to CP. A **seizure disorder** early in life may cause CP, or may be the product of a hidden problem that causes CP in addition to seizures. Unexplained (idiopathic) seizures are hereditary in only a small percentage of cases. Although rare in infants born healthy at or near term, intracerebral hemorrhage and brain embolism, like fetal stroke, are sometimes genetic.

Physical trauma resulting in brain injury to an infant or child, such as physical abuse, accidents causing impact to the head, or near drowning/suffocation, might cause CP. Likewise, ingestion of a toxic substance such as lead, mercury, poisons, or certain chemicals could cause neurological damage. Accidental **overdose** of cer-

tain medications might also cause similar damage to the **central nervous system**.

Prematurity and multiple pregnancy

Advances since the 1980s in the medical care of **pre-mature infants** have dramatically increased the rate of survival of these fragile newborns. However, as gestational age at delivery and birth weight of a baby decrease, the risk for CP dramatically increases. A term pregnancy is delivered between 37 and 41 weeks of gestation. The risk for CP in a preterm infant (32–37 weeks) is increased about five-fold over the risk for an infant born at term. Survivors of extremely preterm births (less than 28 weeks) face as much as a 50-fold increase in risk. About 50% of all cases of CP being diagnosed are in children who were born prematurely.

Two factors are involved in the risk for CP associated with prematurity. First, premature babies are at higher risk for various CP-associated medical complications, such as intracerebral hemorrhage, infection, and difficulty in breathing, to name a few. Second, the onset of premature labor may be induced, in part, by complications that have already caused neurologic damage in the fetus.

A combination of both factors almost certainly plays a role in some cases of CP. The tendency toward premature delivery tends to run in families, but the genetic mechanisms are far from clearly understood.

An increase in multiple pregnancies, especially in the United States, is attributed to the increased use of fertility drugs. As the number of fetuses in a pregnancy increases, the risks for abnormal development and premature delivery also increase. Children from twin pregnancies have four times the risk of developing CP as children from single pregnancies. This is because more twin pregnancies are delivered prematurely or, in some cases, overcrowding occurs in the uterus causing pressure on one infant from contact with the other. The risk for CP in a child of triplets is up to 18 times greater. Furthermore, evidence suggests that a baby from a pregnancy in which its twin died before birth is at increased risk for CP.

By definition, the defect in cerebral function causing CP is nonprogressive. However, the symptoms of CP often change over time. Most of the symptoms of CP relate in some way to the aberrant control of muscles. To review, CP is categorized first by the type of movement or postural disturbance(s) that are present, then by a description of which limbs are affected, and finally by the severity of motor impairment. For example, spastic diplegia refers to continuously tight muscles that have no voluntary control in both legs, while athetoid quadraparesis describes uncontrolled writhing movements and muscle weakness in all four limbs. These three-part descriptions are helpful in providing a general picture, but cannot give a complete description of any one person with CP. In addition, the various presentations of CP do not occur with equal frequency. For example, spastic diplegia is seen in more individuals than is athetoid quadraparesis. CP can also be loosely categorized as mild, moderate, or severe, but these are very subjective terms with no firm boundaries between them.

A muscle that is tensed and contracted is hypertonic, while excessively loose muscles are hypotonic. Spastic, hypertonic muscles can cause serious orthopedic problems, including **scoliosis** (spine curvature), hip dislocation, or contractures. A contracture is shortening of a muscle, usually affecting muscles involved in flexion or extension of a joint, and are aided sometimes by a weak opposing force from a neighboring muscle. Contractures may become permanent or they may resolve without some sort of intervention. Fixed contractures may cause postural abnormalities in the affected limbs. Clenched fists and contracted feet (equinus or equinovarus) are common in people with CP. Spasticity in the thighs causes them to turn in and cross at the knees, resulting in an unusual method of walking known as a scissors gait. Any

of the joints in the limbs may be stiff (immobilized) due to spasticity of the attached muscles.

Athetosis and dyskinesia often occur with spasticity, but do not often occur alone. The same is true of ataxia. It is important to remember that the terms mild CP or severe CP refer not only to the number of symptoms present, but also to the level of involvement of any particular class of symptoms.

Mechanisms that can cause CP are not always restricted to motor-control areas of the brain. Other neurologically based symptoms may include:

- mental retardation or learning disabilities
- behavioral disorders
- seizure disorders
- visual impairment
- hearing loss
- speech impairment (dysarthria)
- abnormal sensation and perception

These problems may have a greater impact on a child's life than the primary physical impairments of CP, although not all children with CP are affected by other problems. Many infants and children with CP have growth impairment. About one-third of individuals with CP have moderate-to-severe mental retardation, one-third have mild mental retardation, and one-third have normal intelligence.

Diagnosis

The signs of CP are not usually noticeable at birth. Children normally progress through a predictable set of developmental milestones through the first 18 months of life. Children with CP, however, tend to develop these skills more slowly because of their motor impairments, and delays in reaching milestones are usually the first symptoms of CP. Babies with more severe involvement with CP are usually diagnosed earlier than others.

Selected developmental milestones, and the ages for normally acquiring them, are given below. If a child does not acquire the skill by the age shown in parentheses, there is some cause for concern:

- sits well unsupported (6–10 months)
- babbles (6–8 months)
- crawls (9–12 months)
- finger feeds, holds bottle (9–12 months)
- walks alone (12–18 months)
- uses one or two words other than “dada” or “mama” (12–15 months)

- walks up and down steps (24–36 months)
- turns pages in books; removes shoes and socks (24–30 months)

Children do not consistently favor one hand over the other before 12–18 months of age, and doing so may be a sign that the child has difficulty using the other hand. This same preference for one side of the body may show up as asymmetric crawling or, later on, favoring one leg while climbing stairs.

It must be remembered that children normally progress at somewhat different rates, and slow beginning accomplishment is often followed by normal development. Other causes for developmental delay, both benign and serious should be ruled out before considering CP as an explanation. CP is nonprogressive, so continued loss of previously acquired milestones indicates that CP is not the cause of the problem.

No single test is diagnostic for CP, but certain factors increase suspicion. The Apgar score measures a baby's condition immediately after birth. Babies that have low Apgar scores are at increased risk for CP. Presence of abnormal muscle tone or movements may indicate CP, as may the persistence of infantile **reflexes**. Imaging of the brain using ultrasound, x rays, MRI, and/or **CT scans**, may reveal structural anomalies. Some brain lesions associated with CP include scarring, cysts, expansion of the cerebral ventricles (hydrocephalus), periventricular leukomalacia (an abnormality of the area surrounding the ventricles), areas of dead tissue (necrosis), and evidence of an intracerebral hemorrhage or blood clot. Blood and urine biochemical tests, as well as genetic tests, may be used to rule out other possible causes, including muscle and peripheral nerve diseases, mitochondrial and metabolic diseases, and other inherited disorders. Evaluations by a pediatric developmental specialist and a geneticist may be of benefit.

Treatment

Therapy

Spasticity, muscle weakness, lack of coordination, ataxia, and scoliosis are all significant impairments that affect the posture and mobility of a person with CP. Physical and occupational therapists work with affected persons and their families to maximize ability to move affected limbs, develop normal motor patterns, and maintain posture. So-called assistive technology, items such as wheelchairs, walkers, shoe inserts, crutches, and braces, are often required. A speech therapist and high-technology aids, such as computer-controlled communication devices, may make a tremendous difference in the life of those who have speech impairments with CP.

Medications

Before fixed contractures develop, muscle-relaxant drugs such as diazepam (Valium), dantrolene (Dantrium), and baclofen (Lioresal) may be prescribed. Botulinum toxin (Botox), a newer and highly effective treatment, is injected directly into the affected muscles. Alcohol or phenol injections into the nerves controlling specific muscles are another option. Multiple medications are available to control seizures, and athetosis can be treated using medications such as trihexyphenidine (Artane) and benztropine (Cogentin).

Surgery

Fixed contractures are usually treated with either serial casting or surgery. The most commonly used surgical procedures are tenotomy (tendon transfer) and dorsal rhizotomy. In tenotomy, tendons of an affected muscle are cut and either repositioned or reattached in a different position, and the limb is then immobilized in a cast in a more normal position while the tendons regrow. A neurosurgeon performing dorsal rhizotomy carefully cuts selected nerve roots in the spinal cord to prevent them from stimulating the spastic muscles. Neurosurgical techniques in the brain, such as implanting tiny electrodes directly into the cerebellum or cutting a portion of the hypothalamus, have very specific applications and have had mixed results.

Education

Parents of a child newly diagnosed with CP are not likely to have the necessary expertise to coordinate the full range of care their child will need. Although knowledgeable and caring medical professionals are indispensable for developing a care plan, a potentially more important source of information and advice is other parents who have dealt with the same set of difficulties. Support groups for parents of children with CP can be significant sources of both practical advice and emotional support. Many cities have support groups that can be located through the United Cerebral Palsy Association, and most large medical centers have special multidisciplinary clinics for children with developmental disorders.

Prognosis

Cerebral palsy can affect every stage of maturation—from childhood through adolescence to adulthood. At each stage, those with CP, along with their caregivers, must strive to achieve and maintain the fullest range of experiences and education consistent with their abilities. The advice and intervention of various professionals remains crucial for many people with CP. Although CP

KEY TERMS

Asphyxia—Lack of oxygen. In the case of CP, lack of oxygen to the brain.

Ataxia—Impaired balance and coordination.

Athetosis—A condition marked by slow, writhing, involuntary muscle movements.

Coagulopathy—A disorder in which blood does not coagulate normally; it can coagulate (clot) either abnormally slowly or abnormally quickly.

Contracture—A shortening of a muscle causing a joint to become stiff or immovable.

Cytokine—A protein associated with inflammation that, at high levels, may be toxic to nerve cells in the developing brain.

Diplegia—Paralysis of corresponding parts on both sides of the body.

Dorsal rhizotomy—A surgical procedure that cuts nerve roots to reduce spasticity in affected muscles.

Dyskinesia—Difficulty with voluntary movement of a muscle.

Hemiplegia—Paralysis of the limbs on one side of a body.

Hypotonia—Reduced tone, referring to a muscle that is loose or flaccid.

Quadripareisis—Partial or incomplete paralysis of all four limbs.

Quadriplegia—Paralysis of all four limbs.

Serial casting—A series of casts designed to gradually move a limb into a more functional position.

Spastic—A condition in which the muscles are rigid, posture may be abnormal, and fine motor control is impaired.

Static encephalopathy—A disease of the brain that does not get better or worse.

Tenotomy—A surgical procedure that cuts the tendon of a contracted muscle to allow lengthening.

itself is not considered a terminal disorder, it can affect a person's lifespan by increasing the risk for certain medical problems. People with mild cerebral palsy may have near-normal life spans, but the lifespan of those with more severe forms may be shortened. However, more than 90% of infants with CP survive into adulthood.

The cause of most cases of CP remains unknown, but it has become clear that birth difficulties are not to blame in most cases. Rather, developmental problems before birth, usually unknown and generally undiagnosable, are responsible for most cases. The rate of survival for preterm infants has leveled off, and methods to improve the long-term health of at-risk babies are being sought. Current research is also focusing on the possible benefits of recognizing and treating coagulopathies and inflammatory disorders in the prenatal and perinatal periods. The use of magnesium sulfate in pregnant women with preeclampsia or threatened preterm delivery may reduce the risk of CP in very preterm infants. The risk of CP can be decreased through good maternal **nutrition**, avoidance of drugs and alcohol during pregnancy, and prevention or prompt treatment of infections.

Health care team roles

The number of health care professionals who provide care for persons with CP is extensive. Pediatricians or family physicians may make the initial diagnosis. However, in the growing environment of primary care, the pediatric nurse practitioner may be the first to describe symptoms or developmental delays associated with CP. Care and treatment is then provided by many health professionals, including general or orthopedic surgeons and neurosurgeons. Radiologists assist in diagnosis and monitoring; speech and language specialists and physical and occupational therapists provide rehabilitative therapy. Psychologists, pastoral counselors, and social workers may provide emotional support to patients and their families, while social workers will help families access resources for care and equipment. Manufacturers of prostheses and assistive devices may also provide services. For most persons with CP, assistive care is a life-long need. In an outpatient environment, nurses play a continuing role as educators for such needs as medication administration and side-effect recognition, in-home adaptations for **physical therapy** necessary between visits to physical therapists, and as a conduit for connecting parents with support groups. Should the child require surgery, the nurse has a perioperative role in caring for the patient.

Prevention

Several maternal-to-fetal cross infections are known to increase the risk for CP, including rubella (German measles, now rare in the United States), cytomegalovirus (CMV), and toxoplasmosis. Each of these infections is considered a risk to the fetus only if the mother contracts it for the first time during that pregnancy. Even in those cases, though, most babies will be born normal. Most

women are immune to all three infections by the time they reach childbearing age, but a woman's immune status can be determined using the so-called TORCH (for TOxoplasmosis, Rubella, Cytomegalovirus, and Herpes) test before or during pregnancy.

Cerebral palsy cannot be cured, but many of the disabilities it causes may be managed through planning and timely care. Treatment for a child with CP depends upon the severity, nature, and location of the primary muscular symptoms, as well as any associated problems that might be present. Optimal care of a child with mild CP may involve regular interaction with only a physical therapist and occupational therapist, whereas care for a more severely affected child may include visits to multiple medical specialists throughout life. With proper treatment and an effective care plan coverage, most people with CP can lead productive, happy lives.

Adequate prenatal monitoring by competent health care professionals is needed to prevent CP. Risk factors should be identified and appropriate tests conducted. Pregnant women who discontinue the use of substances that are potentially harmful to their fetuses significantly reduce the risk of CP in their children.

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- American Academy of Family Physicians. 11400 Tomahawk Creek Pkwy., Leawood, KS 66211-2672. (913) 906-6000. <<http://www.aafp.org>>.
- American Academy of Neurology. 1080 Montreal Ave., St. Paul, MN 55116. (651) 695-1940. <<http://www.aan.com>>.
- American Academy of Pediatrics. 141 Northwest Point Blvd. Elk Grove Village, IL 60007-1098. (847) 434-4000. <<http://www.aap.org/default.htm>>.
- American Academy of Physical Medicine and Rehabilitation. One IBM Plaza, Ste. 2500, Chicago, IL 60611-3604. (312) 464-9700. <<http://www.aapmr.org/consumers/public/amputations.htm>>.
- American College of Foot and Ankle Surgeons, 515 Busse Hwy., Park Ridge, IL 60068-3150. (888) 843-3338. <<http://www.acfas.org/index.html>>.
- American College of Physicians, 190 N. Independence Mall West, Philadelphia, PA 19106-1572. (800) 523-1546 x2600 or (215) 351-2600. <<http://www.acponline.org>>.
- American College of Surgeons. 633 North St. Clair St., Chicago, IL 60611-32311. (312) 202-5000. <<http://www.facs.org>>.
- American Medical Association. 515 N. State St., Chicago, IL 60610. (312) 464-5000. <<http://www.ama-assn.org>>.
- National Association of Pediatric Nurse Associates and Practitioners. 1101 Kings Highway, N., Ste. 206, Cherry Hill, NJ 08034-1912. (856) 667-1773 or (877) 662-7627. <<http://www.napnap.org>>.
- United States Cerebral Palsy Athletic Association. SCPAA National Center, 25 W. Independence Way, Kingston, RI 02881. (401) 792-7130. <<http://www.uscpaa.org/main.htm>>.

OTHER

- American Cerebral Palsy Information Center. <<http://www.cerebralpalsy.org>>.
- Cerebral Palsy and Deaf Organization. <<http://www.cpado.org>>.

- Internet Resources for Special Children.
<<http://www.irsc.org/cerebral.htm>>.
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- National Library of Medicine. <<http://www.nlm.nih.gov/medlineplus/cerebralpalsy.html>>.
- Nemours Foundation.
<http://kidshealth.org/parent/medical/brain/cerebral_palsy.html>.
- UCP National. <<http://www.ucpa.org>>.
- University of Virginia Medical Center.
<<http://hsc.virginia.edu/cm/tutorials/cp/cp.htm>>.

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Cerebrospinal fluid (CSF) analysis

Definition

Cerebrospinal fluid (CSF) analysis is a set of laboratory tests that examine a sample of the fluid surrounding the **brain** and **spinal cord**. This fluid is an ultrafiltrate of plasma. It is clear and colorless. It contains glucose, electrolytes, amino acids, and other small molecules found in plasma, but has very little protein and few cells. CSF protects the **central nervous system** from injury, cushions it from the surrounding bone structure, provides it with nutrients, and removes waste products by returning them to the **blood**. CSF is withdrawn from the subarachnoid space through a needle by a procedure called a lumbar puncture or spinal tap. CSF analysis includes tests in clinical chemistry, hematology, immunology, and microbiology. Usually three or four tubes are collected. The first tube is used for chemical and/or serological analysis and the last two tubes are used for hematology and microbiology tests. This reduces the chances of a falsely elevated white cell count caused by a traumatic tap (bleeding into the subarachnoid space at the puncture site), and contamination of the bacterial culture by skin flora.

Purpose

The purpose of a CSF analysis is to diagnose medical disorders that affect the central nervous system. Some of these conditions are:

- **meningitis** and encephalitis, which may be viral, bacterial, fungal, or parasitic infections
- metastatic tumors (e.g., leukemia) and central nervous system tumors that shed cells into the CSF
- **syphilis**, a sexually transmitted bacterial disease
- bleeding (hemorrhaging) in the brain and spinal cord
- **multiple sclerosis**, a degenerative nerve disease that results in the loss of the myelin coating of the nerve fibers of the brain and spinal cord
- guillain-Barré, a demyelinating disease involving peripheral sensory and motor nerves

Routine examination of CSF includes visual observation of color and clarity and tests for glucose, protein, lactate, lactate dehydrogenase, red blood cell count, white blood cell count with differential, syphilis serology (testing for antibodies indicative of syphilis), **Gram stain**, and bacterial culture. Further tests may need to be performed depending upon the results of initial tests and the presumptive diagnosis. For example, an abnormally high total protein seen in a patient suspected of having a demyelinating disease such as multiple sclerosis dictates CSF protein electrophoresis and measurement of immunoglobulin levels and myelin basic protein.

GROSS EXAMINATION. Color and clarity are important diagnostic characteristics of CSF. Straw, pink, yellow, or amber pigments (xanthochromia) are abnormal and indicate the presence of bilirubin, hemoglobin, red blood cells, or increased protein. Turbidity (suspended particles) indicates an increased number of cells. Gross examination is an important aid to differentiating a subarachnoid hemorrhage from a traumatic tap. The latter is often associated with sequential clearing of CSF as it is collected; streaks of blood in an otherwise clear fluid; or a sample that clots.

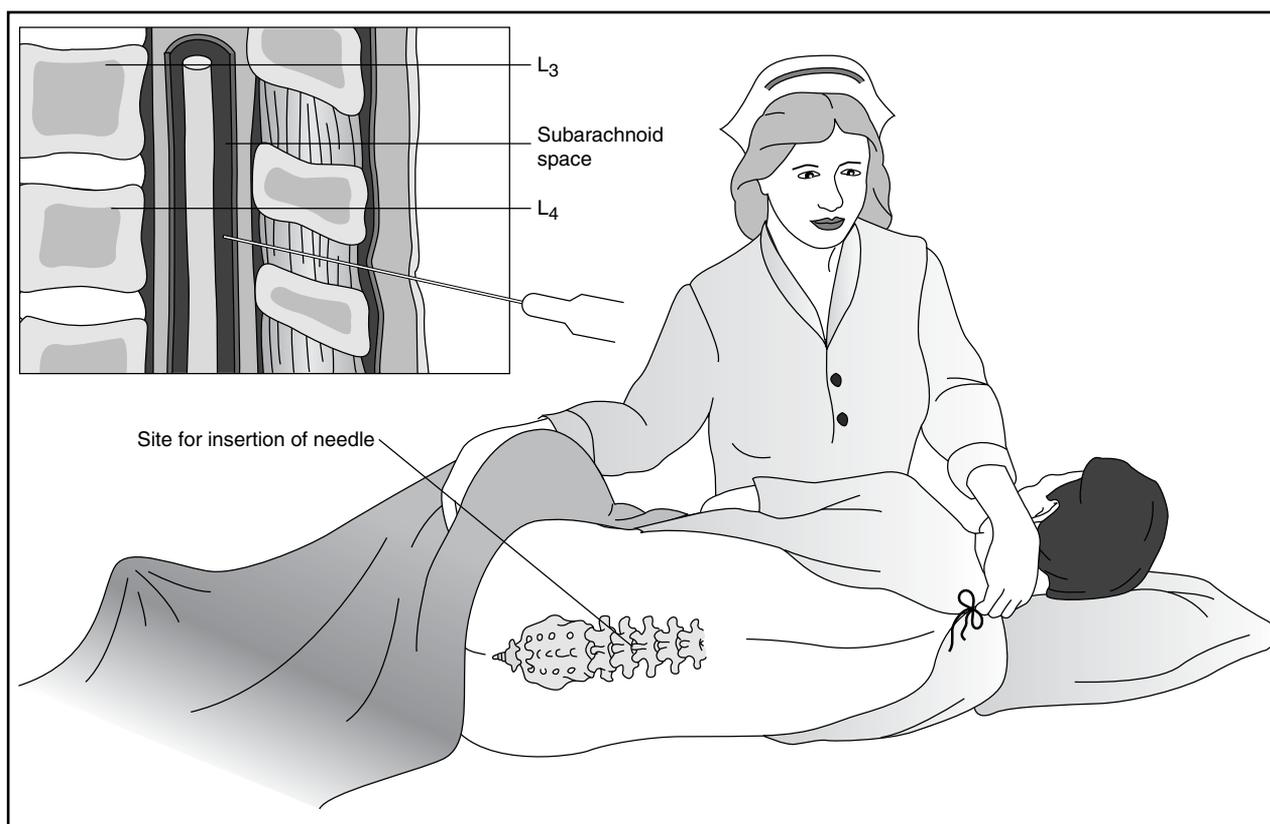
GLUCOSE. CSF glucose is normally approximately two-thirds of the fasting plasma glucose. A glucose level below 40 mg/dL is significant and occurs in bacterial and fungal meningitis and in malignancy.

PROTEIN. Total protein levels in CSF are normally very low, and albumin makes up approximately two-thirds of the total. High levels are seen in many conditions including bacterial and fungal meningitis, multiple sclerosis, tumors, subarachnoid hemorrhage, and traumatic tap.

LACTATE. The CSF lactate is used mainly to help differentiate bacterial and fungal meningitis, which cause increased lactate, from viral meningitis, which does not.

LACTATE DEHYDROGENASE. This enzyme is elevated in bacterial and fungal meningitis, malignancy, and subarachnoid hemorrhage.

WHITE BLOOD CELL (WBC) COUNT. The number of white blood cells in CSF is very low, usually necessitat-



Collection of cerebrospinal fluid (CSF) by lumbar puncture. (Delmar Publishers, Inc. Reproduced by permission.)

ing a manual WBC count. An increase in WBCs may occur in many conditions including infection (viral, bacterial, fungal, and parasitic), allergy, leukemia, multiple sclerosis, hemorrhage, traumatic tap, encephalitis, and Guillain-Barré syndrome. The WBC differential helps to distinguish many of these causes. For example, viral infection is usually associated with an increase in lymphocytes, while bacterial and fungal infections are associated with an increase in polymorphonuclear leukocytes (neutrophils). The differential may also reveal eosinophils associated with allergy and ventricular shunts; macrophages with ingested **bacteria** (indicating meningitis), RBCs (indicating hemorrhage), or **lipids** (indicating possible cerebral infarction); blasts (immature cells) that indicate leukemia; and malignant cells characteristic of the tissue of origin. About 50% of metastatic cancers that infiltrate the central nervous system and about 10% of central nervous system tumors will shed cells into the CSF.

RED BLOOD CELL (RBC) COUNT. While not normally found in CSF, RBCs will appear whenever bleeding has occurred. Red cells in CSF signal subarachnoid hemorrhage, stroke, or traumatic tap. Since white cells may enter the CSF in response to local infection, inflammation, or bleeding, the RBC count is used to correct the

WBC count so that it reflects conditions other than hemorrhage or a traumatic tap. This is accomplished by counting RBCs and WBCs in both blood and CSF. The ratio of RBCs in CSF to blood is multiplied by the blood WBC count. This value is subtracted from the CSF WBC count to eliminate WBCs derived from hemorrhage or traumatic tap.

GRAM STAIN. The Gram stain is performed on a sediment of the CSF and is positive in at least 60% of cases of bacterial meningitis. Culture is performed for both aerobic and anaerobic bacteria. In addition, other stains (e.g., the acid-fast stain for *Mycobacterium tuberculosis*, fungal culture, and rapid identification tests (tests for bacterial and fungal antigens) may be performed routinely.

SYPHILIS SEROLOGY. This involves testing for antibodies that indicate neurosyphilis. The fluorescent treponemal antibody-absorption (FTA-ABS) test is often used and is positive in persons with active and treated syphilis. The test is used in conjunction with the VDRL test for non-treponemal antibodies, which is positive in most persons with active syphilis, but negative in treated cases.

Normal cerebrospinal fluid values in adults

Measurement	Value
Volume	90–150 ml; child 60–100 ml
Clarity	Crystal clear, colorless
Pressure	50–180 mm H ₂ O
Total cell count	0–5 white blood cells/ μ l
Glucose	40–70 mg/dl
Protein	15–45 mg/dl (lumbar) 15–25 mg/dl (cisternal) 5–15 mg/dl (ventricular)
pH	7.30–7.40
CO ₂ content	25–30 mEq/L

SOURCE: Fischbach, F.T. *A Manual of Laboratory Diagnostic Tests*. 4th ed. Philadelphia: J.B. Lippincott, 1992.

Precautions

In some circumstances, a lumbar puncture to withdraw a small amount of CSF for analysis may lead to serious complications. Lumbar punctures should be performed only with extreme caution, and only if the benefits are thought to outweigh the risks. In people who have **bleeding disorders**, lumbar puncture can cause hemorrhage that can compress the spinal cord. If there is increased spinal column pressure, as may occur with a **brain tumor** and other conditions, removal of CSF can cause the brain to herniate, compressing the brain stem and other vital structures and leading to irreversible brain damage or death. Meningitis may be caused by bacteria introduced during the puncture. For this reason, **aseptic technique** must be followed strictly, and a lumbar puncture should never be performed at the site of a localized skin lesion.

Specimens should be handled with caution to avoid contamination with skin flora. They should be refrigerated if analysis cannot be performed immediately.

Description

Lumbar puncture is performed by inserting the needle between the fourth and fifth lumbar vertebrae (L4–L5). This location is used because the spinal cord stops near L2, and a needle introduced below this level will miss the cord. In rare instances, such as a spinal fluid blockage in the middle of the back, a physician may perform a spinal tap in the cervical spine.

Aftercare

After the procedure, the site of the puncture is covered with a sterile bandage. The patient should remain lying for four to six hours after the lumbar puncture. **Vital signs** should be monitored every 15 minutes for

four hours, then every 30 minutes for another four hours. The puncture site should be observed for signs of weeping or swelling for 24 hours. The neurological status of the patient should also be evaluated for such symptoms as numbness and/or tingling in the lower extremities.

Complications

The most common side effect after the removal of CSF is a headache. This occurs in 10–30% of adult patients and in up to 40% of children. It is caused by a decreased CSF pressure related to a small leak of CSF through the puncture site. These headaches usually are a dull **pain**, although some people report a throbbing sensation. A stiff neck and nausea may accompany the headache. Lumbar puncture headaches typically begin within two days after the procedure and persist from a few days to several weeks or months.

Results

- Gross appearance: Normal CSF is clear and colorless.
- CSF opening pressure: 50–175 mm H₂O.
- Specific gravity: 1.006–1.009.
- Glucose: 40–80 mg/dL.
- Total protein: 15–45 mg/dL.
- LD: 1/10 of serum level.
- Lactate: less than 35 mg/dL.
- Leukocytes (white blood cells): 0–5/microL (adults and children); up to 30/microL (newborns).
- Differential: 60–80% lymphocytes; up to 30% monocytes and macrophages; other cells 2% or less. Monocytes and macrophages are somewhat higher in neonates.
- Gram stain: negative.
- Culture: sterile.
- Syphilis serology: negative.
- Red blood cell count: Normally, there are no red blood cells in the CSF unless the needle passes through a blood vessel on route to the CSF.

Health care team roles

Spinal tap is performed by a physician, and laboratory tests are ordered by a physician. Nurses should check the patient's vital signs before the procedure, and monitor the patient for complications.

Laboratory tests are performed by a clinical laboratory scientist, CLS(NCA)/ medical technologist, MT(ASCP)

KEY TERMS

Encephalitis—An inflammation or infection of the brain and spinal cord caused by a virus or as a complication of another infection.

Guillain-Barré syndrome—A demyelinating disease involving nerves that affect the extremities and causing weakness and motor and sensory dysfunction.

Meningitis—An infection of the membranes that cover the brain and spinal cord.

Multiple sclerosis—A disease that destroys the covering (myelin sheath) of nerve fibers of the brain and spinal cord.

Spinal canal—The cavity or hollow space within the spine that contains the spinal cord and the cerebrospinal fluid.

Vertebrae—The bones of the spinal column. There are 33 along the spine, with five (called L1–L5) making up the lower lumbar region.

or clinical laboratory technician, CLT(NCA) or medical laboratory technician, MLT(ASCP).

Resources

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ORGANIZATIONS

American Academy of Neurology. 1080 Montreal Ave., St. Paul, MN 55116-2325. (800) 879-1960. <<http://www.aan.com>>.

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Cerebrovascular accident

Definition

Cerebrovascular accident (CVA) is the medical term for what is commonly termed a stroke. It refers to the injury to the **brain** that occurs when flow of **blood** to brain tissue is interrupted by a clogged or ruptured artery, causing brain tissue to die because of lack of nutrients and oxygen.

Description

The severity associated with cerebrovascular accident can best be demonstrated by the following facts:

- CVA is the leading cause of adult disability in the world.
- Worldwide, one-quarter of all strokes are fatal.
- Stroke is the third leading cause of death in the United States and the leading cause of disability.
- It is estimated that four of every five families in the United States will be affected by stroke in their lifetime,
- More than half a million people in the United States experience a new or recurrent stroke each year.
- Stroke kills about 150,000 Americans each year, or almost one out of three stroke victims.
- Three million Americans are currently permanently disabled from stroke.
- In the United States, stroke costs about \$43 billion per year in direct costs and loss of productivity.
- Two-thirds of strokes occur in people over the age of 65.
- Strokes affect men more often than women, although women are more likely to die from a stroke.
- Strokes affect African Americans more often than Caucasians, and are more likely to be fatal among African Americans.
- The incidence of strokes among people ages 30 to 60 is less than 1%. This figure triples by the age of 80.
- The rate of occurrence for strokes in the United States fell by 15.52% between 1988 and 1998. But the number of deaths from stroke actually rose by 5%.

Causes and symptoms

Arterial blood carries oxygen and nutrients to the cells of the body. When arteries are unable to carry out this function due to rupture, constriction, or obstruction,

the cells nourished by these arteries die. There are two forms of stroke, ischemic, which is caused by a blocked blood vessel that supplies blood to the brain, and hemorrhagic, which is bleeding into or around the brain.

The most common type of stroke is ischemic, which refers to the loss of oxygen and nutrients for brain cells that occurs because the blood supply to a portion of the brain has been cut off. Ischemic strokes account for approximately 80% of all strokes, and can be further broken down into two subtypes: thrombotic, also called cerebral thrombosis, and embolic, also termed cerebral embolism.

Thrombotic strokes are by far the more prevalent of ischemic strokes, and can be seen in nearly all aging populations worldwide. As people grow older, atherosclerosis, or hardening of the arteries, occurs. This results in a buildup of a waxy, cholesterol-laden substance in the arteries, which eventually narrows the interior space, or lumen, of the artery. This arterial narrowing occurs in all parts of the body, including the brain. As the process continues, the occlusion, or shutting off, of the artery eventually becomes complete so that no blood supply can pass through. Usually the occurrence of the symptoms of a thrombotic stroke are much more gradual and less dramatic than other strokes due to the slow, ongoing process that produces it.

Transient ischemic attacks (TIAs) are one form of thrombotic stroke, and usually the least serious. TIAs represent the occlusion of a very small artery, or arteriole. This blockage affects only a small portion of brain tissue and does not leave noticeable permanent ill effects. These transient ischemic attacks last only a matter of minutes, but are a forewarning that part of the brain is not receiving its necessary supply of blood, and, consequently, an insufficient amount of oxygen and nutrients.

Embolic strokes are usually a more spectacular, emergency event. They take place when the heart's rhythm is changed for a number of reasons, and blood clot formation takes place. Such a blood clot can move through the circulatory system until it blocks a blood vessel and stops the blood supply to cells in a specific portion of the body. If the blood clot occludes an artery that nourishes **heart** muscle, it causes **myocardial infarction**, or heart attack. If it blocks off a vessel that feeds brain tissue, it is termed an embolic stroke. Normally, these blockages occur in the brain itself, as when arteries directly feeding portions of brain tissue are blocked by a clot. But occasionally, the obstruction is found in the arteries of the neck, especially the carotid artery.

Approximately 20% of cerebrovascular accidents are termed hemorrhagic strokes, and are generally classified as subarachnoid hemorrhage or intracerebral hemor-

rhage, depending upon the location of the hemorrhage. Hemorrhagic strokes occur when an artery to the brain has a weakness and balloons outward, producing an aneurysm. Such an aneurysm often ruptures due to this inflation and thinning of the arterial wall, causing a hemorrhage in the affected portion of the brain.

Both ischemic and hemorrhagic strokes display similar symptoms. However, which symptoms appear depends upon which portion of the brain is cut off from its supply of oxygen and nourishment. The brain is divided into left and right hemispheres, which control bodily movement on opposing sides of the body. For example, the left hemisphere of the brain is responsible for both motor control of the right side of the body, and its sensory discrimination, just as the right hemisphere is responsible for body movements and feeling on the left side. Deeper brain tissue in the left hemisphere of the brain directs muscle tone and coordination for both the right arm and leg. As the communication and speech centers for the brain are also located in the left hemisphere of the brain, interruption of blood supply to that area can also affect the person's ability to speak.

Besides age, high **blood pressure (hypertension)** is one of the foremost causes of thrombotic stroke. Heart disease, **obesity**, diabetes, smoking, oral contraceptives in women, polycythemia (an increased number of red blood cells), and sleep apnea are also risk factors for thrombotic stroke, as is a diet high in cholesterol-producing, or fatty, foods.

The risk factors for hemorrhagic stroke include high blood pressure that can, over a period of time, cause the ballooning out of arteries known as aneurysm, and also causes the hereditary malformation that produces defective and weakened veins and arteries. Substance abuse is another major cause of hemorrhagic stroke. Cocaine, stimulants such as amphetamine drugs, and chronic **alcoholism** can cause a weakening of **blood vessels** that can result in hemorrhagic stroke.

The symptoms of stroke depend upon the part of the brain that is affected, and how large a portion of brain tissue has been damaged by the CVA. Unconsciousness and even seizures can be initial components of a stroke. Other effects materialize over a time period ranging from minutes to hours, and even, in some rare instances, over several days. Headache, mental confusion, vertigo, **vision** problems, difficulty speaking and communicating, including slurring of words (**aphasia**), and weakness or **paralysis** of one side of the body (hemiplegia) are all symptoms of stroke that are frequently observed. Stroke victims often have facial drooping, or slackness of the facial muscles, on the affected side, as well as difficulty swallowing. The severity of these symptoms will depend

upon the amount of brain tissue that has been damaged and its location in the brain.

Diagnosis

Normally, initial diagnosis will be made based upon observation by health care professionals, and usually a complete neurological examination. Once stroke is suspected, a computed tomography (CT) scan or **magnetic resonance imaging** (MRI) scan is performed to distinguish a stroke caused by blood clot from one caused by hemorrhage, a critical distinction that guides therapy. Blood and urine tests are done routinely to look for possible abnormalities associated with ischemic activity within the body. Electrocardiogram (EKG), **angiography**, and lumbar puncture are all used to rule out any other possible causes of the symptoms.

Treatment

Emergency treatment

Strokes are always considered a medical emergency, and every minute is important in initiating treatment. With the possible exception of TIAs, all other types of stroke are a life-threatening event. A severe CVA that results in **coma** or unconsciousness will require medical monitoring and support, including oxygen and possibly intubation to ensure an adequate airway and to facilitate the patient's breathing. Providing fluids that the person may not be able to take by mouth due to swallowing difficulties may also be necessary.

Emergency treatment of stroke caused by a blood clot is directed at dissolving the clot. This thrombolytic therapy is currently performed most often with tissue plasminogen activator, or t-PA. As t-PA must be administered within three hours of the stroke event, people that awaken with stroke symptoms are usually considered beyond the time limit for t-PA therapy. A five-year clinical trial completed in 1995, and reported by the *New England Journal of Medicine*, showed that stroke patients treated with t-PA within three hours of the stroke were one-third more likely to be left with no permanent residual difficulty.

T-PA therapy carries a 6.4% risk of inducing a cerebral hemorrhage, and is not appropriate for patients with **bleeding disorders**, very high blood pressure, known aneurysms, any evidence of intracranial hemorrhage, or incidence of stroke, head trauma, or intracranial surgery within the past three months. Patients with clot-related (thrombotic or embolic) stroke who are ineligible for t-PA treatment may be treated with heparin or other blood thinners, or, in some cases, with aspirin or other anti-clotting agents.

Emergency treatment of hemorrhagic stroke is aimed at controlling intracranial pressure. Intravenous urea, or mannitol, plus hyperventilation are the most common treatment. **Corticosteroids** may also be used. Patients with bleeding disorders such as those due to anticoagulant treatment should have these disorders reversed, if possible.

Sometimes surgical removal of a clot obstructing an artery is necessary. Hemorrhagic stroke can cause a buildup of pressure on the brain that must be relieved as quickly as possible to prevent further brain damage. In extreme cases, this may require an incision through the **skull** to relieve the pressure. Surgery for hemorrhage due to aneurysm may be performed if the aneurysm is close enough to the cranial surface to allow access. Ruptured vessels are closed off to prevent bleeding. For aneurysms that are difficult to reach surgically, endovascular treatment may be used. In this procedure, a catheter is guided from a larger artery up into the brain to reach the aneurysm. Small coils of wire are discharged into the aneurysm.

Longer term or rehabilitative treatment

Rehabilitation refers to a comprehensive program designed to regain function as much as possible and to compensate for permanent losses. It is based on the patient's individual deficits and strengths. Strokes on the left side of the brain primarily affect the right half of the body, and vice versa. In addition, in left-brain-dominant people, who constitute a significant majority of the population, left brain strokes usually lead to speech and language deficits. Right brain strokes may affect spatial perception, and patients with right brain strokes may also deny their illness, neglect the affected side of their body, and behave impulsively.

Much of the needed care in the days and weeks following a stroke will be to prevent further damage than what has already occurred. The severely ill stroke patient will require frequent repositioning to prevent complications such as **pneumonia** and venous or pulmonary embolism. Deep venous thrombosis, in which a clot forms within a limb immobilized by paralysis, is one of the most common medical complications following stroke. Clots that break free often become lodged in an artery feeding the **lungs**. This type of pulmonary embolism often causes death in the weeks following a stroke. Resuming activity within a day or two after the stroke is an important preventive measure, along with use of elastic stockings on the lower limbs. Drugs that prevent clotting may be given, including intravenous heparin and oral warfarin.



CAT scan of a brain showing a stroke resulting in hemorrhage (white area). (Custom Medical Stock Photo. Reproduced by permission.)

Weakness and loss of coordination of the swallowing muscles may impair swallowing (dysphasia), and allow food to enter the lower airway. This may lead to aspiration pneumonia, another common cause of death shortly after a stroke. Because of the difficulty swallowing, the person who has suffered a stroke may need a temporary or permanent feeding tube inserted into the **stomach** to ensure adequate **nutrition**. Such tubes can be either nasogastric, a thin tube that is inserted through the nose, into the esophagus, and then into the stomach, or a gastric one, which is a wider-lumen tube surgically implanted into the stomach. Less extreme dysphasia may be treated with retraining exercises and temporary use of pureed foods.

Other possible medical complications can include urinary tract infections, pressure ulcers, and **falls**. Urinary catheters are often inserted into the bladder to prevent the skin damage that can be caused by incontinence, but the presence of a catheter may also contribute to infections and loss of bladder tone. Bladder training, which consists of regular interval exercises to regain bladder tone, should begin as soon as possible. Frequent repositioning and good skin care will prevent the development of pressure ulcers, or decubitus ulcers.

Paralysis requires prevention of contractures (the tightening up of paralyzed limbs). Contractures and spasticity may be treated with a combination of stretching and splinting and, besides **exercise**, may include the use of

supportive braces for arms or hands, or using footboards or wearing sneakers when in bed to prevent foot drop.

Occupational therapy improves self-care skills such as feeding, bathing, and dressing, and helps develop effective compensatory strategies and devices for activities of daily living. A speech-language pathologist focuses on communication and swallowing skills. When dysphasia is a problem, a nutritionist can advise alternative meals that provide adequate nutrition.

Rehabilitation may be complicated by cognitive losses, including diminished ability to understand and follow directions. Poor results are more likely in patients with significant or prolonged cognitive changes, sensory losses, language deficits, or incontinence. Depression occurs in an estimated 30–60% of all stroke patients, which is not surprising as they are typically dealing with a tremendous loss of abilities and independence. As such depression will impact upon the person's rehabilitation and recovery, it needs to be addressed, and may require the services of a psychiatrist and psychiatric nurse or mental health assistant. Antidepressants and **psychotherapy** may be used in combination.

Prognosis

The National Institute of Neurological Disorders and Stroke reports that 25% of people who suffer a stroke recover completely, while 20% die within three months after the stroke. Stroke is fatal for nearly twice as many people of African-American heritage as it is for European-Americans. Of the remaining 55% of people who have strokes, 5% will require long-term (nursing home) care. For the rest, rehabilitative and restorative services will be necessary in order for them to regain as much of their former capabilities as possible.

Brain tissue that dies in a stroke cannot regenerate, and stroke survivors may be left with significant deficits. It has been estimated that the most common irreversible damage from stroke is that done to intellectual functions. But as is increasingly shown, emergency treatment and comprehensive rehabilitation can significantly improve both survival and recovery. In some cases, many functions that are lost due to stroke may be performed by other brain regions after a training period, or compensatory actions may be developed to replace lost abilities.

Health care team roles

Rehabilitation is provided by a team of medical professionals, including the services of a neurologist, a physician who specializes in rehabilitation medicine, nurses to both provide care and assist the physician in

coordinating the necessary services the stroke patient needs, a physical therapist, an occupational therapist, a speech-language pathologist, a nutritionist, and a social worker. Rehabilitation services may be provided in an acute care hospital, rehabilitation hospital, long-term-care facility, outpatient clinic, or at home.

Several different physicians may be involved, at one time or another, in the care of the stroke patient:

- A primary care physician (PCP) provides basic medical care to patients.
- A physical medicine and rehabilitation specialist assists patients to recover from or overcome disability or impairment. Often physical therapists work under their supervision.
- A neurologist specializes in disease conditions of the nervous system, and may be consulted to evaluate the extent of actual damage from a stroke.
- In the case of cerebral hemorrhage, a neurosurgeon, a specialist in both neurology and the surgical correction of nervous system damage, may be called upon to do surgery.
- Psychiatrists are licensed medical doctors that are often called upon to evaluate cognitive ability and to treat depression.
- Registered nurses (RNs) or licensed practical nurses (LPNs) are the health care provider that deal most often with the person who has had a CVA. Their duties include taking **vital signs** and monitoring the patient for complications of the stroke. They also educate the patient and family about the nature of strokes, the importance of preventing contractures and maintaining good range of motion, and about adequate nutrition and fluid intake.
- Physical therapists work with disabled stroke patients to maintain and restore range of motion and strength in affected limbs, and to maximize mobility in walking, wheelchair use, and transferring (for instance, from wheelchair to toilet or from standing to sitting). The physical therapist advises on mobility aids such as wheelchairs, braces, and canes.
- A social worker may help coordinate services and ease the transition out of the hospital back into the home, or into an extended care facility, if necessary. Social workers may help counsel the patient and family during the difficult rehabilitation period.
- Nutritionists educate stroke patients about eating nutritious foods and following through on a therapeutic diet as ordered by the physician.

- Occupational therapists help stroke patients to relearn muscular control and coordination in order to carry out normal activities of daily living such as bathing, dressing, and preparing meals.
- Speech-language therapists assist stroke patients who have damage to the speech center in the brain.
- Clinical laboratory scientists draw blood samples or test urine or sputum specimens that are ordered by the physician.
- Radiologic technologists take x rays, **CT scans**, and MRIs to visualize and monitor the brain or other affected organs after a stroke.

All health care team members are aware that the person who has suffered a stroke and the family members who may care for the person at home will need to learn entirely new sets of skills and adaptations. Both the patient and family often experience **stress, anxiety**, and depression. They may need to learn about physical and mental symptoms that are common in stroke patients, and the family may even need to learn how to deliver necessary care. Support groups can provide an important source of information, advice, and comfort for stroke patients and for caregivers. For the stroke patient, joining a support group can be one of the most important steps in the rehabilitation process.

Prevention

An important facet of rehabilitation is preventing the recurrence of stroke. Control of blood pressure is the single most important factor in the prevention of strokes. People should regularly have their blood pressure checked, and if it is found to be consistently elevated (diastolic, or lower blood pressure beat above 90 to 100, systolic or top beat above 140 to 150), a physician should be consulted.

Diet, including the reduction of sodium (salt) intake, exercise, and weight loss, if necessary, are all non-drug treatments for lowering blood pressure. Other natural remedies include the consumption of artichoke, which lowers the fat content of the blood, garlic, now believed to lower cholesterol and blood pressure as well as reduce blood's clotting ability, and ginkgo, which improves circulation and strengthens arteries and veins. The use of **folic acid**, lecithin, and **vitamins B₆, B₁₂, C, and E** is recommended as supportive measures in reducing blood pressure.

Multiple studies have found that aspirin acts as a blood-thinning, or clot-reducing, medication when taken

KEY TERMS

Aneurysm—A pouch-like bulging of a blood vessel.

Angiography—The procedure that enables blood vessels to be seen on film after the vessels have been filled with a substance that shows up opaque on x rays.

Arrhythmia—An abnormality of the rhythm or rate of the heartbeat.

Arteriole—The tiny extensions that arteries eventually break down into as they circulate blood.

Artery—Pliable, three-layered vessels that carry the blood away from the heart.

Atherosclerosis—Disease of the arterial wall in which the inner layer thickens, causing narrowing of the channel and thus impairing blood flow.

Computerized tomography (CT) scan—The diagnostic technique in which the combined use of a computer and x rays passed through the body at different angles produces clear, cross-sectional images of the tissue being examined.

Ischemic—Insufficient blood supply to a specific organ or tissue.

Lumbar puncture—A procedure in which a hollow needle is inserted into the lower part of the spinal

canal to withdraw cerebrospinal fluid (the clear liquid which surrounds the brain and spinal cord), or to inject drugs or other substances.

Magnetic resonance imaging (MRI)—The diagnostic technique that provides high quality cross-sectional images of organs or structures within the body without x rays or other radiation.

Myocardial infarction—Heart attack; sudden death of part of the heart muscle characterized in most cases by severe, unremitting chest pain.

Polycythemia—Increased number of red cells in the blood.

Sleep apnea—A condition in which a person experiences episodes of cessation of breathing lasting 10 seconds or longer during sleep.

Thrombotic—Pertaining to a blood clot formed within an intact blood vessel as opposed to a clot formed to seal the wall of a blood vessel after an injury.

Transient ischemic attack (TIA)—Occlusion of smaller blood vessels to the brain that can produce stroke-like symptoms for anywhere from a few minutes to 24 hours, but leaves no permanent damage.

in small doses. One aspirin tablet per day provides this anti-coagulant prevention.

If necessary, a physician may also order medication to lower blood pressure. These medications include the following categories of drugs:

- Beta blockers are used to reduce the force and speed of the heart-beat.
- Vasodilators are used to dilate the blood vessels.
- Diuretics reduce the total volume of circulating blood and thus the heart's work by removing fluid from the body.
- Lipid-lowering drugs increase the loss of cholesterol from the body or prevent the conversion of fatty acids to cholesterol. This lowers fat levels in the bloodstream.

Resources

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Joan Schonbeck

Certified nurse midwife (CNM) see **Nurse midwifery**

Ceruloplamin test see **Plasma protein tests**

Character disorders see **Personality disorders**

Charts see **Medical charts**

Chemotherapy

Definition

Chemotherapy is the treatment of **cancer** with **anti-cancer drugs**.

Purpose

The purpose of chemotherapy is to kill cancer cells. Not only is it often used to treat patients with cancer that has metastasized (spread) from the site in the body where it originated, today chemotherapy can be used to prevent metastasis as well. Chemotherapy destroys cancer cells throughout the body, killing cells that have broken off from the main tumor and traveled through the **blood** or lymph systems to other parts of the body.

Chemotherapy can cure some types of cancer. In some cases, it is used to slow the growth of cancer cells or to keep the cancer from spreading to other parts of the body. When a cancer has been removed by surgery, chemotherapy may be used to keep the cancer from recurring; this is known as adjuvant therapy. Chemotherapy also can ease the symptoms of cancer, helping some patients to have a better quality of life.

Precautions

There are many different types of chemotherapy drugs. Oncologists (specialists in cancer) determine which drugs are best suited for each patient. This decision is based on the type of cancer, the patient's age, health, and preferences, as well as other drugs the patient is taking. Some patients may not tolerate certain chemotherapy drugs if they have other illnesses such as **heart** disease, kidney disease, or diabetes.

Chemotherapy, whether administered in the hospital, clinic, or at home, is prepared by the pharmacist. The pharmacy and pharmacy assistants provide and reinforce **patient education** about common as well as infrequent side effects of chemotherapy. When administered in the hospital, clinic, physician's office, or other treatment setting, it is usually administered by a specially trained nurse, mid-level practitioner (physician assistant or nurse practitioner), or physician.

Description

More than 50 chemotherapy drugs are currently available to treat cancer, and many more are being tested for their ability to destroy cancer cells. Most chemotherapy drugs interfere with the ability of cells to grow or multiply. Although these drugs affect all cells in the

body, most useful treatments are more effective against rapidly growing cancer cells. Since chemotherapy affects rapidly growing cells, it often affects cells that normally grow rapidly such as cells in the bone marrow, **stomach** intestines, and hair follicles. This is why some of the most common side effects of chemotherapy are bone marrow suppression, nausea, vomiting, and hair loss.

Types of chemotherapy drugs

Chemotherapy drugs are classified based on their mechanisms of action (how they work). The main types of chemotherapy drugs are:

- Alkylating drugs kill cancer cells by directly attacking DNA, the genetic material of the genes. Cyclophosphamide is an example of an alkylating drug.
- Antimetabolites interfere with the production of DNA thereby preventing cells from growing and multiplying. An example of an antimetabolite is 5-fluorouracil (5-FU).
- Antitumor **antibiotics** are made from natural substances such as **fungi** in the soil. They interfere with important cell functions, including production of DNA and cell **proteins**. Doxorubicin and bleomycin belong to this group of chemotherapy drugs.
- Plant alkaloids prevent cells from dividing normally. Vinblastine and vincristine are plant alkaloids obtained from the periwinkle plant.
- Steroid hormones slow the growth of some cancers that depend on hormones. For example, tamoxifen is used to treat breast cancers that depend on the hormone estrogen for growth.

Combination chemotherapy

The oncologist decides which chemotherapy drug or combination of drugs will work best for each patient. The use of two or more drugs together often works better than a single drug alone. This is called combination chemotherapy. Scientific studies and clinical research trials of different drug combinations help determine which combinations are most effective for each type of cancer.

How chemotherapy is administered

Chemotherapy is administered in different ways, depending on the drugs to be given and the type of cancer. The prescribed dose depends on several factors, one of which is the patient's body weight.

Chemotherapy may be administered by one or more of the following methods:

- orally



Patient undergoing high dose stem cell chemotherapy.
(Custom Medical Stock Photo. Reproduced by permission.)

- intramuscular (IM) or subcutaneous injection
- through a catheter or port
- topically

Oral chemotherapy, given by mouth, may be in the form of a pill, capsule, or liquid. This is the easiest method of administration and can usually be done at home.

Intravenous (IV) chemotherapy is injected into a vein. A small needle is inserted into a vein on the hand or lower arm. The needle is usually attached to a small tube called a catheter, which delivers the drug to the needle from an IV bag or bottle.

Intramuscular (IM) chemotherapy is injected into a muscle. Chemotherapy given by **intramuscular injection** is absorbed into the blood more slowly than IV chemotherapy. Because of this, the effects of IM chemotherapy may last longer than chemotherapy given intravenously. Chemotherapy may also be injected sub-

cutaneously (under the skin). Injection of chemotherapy directly into the cancer is called intralesional injection.

Chemotherapy may also be given by a catheter or port permanently inserted into a central vein or body cavity. A port is a small reservoir or container that is placed in a vein or under the skin in the area where the drug will be administered. These methods eliminate the need for repeated injections and may allow patients to spend less time in the hospital while receiving chemotherapy. A common location for a permanent catheter is the external jugular vein in the neck. Intraperitoneal (IP) chemotherapy is administered into the abdominal cavity through a catheter or port. Chemotherapy administered by catheter or port into the spinal fluid surrounding the **brain** or spine is called intrathecal (IT) administration. Catheters and ports may also be placed in the chest cavity, bladder, or pelvis, depending on the location of the cancer to be treated.

Topical chemotherapy is given as a cream or ointment applied directly to the cancer. It may be used to treat certain types of skin cancer.

Treatment location and schedule

Patients may take chemotherapy at home, in the physician's office, or as an inpatient or outpatient at the hospital. Many patients stay in the hospital when first beginning chemotherapy, so they can be observed and monitored for any side effects.

The frequency and duration of chemotherapy given depends on the type of cancer, the patient response to the drugs, patients' overall health and ability to tolerate the drugs, and on the types of drugs used. Chemotherapy administration may take only a few minutes or may last as long as several hours. Chemotherapy may be given daily, weekly, or monthly. A rest period may follow a course of treatment before the next course begins. In combination chemotherapy, more than one drug may be given at the same time, or they may be given alternately, one following the other.

Preparation

A number of medical tests are performed before chemotherapy is started. The oncologist will determine the extent to which the cancer has spread from the results of x rays and other imaging tests and from biopsies. Radiologic technologists and technicians perform imaging studies. Analysis of the biopsy will be performed by a pathologist, assisted by laboratory technicians.

Blood tests, drawn by laboratory technicians or nurses, provide important information about the function of the blood cells and levels of chemicals in the blood. A **complete blood count** (CBC) is commonly performed

before and on a regular basis during treatment. The CBC shows the numbers of white blood cells, red blood cells, and platelets in the blood. Because chemotherapy affects the bone marrow, where blood cells are made, levels of these cells often drop during chemotherapy. The white blood cells and platelets are most likely to be affected by chemotherapy. A drop in the white blood cell count means that the **immune system** may not function properly and the patient may become prone to **infection**. Low levels of platelets may cause a patient to bleed from minimal trauma or even spontaneously with no trauma. A low red blood cell count can lead to anemia (deficiency of red blood cells) and fatigue.

Sometimes, patients taking chemotherapy drugs known to cause nausea are given antiemetics before chemotherapy is administered to lessen feelings of nausea. Two anti-nausea medications that may be used are Kytril and Zofran.

Patients may also be advised to prepare for chemotherapy and reduce nausea by eating and drinking normally until about two hours before a chemotherapy session. They should eat high carbohydrate, low-fat foods and avoid spicy foods.

Aftercare

Patient education about how to control side effects after chemotherapy includes:

- Encouraging patients to adhere to instructions given by their health care team.
- Reinforcing correct use of all prescribed medications.
- Advising patients to eat small amounts of bland foods and drink lots of fluids.
- Instructing patients to get plenty of rest.

Some patients find that breathing fresh air or mild **exercise**, such as walking, helps to relieve the **stress** and side effects associated with chemotherapy.

Complications

Chemotherapy drugs are toxic to normal cells as well as cancer cells. Doses that will destroy cancer cells will likely cause damage to some normal cells. Physicians adjust (titrate) doses to do the least amount of harm possible to normal cells. Some patients feel few or no side effects, and others may experience more serious side effects. In some cases, a dose adjustment is all that is needed to reduce or stop a side effect.

Some chemotherapy drugs have more side effects than others. The most common side effects include:

- nausea and vomiting

- loss of appetite
- hair loss (alopecia)
- anemia and fatigue
- infection
- easy bleeding or bruising
- sores in the mouth and throat
- neuropathy and other damage to the nervous system
- kidney damage

Nausea and vomiting are common, but can usually be controlled by taking antinausea drugs, drinking enough fluids, and avoiding spicy foods. Loss of appetite may be due to nausea or the stress of undergoing cancer treatment. Also, although some chemotherapy drugs cause alopecia, it is almost always temporary and reversible.

Low blood cell counts caused by the effect of chemotherapy on the bone marrow can lead to anemia, infections, and easy bleeding and bruising. Patients with anemia have too few red blood cells to deliver oxygen and nutrients to the body's tissues. Anemic patients feel tired and weak. If red blood cell levels fall too low, a blood transfusion may be given.

Patients receiving chemotherapy are more likely to get infections because white blood cells are reduced. It is important to take measures to avoid infections. When the white blood cell count drops too low, the physician may prescribe medications called colony-stimulating factors that help white blood cells grow. Neupogen and Leukine are two colony stimulants used as treatments to help fight infection.

Platelets are blood particles that make the blood clot. When patients do not have enough platelets, they may bleed or bruise easily, even from small injuries. Patients with low blood platelets should be advised to take precautions to avoid injuries. Medicines such as aspirin and other **pain** relievers can impair platelet function and slow the clotting process.

Chemotherapy can cause irritation and dryness in the mouth and throat. Painful sores may form that can bleed and become infected. Patients should be advised about actions they might take to prevent or reduce mouth irritation. Precautions to avoid this side effect include dental care before chemotherapy begins, brushing the teeth and gums regularly with a soft brush, and avoiding mouthwashes that contain salt or alcohol.

Results

The primary goal of chemotherapy is to cure cancer. Some cancers, such as Hodgkin's disease and acute lym-

KEY TERMS

Adjuvant therapy—Treatment given after surgery or radiation therapy to prevent the cancer from coming back.

Alkaloid—A type of chemical commonly found in plants and often having medicinal properties.

Alykylating drug—A drug that kills cells by directly damaging DNA.

Antiemetic—A medicine that helps control nausea; also called an anti-nausea drug.

Antimetabolite—A drug that interferes with a cell's growth or ability to multiply.

Platelets—Blood cells that function in blood clotting.

phocytic leukemia, may be cured by chemotherapy. Used as adjuvant therapy, in combination with surgery, it may prevent a cancer from spreading to other parts of the body. Some widespread, fast-growing cancers are more difficult to treat. In these cases, chemotherapy may slow the growth of the cancer cells.

Physicians determine the extent to which chemotherapy is effective by closely monitoring the results of medical tests. **Physical examination**, blood tests, and imaging studies are used to monitor and assess the effects of treatment on the cancer.

The outcomes of chemotherapy include:

- Complete remission or complete response. The cancer completely disappears. The course of chemotherapy is completed, and the patient is tested regularly for a recurrence.
- Partial remission or partial response. The cancer shrinks in size but does not disappear. The same course of chemotherapy may be continued, or a different combination of drugs may be tried.
- Stabilization. The cancer does not grow or shrink. Other therapy options may be explored. A tumor may remain stabilized for many years.
- Progression. The cancer continues to grow. Other therapy options may be explored.
- A new type of malignancy may develop, and this secondary cancer may require additional chemotherapy or other treatment.

Health care team roles

Patients with cancer are usually cared for by a multidisciplinary team of health professionals. The patient's family physician or primary care physician collaborates with other specialists, such as surgeons and oncologists. Radiologic technicians perform imaging studies, and nurses and laboratory technicians may obtain samples of blood, urine, and other laboratory tests.

Before and after chemotherapy, nurses explain the goals and effects of drug treatment and help to prepare patients and families. Depending on the treatment plan, cancer patients may also benefit from rehabilitation therapy with physical therapists, nutritional counseling from dietitians, and counseling from social workers or other mental health professionals.

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ORGANIZATIONS

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Chemotherapy drugs *see* **Anticancer drugs**

Chest computed tomography scan *see*
Chest CT scan

Chest CT scan

Definition

Computed tomography (CT) of the chest is performed to diagnose a variety of symptoms, including vas-

cular, cardiac, airway disease as well as cancers that can occur in the thoracic region of the body.

Purpose

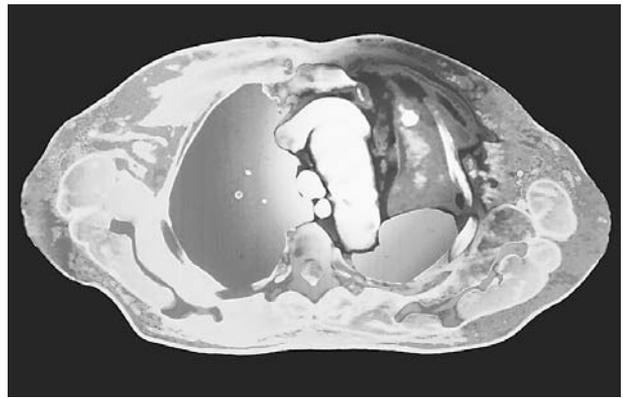
The purpose of the CT scan is to noninvasively and quickly visualize internal organs which may be damaged by disease or trauma.

Precautions

Pregnant women usually defer these types of scans due to the amount of radiation received during the examination; however due to an emergent situation, (e.g., trauma or pulmonary embolism) it may be necessary to scan a gravid woman. Proper shielding is always recommended in these situations. Radiation dose should always be limited to the amount necessary to adequately penetrate the selected body part. Lead shielding will also provide some protection to patients, although most radiation to other organs outside of the chest is from scattering within the body, which cannot be reduced by shielding. The greatest radiation protection is a well-trained technologist who understands the type of exam and who can assess the body habitus of the patient to determine the correct amount of radiation needed for the patient. Patients with a mild allergy to iodine may be premedicated to prevent sequelae of the administration of contrast. If a patient has a severe allergy, then a scan without IV contrast may be undertaken or a different imaging modality may be used to answer the clinical question. Diabetic patients who are taking Glucophage or Glucovance should stop taking the medication at the time of or before the scan and 48 hours after. The medications should only be reinstated after normal renal status has been established through lab values. Stopping and restarting of medications should only be done after consultation with the attending nephrologist.

Description

A brief list of these conditions, which can be imaged by CT, includes **infection**, trauma, aortic dissections, staging for **cancer**, and assessment of interstitial lung disease. The entire chest is imaged, unless a specialized limited exam is ordered to focus on a smaller area. The technique for CT examination of the chest is similar to other anatomic regions of the body. The patient lies on a special table, which moves a patient through an opened gantry, which contains a rotating combination of a x-ray tube and a complex array of sensitive detectors. A radiologic technologist gives the patient instructions to lie still and hold the breath while the images are being acquired. This limits the number of artifacts caused by voluntary



A chest computed tomography (CT) scan shows the collapse of the right lobe of a patient's lung. (Photo Researchers, Inc. Reproduced by permission.)

and involuntary motion. X rays are passed through a patient. As they pass through a patient, the energy of the beam is attenuated, or decreased by the density of the tissue they pass through. The denser the tissue, the fewer number of x rays that pass through the body. Sensitive detectors, which continually rotate around the patient, translate the beam into numbers, which then are translated into shades of gray and viewed as a final image for the radiologist to interpret.

The patient may be scanned with or without IV contrast depending on which type of pathology is to be demonstrated. If a tumor or vascular pathology is suspected, intravenous contrast is usually given. Certain exams do not require IV contrast to get high quality images. These exams include low-dose **lung cancer** screening, lung nodule work ups, and high-resolution chest exams for conditions such as asbestosis. If a lung nodule is the indication for the exam, a non-contrast study may be performed first, to confirm if there is **calcium** in the nodule. If calcium is present in the pattern, then no further examination is required because that is an indicator of a benign lesion. Occasionally, oral contrast will be used to demonstrate a hiatal hernia or a barium paste will be ingested to demonstrate esophageal lesions or stricture. As scanners become faster, patients do not have to hold the breath for as long a period. With current multislice technology, a standard chest CT can be completed in less than ten seconds. This is a great benefit to patients who are short of breath, due to any number of lung conditions, including **emphysema** and chronic obstructive pulmonary disease (COPD). As computer speed and detector sensitivity increases, examination time will continue to decrease with lower cost and radiation exposure.

KEY TERMS

Computed tomography—The technique of imaging a patient with ionizing radiation to diagnose disease process.

Non-ionic intravenous contrast—A injectable x-ray dye that mixes with the blood to enhance structures aiding their ability to be judged as health or diseased.

Preparation

If IV contrast is to be used the patient should remain NPO (not given anything by mouth) for at least four hours. Occasionally to view possible esophageal pathology, patients will ingest oral contrast to help delineate possible mediastinal lymph nodes or gastric tumors. Patients should also remove any metal jewelry or clothing accessories to prevent artifacts from decreasing the diagnostic quality of the images. Certain lab values may be necessary before the scan is undertaken. These would include the BUN (**blood** uria nitrogen) and creatinine levels to assess the patient's renal status. A high creatinine could contraindicate the use of IV contrast as the **kidneys** are the main organs which excrete the contrast. If a patient is on renal dialysis, then the values are usually higher, and the scan is prior to that day's dialysis treatment.

Aftercare

If the patient received IV contrast, a small bandage will be placed over the injection site, and it should be treated with the same care one would receive after donating blood. Patients should also drink plenty of clear fluids to help flush the iodinated contrast out of their kidneys to prevent any kidney damage.

If the patient is in renal failure then it will be necessary to dialyze the patient soon after the procedure. These arrangements should be made before hand with the knowledge and consent of the consulting nephrologist.

If the patient received any oral contrast it will pass through the GI tract with the next day or two. As the contrast used for CT is much thinner than the standard barium used for GI fluoroscopy studies there should be no problems with constipation.

Complications

Several complications are possible, though are relatively unlikely as long as care is taken during the procedure. These precautions would include the careful super-

vision of the injection of the IV contrast as an infiltration could result in a painful collection of contrast around the IV site. If the patient has a known allergy to iodine, then premedication will be necessary to prevent any sort of histamine reaction. The reaction can be mild, such as **hives**, to life-threatening if the patient were to have a larygospasm. With newer and safer non-ionic contrast, reactions have become less frequent, however this does not mean that technologists should be any less vigilant for signs of a mild reaction to the contrast media. There is also a small risk of renal failure in certain high-risk patients.

Results

The results are given in a written report that is sent to multiple locations including the patients referring physician, the file room of the radiology department and to the patient's permanent medical record if they were an inpatient at the time of their study. A verbal report will occasionally be used as well to help speed up the communication of results to the appropriate physicians. If there are previous examinations, the radiologist will consider if there has been a change as judged by the appearance of any pathology on the images.

Health care team roles

The main team member involved in the CT of the chest is the radiologic technologist who has been trained to perform CT exams. If the physician ordering the procedure can confirm the lab values before the patient arrives, and if they are an inpatient, assuring that the patient's IV line is patent and safe for use will streamline the examination.

Resources

BOOKS

- American College of Radiology. *Manual on Contrast Media*. 4th Edition.
- Horton, K. M., and E. K. Fishman "Spiral CT of the Esophagus and Stomach." In *Spiral CT: Principles, Techniques and Applications*. E. K. Fishman and R. B. Jeffery, eds. New York, NY: Lippincott-Raven Press 1998; pp.221–230

J. Paul Dow, Jr.

Chest drainage therapy see **Chest physical therapy**

Chest physical therapy

Definition

Chest **physical therapy** (CPT) is the term for a group of treatments designed to improve respiratory efficiency, promote expansion of the **lungs**, strengthen respiratory muscles, and eliminate secretions from the **respiratory system**.

Purpose

The purpose of chest physical therapy, also called chest physiotherapy, is to help patients breathe more freely and to get more oxygen into the body.

Chest physical therapy includes postural drainage, chest percussion, chest vibration, turning, breathing exercises, coughing, and incentive spirometry. CPT is usually done in conjunction with other treatments to rid the airways of secretions. These other treatments include suctioning, nebulizer treatments, and the administration of expectorant drugs.

Chest physical therapy can be used with newborns, infants, children, and adults. People who benefit from chest physical therapy exhibit a wide range of problems that make it difficult to clear secretions from their lungs.

Patients who may receive chest physical therapy include those with **cystic fibrosis**, neuromuscular diseases (such as Guillain-Barré syndrome), progressive muscle weakness (such as myasthenia gravis), or tetanus. People with lung diseases such as **pneumonia**, bronchitis, and some forms of chronic obstructive pulmonary disease (COPD), including chronic bronchitis, also benefit from chest physical therapy. CPT should not be used in the treatment of patients diagnosed with **asthma**.

People without specific lung problems but who are likely to aspirate their mucous secretions because of diseases such as **cerebral palsy** or **muscular dystrophy** also receive chest physical therapy, as do those who are bedridden or confined to a wheelchair. In addition, CPT may be part of treatment after surgery for patients who develop difficulty taking deep breaths.

Precautions

While the doctor ultimately determines which type of therapy can be performed, health care professionals know that not all forms of chest physical therapy are appropriate for all patients. Postural drainage and percussion should not be administered to patients who:

- have just eaten or are vomiting
- have acute asthma or tuberculosis

- have brittle bones or broken ribs
- are bleeding from the lungs or are coughing up **blood**
- are experiencing intense pain
- have increased pressure in the skull
- have head or neck injuries
- have collapsed lungs or a damaged chest wall
- recently experienced a **heart** attack
- have a pulmonary embolism or lung abscess
- have an active hemorrhage
- have injuries to the spine
- have open **wounds** or burns
- have had recent surgery

Description

Chest physical therapy can be performed in a variety of settings including critical care units, hospitals, **nursing homes**, outpatient clinics, and in the patient's home. Depending on the circumstances, chest physical therapy may be performed by anyone ranging from a respiratory care therapist to a trained member of the patient's family. Patients can be taught to perform some therapies.

Lengths of therapies and their costs vary. Some therapies may be part of ongoing treatment for a chronic condition. Special equipment may be needed for some procedures, such as percussion, and may be covered by the patient's health plan.

Chest physical therapy encompasses a variety of procedures; which ones are applied depends on the patient's needs. Hospitalized patients are reevaluated frequently to establish which procedures are most effective and best tolerated. Patients receiving long term chest physical therapy are reevaluated about every three months.

Turning

Turning from side to side permits lung expansion. Patients who cannot turn themselves are turned by a caregiver. The head of the bed is also elevated to promote drainage if the patient can tolerate this position. Critically ill patients and those dependent on mechanical respiration are turned once every one to two hours around the clock.

Coughing

Coughing helps break up secretions in the lungs so that the mucus can be suctioned out or expectorated. However, for patients with conditions like COPD, it can be painful to cough normally. An important part of chest



A patient with cystic fibrosis receives chest physical therapy after using nebulizer therapy to loosen the mucus in her lungs. (Photograph by Simon Fraser. Science Source/Photo Researchers. Reproduced by permission.)

physical therapy is teaching patients to clear their airways by gentler methods, such as with a controlled cough or by “huffing.”

Before either technique, patients are advised to sit upright and drink a glass of water. For the controlled cough, patients purse their lips and take a deep breath. They hold their breath for several seconds and then make two brief, gentle coughs. Huffing also starts with pursing the lips and taking a deep breath. After holding the breath for several seconds, patients exhale by using the **stomach** muscles to push the air out. The vocal chords remain open so that the cough has almost a whispery sound. Coughing and huffing are repeated several times a day as needed.

Deep breathing exercises

Deep breathing helps expand the lungs and forces better distribution of the air into all areas. The patient may initially need to lie down to do these exercises, but eventually it is done while sitting upright, then while walking.

Patients may find it helpful to monitor their breathing by placing a hand on their abdomen to provide a sense of their regular breathing pattern. The patient then starts by taking a deep breath through the nose, then purses the lips as if to whistle. The patient then exhales the air slowly through pursed lips. The exhalation should take twice as long as the inhalation. A patient may start by inhaling for two seconds and then exhaling for four. After taking several deep breaths, the patient breathes at a normal rhythm and begins another cycle of deep breathing. The patient builds up to taking deeper breaths, following a schedule given by the health care team. Generally, COPD patients practice deep breathing exercises for 20 minutes each day.

Incentive spirometry

The incentive spirometer helps the patient improve lung function. This self-administered therapy involves inhaling into a tube attached to a device. The specific technique and goal depends on the type of spirometer. The patient receives directions from the doctor, nurse, or respiratory therapist.

With a breath flow-oriented device, the patient inhales through a tube to raise a ball inside the plastic spirometer chamber. The drop in pressure causes the ball to rise, and the goal is to keep the ball in the air for as long as possible.

For a volume-oriented device, the patient sets a pointer on the chamber at the desired breath volume level. The patient inhales into the tube and attempts to raise a piston inside the chamber so that the volume marker reaches that level.

Hybrid volume accumulators combine a flow-oriented device with a volume-oriented device. A piston inside a cylinder responds to negative pressure from the patient’s inhalation.

Some devices have a component designed for exhalation. If the model does not include an exhaling function, the patient breathes out air naturally.

At the end of the session, the patient takes a deep breath and then coughs. The length of therapy and the number of exercises done depend on the patient’s condition and is determined by a respiratory therapist or other health professional.

Postural drainage

Postural drainage uses gravity to assist in draining secretions from the lungs and into the central airway where they can either be coughed up or suctioned out. This therapy generally lasts a maximum of 30 minutes. If various positions are tried to induce a cough, the patient may remain in one position for from five to 15 minutes. The health care team guides the patient in determining the amount of time needed. Each position reaches a specific area of the lungs. Chest drainage positions include:

- the patient seated with head back
- the patient seated with head bent forward
- the patient lying face up with feet higher than the head
- the patient lying face down with feet higher than the head
- the patient lying first on one side, then the other, with feet higher than the head

Critical care patients and those depending on mechanical ventilation receive postural drainage therapy

four to six times daily. Patients at home are given schedules set by their doctor or respiratory therapist. Percussion and vibration may be performed in conjunction with postural drainage.

Percussion

Percussion, also called cupping or clapping, involves rhythmically striking the chest wall with cupped hands. Mechanical devices can also be used. Percussion results in breaking up thick secretions in the lungs so that they can be more easily removed. Percussion is performed on each lung segment for one to two minutes at a time.

Vibration

Vibration therapy is done for one minute after percussion therapy or may be used instead of percussion therapy for patients who may be too sore or frail to tolerate percussion. The purpose is also to help break up lung secretions. Vibration can be performed either mechanically or manually. When done manually, the person performing the vibration places his or her hands against the patient's chest and creates vibrations by quickly contracting and relaxing arm and shoulder muscles while the patient exhales. The procedure is repeated several times each day for about five exhalations.

Preparation

Preparation for chest physical therapy starts with an evaluation of the patient's condition to determine which chest physical therapy techniques would be most beneficial. Since most therapies are done at home, **patient education** is extremely important. The doctor, nurse, physical therapist, or respiratory therapist instructs the patient or caregiver in chest physical therapy techniques. The therapy should be explained and demonstrated by the health professional. Then the patient or caregiver should try the therapy. This will demonstrate whether the patient understands the therapy or if more instruction is needed.

Aftercare

Patients should be advised to practice **oral hygiene** procedures to lessen the bad taste and odor of the secretions that they spit out.

Complications

Risks and complications associated with chest physical therapy depend on the health of the patient. Although chest physical therapy usually poses few problems, the health care team should be aware that in some patients it may cause:

- oxygen deficiency if the head is kept lowered for drainage
- increased intracranial pressure
- temporary low blood pressure
- bleeding in the lungs
- pain or injury to the ribs, muscles, or spine
- vomiting
- inhaling secretions into the lungs
- heart irregularities

Results

The health care team should tell patients that CPT is often an ongoing treatment, with some or all therapies done daily. A positive response to treatment can be assessed by:

- increased volume of sputum secretions
- ease in breathing
- changes in breath sounds
- improved vital signs
- improved chest x ray
- increased oxygen in the blood as measured by arterial blood gas values

Health care team roles

The doctor typically orders chest physical therapy for a patient. A nurse or respiratory therapist provides therapy when a patient is hospitalized. For people seen on an outpatient basis, the emphasis is generally on patient education.

Patient education

Effective patient education is vital because chest physical therapy is often performed at home. A doctor, nurse, or respiratory therapist explains and demonstrates techniques such as breathing, percussion, and incentive spirometry. The patient or caregiver performs the therapy under the health professional's observation to be sure it can be done correctly independently.

Nurses and respiratory therapists also participate in public awareness education, such as anti-smoking campaigns.

Training

Chest physical therapy is part of training for physicians and nurses specializing in cardiopulmonary treatment, and for respiratory therapists (also known as respi-

ratory care practitioners). Therapists must have at least an associate degree, which is earned after completion of a two-year program. There are also four-year bachelor degree programs for this profession. Graduates with both types of degrees are certified after passing the examination given by the National Board for Respiratory Care.

Resources

BOOKS

- Frownfeller, Donna, et al. *Principles & Practices of Cardiopulmonary Physical Therapy, 3rd Edition*. St. Louis: Harcourt Health Sciences, 1996.
- Haas, Francois, and Sheila Sperber Haas. *The Chronic Bronchitis and Emphysema Handbook*. New York: John Wiley & Sons, 2000.
- Hough, Alexandra. *Physiotherapy in Respiratory Care*. London: Chapman & Hall, 1996.

ORGANIZATIONS

- American Association for Respiratory Care. 11030 Ables Lane, Dallas, TX 75229. <<http://www.aarc.org>>.
- American College of Chest Physicians. 3300 Dundee Road, Northbrook, IL 60062-2348. (847) 498-1400. <<http://www.chestnet.org>>.
- American Lung Association. 1740 Broadway, New York, NY 10019. (212) 315-8700. <<http://www.lungusa.org>>.
- American Physical Therapy Association. www.apta.org.
- Cystic Fibrosis Foundation. 6931 Arlington Road, Bethesda, MD 20814. (800) FIGHT-CF. <<http://www.cf.org>>.
- National Board for Respiratory Care. 830 Nieman Road, Lenexa, KS 66214. (913) 599-4200. <<http://www.nbr.org>>.
- National Heart, Lung, and Blood Institute. National Institutes of Health. Building 31, 4A21, 9000 Rockville Pike, Bethesda, MD 02005. <<http://www.nhlbi.gov>>.

Liz Swain

Chest radiography see **Chest x ray**

Chest tube maintenance

Definition

A chest tube is a drain placed into the pleural space to restore intrapleural pressure and reinflate the lung after it has collapsed. It also acts to prevent fluid and air from returning to the chest. Chest tube maintenance includes the actions performed by the nurse or other health care professional to keep the tube functioning properly.

Purpose

Under normal circumstances, intrapleural pressure is below atmospheric pressure. When this pressure changes because of excess air and/or fluid, the lung may collapse. If this occurs, a chest tube is inserted into the intrapleural space. This lets excess fluids drain, restores normal pressure, reinflates the lung, and allows adequate **gas exchange**. Persons experiencing a pleural effusion (accumulation of fluid in the spaces of the pleura), hemothorax (accumulation of **blood** in the pleural cavity), pneumothorax (collapsed lung), and empyema (accumulation of pus in the pleural cavity) may all require the insertion of a chest tube.

Precautions

The patient requiring a chest tube is acutely ill because any change in the intrapleural pressure compromises the patient's ability to breathe. An oxygen source, suction, and emergency equipment must be nearby when this procedure is performed.

Description

Depending on the patient's condition, the chest tube insertion may occur at the bedside, in the emergency room, or in the operating room. In any case, the insertion of a chest tube is a sterile procedure. Most hospitals have chest tube insertion trays containing all of the necessary supplies. First, the health care provider administers a local anesthetic. The patient is positioned according to the type of lung collapse being treated. After making a small incision, the physician inserts the chest tube. To avoid accidental puncture of the lung or pleura, the patient should be reminded not to cough or move during the procedure. Once the chest tube is in and sutured in place, the tube will be attached to a drainage system. Vaseline gauze may be placed at the chest tube insertion site to make certain an adequate seal has been achieved. Sterile 4 × 4 gauze pads will be placed over the Vaseline gauze, then securely taped. It is wise to tape the far end of the chest tube to the patient's chest to prevent dislodgement.

Preparation

The patient may be anxious about the procedure. Providing privacy and emotional support, along with explaining the procedure may help calm the patient. The nurse should perform a baseline assessment and take **vital signs**. An **informed consent** should be signed if the patient is able to do so. The physician may order pre-

medications, which should be administered by the nurse as prescribed.

Aftercare

After the chest tube has been inserted, it is the nurse's responsibility to maintain a patent (clear) and intact pleural drainage system. The chest tube will be connected to about 6 ft (1.8 m) of rubbery tubing that leads to a collection device several feet below the chest. The patient should be instructed to avoid lying on the tubing, and the nurse must make certain no kinks occur. All tubing connections should be taped to prevent air leaks.

The chest drainage system has a separate water seal that acts as a one-way valve. The nurse adds a specified amount of sterile saline to this water seal chamber and makes sure the end of the tubing stays in the fluid. When air is pushed out of the pleural space and through the tubing, it bubbles into the saline and cannot return to the chest. If necessary, suction may be added to the drainage system. The depth of the saline determines the maximal allowable suctioning for the system.

The nurse should note and document the amount and color of the chest tube drainage, and the level of drainage should be marked at the end of each shift. The patient's respiratory status should be assessed frequently. It is normal to note decreased breath sounds on the side of the chest tube. The patient should be encouraged to perform coughing and deep-breathing exercises.

Complications

Several complications can occur when managing a patient with a chest tube. If the tube accidentally becomes dislodged, the open insertion site should be quickly covered with Vaseline gauze and the physician notified. If the tubing becomes disconnected from the drainage system, the chest tube should be clamped. (Padded clamps should be kept at the bedside at all times.) Both of these situations, if untreated, could allow air to enter the lung. Sometimes clots can form within the tube and prevent free drainage. If this happens, the tube should be milked gently, squeezing it to move the clot, but not handling it so firmly that the tubing becomes occluded.

If the drainage system unit is damaged or cracked, allowing atmospheric pressure into the system, the uncontaminated end of the connective tubing should be placed into sterile saline or water to a depth of 0.79 in (2 cm) until a new system can be obtained. Finally, a patient with a chest tube is at increased risk for **infection**. This risk can be reduced by cleaning the chest tube site and changing the dressing regularly.

KEY TERMS

Atmospheric pressure—The force exerted by air at any point on the earth's surface. Mean atmospheric pressure at sea level is approximately 1,000 millibars (100 kilopascals), give or take 5%.

Empyema—A collection of pus in the pleural space.

Hemothorax—Blood in the pleural cavity, usually caused by a chest injury.

Intrapleural—Situated within the pleura or pleural cavity

Pleura—Thin membrane that covers each half of the thorax, surrounding and protecting the lung on that side.

Pleural cavity—The space within each pleura, which contains the lungs.

Pleural effusion—Fluid in the pleural cavity, caused by, among other things, congestive heart failure, cancer, tuberculosis, and lung infections.

Pneumothorax—Air in the pleural cavity, which causes the lung to collapse. Causes include lung disease, penetrating trauma, and certain medical procedures, including ventilation and cardiopulmonary resuscitation.

Valsalva maneuver—Holding the breath while bearing down. This maneuver may be used to interrupt a mild heart arrhythmia or to prevent air from entering the pleural cavity when a chest tube is removed.

Results

The chest tube can be removed when one of the following has happened:

- The lung has fully expanded.
- No air leak has developed during a 24–48 hour period.
- Less than 5.07 oz (150 ml) of fluid has drained in a 24-hour period.

Normally, the physician removes the chest tube while the patient performs a Valsalva maneuver. Vaseline gauze is immediately applied over the insertion point. This prevents any air from entering the pleural space.

Health care team roles

The physician is responsible for inserting the chest tube and is usually responsible for its removal. (Some nurse prac-

tice acts allow nurses to remove chest tubes.) The nurse assists with the insertion procedure, assesses the patient's respiratory status afterwards, and maintains a patent chest tube.

Resources

BOOKS

Ignatavicius, Donna D., et al. *Medical-Surgical Nursing Across the Health Care Continuum*. Philadelphia: W.B. Saunders Company, 1999.

PERIODICALS

Blank-Reid, Cynthia A., and Paul C. Reid. "Taking the Tension Out of Traumatic Pneumothoraxes." *Nursing* 29 (April 1999): 41.

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Deanna M. Swartout-Corbeil, R.N.

Chest x ray

Definition

A chest x ray is a procedure used to evaluate organs and structures within the chest for symptoms of disease. Chest x rays include views of the **lungs**, **heart**, small portions of the gastrointestinal tract, and the bones of the chest area. X rays are a form of radiation that can penetrate the body and produce an image on an x ray film. Another name for the x ray image is radiograph.

Purpose

Chest x rays are ordered for a wide variety of diagnostic purposes. In fact, this is probably the most frequently performed x ray exam. In some cases, chest x rays are ordered for a single check of an organ's condition, and at other times, serial x rays are ordered to compare to previous studies. Some common reasons for chest x rays include:

Pulmonary disorders

Chest films are frequently ordered to diagnose or rule out **pneumonia**, bronchitis, pleurisy, **tuberculosis**, and other acute illnesses. Other pulmonary disorders such as **emphysema** or pneumothorax (presence of air or gas in the chest cavity outside the lungs) may be detected or evaluated through the use of chest x ray. It might also show vascular damage in the lung, which would require further evaluation.

Cancer

A chest x ray may be ordered by a physician to check for possible tumors of the lungs, thyroid, lymph nodes, or even the displacement of an organ by a tumor, if present. Chest x rays can occasionally be used to check for secondary spread of **cancer** from one organ to another.

Cardiac disorders

Although less sensitive than **echocardiography** to evaluate the heart, chest x ray is preferred to check for disorders such as congestive **heart failure** or pulmonary **edema**. Pericardial effusion (fluid surrounding the heart), if present, and cardiac size will also be noted on the chest x ray.

Other

Chest x rays can be used to see **foreign bodies** that may have been swallowed or inhaled, and to evaluate response to treatment for various diseases. The chest x ray is also used to verify correct placement of chest tubes or catheters in acutely ill patients.

Precautions

Pregnant women, particularly those in the first or second trimester, should not have chest x rays unless absolutely necessary. If the exam is ordered, women who are, or could possibly be, pregnant must wear a protective lead apron, with the full coverage adjusted for the direction of the x-ray beam. Because the procedure involves radiation, care should always be taken to avoid overexposure, particularly for children. However, the amount of radiation from one chest x ray procedure is minimal.

Description

Routine chest x rays consist of two views: the frontal view (referred to as posterior-anterior or PA) and the lateral (side) view, with the left side against the x-ray board. It is preferred that the patient stand for this exam.

The patient must remain motionless, and will be asked to take in a big breath for each x ray. Filling the lungs with air expands the lung fields, and shows the anatomy at its most optimum. In addition, the deep inspiration of air also helps the patient remain motionless, which is critically important in such a short x-ray exposure.

The chest x ray may be performed in a physician's office or referred to an outpatient radiology facility or hospital radiology department. In some cases, particularly for bedridden patients, a portable chest x ray may be taken. Portable films are sometimes of poorer quality than those taken with permanent equipment, but are the

best choice for some patients or situations. Bedridden patients may be placed in as upright a position as possible to get the best possible image.

Preparation

There is no advance preparation necessary for chest x rays. Once the patient arrives at the exam area, the patient will undress to the waist, and wear a gown or drape as provided by the facility. All necklaces will be removed as well.

Aftercare

No aftercare is required by patients who have chest x rays.

Complications

The only risk associated with chest x ray is minimal exposure to radiation, particularly for pregnant women and children. Those patients should use protective lead aprons during the procedure. Technologists are cautioned to carefully check possible dislodging of any tubes or monitors in the chest area from the patient's placement during the exam, if IVs (intravenous lines) or chest tubes are in place.

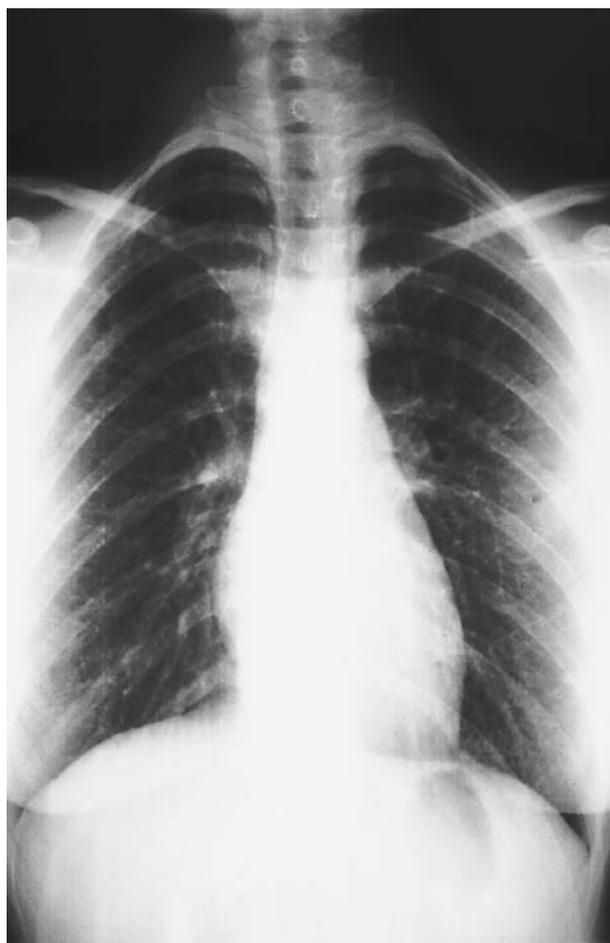
Results

A radiologist, or physician specially trained in the technique and interpretation of x rays, will evaluate the results. A normal chest x ray will show normal structures for the age and medical history or the patient. Findings, whether normal or abnormal, will be provided to the referring physician in the form of a written report.

Abnormal findings on chest x rays are used in conjunction with a physician's physical exam, medical history and other diagnostic tests to reach a final diagnosis. Often a patient can have normal appearing x rays and still have underlying diseases or conditions. Interpretation of chest x rays is most accurate when compared to previous chest studies. The patient may be asked to help the radiology facility in locating previous chest radiographs from other facilities.

Pulmonary disorders

Pneumonia shows up on radiographs as a patchy white area of density, as a result of fluid in the lung(s). If the bronchi, which are usually not visible, can be seen, a diagnosis of bronchial pneumonia may be made. Widening of the spaces between ribs, or very large, dark lung fields, also can be a radiographic sign of emphyse-



A chest x ray of normal, healthy adult lungs. (Photograph by John Smith, Custom Medical Stock Photo. Reproduced by permission.)

ma. Other pulmonary diseases may also be detected or suspected through chest x ray.

Cancer

In nearly all patients with **lung cancer**, some sort of abnormality can be seen on a chest radiograph. Hilar masses (enlargements at that part of the lungs where vessels and nerves enter) are one of the more common signs, as are abnormal masses and fluid buildup on the outside surface of the lungs or surrounding areas. Interstitial lung disease, which is a large category of disorders, many of which are related to exposure to substances (such as asbestos fibers), may be detected on a chest x ray as fiber-like deposits, often in the lower portions of the lungs.

Other

Congestive heart failure and other cardiac diseases may be diagnosed on the view of the heart and lung in a chest radiograph. **Fractures** of the sternum and ribs are

KEY TERMS

Bronchi—Plural of bronchus. The air passages in the lungs through which inhaled air passes on its way to the lungs.

Diaphragm—The large muscle that is located between the abdomen and the chest area. The diaphragm aids in breathing.

Gastrointestinal—The digestive organs and structures, including the stomach and intestines.

Interstitial lung disease—About 180 diseases fall into this category of breathing disorders. Injury or foreign substances in the lungs, (such as asbestos fibers) as well as infections, cancers, or inherited disorders may cause the diseases. They can lead to breathing or heart failure.

Lymphoid—Tissues relating to the lymphatic system. A thin yellowish fluid, called lymph fluid, travels throughout the body. The lymphatic system helps control fluids in the body.

Portable chest x ray—An x ray procedure taken by equipment that can be brought to the patient. The resulting radiographs may not be as high in quality as stationary x ray radiographs, but allow a technologist to come to the bedridden patient.

Pulmonary—Refers to the lungs and the breathing system and function.

Serial x rays—A number of x rays performed over time in the disease progression or treatment intervals. The radiographs will be compared to one another to track changes.

Sternum—Also referred to as the breast bone, this is the long flat bone in the middle of the chest.

Thorax—The chest area, which runs between the abdomen and neck and is encased in the ribs.

X ray—A form of electromagnetic radiation with shorter wavelengths than normal light. X rays can penetrate most structures.

sometimes also detected as breaks in the bone visible on the film. In some instances, the view of the diaphragm may indicate an abdominal problem. Foreign bodies which may have been swallowed or inhaled can usually be located by the radiologist as they will see the object either in the esophagus, or the upper part of the **stomach**, and will look different from any other tissue or structure in the chest. Serial chest x rays may be ordered to track changes in the position of an object over a period of time.

Health care team roles

The technologist performing the chest x ray is a highly trained professional and provides films for the radiologist to interpret. The technologist should be able to be versatile, should the patient have any physical challenges in complying with the x ray. In performing bedside, or portable chest x rays, often the assistance of nursing staff becomes necessary due to the condition of the patient. It should be the goal of both the technologist and/or nurse to ensure patient comfort, while getting the best possible radiograph.

Patient education

The technologist will explain the exam to the patient so that they feel comfortable with the procedure. Most adult patients are familiar with a chest x ray, nevertheless, a brief discussion between technologist and patient is important. Keeping the patient immobile during the exposure will limit having to repeat the x ray.

Resources

ORGANIZATIONS

American Lung Association. 432 Park Avenue South, New York, NY 10016. (212)889-3370.
<<http://www.lungusa.org>>.

Emphysema Anonymous, Inc. P.O. Box 3224, Seminole FL 34642. (813)391-9977.

The National Heart, Lung and Blood Institute. Building 31, Room 4A21, Bethesda MD 20892. (301)496-4236.
<<http://www.nhlbi.nih.gov>>.

OTHER

Pulmonary Perspectives. The American College of Chest Physicians, 3300 Dundee Road, Northbrook IL 60062. (847) 498-1400. <<http://www.chestnet.org>>.

RSNA Radiology Info Online. <<http://www.radiologyresource.org>>. (June 6, 2001).

Debra Novograd, B.S.,R.T.(R)(M)

Chigong see **Qigong**

Child abuse

Definition

Child abuse is a blanket term for four types of child mistreatment: physical abuse, sexual abuse, emotional abuse, and neglect. In many cases children are the victims of more than one type of abuse. The abusers can be parents or other family members, caretakers such as

teachers and babysitters, acquaintances (including other children), and (in rare instances) strangers.

Description

Prevalence of abuse

Child abuse was once viewed as a minor social problem affecting only a handful of children in the United States. In recent years, however, it has received close attention from the media, law enforcement, and the helping professions, and with this has come a sharp rise in the number of reported cases. But because abuse is often hidden from view and its victims too young or fearful to speak out, some experts suggest that its true prevalence may be much greater than the official data indicate. In 1999, Child Protective Service (CPS) agencies investigated 3 million reports that involved the maltreatment of approximately 4 million children.

The CPS ranks neglect as the most common form of child maltreatment, comprising an estimated 54% of investigations in 1997. Physical abuse accounted for 24%; sexual abuse, 13%; emotional maltreatment, 6%; and medical neglect, 2%. Many children suffer more than one type of maltreatment.

Although experts are quick to point out that abuse occurs among all social, ethnic, and income groups, reported cases usually involve poor families with little education. Young mothers, single-parent families, and parental alcohol or drug abuse are also common in reported cases. According to recent statistics, more than 90% of abusing parents have neither psychotic nor criminal personalities. Rather, they tend to be lonely, unhappy, angry, young, single parents who do not plan their pregnancies. About 10%, or perhaps as many as 40%, of abusive parents were themselves physically abused as children, but most abused children do not grow up to be abusive parents.

Additional factors that contribute to child abuse include lack of parenting skills, unrealistic expectations about children's behavior and capabilities, social isolation, and frequent family crises. Child abuse is a symptom that parents are having difficulty coping with their situation.

In 1999, the majority of child abusers (75%) were parents, and another 10% were other relatives of the victim. About 13% of all perpetrators were classified as non-caretakers or unknown. People who were in other caretaking relationships to the victim (e.g., child care providers, foster parents, and facility staff) accounted for only 2% of perpetrators. In many states, perpetrators of child maltreatment by definition must be in a caretaking role.

Types of abuse

PHYSICAL ABUSE. Physical abuse is the nonaccidental infliction of physical injury to a child. The abuser is usually a family member or other caretaker, and is more likely to be male. In 1996, 24% of the confirmed cases of child abuse in the United States involved physical abuse. A rare form of physical abuse is Munchausen syndrome by proxy, in which a caretaker (most often the mother) seeks attention by making the child sick or appear to be sick.

SEXUAL ABUSE. Child sexual abuse is defined as any activity with a child under the age of legal consent that is for the sexual gratification of an adult or a significantly older child. It includes, among other things, sexual touching and penetration, persuading a child to expose his or her sexual organs, and allowing a child to view pornography. In most cases the child is related to or knows the abuser, and about one in five abusers are themselves underage. Sexual abuse was present in 12% of the confirmed 1996 abuse cases. An estimated 20–25% of females and 10–15% of males report that they were sexually abused by age 18.

EMOTIONAL ABUSE. Emotional abuse, according to Richard D. Krugman, director of the Kempe Center in Denver, “has been defined as the rejection, ignoring, criticizing, isolation, or terrorizing of children, all of which have the effect of eroding their self-esteem.” Emotional abuse usually expresses itself in verbal attacks involving rejection, scapegoating, belittlement, and so forth. Because it often accompanies other types of abuse and is difficult to prove, it is rarely reported.

NEGLECT. Neglect—failure to satisfy a child's basic needs—can assume many forms. Physical neglect is the failure (beyond the constraints imposed by poverty) to provide adequate food, clothing, shelter, or supervision for a child. Emotional neglect is the failure to satisfy a child's normal emotional needs, or behavior that damages a child's normal emotional and psychological development (such as permitting drug abuse in the home). Failing to see that a child receives proper schooling or medical care is also considered neglect. Neglect was found in 52% of 1996 abuse cases.

Causes and symptoms

Physical abuse

Physical abuse, which can be triggered by such normal child behavior as crying or dirtying a diaper, often occurs when a parent loses control and lashes out at a child. Unlike nonabusive parents, who may become angry at or upset with their children from time to time but

CHILD ABUSE: SIGNS AND SYMPTOMS

Although these signs do not necessarily indicate that a child has been abused, they may help adults recognize that something is wrong. The possibility of abuse should be investigated if a child shows a number of these symptoms, or any of them to a marked degree:

Sexual Abuse

Being overly affectionate or knowledgeable in a sexual way inappropriate to the child's age
 Medical problems such as chronic itching, pain in the genitals, venereal diseases
 Other extreme reactions, such as depression, self-mutilation, suicide attempts, running away, overdoses, anorexia
 Personality changes such as becoming insecure or clinging
 Regressing to younger behavior patterns such as thumb sucking or bringing out discarded cuddly toys
 Sudden loss of appetite or compulsive eating
 Being isolated or withdrawn
 Inability to concentrate
 Lack of trust or fear someone they know well, such as not wanting to be alone with a babysitter
 Starting to wet again, day or night/nightmares
 Become worried about clothing being removed
 Suddenly drawing sexually explicit pictures
 Trying to be "ultra-good" or perfect; overreacting to criticism

Physical Abuse

Unexplained recurrent injuries or burns
 Improbable excuses or refusal to explain injuries
 Wearing clothes to cover injuries, even in hot weather
 Refusal to undress for gym
 Bald patches
 Chronic running away
 Fear of medical help or examination
 Self-destructive tendencies
 Aggression towards others
 Fear of physical contact—shrinking back if touched
 Admitting that they are punished, but the punishment is excessive (such as a child being beaten every night to "make him/her study")
 Fear of suspected abuser being contacted

Emotional Abuse

Physical, mental, and emotional development lags
 Sudden speech disorders
 Continual self-depreciation ("I'm stupid, ugly, worthless, etc.")
 Overreaction to mistakes
 Extreme fear of any new situation
 Inappropriate response to pain ("I deserve this")
 Neurotic behavior (rocking, hair twisting, self-mutilation)
 Extremes of passivity or aggression

Neglect

Constant hunger	Poor personal hygiene	No social relationships
Constant tiredness	Poor state of clothing	Compulsive scavenging
Emaciation	Untreated medical problems	Destructive tendencies

A child may be subjected to a combination of different kinds of abuse. It is also possible that a child may show no outward signs and hide what is happening from everyone.

Source: Kidscape, <http://www.solnet.co.uk/kidscape/kids5.htm>. Reprinted by permission.

are genuinely loving, abusive parents tend to harbor deep-rooted negative feelings toward their children.

Unexplained or suspicious bruises or other marks on the skin, such as **burns**, are common signs of physical abuse. **Skull** and other bone **fractures** are often seen in young children, and in fact, head injuries are the leading cause of death from abuse. Children less than a year old are particularly vulnerable to injury from shaking. This is called shaken baby syndrome or shaken impact syndrome. Not surprisingly, physical abuse also causes a wide variety of behavioral changes in children.

Sexual abuse

According to psychological experts, the two prerequisites for this form of maltreatment include sexual arousal to children and the willingness to act on this arousal. Factors that may contribute to this willingness include alcohol or drug abuse, poor impulse control, and the mistaken belief that such sexual behaviors are acceptable and not harmful to the child. The chances of abuse are higher if the child is developmentally handicapped or vulnerable in some other way.

Genital or anal injuries or abnormalities (including the presence of sexually transmitted diseases) can be signs of sexual abuse, but often there is no physical evidence. In fact, physical examinations of children in cases of suspected sexual abuse supply grounds for further suspicion only 15–20% of the time. **Anxiety**, poor academic performance, and suicidal tendencies are some behavioral signs of sexual abuse, but these are also found in children suffering other kinds of **stress**. Excessive masturbation and other unusually sexualized kinds of behavior are more closely associated with sexual abuse itself.

Emotional abuse

Emotional abuse can happen in many settings: at home, at school, on sports teams, and so on. Some of the possible symptoms include loss of self-esteem, sleep disturbances, head- or stomachaches, school avoidance, and running away from home.

Neglect

Many cases of neglect occur because the parent experiences strong negative feelings toward the child. At other times, the parent may truly care about the child, but lacks the ability or strength to provide for the child's needs adequately because they are handicapped by depression, drug abuse, mental retardation, or some other problem.

Neglected children often do not receive adequate nourishment or emotional and mental stimulation. As a result, their physical, social, emotional, and mental development is hindered. They may, for instance, be underweight, develop language skills less quickly than other children, and seem emotionally needy.

Diagnosis

Doctors and many other professionals who work with children are required by law to report suspected abuse to their state's CPS agency. Abuse investigations are often a group effort involving medical personnel, social workers, police officers, teachers, and others. Some hospitals and communities maintain child-protection teams that respond to cases of possible abuse. Careful questioning of the parents is crucial, as is interviewing the child (if he or she can speak). The investigators must ensure, however, that their questioning does not further traumatize the child. A **physical examination** for signs of abuse or neglect is, of course, always necessary, and may include x rays, **blood** tests, and other procedures.

Treatment

Notifying the appropriate authorities, treatment of the child's injuries, and protecting the child from further harm are the immediate priorities in abuse cases. If the child does not require hospital treatment, protection often involves placing him or her with relatives or in foster care. Once the immediate concerns are dealt with, it becomes essential to determine how the child's long-term medical, psychological, educational, and other needs can best be met, a process that involves evaluating not only the child's needs but also the family's (such as drug abuse counseling or parental skills training). If the child has brothers or sisters, the authorities must determine whether they have been abused as well. On investigation, signs of physical abuse are discovered in about 20% of the brothers and sisters of abused children.

Prognosis

Child abuse can have lifelong and devastating consequences. Research has shown that abused children and adolescents are more likely, for instance, to do poorly in school, suffer emotional problems, develop an antisocial personality, become promiscuous, abuse drugs and alcohol, and attempt suicide. As adults they may have trouble establishing intimate relationships. Whether professional treatment is able to moderate the long-term psychological effects of abuse is a question that remains unanswered.

KEY TERMS

Child maltreatment—Another name for child abuse or neglect.

Munchausen syndrome by proxy—A rare form of physical abuse wherein a caretaker (most often the mother) seeks attention by making the child sick or appear to be sick.

Perpetrator—Any person who inflicts abuse of any form on a child, including neglect.

Health care team roles

Nursing staff and allied health professionals can assist in the treatment of child abuse by being aware of physical symptoms and emotional reactions caused by abuse or neglect. During the diagnosis and treatment phase, nursing staff and allied health professionals can help patients and perpetrators by providing appropriate educational materials, and referrals to community and individual supportive programs.

Prevention

Government efforts to prevent abuse include home-visitor programs aimed at high-risk families, and school-based efforts to teach children how to respond to attempted sexual abuse.

When children reach age three, parents should begin teaching them about “bad touches” and about confiding in a trusted adult if they are touched or treated in a way that makes them uneasy. Parents also need to **exercise** caution in hiring babysitters and other caretakers. Anyone who suspects abuse should immediately report those suspicions to the police or his or her local CPS agency, which will usually be listed in the blue pages of the telephone book under Rehabilitative Services or Child and Family Services, or in the yellow pages. Round-the-clock crisis counseling for children and adults is offered by the Childhelp USA/IOF Foresters National Child Abuse Hotline. The National Committee to Prevent Child Abuse is an excellent source of information on the many support groups and other organizations that help abused and at-risk children and their families. One of these organizations, National Parents Anonymous, sponsors 2,100 self-help groups throughout the United States, Canada, and Europe. Telephone numbers for its local groups are listed in the white pages of the telephone book under Parents Anonymous or can be obtained by calling the national headquarters.

Resources

BOOKS

Krugman, Richard D. “Child Abuse & Neglect.” In *Pediatric Diagnosis & Treatment*. Edited by William W. Hay, Jr., et al. Stamford, CT: Appleton & Lange, 1997.

ORGANIZATIONS

Childhelp USA/IOF Foresters National Child Abuse Hotline. (800) 422-4453.

National Clearinghouse on Child Abuse and Neglect Information. PO Box 1182, Washington, DC 20013-1182. (800) 394-3366. <<http://www.calib.com/nccanch>>.

National Committee to Prevent Child Abuse. 200 S. Michigan Avenue, 17th Floor, Chicago, IL 60604. (312) 663-3520. <<http://www.childabuse.org>>.

National Parents Anonymous. 675 W. Foothill Blvd., Suite 220, Claremont, CA 91711. (909) 621-6184. <<http://www.parentsanonymous.org>>.

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Bethanne Black

Childbirth

Definition

Childbirth includes both labor (the process of birth) and delivery (the birth itself); it refers to the entire process as an infant makes its way from the womb down the birth canal to the outside world.

Description

Childbirth usually begins spontaneously, following about 280 days after conception, but it may be started by artificial means if the **pregnancy** continues past 42 weeks gestation, or if complications develop. Labor may also begin prematurely. The average length of labor is about 14 hours for a first pregnancy and about eight hours in subsequent pregnancies. However, many women experience a much longer or shorter labor.

Labor can be described in a series of phases.

First phase of labor

During the first phase of labor, the cervix dilates (opens) from 0–10 cm (0–4 in). This phase has an early, or latent, phase and an active phase. During the latent phase, progress is usually very slow. It may take quite a

while and many contractions before the cervix dilates the first few centimeters. Contractions increase in strength and frequency as labor progresses. Most women are relatively comfortable during the latent phase.

As labor begins, the muscular wall of the uterus contracts and relaxes as the cervix thins and expands. As a portion of the amniotic sac surrounding the baby is pushed into the opening, it bursts under the pressure, releasing amniotic fluid (water breaking). Sometimes the amniotic sac breaks before labor begins.

During this first phase the birth attendant or nurse will do periodic pelvic exams to determine how the labor is progressing. If the contractions aren't forceful enough to open the cervix, a drug called oxytocin (Pitocin) may be given to make the uterus contract.

As **pain** and discomfort increase, women may be tempted to request pain medication or anesthetics. If possible, though, these should be delayed until the active phase of labor begins—at which point the medication will not slow down or stop the labor.

The active stage of labor is faster and more efficient. In this phase, contractions are longer and more regular, usually occurring about every two to three minutes. These stronger contractions are also more painful. Women who use the breathing exercises learned in childbirth classes find that these can help them cope with the pain experienced during this phase. Many women also receive some pain medication at this point—either a short-term narcotic or epidural anesthesia.

As the cervix dilates to 8–9 cm (3.15–3.54 in), the transition phase begins. This refers to the progression from the first phase, during which the cervix dilates, to the second phase, during which the baby is pushed out through the birth canal. As the cervix dilates completely and the baby's head begins to descend, women feel the urge to push or bear down.

Second stage of labor

When the top of the baby's head appears at the opening of the vagina, the birth is nearing completion. First the head passes under the pubic bone. It fills the lower vagina and stretches the perineum. This position is called "crowning," since only the crown of the head is visible. When the entire head is out, the shoulders follow. The attending practitioner may suction the baby's mouth and nose to ease its first breath. The rest of the baby usually slips out easily, and the umbilical cord is cut.

Episiotomy

As the baby's head appears, the perineum may be stretched so tightly that the baby's progress is slowed. If

there is risk of tearing the mother's tissue, the doctor or midwife may make a small incision, called an episiotomy, into the perineum to enlarge the vaginal opening. If the woman has not had an epidural or pudendal block, she will get a local anesthetic to numb the area. Once the episiotomy is made, the baby is born with a few pushes.

Third stage

In the final stage of labor, the placenta is pushed out of the vagina by the continuing uterine contractions. The placenta is pancake shaped and about 10 in (25.4 cm) in diameter. During the pregnancy it was attached to the uterine wall and conveyed nourishment from the mother to the fetus. Continuing uterine contractions release it from the uterus at this point. It is important that all of the placenta be removed from the uterus. If it is not, the uterine bleeding that is normal after delivery may be much heavier, and uterine **infection** may occur.

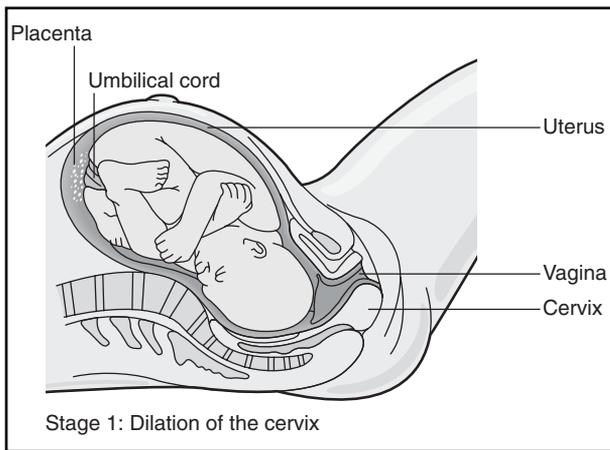
Breech presentation

Approximately 4% of babies are in what is called a "breech" position when labor begins. In breech presentation, the baby's bottom or legs press against the cervix and are positioned to enter the birth canal. An obstetrician may attempt to turn the baby to a head-down position using a technique called version before labor begins. This is only successful approximately half the time.

The risks of vaginal delivery with breech presentation are much higher than with a head-first presentation. In these cases the mother and attending practitioner will need to weigh the risks and decide whether to deliver via cesarean section or attempt a vaginal birth. The extent of the risk depends to a great extent on the type of breech presentation, of which there are three:

- *Frank breech*—the baby's legs are folded up against its body. This is the most common and the safest for vaginal delivery.
- *Complete breech*—the baby's legs are crossed under and in front of the body.
- *Footling breech*—one or both legs are positioned to enter the birth canal. Vaginal delivery with this presentation is considered unsafe.

Several factors should be considered before attempting a vaginal **breech birth**. An ultrasound examination should be done to be sure the baby's head is not unusually large, and that it is flexed (tilted forward) rather than hyperextended (tilted back). Fetal monitoring and close observation of the progress of labor are also important. If labor slows or there is any sign that it will be difficult for the baby to pass through the pelvis it may be safer to consider a cesarean section.



(Illustration by Hans & Cassidy.)

Forceps delivery

If the labor is not progressing as it should, the baby appears to be in distress, or the mother is too exhausted to push, the doctor may opt for a forceps delivery. A forceps is a spoon-shaped device that resembles a set of salad tongs. It is placed around the baby's head so the doctor can pull the baby gently out of the vagina. Forceps can be used after the cervix is fully dilated.

Before placing the forceps around the baby's head, pain medication or anesthesia may be given to the mother. The doctor may use a catheter to empty the her bladder, and may clean the perineal area with soapy water. Often an episiotomy is done before a forceps birth, although tears can still occur.

The obstetrician slides half of the forceps at a time into the vagina and around the side of the baby's head to gently grasp the head. When both halves are in place, the doctor pulls on the forceps to help the baby through the birth canal as the uterus contracts. Sometimes the baby can be delivered this way after the very next contraction.

When used by an experienced physician, forceps can save the life of a baby in distress. Complications from this type of delivery include nerve damage or bruises to the baby's face. The frequency of forceps delivery varies from one hospital to the next, depending on the experience of staff and the types of anesthesia offered at the hospital. Some obstetricians accept the need for a forceps delivery as a way to avoid cesarean birth. Others don't use forceps at all.

Vacuum-assisted birth

This method of helping a baby out of the birth canal was developed as a gentler alternative to forceps. As with forceps, vacuum-assisted birth can only be used after the cervix is fully dilated and the head of the fetus has begun

to descend through the pelvis. In this procedure, the doctor uses a device called a vacuum extractor, placing a large rubber or plastic cup against the baby's head. A pump creates suction that gently pulls on the cup to gently ease the baby down the birth canal. The force of the suction may cause a bruise on the baby's head, but it fades in a day or so.

The vacuum extractor is not as likely as forceps to injure the mother, and it leaves more room for the baby to pass through the pelvis. However, there may be problems in maintaining the suction with this method, and there is the potential for **brain** damage if repeated attempts are made, so forceps may be a better choice if it is important to remove the baby quickly.

Cesarean sections

A cesarean section, also called a C-section, is a surgical procedure in which incisions are made through a woman's abdomen and uterus to deliver her baby. The procedure is used to deliver nearly 25% of babies born in the United States; the rate can be as high as 60% for mothers who have had a previous C-section. Cesarean sections are performed whenever abnormal conditions complicate labor and vaginal delivery, threatening the life or health of the mother or the baby.

Labor complications include: abnormalities in the mother's birth canal; abnormalities in the fetus's position; an unusually large baby; and abnormalities in the labor, including weak or infrequent contractions. Another complication is fetal distress, a condition in which the fetus does not get enough oxygen. This can lead to fetal brain damage. The mother's health can also influence the decision to deliver by C-section, especially if she has vaginal herpes, pregnancy-induced **hypertension**, or diabetes.

Causes and symptoms

One of the earliest signs of approaching labor is loss of the "mucous plug," the thick secretion that covers the cervix during the nine months of pregnancy to protect the fetus from infection. Another is the "bloody show," which is produced by broken capillaries in the cervix. Both the mucous plug and the bloody show appear as the cervix begins to expand and dilate in preparation for labor.

The most common indication that labor has begun is the onset of contractions. Sometimes women have trouble telling the difference between early contractions and false labor pains, but the biggest distinction is that true labor pains develop a regular pattern, with contractions coming closer together.

Another less common sign that labor is beginning is the breaking of the amniotic sac that cushioned the baby during the pregnancy. When it breaks, it releases water in a trickle or a gush. Only about 10% of women actually experience this water flow in the beginning of labor, however. Most of the time, the rupture occurs sometime later in labor. If the amniotic sac doesn't rupture on its own, the birth-attendant may break it during labor.

A few women have **diarrhea** or nausea as labor begins. Others notice a sudden surge of energy and the urge to clean or arrange things right before labor begins; this is known as "nesting."

Diagnosis

The progression of labor can be determined by measuring how much the cervix has dilated. The degree of dilation is estimated by feeling the opening cervix during a pelvic exam. Dilation is measured in centimeters, from 0–10 cm (0–4 in). Contractions that cause the cervix to dilate are the sign of true labor.

Fetal monitoring

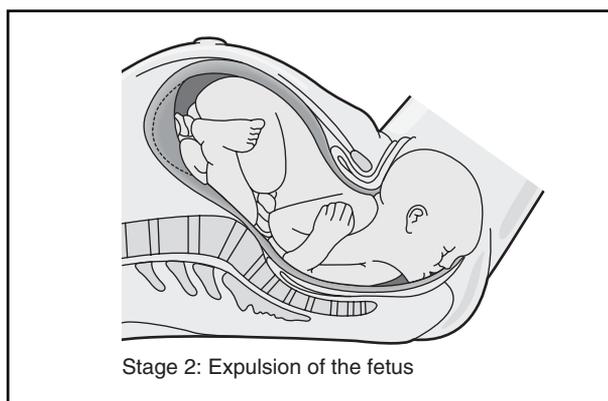
Fetal monitoring is a process in which the baby's **heart** rate is monitored for indicators of **stress** during labor and birth. There are several types of fetal monitoring.

A special **stethoscope** called a fetoscope may be used. This is a simple and noninvasive method.

The Doppler method uses ultrasound; it involves a handheld listening device that transmits the sounds of the heart rate through a speaker or into an attached ear piece. It can usually pick up the heart sounds 12 weeks after gestation. This method offers intermittent monitoring. It allows the mother freedom to move about and is also useful during contractions.

Electronic (external) fetal monitoring, in which a monitor is strapped to the mother's abdomen, uses ultrasound to measure the fetal heartbeat in relation to the mother's contractions. It is often used in high-risk pregnancies, and is not always recommended for low-risk ones because it renders the mother immobile. External monitoring can be done intermittently, as needed.

Internal monitoring provides continuous monitoring for the high-risk mother. It requires the mother's water to be broken and that she be 2–3 cm (0.75–1.25 in) dilated. An electrode is attached to the baby, usually on the head, and a pressure catheter records the strength of uterine contractions. Internal monitoring is more accurate than external fetal monitoring, because external monitors are more likely to slip off. Internal monitoring is continuous.



(Illustration by Hans & Cassidy.)

Telemetry monitoring, the newest type, is similar to electronic monitoring, but uses radio waves beamed from a transmitter worn by the mother to measure the fetal heartbeat. The mother is able to remain mobile while still being monitored continuously.

FETAL MONITORING RESULTS. The results of internal and external fetal monitoring are both displayed and printed. Most interpretations are based on the printed tracing. The top tracing reflects fetal heart rate; the bottom tracing measures contractions. Baseline fetal heart rate is considered normal if it is between 120 and 160 beats per minute (bpm). Monitoring of contractions with an external fetal monitor gives the frequency and duration of the contractions. Internal monitoring of contractions can provide contraction intensity values.

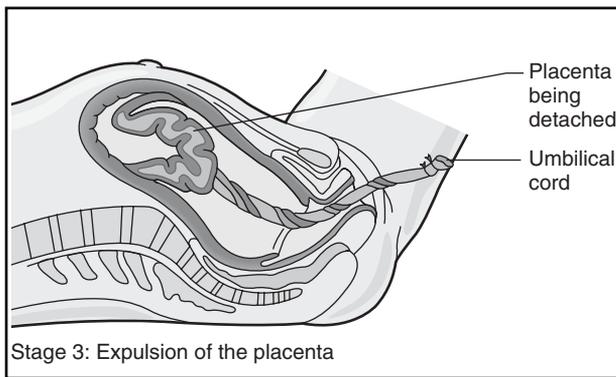
Treatment

Childbirth options

Most women choose some type of pain relief during childbirth, ranging from **relaxation** and imagery to powerful drugs. The specific choice may depend on what's available, the woman's preferences, her doctor or midwife's recommendations, and how the labor is proceeding. All drugs have some risks and some advantages.

REGIONAL ANESTHETICS. Regional anesthetics include epidurals and spinals. Depending on the type of medication used, these types of anesthesia can block nerve signals, causing temporary pain relief, or a loss of sensation from the waist down. An epidural or spinal block can provide complete pain relief during cesarean birth.

An epidural is placed with the woman lying on her side or sitting up in bed with the back rounded to allow more space between the vertebrae. Her back is scrubbed with antiseptic, and a local anesthetic is injected in the skin to numb the site. The needle is inserted between two



(Illustration by Hans & Cassidy.)

vertebrae and through the tough tissue in front of the spinal column. A catheter is threaded through the needle and the needle is then removed. The anesthetic then drips continuously through the catheter.

Epidurals provide complete pain relief and can help conserve a woman's energy, allowing her to relax or even sleep during labor. This method requires an IV and fetal monitoring. It may be harder for a woman to bear down when it comes time to push, although the amount of anesthesia can be adjusted as this stage nears.

Spinal anesthesia is used primarily for C-section delivery. Unlike epidural anesthesia, which is administered continuously in the space around the spinal column, spinal blocks are one-time injections of anesthetic that go directly into the fluid that surrounds the spine. Although this method disables motor nerves, preventing women who use it from pushing during delivery, this is not an issue during a C-section. Spinals provide quick and strong anesthesia and permit major abdominal surgery with minimal pain.

NARCOTICS. Short-acting narcotics can ease pain and do not interfere with a woman's ability to push. However, they can cause sedation, dizziness, nausea, and vomiting. Narcotics cross the placenta and may slow down a baby's breathing. For this reason they can not be given too close to the time of delivery.

METHODS OF PREPARATION. Health care providers often use psychoprophylaxis to help expectant mothers prepare for childbirth. These techniques use relaxation and breathing exercises along with other methods to diminish the discomfort and fear many women experience in childbirth. Although several distinct methods have evolved since the 1930s, when psychoprophylaxis first gained acceptance in the medical community, most doctors, nurses, and midwives today use a combination of approaches to instruct their patients.

The Read method is named for Dr. Grantly Dick-Read, the English obstetrician who developed it in the 1930s. This method aims to decrease the fear and tension surrounding childbirth by educating the mother about the birth process, and using relaxation and deep breathing techniques.

Lamaze, or Lamaze-Pavlov, is probably the best-known method in the United States today, although the pure Lamaze method is rarely used. It first became widely popular in the 1960s. The Lamaze method combines breathing exercises with concentration on a focal point to allow mothers to control pain while maintaining consciousness. This also allows the flow of oxygen to the baby and to the muscles in the uterus to be maintained. A partner coaches the mother throughout the birthing process.

The LeBoyer method stresses a relaxed delivery in a quiet, dim room that prevents overstimulation of the baby. Mother-child bonding is fostered by placing the baby on the mother's abdomen and by having the mother massage the baby immediately after delivery. Then the father washes the baby in a warm bath.

The Bradley method is called father-coached childbirth because it encourages the father to serve as coach throughout the labor. It encourages normal activities during the first stages of labor.

A newer method, called water birthing, allows mothers to labor and sometimes deliver—provided a doctor, nurse, or midwife is at hand—in a pool of warm water. The water supports and relaxes the mother, making labor more comfortable.

Prognosis

National U.S. health goals are to reduce the maternal mortality rate to no more than 3.3 deaths per 100,000 live births. The baseline in 1998 was 7.1 maternal deaths per 100,000 live births. The target for fetal and infant death reduction during the perinatal period (28 weeks of gestation to seven days or more after birth) is no more than 4.5 per 1,000 live births plus fetal deaths. The baseline in 1997 was 7.5 per 1,000.

Health care team roles

The nurse or nurse-midwife caring for the patient during labor and delivery will perform the following:

- Obtain an initial history and perform a **physical examination** upon admission.
- Determine the position of the baby.
- Assess for rupture of membranes.

- Determine the cervical dilation, effacement, and level of descent (station), and confirm presenting part through vaginal exam.
- Monitor vital signs.
- Monitor baby's heartrate and measure frequency and duration of contractions. Apply fetal monitoring apparatus if ordered. Observe tracing and record results in patient's record.
- Encourage involvement of the father and provide explanations to him as requested.
- Insert IV if ordered. Obtain laboratory specimens; evaluate results.
- Provide comfort measures through emotional support, changing pads, giving ice chips if allowed, giving back massages, assisting with breathing during contractions, administering pain medications, and assisting with regional anesthesia administration.
- Implement emergency measures if necessary.
- Assist with vaginal exams, rupturing the membranes (amniotomy) and other procedures as indicated.
- Prepare for delivery by setting up instruments, transporting to delivery room or readying birthing bed, and preparing equipment for initial newborn care.
- Provide coaching during pushing and delivery.
- Receive the baby after delivery and perform initial newborn care.
- Administer medications as ordered.
- Assess the mother and baby frequently after delivery.
- Provide perineal care for the mother.
- Monitor mother's and baby's vital signs.
- Assist mother with breastfeeding.
- Facilitate bonding of baby with mother, father, and other family members.

Resources

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- Pillitteri, Adele. *Maternal & Child Health Nursing*. 3rd ed. Philadelphia: Lippincott, 1999.

ORGANIZATIONS

- American Academy of Husband-Coached Childbirth. PO Box 5224, Sherman Oaks, CA 91413. (800) 423-2397; in California (800) 422-4784. www.bradleybirth.com.
- The American College of Nurse-Midwives. 818 Connecticut Ave. NW, Suite 900, Washington, D.C. 20006. (202) 728-9860. www.acnm.org.

KEY TERMS

Amniotic sac—The membranous sac that surrounds the embryo and fills with watery fluid as pregnancy advances.

Breech birth—Birth of a baby bottom- or feet-first, instead of the usual head first delivery. This can add to labor and delivery problems because the baby's bottom doesn't mold a passage through the birth canal as well as the head.

Cervix—A small cylindrical organ, about an inch (2.54 cm) or so long and less than an inch around, that makes up the lower part and neck of the uterus. The cervix separates the body and cavity of the uterus from the vagina.

Embryo—The unborn child during the first eight weeks of its development following conception.

Gestation—The period from conception to birth, during which the developing fetus is carried in the uterus.

Perineum—The area between the thighs that lies behind the genital organs and in front of the anus.

Placenta—The organ that develops in the uterus during pregnancy and that links the blood supplies of mother and baby.

Association of Women's Health, Obstetric, and Neonatal Nurses. 2000 L Street, NW, Suite 740, Washington, D. C. 20036. (800) 673-8499 U.S., (800) 245-0231 Canada. www.awhonn.org.

International Childbirth Education Association. PO Box 20048, Minneapolis, MN 55420. (612) 854-8660. www.icea.org.

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Childbirth education

Definition

Childbirth education prepares the mother and usually her partner for labor and birth. It may also include information on cesarian birth, breastfeeding, maternal postpartum issues, and **neonatal care**. Special classes may be available for adolescent mothers, vaginal birth after cesarian birth, siblings, and grandparents. Classes may consist of lectures, slides, videos, demonstration, and practice.

Description

Based on the goals of the facility or instructor, childbirth education classes can vary considerably in terms of content. For example, some classes may focus primarily on the childbirth process, while others provide information on wellness behaviors during the different trimesters of **pregnancy**. Classes offered by some facilities may not include information on postpartum contraceptive choices. Some classes provide information on fetal growth and development and maternal changes during pregnancy. These classes are usually offered earlier in a woman's pregnancy while classes that focus primarily on labor and delivery are offered later. Some obstetric practices may provide gestational-appropriate information at each prenatal visit; others may focus primarily on the mother's questions or concerns. Some practices may offer classes that complement the information given during prenatal visits or they may have on hand a list of classes that pregnant women may want to contact.

Content areas that may be included in childbirth education classes are:

- maternal changes in early pregnancy: physical and emotional
- fetal growth and development
- risks of certain environmental factors on fetal development
- maternal self-care: **nutrition**, rest, **exercise**, work accommodations
- common discomforts in pregnancy and safe/unsafe relief measures
- sexuality and pregnancy
- signs and symptoms of complications of pregnancy
- signs of preterm labor
- signs of the initiation of labor
- symptoms which require a call to the obstetric provider
- what to expect during labor and delivery



A midwife meets with a pregnant patient. (Photograph by Cliff Moore. Science Source/Photo Researchers. Reproduced by permission.)

- labor and delivery analgesia/anesthesia options
- breathing and **relaxation** techniques
- role of certified nurse midwife versus obstetrician
- role of the coach
- making a birth plan; hiring a doula
- episiotomy issues
- breastfeeding versus formula
- breastfeeding techniques, normal/abnormal problems, and relief measures
- neonatal care and safety issues
- postpartum contraception
- tour of labor and delivery area of affiliated health care center

Viewpoints

Childbirth education classes are offered based on the premise that knowledge about what to expect during labor and delivery prepares a woman for the process. For example, fear of the unknown is associated with increased **pain** and muscle tension. Childbirth classes traditionally teach breathing and relaxation techniques for women to use during labor and delivery. It is believed that these techniques enable the mother to better manage the pain of childbirth, feel more in control, have a better birth experience, and bond more readily with her newborn. Some childbirth classes promote a particular method and philosophy, such as the Lamaze and the Bradley methods.

The Lamaze method is supported by the American Society for Psychoprophylaxis in Obstetrics (ASPO) and was popularized by the French physician Ferdinand Lamaze. Classes focus on breathing, movement and posi-

tioning during labor, use of massage and relaxation techniques, the role of labor support, use of heat and cold, and water therapy. The ASPO/Lamaze philosophy is:

- Birth is normal, natural, and healthy.
- The birth experience profoundly affects women and their families.
- Women's inner wisdom guides them through birth.
- Women's confidence and ability to give birth is either enhanced or diminished by the care provider and place of birth.
- Women have the right to give birth free from routine medical interventions.
- Birth can safely take place in birth centers and homes.
- Childbirth education empowers women to make informed choices in health care, to assume responsibility for their health, and to trust their inner wisdom.

The Bradley method was designed by Robert Bradley, an obstetrician. During the 12 sessions, Bradley classes emphasize a special pregnancy diet, maternal changes during pregnancy, the coach's role, special coaching techniques, the importance of natural childbirth, sex during pregnancy, the first, second, and third stages of labor, pushing during labor, making a birth plan, labor rehearsal, postpartum information, breastfeeding, and newborn care. The Bradley method's goals are:

- natural childbirth
- active participation of the husband coach
- excellent nutrition as the foundation of a healthy pregnancy
- avoidance of drugs during pregnancy, birth, and breastfeeding unless absolutely necessary
- relaxation and natural breathing
- tuning in to the body
- responsibility of parents for the safety of the birth place, procedures, attendants, and emergency backup
- immediate and continuous contact with the newborn
- initiation of breastfeeding at birth
- preparation of parents for unexpected situations such as emergency childbirth and cesarian delivery

Childbirth education classes provide information to pregnant women in an environment of their peers, where they meet with other women or couples at the same stage of pregnancy. By educating women about the childbirth process, these classes enable women to focus on their particular issues during prenatal visits, while still receiving general pregnancy and childbirth information. Issues raised during the classes allow women time to reflect on

Questions to consider when making a birth plan

How have you tried to prepare yourself for labor? How has your partner or support person been involved?

What do you think labor will be like?

How much pain do you think you will have in labor? Why do you think it will be like that?

Do you want pain medications, or do you want to avoid them? Which pain medications would you prefer?

How long do you think your labor will last? Why do you think it will be that long?

Which support people will be with you during labor? How is each related to you?

Who is welcome to be at the birth?

What do you want your support person to do for you when you are in labor?

What is most scary to you about being in labor and giving birth?

What is most important to you about this birth?

How do you feel about:

monitoring the baby during labor?

mobility during labor?

positions during labor?

an IV?

having your bag of water broken?

using breathing and relaxation techniques to help you through the contractions?

medication to relieve pain during labor?

an epidural anesthetic to take away the pain of labor?

episiotomy procedure?

If a cesarean becomes necessary, do you have any special requests?

If the birth is planned at home or at a birth center, what are your plans in case of transport?

What are your preferences for baby care, feeding, and rooming?

If you had a baby before, did anything happen that might affect you during labor this time?

SOURCE: Wheeler, L. *Nurse-Midwifery Handbook: A Practical Guide to Prenatal and Postpartum Care*. Philadelphia: Lippincott-Raven Pub., 1997.

the choices they want for their birth experience. In addition, these classes often are a springboard for new groups where mothers get together postpartum with their newborns. Friendships formed during class time can help avoid the isolation sometimes existing in the postpartum period.

Professional implications

While some women benefit from choosing a particular method of childbirth education, many women prefer using a more eclectic approach. The more nurses and other health care professionals are informed of various methods, the better equipped they are to assist women to have the type of childbirth they choose. The various breathing and focusing techniques provide relief from or a decrease in pain through distraction and muscle relaxation. There are many ways to achieve these goals. It is important for nurses to provide options while allowing women to make their own choices. Taking a series of

KEY TERMS

Doula—A doula is someone who undergoes special training to enable them to support women during childbirth and into the postpartum period.

Episiotomy—A surgical incision made to enlarge the perineal area for delivery, to avoid tearing of the tissues, especially with a large neonate or during a difficult birth. Many women request the avoidance of a routine episiotomy. To avoid performing an episiotomy, certified nurse midwives may stretch the perineum with perineal massage.

Perineum—The area encompassing the anus and the vagina.

classes and doing the required homework requires time, effort, and motivation. Many women come into childbirth virtually unprepared. Labor and delivery nurses may choose to select different aspects of a variety of methods and incorporate them into their own practice.

It is helpful for office obstetric nurses to be aware of the various classes in their areas, even classes not listed by their own facility. One may be able to request permission to sit in on some classes or to view the class content list. This enables the provider to know what information, accurate or otherwise, is available to pregnant women and to address issues as needed during prenatal visits. If not provided during the classes, obstetric providers may wish to offer instruction on exercises women can do at home that will facilitate the birth process: abdominal and back exercises for strength and flexibility, Kegel (pelvic floor muscle) exercises to promote perineal healing and to counteract **stress** incontinence, tailor sitting and squatting to stretch perineal and pelvic floor muscles, and pelvic rocking to relieve lower backache.

Nurses also need to be culturally sensitive. While most husbands may wish to participate in the birth process, this may be an uncomfortable practice in some cultures. In addition, some men, regardless of their cultural background, may not want to participate in the birth process. The birthing woman may wish instead to have a female relative or friend as a support person. As long as a practice is medically safe, nurses need to respect the choices of the birthing woman and her family.

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Chloride test *see* **Electrolyte tests**

Choking *see* **Foreign bodies**

Cholangiocarcinoma *see* **Liver cancer**

Cholecalciferol *see* **Vitamin D**

Cholecystography *see* **Gallbladder x rays**

Cholesterol tests *see* **Lipid tests**

Chorea *see* **Movement disorders**

Chorionic villus sampling

Definition

Chorionic villus sampling (CVS) is a prenatal procedure for the removal by needle of chorionic villi and culture and examination of the fetal cells obtained. The cells are used in tests for genetic and chromosomal abnormalities of a fetus as early as 10 to 12 weeks of gestation.

Purpose

Women who are at risk of carrying a fetus with a genetic or chromosomal defect may be counseled to have a prenatal screening test such as CVS or **amniocentesis**. CVS, which is performed at 10 to 12 weeks after a woman's last menstrual period, may be offered as an alternative to amniocentesis, the more commonly used test for prenatal diagnosis of genetic disorders, which is performed usually at 15 to 18 weeks. Earlier diagnosis of congenital defects is especially beneficial in cases where the parents' desire to know the results as early in **pregnancy** as possible, for instance, when therapeutic abortion is being considered, as the risks associated with abortion increase with gestational age.

Prenatal screening can diagnose some genetic and virtually all chromosomal disorders and is advised for women who have one or more of the following risk factors:

- Women age 35 and older. The chance of having a child with certain chromosomal birth defects increases with maternal age. The most common chromosomal disorder is **Down syndrome**, a combination of mental and physical abnormalities caused by the presence of an extra copy of chromosome 21. The occurrence of Down syndrome in children born to women in their 20s is approximately 1 in 1,250, but increases to 1 in 400 by age 35, and to 1 in 100 at age 40.
- A child or previous pregnancy with a birth defect, or a history of miscarriages. A woman who has already had a child or pregnancy diagnosed with a genetic birth defect or chromosomal abnormality, or who has had multiple miscarriages, is at increased risk of having a child with a genetic disorder.
- Determination of the sex of a fetus when the mother is known to be a carrier of a sex-linked genetic disease (for example, **hemophilia A**).
- Other family history of genetic disease. Couples who do not have an affected child but who have family medical histories of genetic or chromosomal abnormalities or are known through genetic screening to be carriers of an inherited disease are at increased risk of having an affected child. Prenatal testing is offered only when the suspected condition can be diagnosed before birth.

Precautions

Chorionic villus sampling usually is not recommended for:

- A woman whose pregnancy has progressed further than about 12 weeks, counted from the first day of the last menstrual period.
- A woman who is experiencing bleeding or spotting.
- In the presence of certain vaginal infections.
- When there are uterine abnormalities, such as a bicornuate (double) uterus or uterine fibroids.
- Women who would not consider intervening in a pregnancy where a genetic abnormality is detected.

Women who are concerned about the risk of **miscarriage** associated with CVS can be offered amniocentesis or a noninvasive alternative. One such alternative is a maternal **blood** test called triple marker screening or multiple marker screening, which is performed no sooner than 15 weeks but no later than 20 weeks of pregnancy. A sample of the pregnant woman's blood is analyzed for three substances produced by the fetus and passed into the

mother's blood: alpha fetoprotein (AFP), human chorionic gonadotropin (HCG), and unconjugated estriol (UE3). Elevated AFP may indicate the presence of anencephaly or spina bifida; HCG is increased and AFP and UE3 are decreased in Down syndrome. This screening test, however, does not definitively diagnose a genetic defect and has a relatively high rate of false negatives, but it can help to identify an unborn baby at increased risk for these birth defects. A pregnant woman whose triple marker results are indicative of a fetus at risk would be encouraged to undergo further screening, such as ultrasound and/or amniocentesis (the timing of the triple marker screening rules out CVS) to provide a definitive diagnosis.

Since only cells and not fluid are collected, CVS does not allow evaluation of AFP to indicate the presence of neural tube defects. AFP is then generally measured by a maternal blood test at 15–20 weeks, but with less accuracy than would be obtained with an amniotic fluid sample.

A CVS sample may be obtained either via the vagina and cervix (transcervical CVS) or through the abdomen (transabdominal CVS). Women who have a retroverted (tipped) uterus should be sampled transabdominally, since studies have shown the risk of miscarriage to be lower than when the procedure is done transcervically. In cases where the location of the placenta contraindicates transabdominal CVS, amniocentesis should be offered as an alternative screening test. Amniocentesis, however, is only rarely performed in the first trimester.

Although CVS is over 99% accurate in ruling out certain chromosomal birth defects and specific genetic problems, it is slightly more likely than amniocentesis to give inconclusive results. Amniocentesis, then, may be used as a back-up screening procedure. However, the patient should be cautioned that not all birth defects can be ruled out before birth and no prenatal test can guarantee the birth of a healthy baby. Because it is performed earlier in pregnancy than amniocentesis, CVS sampling is more likely to detect fatal genetic diseases that result in miscarriages after the diagnosis has been established.

Description

Chorionic villus sampling has been in use increasingly since the 1980s. The CVS procedure involves taking a sample of the chorion frondosum—the part of the chorionic membrane that contains the villi, microscopic, finger-like projections that emerge from the chorionic membrane to form the placenta—for laboratory analysis. The chorion is the outermost membrane surrounding the developing fetus; the amnion is the inner membrane that contains the amniotic fluid. The cells that make up the chorionic villi are of fetal origin, and, thus, normally

have the same genetic makeup as the fetus. The sample may be obtained with a catheter, a thin, plastic tube, inserted through the vagina and the cervix (transcervical CVS) or with a needle through the abdominal wall (transabdominal CVS); both sampling methods take about five minutes to perform (not including preparation time), are equally effective, and carry similar risks.

Chorionic villus sampling is best performed between 10 and 12 weeks of pregnancy. **Abdominal ultrasound** is used to determine the position of the uterus, the position of the placenta within the uterus, and the size of the amniotic sack. The woman assumes the lithotomy position (on her back with her feet in stirrups). In transcervical CVS, the vulva, vagina, and cervix are thoroughly cleansed with antiseptic; no anesthetic is required. A speculum is inserted into the vagina and opened, then, using ultrasound as a guide, the doctor inserts a catheter through the cervix and into the uterus. The catheter is carefully advanced to the chorionic villi and suction is applied with the syringe attached to the catheter to obtain a small sample of the villi. The catheter is then carefully withdrawn.

In transabdominal CVS, the appropriate area on the woman's abdomen is cleansed thoroughly with antiseptic and a local anesthetic may be injected to numb the area. With ultrasound guidance to strictly avoid the placenta, a long needle is inserted through the woman's abdominal wall, through the uterine wall and to the chorionic villi. Suction is applied with the syringe attached to the needle to obtain a small sample of the villi, and the needle is then carefully withdrawn.

Most women report that transcervical CVS feels similar to the procedure for a Pap smear. The passage of the catheter through the cervix may cause cramping, and some women experience cramping or pinching sensations when the sample is taken. There is generally little or no discomfort associated with the transabdominal procedure. Occasionally, when insufficient villus material is obtained, a second sampling procedure must be performed.

The chorionic villus sample is immediately placed into a sample dish containing nutrient medium for transport to the cytogenetics laboratory. At the laboratory, the sample is examined under the **microscope** so that any contaminating cells or material may be carefully removed. The villi can be analyzed immediately, or incubated for a day or more to give the cells time to undergo division. When the cells are in the midst of dividing, they are spread onto a slide and examined under a microscope. Cells that have clearly separated chromosomes are photographed to allow analysis of the type and number of chromosomes. The chromosomal images are collected in a report called a karyotype, which shows the number,

shape, size, and arrangement of chromosomal pairs. For biochemical studies, deoxyribonucleic acid (DNA) is extracted from cultured chorionic villus cells. Depending upon which tests are performed, results may be available as early as two days or up to ten days after the procedure.

The chorionic villus sampling procedure costs about \$3,000, including ultrasound, laboratory, and counseling charges. Some insurance plans may provide some level of coverage for this test.

Preparation

Thorough pre-CVS counseling is strongly recommended to give the couple the opportunity to make informed decisions about prenatal diagnosis. The couple should be provided with literature about CVS and genetic screening options to read prior to the counseling conference, so that any questions or concerns they may have can be addressed at that time. Prior to the procedure, the woman will likely be asked to sign a consent form.

For the procedure itself, the woman will be instructed to drink fluids and refrain from urinating so that the bladder is partly filled; excessive and uncomfortable bladder filling is not necessary. A filled bladder can help to properly position the uterus and create a better ultrasound picture for guiding the CVS procedure.

Aftercare

After the sample is taken, the fetal heartbeat is checked by ultrasound before the woman leaves the examination room. A follow-up ultrasound procedure may be scheduled two to four days after CVS to ascertain the health of the fetus.

Most physicians recommend that the woman have someone drive her home after the CVS procedure and that she limit strenuous activity for the remainder of the day. A woman who experiences excessive bleeding, vaginal discharge, **fever**, or abdominal **pain** after the procedure should consult her doctor.

Women with Rh negative blood may receive a Rho (D) immune globulin (RhoGAM) injection to avoid Rh incompatibility.

Advances in prenatal treatment have made it possible to treat some genetic defects diagnosed by prenatal screening before birth. Congenital adrenal hyperplasia (CAH), for example, is an inherited birth defect in which an enzyme deficiency causes a female fetus to develop abnormal external genitalia by the 16th week of pregnancy. Prenatal diagnosis by CVS in pregnancies known to be at risk of CAH allows the fetus to be treated with hormones during the critical period of development from 10 to 16 weeks of gestation and can circum-

vent the need for surgery after birth. For conditions in which prenatal treatment is not available, prenatal diagnosis can allow parents the opportunity to discuss their options with genetic counselors or other health care providers, to plan the delivery, and to prepare emotionally for the birth.

Complications

Of women who undergo transcervical CVS, one third experience minimal vaginal spotting and 7–10% experience vaginal bleeding; bleeding that is heavier than during a normal menstrual period should be reported to the doctor. One out of five women experience cramping following the procedure. Rupture of the amniotic membranes is a rare but serious complication that can lead to **infection** and/or miscarriage. The risk of miscarriage after CVS is 1–3%, compared to 0.5–1% for amniocentesis. A woman with Rh negative blood who is carrying an Rh positive fetus may be at an increased risk for developing Rh incompatibility following CVS and should be treated with Rho immune globulin.

In the early 1990s, there were several reports linking babies born with missing or shortened fingers or toes and abnormalities of the tongue and lower jaw with CVS performed before the tenth week of pregnancy. These reports raised concerns about the safety of CVS, although this type of limb defect is known to occur in approximately 1 out of every 1,700 babies. Subsequent studies of the risk of limb defects following CVS have produced conflicting results, and CVS safety studies continue. A study by the World Health Organization's CVS Registry, which performs ongoing assessment of CVS, reported in 1999 that the risk of these limb defects in babies born to more than 200,000 women who had CVS was not significantly increased compared to the norm. CVS is now generally performed only at ten weeks or later, and all women being offered CVS should be advised of the limited risk of limb defects.

There is risk with CVS of getting a "placental mosaicism" artifact in which the cultured cells contain some abnormal chromosomes that originate in the placenta and are not related to the fetus. Mosaicism occurs when cells have two or more distinct chromosome counts. This occurs when nondisjunction (failure of chromatids to separate) occurs in germ line cells (after fertilization). The fetus may be normal, and the only way to rule out actual mosaicism is to follow up with amniocentesis. There is also a risk that insufficient chorionic villi are collected for analysis, or that the cells collected are contaminated with cells of maternal origin. In this case, a second sampling procedure is performed

about a week later, or amniocentesis may be offered as an alternative.

Results

The chorionic villus cells are cultured and photographed through a microscope during **cell division** to obtain images of the chromosomes. The images are sorted, identified, and reported in a karyotype. Humans have 23 pairs of chromosomes, including the sex chromosomes. The karyotype allows detection of aneuploidies (extra copies of chromosomes), chromosomal deletions, and gross chromosomal translocations. The gender of the fetus is identified from the sex chromosomes, and can be reported to the parents upon request.

DNA studies are performed when indicated by a family history of genetic disorders. DNA is the biochemical molecule that stores genetic information in the chromosomes. The DNA is extracted from the chorionic villus cells, and analysis of the DNA allows prenatal diagnosis of over 200 diseases, including Tay-Sachs disease, **cystic fibrosis**, sickle-cell anemia, and **muscular dystrophy**.

Health care team roles

The genetic counselor, physician, or other health care provider will provide information to the couple considering CVS and explain the procedure and its risks, and alternative procedures. Counselors can also advise parents of their options when they learn that their unborn child has an inherited disorder and/or help them prepare emotionally for the delivery of a child with a birth defect.

The obstetrics team carries out the ultrasound and CVS procedure, and ensures that the chorionic villus cells are properly handled for transport to a cytogenetics laboratory. The team of physician(s) and nurses also provide practical and psychological support for the couple undergoing prenatal diagnosis.

Technologists in the cytogenetics laboratory perform cell culture on the chorionic villus cells, fix a sample of cells during cell division, prepare the cells on a slide for microscopic analysis, and make photographs of the chromosomes of dividing cells to be collated in a karyotype. Cytogenetic technologists are also involved in the extraction of DNA from the cells and the biochemical testing of the DNA.

Training

The obstetrician receives special training in the procedure for collecting the chorionic villus specimen. Cytogenetic laboratory technologists, CLSp(CG) are specially trained in sterile techniques for cell culture,

KEY TERMS

Alpha fetoprotein—A serum protein produced by the fetus during pregnancy and passed to the mother's blood, useful in the prenatal diagnosis of multiple births or birth defects.

Amniocentesis—A prenatal screening procedure in which a sample of amniotic fluid from the amniotic sac in the uterus of a pregnant woman is obtained by inserting a needle through the abdominal wall.

Aneuploidy—An irregular number of chromosomes caused by the loss or addition of one or more chromosomes or parts of chromosomes.

Chromosomes—Tightly compressed rod-like structures that carry DNA; humans have 23 pairs of chromosomes including the sex chromosomes.

Cystic fibrosis—An inherited chronic disease of the exocrine glands, characterized by the production of viscous mucus that obstructs the pancreatic ducts and bronchi, leading to infection and fibrosis.

Down syndrome—Also called trisomy 21, a genetic disorder, associated with the presence of an extra copy or a rearrangement of chromosome 21, characterized by mild to severe mental retardation, weak muscle tone, a low nasal bridge, and epicanthic folds at the eyelids; formerly called mongolism.

Human chorionic gonadotropin—A hormone produced by the developing placenta that stimulates the production of estrogen and progesterone; its presence in maternal blood or urine is used to diagnose pregnancy.

Karyotype—A report in which photographic images of the chromosomes of a cell are displayed as a systematized arrangement of pairs in descending order of size.

Muscular dystrophy—An inherited disease in which muscles become gradually wasted and are replaced by scar tissue and fat, sometimes also affecting the heart.

Neural tube defect—Any of a group of inherited abnormalities of brain and spinal cord development, including spina bifida and anencephaly, caused by failure of the neural tube to close properly during development.

Rh incompatibility—An Rh negative person who is exposed to Rh positive red blood cells. When an Rh negative mother becomes pregnant with an Rh positive fetus, the fetal red blood cells may enter the maternal circulation and stimulate production of Rh antibodies. This process can be prevented by administration of Rho immune globulin prior to or during the pregnancy.

Sickle-cell anemia—An inherited chronic blood disease that occurs primarily among persons of African descent characterized by abnormal hemoglobin that causes red blood cells to become sickle-shaped and nonfunctional, leading to an enlarged spleen, chronic anemia, weakness, joint pain, and formation of blood clots.

Tay-Sachs disease—A rare and fatal inherited disease occurring chiefly in persons of eastern European Jewish origin, characterized by a red spot on the retina, gradual blindness, and paralysis.

Ultrasound—Also called ultrasonography, a diagnostic imaging technique that uses reflected high-frequency sound waves to visualize internal body structures or organs, especially useful as a non-invasive prenatal diagnostic tool.

photomicrography, construction of the karyotype report, and biochemical analysis of DNA.

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Patricia L. Bounds, Ph.D.

Chromosome studies see **Genetic testing**

Chronic kidney failure

Definition

Chronic kidney failure occurs when disease or disorder damages the **kidneys** so that they can no longer adequately remove fluids and wastes from the body or maintain proper levels of kidney-regulated chemicals in the bloodstream.

Description

Chronic kidney failure, also known as chronic renal failure, affects over 250,000 Americans annually. It may be caused by a number of diseases and inherited disorders, but the progression (end result) of chronic kidney failure is always the same. The kidneys, which serve as the body’s natural filtration system, gradually lose their ability to remove fluids and waste products (urea) from the bloodstream. They also fail to regulate certain chemicals in the bloodstream and allow protein to leak into the urine. Chronic kidney failure is irreversible and eventually leads to total kidney failure, known as end-stage renal disease (ESRD). Without treatment and intervention to remove wastes and fluids from the bloodstream, ESRD is inevitably fatal.

Causes and symptoms

Kidney failure is caused by acquired disease or hereditary disorders in the kidneys. The four most common causes of chronic kidney failure include:

- **Diabetes.** **Diabetes mellitus** (DM), both insulin dependant (IDDM) and non-insulin dependant (NIDDM), occurs when the body cannot produce and/or use insulin, the hormone necessary for the body to process glucose. Long-term diabetes may cause the glomeruli, the filtering units located in the nephrons of the kidneys, to gradually lose function.
 - **Hypertension.** High **blood pressure** is both a cause and a result of kidney failure. The kidneys can become stressed and ultimately sustain permanent damage from **blood** pushing through them at excessive pressures over long periods of time.
 - **Glomerulonephritis.** Glomerulonephritis is an inflammation of the glomeruli, or filtering units of the kidney. Certain types of glomerulonephritis are treatable, and may only cause a temporary disruption of kidney functioning.
 - **Polycystic kidney disease.** Polycystic kidney disease is an inherited disorder that causes cysts to form in the kidneys. These cysts impair the regular functioning of the kidney.
- Less common causes of chronic kidney failure include kidney **cancer**, obstructions such as **kidney stones**, pyelonephritis, reflux nephropathy, systemic lupus erythematosus, amyloidosis, sickle cell anemia, Alport syndrome, and oxalosis.
- Initially, symptoms of chronic kidney failure develop slowly. Even individuals with mild to moderate kidney failure may have few symptoms in spite of increased urea in their blood. Among signs and symptoms that may be present at this point are frequent urination during the night and high blood pressure.
- Most symptoms of chronic kidney failure are not apparent until kidney disease has progressed significantly. Common symptoms include:
- **Anemia.** The kidneys are responsible for the production of erythropoietin (EPO), a hormone that stimulates red cell production. If kidney disease causes shrinking of the kidney, this red cell production is hampered.
 - **Bad breath or a bad taste in mouth.** Urea in the saliva may cause an ammonia-like taste in the mouth.
 - **Bone and joint problems.** The kidneys produce **vitamin D**, which aids in the absorption of **calcium** and keeps bones strong. In patients with kidney failure, bones may become brittle, and in children, normal growth may be stunted. Joint **pain** may also occur as a result of unchecked phosphate levels in the blood.
 - **Edema.** Puffiness or swelling around the eyes and legs.
 - **Frequent urination.**
 - **Foamy or bloody urine.** Protein in the urine may cause it to foam significantly. Blood in the urine may indicate bleeding from diseased or obstructed kidneys, bladder, or ureters.
 - **Headaches.** High blood pressure may trigger headaches.

- Hypertension, or high blood pressure. The retention of fluids and sodium causes blood volume to increase, which, in turn, causes blood pressure to rise.
- Increased fatigue. Toxic substances in the blood and the presence of anemia may cause feelings of exhaustion.
- Itching. **Phosphorus**, which is typically eliminated in the urine, accumulates in the blood of patients with kidney failure. This heightened phosphorus level may cause itching of the skin.
- Low back pain. Pain where the kidneys are located, in the small of the back below the ribs.
- Nausea, loss of appetite, and vomiting. Urea in the gastric juices may cause upset **stomach**. This can lead to malnutrition and weight loss.

Diagnosis

Kidney failure is typically diagnosed and treated by a nephrologist, a physician specializing in kidney disease. The patient suspected of having chronic kidney failure will undergo an extensive blood work-up, usually performed by a laboratory technologist or technician. Blood tests will assess the levels of creatinine, blood urea nitrogen (BUN), uric acid, phosphate, sodium, and potassium in the blood. Urine samples will also be collected, usually over a 24-hour period, to assess protein loss.

Uncovering the cause of kidney failure is critical to proper treatment. A full assessment of the kidneys is necessary to determine if the underlying disease is treatable and if the kidney failure is chronic or acute. X ray, MRI, computed tomography scan, ultrasound, renal biopsy, and/or arteriogram of the kidneys may be employed to determine the cause of kidney failure and level of remaining kidney function. X rays and ultrasound of the bladder and/or ureters may also be taken. Most imaging studies are performed by radiology technicians.

Treatment

Chronic kidney failure is an irreversible condition. Hemodialysis, **peritoneal dialysis**, or kidney transplantation must be employed to replace the lost function of the kidneys if the failure progresses to ESRD. In addition, dietary changes and treatment to relieve specific symptoms such as anemia and high blood pressure are critical to the treatment process.

Hemodialysis

Hemodialysis is the most frequently prescribed type of dialysis treatment in the United States. Most hemodialysis patients require treatment three times a week, for an average of three to four hours per dialysis

“run” depending on the type of dialyzer used and their current physical condition. The treatment involves circulating the patient’s blood outside of the body through an extracorporeal circuit (ECC), or dialysis circuit. The dialysis circuit consists of plastic blood tubing, a two-compartment filter known as a dialyzer, or artificial kidney, and a dialysis machine that monitors and maintains blood flow and administers dialysate, a chemical bath used to draw waste products out of the blood. The patient’s blood leaves and enters the body through two needles inserted into the patient’s vein, called an access site, and is pushed through the blood compartment of the dialyzer. Once the patient’s blood is inside the dialyzer, excess fluids and toxins are pulled out of the bloodstream and into the dialysate compartment, where they are carried out of the body. At the same time, electrolytes and other chemicals in the dialysate solution move from the dialysate into the bloodstream. The purified, chemically balanced blood is then returned to the body. Specially trained nurses and dialysis technicians supervise and monitor patients during treatment.

Peritoneal dialysis

In peritoneal dialysis (PD), the peritoneum, (lining of the abdomen) acts as a blood filter. A catheter is surgically inserted into the patient’s abdomen. During treatment, the catheter is used to fill the abdominal cavity with liquid dialysate. Waste products and excess fluids move from the patient’s bloodstream into the dialysate solution. After a waiting period of 6 to 24 hours, depending on the treatment method used, the waste-filled dialysate is drained from the abdomen, and replaced with clean dialysate. There are three types of peritoneal dialysis, which vary by treatment time and administration method: continuous ambulatory peritoneal dialysis (CAPD), continuous cyclic peritoneal dialysis (CCPD), and intermittent peritoneal dialysis (IPD).

Kidney transplantation

Kidney transplantation involves surgically implanting a functioning kidney, known as a graft, from a **brain** dead organ donor (a cadaver transplant), or from a living donor, to a patient with ESRD. Patients with chronic renal disease who need a transplant and do not have a living donor register with UNOS (United Network for Organ Sharing), the federal organ procurement agency. UNOS places patients on a waiting list for a cadaver kidney transplant. Kidney availability is based on the patient’s health status. When the new kidney is transplanted, the patient’s diseased kidneys may or may not be removed, depending on the circumstances surrounding the kidney failure. A regimen of immunosuppressive

(anti-rejection) medication is required after transplantation surgery.

Dietary management

A diet low in sodium, potassium, and phosphorous, three substances that healthy kidneys excrete, is critical in managing kidney disease. Other dietary restrictions, such as a reduction in protein, may be prescribed depending on the cause of kidney failure and the type of dialysis treatment employed. Patients with chronic kidney failure also need to limit their fluid intake. Patients may receive instruction about appropriate dietary measures from registered dietitians, nutritionists, nurses, or health educators.

Medications and dietary supplements

Kidney failure patients with hypertension typically take medication to control their high blood pressure. Epoetin alfa, or EPO (Epogen), a hormone therapy, and intravenous or oral **iron** supplements are used to manage anemia, especially if the kidneys have been surgically removed. A multivitamin may be prescribed to replace **vitamins** lost during dialysis treatments. Vitamin D, which promotes the absorption of calcium, along with calcium supplements, may also be prescribed.

Since 1973, **Medicare** has reimbursed up to 80% of ESRD treatment costs, including the costs of dialysis and transplantation as well as the costs of some medications. To qualify for benefits, a patient must be insured or eligible for benefits under Social Security, or be a spouse or child of an eligible American. Private insurance and state **Medicaid** programs often cover the remaining 20% of treatment costs.

Prognosis

Early diagnosis and treatment of kidney failure is critical to improving length and quality of life in chronic kidney failure patients. Patient outcome varies; it depends on the cause of chronic kidney failure and the method chosen to treat it. Overall, patients with chronic kidney disease leading to ESRD have a shortened life span. According to the United States Renal Data System (USRDS), the life span of an ESRD patient is 18-47% of the life span of the age-sex-race matched general population. ESRD patients on dialysis have a life span that is 16-37% of the general population.

The demand for kidneys to transplant continues to exceed supply. Cadaver kidney transplants have a 50% chance of functioning nine years, and living donor kidneys that are well-matched (have two matching antigen pairs) have a 50% chance of functioning for 24 years.

KEY TERMS

End-stage renal disease (ESRD)—Total kidney failure; chronic kidney failure is diagnosed as ESRD when kidney function falls to 5-10% of capacity.

Nephrotic syndrome—Characterized by protein loss in the urine, low protein levels in the blood, and fluid retention.

Ureters—The two ducts that pass urine from each kidney to the bladder.

However, some transplant grafts have functioned for more than 30 years.

Health care team roles

Patients with chronic kidney failure are treated by a team that includes nephrologists, dialysis technicians, nurses, radiology technicians, and laboratory technicians. Patients undergoing kidney transplant are cared for by a transplant team headed by a transplant surgeon. Registered dietitians, nutritionists, and nurses instruct patients about dietary changes to manage their disease.

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American Kidney Fund (AKF). Suite 1010, 6110 Executive Boulevard, Rockville, MD 20852. (800)638-8299. <<http://www.arbon.com/kidney/>>.

National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). Natcher Building - 6AS-13K, 45 Center Drive, Bethesda, MD 20892-6600. <<http://www.niddk.nih.gov>>.

National Kidney Foundation (NKF). 30 East 33rd Street, New York, NY 10016. (800)622-9020. <<http://www.kidney.org>>.

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Barbara Wexler

Chronic leukemias see **Leukemias, chronic**

Chronic obstructive pulmonary disease see **Emphysema**

Chylomicron test see **Lipoproteins test**

Circulation support see **Mechanical circulation support**

Classification of teeth

Definition

Classification of teeth refers to the position of the first molars, and how they bite together.

Description

In 1844 J.F. Cravens, a dentist from Indianapolis, discussed the first dental deformities. He studied the first molar biting relationship and how the molars should line up with each other on the upper and lower jaws. Cravens called the first molar the “patriarch of the mouth,” meaning the first molar determined the bite relationship for the entire mouth. J.N. Farrar, a leading dentist, in 1880 discussed the teeth relationship as an irregularity in his book “A Treatise on the Irregularities of the Teeth and Their Corrections.”

In 1905 at the 4th Annual Meeting of American Society of Orthodontics the subject was again broached, but this time by Edward H. Angle, a dentist who dis-

agreed with the other leading dentists and their terms and names of bite relationships. Angle had devised a simple and logical classification system for the teeth irregularities and deformities, which he didn’t believe were irregularities or deformities at all, but rather malocclusions. He felt the first molar was “king of the mouth” and the basis for the classification of **malocclusion** of the teeth. Angle had studied Cravens’s work and knew he could prove the theories.

Angle’s classification system refers to the position of first molars and how they bite together and is broken into three main categories: Class I, II, III.

- Class I: The normal biting relationship between the upper and lower teeth and jaw, also known as a balanced bite. The front teeth may be spaced apart or crowding of the anterior teeth may be seen, but the biting relationship of the first molars is balanced.
- Class II: The lower first molar is posterior or more towards the back of the mouth than the upper first molar. In this abnormal biting relationship the upper front teeth of the jaw protrude further than the lower jaw, commonly called “buck teeth.” There is a convex appearance in the profile of the patient with a receding chin and lower lip. Class II problems can be due to insufficient growth of the lower jaw or an over growth of the upper jaw, or a combination of the two. Class II cases are commonly genetically inherited and can be aggravated by environmental factors such as thumb sucking.
- Class III: The lower first molar is anterior or more towards the front of the mouth than the upper first molar. In this abnormal relationship the lower teeth and jaw project further forward than the upper teeth and jaws. There is a concave appearance in the profile with a prominent chin. Class III problems are commonly due to an overgrowth in the lower jaw or undergrowth of the upper jaw or a combination of the two. Like Class II, Class III is genetically inherited. Orthodontia may help relieve the class III biting relationship, but often surgery is required to shorten the lower jaw.

Viewpoints

The classification system founded by Angle represented a milestone in the dental profession, because for the first time the concept of diagnostic arrangement based on science was discussed and it opened the way to etiological research of malocclusions. Angle was firmly persuaded that the upper first molars always erupted in a fixed, constant position on the facial bulk, “Upper first molar as basis of diagnosis in orthodontia,” thereby making a set classification system that could be used univer-

KEY TERMS

Anterior—Towards the front.

Etiology—The study of the origin.

Malocclusion—The relationship of the molars is not right, known as a “bad bite.”

Orthodontia—The science of studying malocclusions of the mouth.

Posterior—Towards the back.

sally. This viewpoint was not accepted by a few other dentists, primarily J.N. Farrar, who refused to think this system was correct or would work in dentistry. Many other American dentists grasped this new idea of classification and a new age in orthodontia began.

It took some years for other nations of the world to grasp this system, but American universities began teaching it soon after it was introduced, with the first school of orthodontics established in 1905 by Edward Angle. Many Italian universities have yet to employ this basic system. Japan, England, and many other countries use this method of classification of the teeth, making it an international system for malocclusion in dentistry.

Professional implications

The classification of the teeth for malocclusion has given dentists and orthodontists a much simpler way to diagnose malocclusions. Using this classification system of the teeth universally keeps dentists and orthodontists from getting confused about bite relationships and malocclusion, and facilitates the sharing of information concerning these subjects.

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ORGANIZATIONS

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<<http://www.aaortho.org>>.

The American Board of Orthodontics, 401 N. Lindbergh Blvd., Ste. 308, St. Louis, MO 63141. (314) 432-6130.

E-Mail: amboard@earthlink.net.

<<http://www.americanboardortho.com>>.

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Robert S. Quinn, Orthodontic Specialist, 450 Sutter Street #1715, San Francisco, CA 94108. (415) 433-4045.

<<http://www.drrobquinn.com>>.

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Cindy F. Ovard, RDA

Climacteric see **Menopause**

Clinical laboratories see **Medical laboratories**

Clinical laboratory science see **Medical laboratory technology**

Clinical nurse specialist

Definition

Clinical nurse specialists (CNSs) are licensed registered nurses with additional master's or doctorate level training in CNS. These **advanced practice nurses** are clinical experts in theory-based or research-based nursing, focusing on specific specialty areas.

Description

A CNS is an advanced practice nurse. There are four categories of advanced practice nurses: nurse practitioners, certified nurse-midwives (CNMs), clinical nurse specialists, and certified **registered nurse** anesthetists. Advanced practice nurses typically are registered nurses (RNs) who have gone on to complete master's degree programs. CNSs have broadened patient care roles because of their advanced training and often provide direct patient care without supervision by a doctor. Sometimes, they have the authority to prescribe medications. This authority is granted on the state level and varies from state to state.

CNSs assume many roles within the health care delivery system. While many are in the clinical setting, others also work as educators, administrators, consultants, researchers, change agents, and case managers. CNSs can become specialized in the areas of adult psychiatry, child psychology, community health, home health, gerontology, and medical-surgical, as well as oncology, perinatal critical care, critical care, and rehab. Some in areas of specialty certification classify themselves as CNSs, and others use the umbrella term of advanced practice nursing. There are all kinds of other

KEY TERMS

Certified nurse-midwives (CNMs)—Advanced practice nurses who provide prenatal and gynecological care to healthy women. These nurses deliver babies in all types of settings and offer postpartum care.

Certified registered nurse anesthetists—An advanced practice nurse who administers anesthesia as sole providers or as part of health care teams.

Charge agents—Nurses who work to make changes within systems to improve the delivery of clinical care.

Nurse practitioner—An advanced practice nurse delivering front-line primary and acute care.

certifications, including those of **wound care** nurses, case managers, and administrators, that CNSs might earn in addition to the certification as CNS.

In March 2000, the number of RNs prepared to practice in at least one advanced practice role was estimated to be 196,279, which is about 7.3% of the total RN population. The largest group among the advanced practice nurses was the nurse practitioners, followed by the CNSs. These two groups together made up about 80% of all advanced practice nurses. There were about 54,374 CNSs (up from 53,500 in 1996), which does not include those who were certified as both nurse practitioners and CNSs. While about 36.9% of the CNSs were employed in nursing, only about 24% were practicing under the position title of CNS. Nearly a quarter of CNSs reported working in **nursing education** positions.

Work settings

The work settings of CNSs include all those settings where one would find nurses and other health care providers. CNSs work in the acute care, long-term care, and intermediate care settings. They work in clinical education within health care facilities, as well as in nursing education programs as faculty teaching nursing. Other settings in which CNSs work include outpatient and ambulatory care, private practice, home health, physician office practice, subacute care, government or military service, community health centers, health care administration, private industry (working for drug companies or manufacturers, in managed care, and other areas of the private sector), and nurse-managed centers, which are health centers completely run by nurses. Within these

categories, CNSs work in assisted living facilities; specialized hospital areas, such as **cardiac catheterization** labs; correctional facilities; dialysis units; parish nursing; and psychiatric hospitals.

Education and training

First of all, nurses must have a baccalaureate degree, or its equivalent, to enroll in a CNS program. To use the title of CNS, the nurse must have a minimum of a master's degree from an education program that prepares CNSs. The training is graduate-level education. Some universities have a fast track program whereby they will accept individuals who do not have a baccalaureate and move them into a master's program. CNSs also take a certification exam in a specialty, offered by one of the nationally recognized certification entities.

CNS students go through advanced theory and practice training, revolving around the three areas of influence, that impact on direct patient care, others supervising direct patient care, and patient care systems. The general areas of learning that are included in this graduate education are theoretical foundations; phenomena of concern; assessment and intervention/design and development; clinical inquiry; technology, products, and devices; teaching and coaching; change, persuasion, influence, and negotiation; systems thinking, consultation theory; measurement; and evaluation methodologies. Under the umbrella of theory, CNSs learn to understand health, illness, and wellness as subjective experiences. They also learn to understand health behavior and health behavior change, as well as the theories of learning, **stress**, consultation, and organizational development. On the clinical side, CNSs focus on awareness, knowledge, and skill in cognitive work in the three spheres of influence. They learn about technology, products, and devices, as well as how to teach and coach patients and other health care providers.

The American Nurses Credentialing Center certifies CNSs as adult psychiatric, child psychology, community health, home health, gerontology, and medical-surgical CNSs. There also are other certifying bodies, including the rehabilitation nursing certification board, oncology nursing certification corporation, and American association of critical care nurses certification.

Advanced education and training

The master's-prepared clinical specialist can go on to get a doctorate. Each certifying body has its own requirements for recertification. State licensing boards may also have continuing education requirements.

The CNS at the doctoral level typically focuses on research. Although there is a research component to the masters, the doctorate training, more often than not, is a research degree.

Future outlook

The outlook is good for all types of nurses, especially those at the RN level or higher. It is projected that if current trends continue, demand will exceed supply of RNs by about 2010. It is possible that as many as 114,000 jobs for full-time-equivalent RNs are going to go unfilled nationwide by 2015. This is due to a growing elderly population with mounting health care needs, an aging RN workforce, the expansion of primary care, and technological advances that require more highly trained nurses.

Resources

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American Association of Colleges of Nursing. One Dupont Circle, NW, Suite 530. Washington, DC 20036. (202) 463-6930. <<http://www.aacn.nche.edu>>.

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Lisette Hilton

Cloning see **Genetic engineering**

Clotting disorders see **Bleeding disorders**

CNS stimulants see **Central nervous system stimulants**

Coagulation disorders see **Bleeding disorders**

Coagulation tests

Definition

Hemostasis has been described as “a process by which the body spontaneously stops bleeding and maintains **blood** in the fluid state within the vascular compartment.” There are at least four major systems that are involved in this complex process: the vasculature system, the platelets, the fibrin-forming system, and the fibrin-lysing system. Hemostasis has also been further segregated into stages or steps. These are primary hemostasis, which is the interaction of the injured blood vessel and platelets; secondary hemostasis, which is referred to historically as the **blood coagulation** process; and tertiary hemostasis, which is the process of fibrinolysis (clot destruction). The first two stages are assessed by blood coagulation tests that evaluate platelets, circulating coagulation factors, and **blood vessels**.

Purpose

Coagulation tests are performed to aid in the diagnosis of **bleeding disorders**, monitor the effectiveness of anticoagulant therapy, and confirm a patient’s blood clotting status prior to surgery.

Precautions

Before administering the test, the patient should be asked to list the medications he or she is taking, and whether or not he or she has recently experienced active bleeding, acute **infection** or illness, or undergone a blood transfusion, as these factors could adversely affect their coagulation test results. Some of the medications that can affect coagulation results include **antacids**, **antibiotics**, anticoagulants, **antihistamines**, aspirin, diuretics, nicotine, **nonsteroidal anti-inflammatory drugs**, oral contraceptives, steroids, tranquilizers, and **vitamins C** and **K**. If a patient is currently being medicated, the testing facility should be contacted to determine the acceptability of the blood sample. From the moment the blood specimen is drawn until the test is completed, the handling of the specimen is critical in coagulation studies. Assuming that the specimen is drawn correctly, the following procedures should be followed.

Collection of blood for coagulation tests

There is a generally held belief that the first tube in a case where multiple specimens are drawn should never be used for any hemostasis assay, because tissue thromboplastin from the initial venipuncture may affect coagulation test results. In addition, the tube(s) for coagulation

testing should be filled before any tubes containing EDTA. If coagulation tests are the only studies ordered, a discard tube should be drawn before filling the blue-stoppered citrate tube used for the tests.

Anticoagulant for coagulation tests

The anticoagulant of choice for coagulation testing is sodium citrate, which reversibly chelates **calcium**. Evacuated blue-top tubes containing sodium citrate are available commercially with a 3.8% (129 mmol/L) or 3.2% (109 mmol/L) citrate concentration. Blue-stoppered tubes are manufactured to draw nine parts of whole blood to one part of liquid sodium citrate already present in the tube. Thus, when using an evacuated system, blood must be allowed to flow into the tube until it stops automatically. This provides for the 90% fill ratio required for coagulation testing. Ideally the plasma specimen is tested within four hours of collection. If this is not possible then the samples should be frozen until testing. Gross hemolysis is usually a criterion for sample rejection.

Description

The first or primary event that stops bleeding from a very small wound is the formation of a platelet plug, which seals the hole in the vessel wall. This is followed by arteriolar vasoconstriction. The plug in turn is strengthened by fibrin strands. Exposure to collagen and subendothelial components is thought to be the trigger that causes the platelets to aggregate and form the primary plug. Aggregation has been proven to be dependent on the Von Willebrand factor and other plasma factors, such as ADP release from lysed red cells or platelets after exposure to collagen. A defect in one of these plasma factors, a qualitative defect in platelets, a reduced number of platelets (thrombocytopenia), or a defect in the blood vessel wall can result in failure of the primary hemostatic stage, causing spontaneous bleeding or purpura.

The blood clotting or coagulation system is a proteolytic cascade. Each enzyme of the pathway is present in plasma in an inactive (zymogen) form, which, when activated, releases the active factor from the precursor molecule. An active factor then “switches on” the next factor. The mechanism functions as a series of positive and negative feedback loops to effectively control the process. The main aim of this process is to produce thrombin, which can convert soluble fibrinogen into insoluble fibrin, thus forming the clot.

There are three phases of coagulation, the intrinsic and extrinsic (tissue factor) pathways that provide alternative routes for the generation of factor X and the final common pathway that results in thrombin formation. The distinction between the intrinsic and extrinsic pathways

is important for understanding the laboratory tests of coagulation. It is not relevant for the real-life process of blood clotting in the body, which may involve both pathways to different extents. Experts are unclear as to which pathway is involved in venous thromboembolic diseases such as deep vein thrombosis and pulmonary embolism.

Bleeding disorders

According to the cascade theory, each coagulation factor is converted to its active form by the preceding factor in a series of biochemical chain reactions. If there is a deficiency of any one of the factors, coagulation cannot proceed at a normal rate, initiation of the next reaction is delayed, and the time required for clotting is prolonged, resulting in bleeding from injured vessels for a longer time. Bleeding disorders can be either acquired or inherited (congenital). Von Willebrand’s disease is the most common hereditary coagulation disorder; it results in problems with platelet quality and can cause mild to moderately severe bleeding. Inherited disorders also include **hemophilia** A and B, which are associated with a decrease in factor VIII or IX activity, respectively. Because the **liver** produces many of the coagulation factors, diseases that affect the liver may be associated with clotting abnormalities. Disseminated intravascular coagulation (DIC), anticoagulant therapy, and thrombocytopenia also increase bleeding tendencies.

There are several tests available to aid in the diagnosis of bleeding disorders and monitor anticoagulation therapy, and the most common are listed below.

Platelet count

Platelets are disk-shaped structures formed by the detachment of cytoplasm from megakaryocytes. They aid in the coagulation process by attaching or adhering to the walls of injured blood vessels, where they stick together to form the initial platelet plug. A low platelet count may occur in patients with **AIDS**, viral infections, lymphoma, and lupus erythematosus, or in patients taking certain drugs, most notably quinine and quinidine. Decreased platelet production is also a cause of thrombocytopenia, and may be due to aplastic anemia, leukemia, lymphoma, or bone marrow fibrosis.

When collecting a specimen for a platelet count, EDTA is the anticoagulant of choice. The test is most commonly performed on an automated instrument which employs impedance measurement to count platelets, red blood cells, and white blood cells. Impedance counting is also known as the Coulter principle. According to Beckman Coulter, a major manufacturer of cell counters, the methodology works as follows: “A small opening (aperture) between electrodes is the sensing zone through

which suspended particles pass. In the sensing zone each particle displaces its own volume of electrolyte. Volume displaced is measured as a voltage pulse; the height of each pulse being proportional to the volume of the particle. Several thousand particles per second are individually counted and sized with great accuracy.” Automated cell counters also report the Mean Platelet Volume (MPV) or Platelet Distribution Width (PDW), two indices used to determine the relative size of the platelets being counted. Since a variety of factors can affect results (e.g., fibrin clots in EDTA blood, platelet clumping in capillary samples), a platelet estimate can also be performed to verify count accuracy. This is done by counting the platelets seen on a blood film by microscopic examination. Each platelet seen per field is estimated to be equivalent to 20,000 platelets/ μL . This means 10 platelets per field would correspond to a platelet count of 200,000/ μL . When results are questionable, manual platelet counts may be performed using light or phase contrast microscopy. The procedure is as follows: the sample is first treated with 1% ammonium oxalate counting fluid, then charged into a Neubauer hemacytometer chamber. The chamber is placed in a moist Petri dish for 10 minutes to allow the cells to settle. The chamber is then placed on the **microscope** platform and the platelets in the 25 small center squares of the chamber grid are systematically counted. The number obtained is multiplied by 1,000 to give the platelet count per microliter of blood.

Thrombin time

This test is used to screen for abnormalities in the conversion of fibrinogen to fibrin. These may be caused by qualitative or quantitative abnormalities of fibrinogen or by inhibitors, such as heparin or fibrin/fibrinogen split products. The principle of the thrombin time test is that the exogenous addition of thrombin to plasma converts fibrinogen to fibrin and bypasses both the intrinsic and extrinsic pathways. The time it takes for the patient’s plasma to clot on addition of thrombin, referred to as the thrombin time, is a function of fibrinogen concentration. The test procedure involves adding one part of a known concentration of thrombin to one part of the patient’s citrated plasma and the clotting time is recorded. A reference range should be established by each testing facility, but a range of 14.0 to 20.0 seconds is considered normal.

Prothrombin time (PT)

The PT measures the function of the extrinsic and common pathways of the coagulation cascade. A reagent containing tissue thromboplastin (factor III) of rabbit **brain** origin and calcium is commonly used as an activating substance. Factor III (thromboplastin) initiates the

extrinsic pathway by forming a complex with factor VII. Calcium is needed to replace the plasma calcium that was chelated by the citrate in the blood collection tube. The PT is timed from the moment that the reagent is added to the plasma until the sample clots. As the factor VII-tissue thromboplastin complex activates factor X, the coagulation cascade proceeds into the common pathway. After formation of thrombin, fibrin will form at a normal rate only if factors involved in the extrinsic pathway (VII) and common pathway (X, V, II, I) are present in adequate amounts. If the PT is normal, then the sample contains adequate levels of factors VII, X, V, II, and I.

The PT test is used to (1) screen for hereditary or acquired factor deficiencies in the extrinsic/common pathway (i.e., VII, X, V, II, I), (2) screen for specific factor or non-specific inhibitors (such as the lupus anticoagulant), (3) monitor anticoagulant therapy with **vitamin K** antagonists such as Coumadin and warfarin, and (4) assess the effect of vitamin K deficiency, which is an index of liver damage in patients with chronic liver disease.

The results of the PT depend on the source and preparation of the thromboplastin reagent used, the instrumentation selected to perform the test, and the handling of the patient’s sample. The PT may be reported as the clotting time in seconds or as the INR (international normalized ratio). The INR is preferred to the clotting time measured in seconds because different thromboplastin reagents have different sensitivities to warfarin-induced changes in levels of clotting factors. Since the potency of different commercially prepared calcium-thromboplastin reagents varies, the International Sensitivity Index (ISI) was developed to describe the relative strength of each reagent. This index is a measure of the sensitivity of the thromboplastin used in PT assays. The higher the ISI, the less sensitive the thromboplastin. The INR is calculated by dividing the patient PT value by the established mean PT value of the normal population in each testing facility. This value is then raised to the power of the ISI. Use of the INR eliminates the interlaboratory variation seen with prothrombin times measured in seconds.

Activated partial thromboplastin time (aPTT)

The aPTT measures the function of the intrinsic and common pathways of the coagulation cascade. To begin the test, a reagent containing a contact activator (cephalin) and a phospholipid substitute for platelet factor III is incubated with the patient’s platelet-poor plasma. During this incubation period, the intrinsic pathway is initiated by conversion of XII to XIIa, which then converts XI to XIa. The cascade does not proceed any further, since the subsequent conversion of IX to IXa

requires calcium ions. At this point, calcium is added as a second reagent. After recalcification, fibrin will form at a normal rate only if the factors involved in the intrinsic pathway (prekallikrein, high molecular weight kininogen [HMWK], XII, XI, IX, VIII) and common pathway (V, X, II, I) are present in adequate amounts. This rate of clotting measures the overall coagulant activity. The term “partial” in aPTT is used because platelet substitutes (the phospholipid emulsion) are not capable of activating the extrinsic pathway. This requires “complete” thromboplastin (tissue factor). Thus, the aPTT bypasses the extrinsic pathway and is unaffected by any abnormalities of factor VII. The aPTT is used to (1) screen for hereditary or acquired deficiencies of factors in the intrinsic/common pathway (i.e., all factors except VII and XIII), (2) screen for specific factor or non-specific inhibitors (such as the lupus anticoagulant), and (3) monitor anticoagulant therapy with parenteral heparin. Intrinsic coagulation disorders are apparent when the aPTT is prolonged and the prothrombin time is normal. For screening purposes, the aPTT is usually done in combination with other tests, such as the prothrombin time, which evaluates the factors of the extrinsic pathway. The combination of tests narrows the list of possible missing or defective factors. Results of the aPTT are prolonged by factor VIII deficiency (Hemophilia A) and factor IX deficiency (Hemophilia B). When the aPTT test is being used to monitor the effect of heparin, the test is done before the first dose of heparin and then as necessary to monitor therapeutic dosage. The activated clotting test (ACT) may be used in place of the aPTT to monitor heparin therapy. This test is performed by adding kaolin, (a clay that activates factor XII), or other clotting activator to the patient’s plasma and measuring the time required for clot formation.

Bleeding time test

The bleeding time (BT) is defined as the time between making a small incision through a skin capillary and the moment the bleeding stops. It is an *in vivo* measurement of platelet participation in small blood vessel hemostasis, and is one of the simplest and best tests of overall platelet function. This test is used to determine how well platelets interact with the blood vessel wall to form a blood clot. The test is usually performed on patients who have a history of prolonged bleeding after cuts, or who have a family history of bleeding disorders, or as a preoperative test to determine a patient’s likely bleeding response during and after surgery. There are four methods used: the Ivy method, template, modified template, and Duke method. With all methods the skin is cut in an area void of visible veins. The time from when the incision is made until all bleeding has stopped is

measured and recorded as the bleeding time. Every 30 seconds, filter paper or a paper towel is used to draw off the blood. The test is finished when bleeding has stopped completely.

Fibrinogen

The fibrinogen test aids in the diagnosis of suspected clotting or bleeding disorders caused by fibrinogen abnormalities which include the absence of fibrinogen, low fibrinogen concentration, or functionally abnormal fibrinogen. Reduced fibrinogen levels can be found in liver disease, **prostate cancer**, lung disease, bone marrow lesions, malnutrition, and certain bleeding disorders. Obstetric complications or trauma may also cause low levels. Patients who have received multiple blood transfusions may exhibit low fibrinogen levels because banked blood does not contain fibrinogen. Fibrinogen levels are also decreased in approximately 50% of patients with disseminated intravascular coagulation (DIC). In this condition the coagulation process is triggered by malignancy, severe injury, sepsis (and other conditions) and continues unabated, causing systemic clots to form until coagulation factors and platelets are depleted. This process is followed by internal hemorrhage. The fibrinogen test is performed by adding thrombin to specific dilutions of the patient’s plasma and measuring the amount of time it takes for the sample to clot.

Anticoagulation therapy with low molecular weight heparin (LMWH)

The anticoagulating effects of LMWH (heparin of smaller chain length) are easier to predict than standard heparin, and LMWH is associated with a lower risk of excessive bleeding and heparin induced thrombocytopenia. However, the effects of LMWH cannot be measured using the aPTT or activated clotting test (ACT). LMWH therapy is monitored by the anti-factor Xa assay. The antifactor Xa activity of heparin has been considered important because it is relatively unaffected by the molecular weight of heparin and therefore less influenced by the effect of potent heparin antagonists which can be released from platelets. The anti-factor Xa assay measures the anti-Xa effect of LMWH whereby heparin in a citrated plasma sample combines with antithrombin, forming a complex that inhibits an excess of purified factor Xa. Measurement of the clotting activity of residual factor Xa is done by the addition of phospholipids and calcium in the presence of a substrate plasma. This substrate plasma brings to the assay an excess of AT-III and other coagulation factors, thus eliminating interferences by the factors that are already present in the plasma being tested.

KEY TERMS

Anticoagulant—A substance that suppresses or counteracts coagulation of the blood.

Coagulation—The process of blood clotting.

Coagulation cascade—The sequence of biochemical activities, involving clotting factors, that stops bleeding by forming a clot.

Coagulation factors—Substances in the blood that act in sequence to stop bleeding by forming a clot.

Coumadin—An anticoagulant taken to prevent blood clots.

Fibrin—The insoluble protein formed by the action of thrombin on fibrinogen and stabilized by the action of factor XIIIa. Fibrin forms strands that add bulk to a forming blood clot to hold it in place and help “plug” an injured blood vessel wall.

Fibrinogen—A type of blood protein called a globulin that interacts with thrombin to form fibrin.

Fibrinolytic (thrombolytic) therapy—The intravenous administration of a drug to break up a blood clot.

Hemostasis—The process the body uses to stop the flow of blood when the vascular system is damaged.

Heparin—A medication that prevents blood clots by enhancing the activity of antithrombin. The heparin-antithrombin complex inhibits the activity of factor Xa, thrombin, and other clotting factors.

International Normalized Ratio (INR)—A measurement system that standardizes the prothrombin time to help monitor anticoagulant activity for clients receiving warfarin (Coumadin) therapy. It is recommended by the World Health Organization (WHO) for more consistent reporting of prothrombin time results, as it eliminates variation in PT results between laboratories caused by differences in the sensitivity of thromboplastin reagents.

Partial thromboplastin time—A test that measures the function of the clotting factors of the intrinsic pathway.

Platelet—An irregularly shaped cell-like particle in the blood that is an important part of blood clotting. Platelets are activated when an injury causes a blood vessel to break. They change shape from round to spiny, “sticking” to the broken vessel wall and to each other to begin the clotting process.

Prothrombin—A protein in blood plasma that is converted to thrombin during the clotting process.

Thrombin—An enzyme in blood plasma that converts fibrinogen to fibrin during the last stage of the clotting process.

Thromboplastin—A tissue substance that initiates the intrinsic coagulation pathway.

Thrombus—A solid mass of blood constituents (blood clot) formed in the heart or vessels.

Complications

Other than potential bruising at the puncture site, and/or dizziness, there are no complications associated with this test.

Results

The absolute numbers that are considered normal vary from one laboratory to another. Any results reported should come with information regarding the testing facility’s normal range. The values listed below are representative of normal values. The patient’s physician is the best person to consult about a specific test level.

- Platelets: A normal platelet count ranges between 150,000 and 400,000/ μL . Platelet counts under 50,000/ μL put a patient at risk for severe bleeding, while counts below 30,000/ μL are considered critical.

- Thrombin time: Reference values for the thrombin time are 14 to 15 seconds or within five seconds of the control.
- Prothrombin time: PT results are reported in seconds and/or the International Normalized Ratio (INR). The normal range for the prothrombin time reported in seconds is between 11 and 13 seconds. Therapeutic levels for patient receiving Coumadin therapy generally are between 1.5 and 2-fold normal, or in terms of the INR, between 2.0 and 3.0.
- Activated partial thromboplastin time: The normal range is between 20 and 36 seconds. If a patient is being anticoagulated with heparin, a result approximately 1.5 to 2.5 times the normal control value is usually a therapeutic goal.
- Bleeding time: A normal bleeding time for the Ivy method is less than five minutes from the time of the incision until all bleeding from the wound has stopped.

Some texts extend the normal range to eight minutes. The normal value for the template method is eight minutes or less, while for the modified template method, up to 10 minutes is considered normal. Normal for the Duke method is three minutes or less.

- Fibrinogen: Normal reference values for fibrinogen are 200 mg/dL-400 mg/dL for adults and 125 mg/dL-300 mg/dL for newborns.

Health care team roles

Coagulation tests are ordered and interpreted by physicians (in some cases pharmacists). The samples may be collected by a nurse, physician assistant, phlebotomist, or technician. Testing is preformed by a clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) or by a clinical laboratory technician, CLT(NCA)/medical laboratory technician, MLT(ASCP).

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Victoria E. DeMoranville

Cobalain see **Vitamin B₁₂**

Code of ethics for nurses

Definition

A code of ethics is a guide for an individual or group to follow in making decisions regarding ethical issues.

Description

In the broadest sense, ethics are the principles that guide an individual, group, or profession in conduct. Although nurses do make independent decisions regarding patient care, they are still responsible to the profession as a whole in how those decisions are made. From the earliest concept of nursing, the proper behavior and conduct of a nurse was closely scrutinized. Florence Nightingale wrote of specific issues of conduct and moral behavior. The Nightingale pledge that was composed in 1893 by nursing instructor Lystra Gretter includes the vow "to abstain from whatever is deleterious and mischievous and will not take or knowingly administer any harmful drug."

Over the last 100 years, nursing has evolved into a very complex professional field. Nurses are now faced with life and death decisions, sometimes on an hourly basis. Medical care has advanced to the point that new technology with its potential benefit or harm to a patient changes constantly. Although the private conduct of a nurse is no longer controlled by the employer, the effects of that lifestyle on the nurse's ability to think and respond to patients while on duty falls under the code of ethics.

Viewpoints

The study of ethics is actually a branch of philosophy. The word ethics is derived from the Greek term *ethos* which means customs, habitual usage, conduct, and character. The study of ethics has led to the identification of basic concepts including rights, autonomy, beneficence, nonmaleficence, justice, and fidelity. Understanding these concepts assists the nurse with making decisions during difficult situations.

Rights

Webster defines a right as "something to which one has a just claim or the power or privilege to which one is justly entitled." **Patient rights** have evolved to the point that federal legislation has been passed in the United States to protect a patient's individual rights. A Patient's Bill of Rights was initially developed by the American Hospital Association in 1973 and revised in 1992. All hospitals are now required by law to inform patients of these rights upon admission to the hospital.

Autonomy

Autonomy comes from the latin *auto* meaning “self” and *nomy* which means “control.” Individuals must be given the rights to assist in their own decision making. This ethical concept has led to the need for **informed consent**. Sometimes patients’ religious or cultural beliefs lead them to make decisions regarding their own care that may seem controversial or even dangerous. However, the concept of autonomy gives them the right to make those decisions unless they are mentally impaired.

Beneficence and nonmaleficence

Beneficence means to do good, not harm, to other people. Nonmaleficence is the concept of preventing intentional harm. Both of these ethical concepts relate directly to patient care. In the American Nurses Association Code for Nurses, there is a specific charge to protect patients by specifying that nurses should report unsafe, illegal, or unethical practices by any person. Nurses are often faced with making decisions about extending life with technology, which might not be in the best interest of the patient. Often the concept of weighing potential benefit to the patient against potential harm is used in making these difficult decisions, along with the patient’s own stated wishes.

Justice

The word justice is closely tied with the legal system. However, the word refers to the obligation to be fair to all people. In 2001, healthcare economics have hospitals and other providers stretching their resources to their limits. Economic decisions about healthcare resources have to be made based on the number of patients who would benefit. The potential of rationing care to the frail elderly, poor, and disabled creates an ethical dilemma that is sure to become even more complicated in the future.

Fidelity

Fidelity refers to the concept of keeping a commitment. Although the word is more closely used to describe a marital relationship, fidelity is the concept of accountability. What is the nurse’s responsibility to his or her patient, employer, society, or government? Privacy and confidentiality are concepts that could be challenged under the concept of fidelity. If a nurse is aware of another healthcare giver who is impaired, but the circumstances are private or confidential, how is the conflict resolved?

Professional implications

As a general rule, nurses are employed by a hospital, clinic, or private practice. Decisions that are made about patient care are not totally independent. Every decision creates a ripple effect and touches someone else in the health care field. One of the purposes of a code of ethics is to help nurses keep perspective and a balanced view regarding decisions. One way to study a code of ethics is to look at a case study.

J. L. presents herself to the emergency room with lower right abdominal **pain**. J. L. is a 17-year-old white female and is accompanied by her mother. J. L.’s mother is a nurse and works in another department of the hospital. The mother signed all of J. L.’s admission paperwork and received the Patient Bill of Rights. Although J. L.’s pain does not seem severe enough for **appendicitis**, she does have a history of **fever** for 24 hours and her temperature in the hospital is 100.8°F (38°C). An ultrasound that did not show appendicitis had been done earlier in the day. She was told to report to emergency room if the fever rose. After J. L. reports her symptoms to both a nurse and a physician assistant, she is examined briefly by emergency department physician. The staff assumes that J. L.’s mother wants to stay in the room and does not seek the patient’s permission. As a part of her history, J. L. informs them she is not sexually active and is on the second day of her menstrual cycle. The mother can tell by the tone of questioning that the staff does not believe J. L. is still a virgin. After a two-hour delay, including having to repeat the **urinalysis** because of a lost specimen, the emergency physician decides a pelvic exam needs to be done. The pelvic exam is traumatic for the patient, despite her mother’s best efforts to calm her. J. L. is told in a condescending tone that the exam hurts because of her failure to relax. Following the exam, the physician tells J. L. and mother that her **blood** count is normal, the urinalysis was inconclusive because of menstrual blood, and the patient was uncooperative in giving a catheterized specimen.

J. L. and her mother were informed a **pregnancy test** was done, because the staff have experienced “immaculate conceptions” in their department. The only time that J. L. and her mother had contact with an RN during this time was when she was initially triaged and when the discharge instructions were handed to her mother. J. L. and her mother were sent home with instructions. Her pain subsided without treatment.

Although this case study is not one of life and death decision making, there were numerous violations of the patient’s rights and of the nursing code of ethics. The patient’s right to privacy was violated. It is questionable whether the patient (J. L.) ever saw the Patient’s Bill of

KEY TERMS

Beneficence—The obligation to do good, not harm, to other people.

Ethics—A specific area of study of morality, which concentrates on conduct and human values.

Maleficence—The act of intentionally doing harm or evil. Nonmaleficence is the principle of purposefully not doing harm.

Rights, since it was given to her mother. J. L. was sexually inactive and a virgin, so the question of nonmaleficence is raised by the traumatic pelvic exam. The question of abandonment is also raised due to lack of nursing attention. If J. L. had asked her mother to leave during the exams, could confidentiality have been breached by the mother the next day by checking the hospital computer for reports? The answer to all of the above questions is *yes*; areas of nursing code of ethics could have been broken. No one died, but there must be constant re-education of staff regarding the importance of these issues.

In an attempt to keep the concept of ethical care in the forefront of nurses, physicians, and other healthcare worker's minds, hospitals have ethics committees or even an ethicist on staff. Special educational seminars may be offered or actual case studies reviewed. Some hospitals have protocols for requesting an ethics consult at the bedside. These type of consults are usually seen in ICU or trauma situations where ceasing life support is being discussed.

A new area of potential ethical dilemma was discussed in the July 2, 1999, *Online Journal of Issues in Nursing*. Silva and Ludwick discussed the pros and cons of interstate practice laws. As new laws are passed that allow more fluid movement of nurses between states, new issues of ethical behavior may arise. The initial reaction of most people in the health care field is that a nurse practices the same way everywhere, but there are subtle differences in the laws between states. For example, there are different definitions of minors and when minors can be emancipated to make their own decisions. Are there differences in state laws regarding patients with impaired decision-making capabilities? What if the nurse is not aware of the subtle differences in each state's law?

Communication technology such as the Internet is also complicating ethical issues. Do web sites that encourage patients to describe symptoms to on-line nurses expose too great a risk? What backup mechanisms are

in place if a patient talking to a triage nurse gets disconnected or loses consciousness? How can there be assurances of confidentiality in a telenursing setting? Silva and Ludwick encouraged their readers to "be proactive and stimulate critical thinking about ethics and interstate practice."

A nursing code of ethics cannot remain a stagnant document. As new issues arise in nursing and healthcare practice, they must be addressed and possibly included in a formal statement. The American Nurses Association (ANA) Code for Nurses with Interpretive Statements was approved in 1985 and was still being used in mid-2001. A task force met in 1996 and began the process of reviewing and revising the code. A draft of the new code is anticipated to be approved and released in 2001. The new code is more comprehensive than the 1985 code. It is the responsibility of all professional nurses to be aware of the Code for Nurses and any changes that may be made in the future. It is also the responsibility of each individual nurse to practice ethical care on a daily basis.

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Cognitive-perceptual rehabilitation

Definition

Cognitive-perceptual rehabilitation addresses the impairments, functional limitations, and disabilities that result from a deficit in cognition or perception. Cognition

refers to the mental processes of comprehension, judgment, **memory**, and reasoning. Perception is part of the cognitive process, and is characterized by the conscious recognition and interpretation of sensory stimuli for knowledge or motivation of action.

Purpose

Individuals who have neurological insult (trauma to the **brain**), whether mild or severe, may experience cognitive and perceptual difficulties. Researchers have found that 75–90% of children with learning disabilities present with motor difficulties, which often are accompanied by perceptual deficits. In one study, over half of patients admitted for cognitive rehabilitation due to **head injury** also presented with visual perceptual impairments. In addition, individuals who have experienced strokes or inflammatory or infectious brain diseases, such as **meningitis** or encephalitis, are at risk for perceptual and cognitive disorders.

Cognitive and perceptual rehabilitation is indicated when a patient or client presents with deficits in these areas during the medical, **physical therapy**, or **occupational therapy** assessment. Difficulties may appear in equilibrium and vestibular functions, automatic postural reactions, fine and visual motor performance, motor planning abilities, and/or sensory integration. The individual may remember events incorrectly and have difficulty perceiving new information. In addition, he or she may have inappropriate responses to sensory input due to deficits in sensory processing.

Unilateral spatial inattention, a visual perceptual dysfunction occurring most frequently in patients who have had a stroke, traumatic brain injury, or tumor, may be detected by asymmetries in performance. For example, in drawing a clock, the individual may place all of the numbers on the right half of the clock only. When an individual has visual, auditory, or tactile agnosia, he or she is unable to recognize and name a common object using one of the senses of sight, **hearing**, or touch, respectively. Visuospatial disorders are manifested by the inability to discern spatial relationships. Visuoconstructive disabilities occur when an individual is unable to synthesize parts into a whole, such as building a tower from blocks or copying a line drawing. Vestibular impairments may present as dizziness or imbalance with certain movements or head positions. Many standardized tests exist to assess perceptual performance in children or adults.

Description

Intervention is found in either direct therapy or indirect therapy. Direct therapy usually focuses on the par-

ticular tasks or skills to be learned, with compensatory behaviors filling in for abilities that are missing. In contrast, indirect therapy focuses on rehabilitating the underlying dysfunction of the **central nervous system** (CNS), in hopes that improvement of the dysfunction will transfer to skill attainment.

Sensory integration and motor control approaches are considered indirect therapies. Sensory integration is an approach, used often with children, in which sensory input is provided within the context of a meaningful activity, usually play-related. The goal is that the child will display appropriate responses and gain experience in organization of sensory input. When using the motor control approach, task-oriented behavior is practiced to enhance perceptual information from the feedback and feedforward mechanisms in the CNS. Verbal and visual cues, in addition to varying the practice situation, are all used to assist in facilitating appropriate performance that can be applied to a variety of situations.

An example of direct therapy is functionally relevant motor skill training. Balance, locomotion, body awareness, and eye-hand coordination tasks are practiced in the context of activities of daily living, e.g., tying a shoe. Tasks are broken down into simple parts, then as a whole, and practiced in a variety of ways for carryover to different situations. Visual perceptual rehabilitation usually takes the form of direct therapy as well. Clients are trained to use eye and head movements along with visual markers to scan their environment, compensating for unilateral spatial inattention. Clients with visuospatial and visuoconstructive disorders are trained by progressing from simple to more complex tasks, using verbal, proprioceptive, and vestibular input to aid in performing the tasks. Treatment of vestibular impairments takes place in a similar fashion. The patient is habituated to certain head movements through practice, then is progressed to more complex ones as tolerance increases.

Cognitive **prosthetics**, another form of direct therapy, may be used in the rehabilitation of an individual with impairments in brain processes. Prosthetics, in the form of computer technology, are used to compensate for the individual's impairments by altering the environment for optimum function. Highly individualized computer software is used to provide an individual with the support necessary to successfully perform tasks of daily living. For example, it may sequence steps of a task, or convert written words to pictures or speech.

Regardless of the interventions selected, the underlying strategies for working with an individual who has cognitive-perceptual dysfunction are similar. Goals should be clear and relevant to the patient to reduce con-

KEY TERMS

Feedback—Peripheral sensory input which indicates a need for correction of errors.

Feedforward—The use of previous motor learning to anticipate errors in movement planning, allowing for advance correction.

Proprioceptive—Pertaining to sensations of body movements and position.

Sensory integration—The processing and organization of sensory input.

Unilateral spatial inattention—Perceptual unawareness of stimuli on one side of the body, associated with a cortical or subcortical lesion in the opposite side of the brain.

Vestibular—Pertaining to the inner ear structures associated with balance and position sense.

fusion and increase motivation. In the beginning, the complex should be broken down into simple parts with verbal, visual, tactile, or other cues provided as necessary. Distractions in the environment should be decreased at first. As progress is made, tasks then move toward more complexity.

Results

Progress may be slow, depending upon the severity of disability, individual motivation, family support, etc. The desired outcome, however, is that the individual learns to better modulate and discriminate sensory input in order to process it and respond to it appropriately. This may occur as an actual change in neural function, or through the use of compensatory measures. An increase in functional ability and reduction in disability are the ultimate goals.

Health care team roles

Cognitive-perceptual rehabilitation truly requires a transdisciplinary approach. Any or all of the following individuals may be involved, depending upon the specific needs of the individual: family physician, neurologist, psychiatrist, ophthalmologist, otologist, psychologist, occupational therapist, physical therapist, speech and language pathologist, recreational therapist, and vocational education specialist.

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Cold injuries

Definition

Cold injuries include frostbite and frostnip. Frostbite is the term for damage to skin and other tissues caused by freezing. Frostnip is a milder form of cold injury.

Description

In North America, frostbite is largely confined to Alaska, Canada, and the northern states. However, it can occur whenever people are exposed to sustained cold temperatures without proper protection. Recent years have witnessed a substantial decline in the number of cold injury cases, probably for several reasons, including better winter clothing and footwear and greater public understanding of how to avoid cold-weather dangers. At the same time, the nature of the at-risk population has changed. Increased numbers of homeless people have made frostbite an urban as well as a rural **public health** concern. The growing popularity of outdoor winter activities has also expanded the at-risk population.

Causes and symptoms

Frostbite

Skin exposed to temperatures slightly below the freezing mark can take hours to freeze, but very cold temperatures can freeze skin in minutes or seconds. Air temperature, wind speed, and moisture all affect how rapidly skin becomes cold. A strong wind can lower skin temperature considerably by dispersing the thin protective layer of warm air that surrounds human bodies. Wet clothing readily draws heat away from skin because water is a potent conductor of heat. The evaporation of moisture from the surface of skin also produces cooling. For these reasons,

wet skin or clothing on a windy day can lead to frostbite even if the air temperature is above the freezing mark.

The extent of any permanent injury, however, is determined not by how cold skin and underlying tissues become but by how long they remain frozen. Consequently, homeless people and others whose self-preservation instincts may be clouded by alcohol or psychiatric illness face a greater risk of frostbite-related health effects because they are more likely to stay out in the cold when prudence dictates seeking shelter or medical attention. Alcohol and smoking also affect **blood** circulation in the extremities in a way that can increase the severity of injury. A review of 125 Saskatchewan frostbite cases found a tie to alcohol in 46% and to psychiatric illness in 17%. Other risk factors identified by researchers include inadequate clothing, previous cold injury, fatigue, wound **infection**, atherosclerosis, and diabetes. Driving in poor weather can also be dangerous. Vehicular failure was a predisposing factor in 15% of the Saskatchewan cases.

Three nearly simultaneous physiological processes underlie frostbite injury: tissue freezing, tissue hypoxia, and the release of inflammatory mediators. Tissue freezing causes the formation of ice crystals and other changes that damage and eventually kill cells. Much of this harm occurs because the ice produces pressure changes that cause water (crucial for cell survival) to flow out of cells. Tissue hypoxia (oxygen deficiency) occurs when **blood vessels** in the hands, feet, and other extremities narrow in response to cold. Among its many tasks, blood transfers body heat to skin, which then dissipates the heat into the environment. Blood vessel narrowing is the body's way of protecting vital internal organs at the expense of the extremities by reducing heat flow away from the core or center portions of the body. However, blood also carries life-sustaining oxygen to skin and other tissues, and narrowed vessels result in oxygen starvation. Narrowing also causes acidosis (an increase in tissue acidity) and increases blood viscosity (thickness). Ultimately, blood stops flowing through capillaries (tiny blood vessels that connect arteries and veins), and blood clots form in the arterioles and venules (the smallest arteries and veins). Damage also occurs to endothelial cells that line blood vessels. Hypoxia, blood clots, and endothelial damage lead, in turn, to the release of inflammatory mediators (substances that act as links in the inflammatory process), which promote further endothelial damage, hypoxia, and cell destruction.

Frostbite is classified by degree of injury (first, second, third, or fourth), or simply divided into two types, superficial (corresponding to first- or second-degree injury) and deep (corresponding to third- or fourth-degree injury). Most frostbite injuries affect the feet or

hands. The remaining 10% of cases typically involve ears, nose, cheeks, or penis. Once frostbite sets in, an affected part begins to feel cold and usually becomes numb. This is followed by a feeling of clumsiness. Skin turns a white or yellowish color. Many individuals experience severe **pain** in the affected part during rewarming treatment. This is often followed by an intense throbbing pain that arises two or three days later and can last for days or weeks. As skin begins to thaw during treatment, **edema** (excess tissue fluid) often accumulates, causing swelling. In second- and higher-degree frostbite, blisters appear. Third-degree frostbite cases produce deep, blood-filled blisters and, during the second week, a hard black eschar (scab). Fourth-degree frostbite penetrates below the skin to the muscles, tendons, nerves, and bones. In severe cases of frostbite the dead tissue can mummify and drop off. Infection is also a possibility.

Frostnip

Like frostbite, frostnip is associated with ice crystal formation in tissues, but no tissue destruction occurs and any crystals dissolve as soon as the skin is warmed. Frostnip affects areas such as the earlobes, cheeks, nose, fingers, and toes. The skin turns pale and one experiences numbness or tingling in the affected part until warming begins.

Diagnosis

Frostbite diagnosis relies on a **physical examination** and may also include conventional radiography (x rays), **angiography** (x-ray examination of the blood vessels using an injected dye to provide contrast), thermography (use of a heat-sensitive device for measuring blood flow), and other techniques for predicting the course of injury and identifying tissue that requires surgical removal. During the initial treatment period, however, a physician cannot judge how a case will progress. Diagnostic tests only become useful between three and five days after rewarming, once the blood vessels have stabilized.

Treatment

Frostbite

Emergency medical help should always be summoned whenever frostbite is suspected. While waiting for help to arrive, one should, if possible, remove wet or tight clothing and put on dry, loose clothing or wraps. A splint and padding are used to protect an injured area. Rubbing an injured area with snow or anything else is dangerous. The key to prehospital treatment is to avoid partial thawing and refreezing, which releases more



Human hand with frostbite. (Photo Researchers, Inc. Reproduced by permission.)

inflammatory mediators and makes an injury substantially worse. For this reason, the affected part must be kept away from heat sources such as campfires and car heaters. Experts advise rewarming in the field only when emergency help will take more than two hours to arrive and refreezing can be prevented.

Because the outcome of a frostbite injury cannot be initially predicted, all hospital treatment follows the same protocol. Treatment begins by rewarming the affected part for 15–30 minutes in water at a temperature of 104–108°F (40–42.2°C). This rapid rewarming halts ice crystal formation and dilates narrowed blood vessels. Aloe vera (which acts against inflammatory mediators) is applied to the affected part, which is then splinted, elevated, and wrapped in a dressing. Depending on the extent of injury, blisters may be debrided (cleaned by removing foreign material) or simply covered with aloe vera. A tetanus shot and possibly penicillin are used to prevent infection, and the injured person is given ibuprofen to combat inflammation. Narcotics are needed in most cases to reduce the excruciating pain that occurs as sensation returns during rewarming. Except when injury is minimal, treatment generally requires a hospital stay of several days, during which **hydrotherapy** and **physical therapy** are used to restore health to the affected body parts. Experts recommend a cautious approach to tissue removal, and advise that 22–45 days must pass before a decision on amputation can safely be made.

Alternative practitioners suggest several kinds of treatment to speed recovery from frostbite after leaving a hospital. Bathing the affected part in warm water or using contrast hydrotherapy may help enhance circulation. Contrast hydrotherapy involves a series of hot and cold water applications. A hot compress (as hot as the patient can stand) is applied to the affected area for three minutes followed by an ice cold compress for 30 seconds. These

applications are repeated three times each, ending with the cold compress. Nutritional therapy to promote tissue growth in damaged areas may also be helpful. Homeopathic and botanical therapies may also assist recovery from frostbite. Homeopathic *Hypericum* (*Hypericum perforatum*) is recommended when nerve endings are affected (especially in the fingers and toes) and *Arnica* (*Arnica montana*) is prescribed for **shock**. Cayenne pepper (*Capsicum frutescens*) can enhance circulation and relieve pain. Drinking hot ginger (*Zingiber officinale*) tea also aids circulation. Other possible approaches include acupuncture to avoid permanent nerve damage and **oxygen therapy**.

Frostnip

Frostnipped fingers are helped by blowing warm air on them or holding them under one's armpits. Other frostnipped areas can be covered with warm hands. The injured areas should never be rubbed.

Prognosis

The rapid rewarming approach to frostbite treatment, pioneered in the 1980s, has proved to be much more effective than older methods in preventing tissue loss and amputation. A study of 56 first-, second-, and third-degree frostbite patients treated with rapid rewarming in 1982–85 found that 68% recovered without tissue loss, 25% experienced some tissue loss, and only 7% needed amputation. In a comparison group of 98 patients, treatment using older methods resulted in a tissue loss rate of 35% and an amputation rate of nearly 33%. Although the comparison group included a higher proportion of second- and third-degree cases, the difference in treatment results was determined to be statistically significant.

The extreme throbbing pain that many frostbite sufferers endure for days or weeks after rewarming is not the only prolonged symptom of frostbite. During the first weeks or months after a cold injury, people often experience tingling, a burning sensation, or a sensation resembling shocks from an electric current. Other possible consequences of frostbite include skin-color changes, nail deformation or loss, joint stiffness and pain, hyperhidrosis (excessive sweating), and heightened sensitivity to cold. For everyone, a degree of sensory loss lasting at least four years—and sometimes a lifetime—is inevitable.

Health care team roles

The head of most health care teams is a physician. A physician determines a plan for treatment, provides guidance, assigns tasks for other members of the team, and monitors progress. Paramedics or other persons render-

ing **first aid** are also members of the team by providing immediate or early assistance to persons with frostbite or frostnip. Nurses may provide treatment alongside physicians. Physical therapists may become involved with rehabilitation of serious cases of frostbite. Occasionally, surgeons are called upon to amputate (remove) portions of bodies that have become too severely damaged to recover from frostbite.

Prevention

With appropriate knowledge and precautions, frostbite can be prevented even in the coldest and most challenging environments. Appropriate clothing and footwear are essential. To prevent heat loss and keep blood circulating properly, clothing should be worn loosely and in layers. Covering the hands, feet, and head is also crucial for preventing heat loss. Outer garments need to be wind and water resistant, and wet clothing and footwear must be removed and replaced as quickly as possible. Alcohol and drugs should be avoided because of their harmful effects on judgment and reasoning. Experts also warn against alcohol use and smoking in the cold because of the circulatory changes they produce. Paying close attention to weather reports before venturing outdoors and avoiding unnecessary risks such as driving in isolated areas during a blizzard are also important.

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Cold sore

Definition

A cold sore is a clear, fluid-filled blister, which often appears on the lips or nose. Cold sores, also referred to as **fever** blisters, are caused by a viral **infection**, herpes simplex virus Type 1 (HSV-1).

Description

Cold sores are painful, unsightly, and often recurrent. HSV-1 often occurs on the lower face but can occur on the genitals or buttocks. Though rarely fatal, HSV-1 can be serious if cold sores occur in newborns, the chronically ill, or the elderly.

Other names for cold sores are oral herpes, labial herpes, herpes labialis, and herpes febrilis. They are different from common canker sores because they usually are on the lips, whereas canker sores usually occur inside the mouth, on the tongue, or inside the cheeks. Cold sores rarely occur inside the mouth except during the initial episode.

While there are eight types of herpes **viruses**, cold sores are only caused by HSV-1 or herpes simplex virus Type 2 (HSV-2). It is commonly believed that herpes simplex virus type 1 infects above the waist and herpes simplex virus type 2 infects below the waist. This is not completely true. HSV-1 does appear on the genitals and sometimes on other areas of the body. Nurses and other health care workers have been known to get herpetic sores after the virus has entered a break in the skin of their fingers.

Oral herpes is very common. About 50-80% (some estimates are as high as 90%) of Americans are thought to carry antibodies for HSV-1. Most people who are exposed to HSV-1 become infected but only 10% of

those people have symptoms, such as sores, and experience recurring outbreaks of the infection. Of the 50 million Americans thought to be infected with HSV-1, most acquired the virus when they were children and only about 5% are bothered enough by HSV-1 to consider it a medical problem.

Anyone can become infected by the herpes virus, and once a person is infected the virus remains latent for life. Herpes viruses are spread from person to person by direct skin-to-skin contact and, sometimes, by respiratory transmission (coughing or sneezing). The highest risk for spreading the virus is the time period beginning with the appearance of blisters and ending with scab formation. However, infected persons need not have visible blisters to spread the infection to others, since the virus may be present in the saliva without obvious oral lesions.

Viruses are different from **bacteria**. While bacteria are independent and can reproduce on their own, viruses enter human cells and force the cells to make more of the virus. The infected human cell is usually killed and releases thousands of new viruses. The cell death and resulting tissue damage causes the actual cold sores. In addition, the herpes virus can infect a cell and instead of making the cell produce new viruses, it hides inside the cells of the nervous system. This is called “latency.” A latent virus can wait inside the nervous system for days, months, or even years. At some future time, the virus “awakens” and causes the cell to produce thousands of new viruses which cause an active infection.

This process of latency and active infection is best understood by considering the cold sore cycle. An active infection is obvious because cold sores are present. The first infection is called the “primary” infection. This active infection is then controlled by the body’s **immune system** and the sores heal. In between active infections the virus is latent. At some point in the future, latent viruses become activated and once again cause sores. These are called “recurrent” infections. Although it is not known what triggers the latent virus to activate, several conditions seem to bring on infections. These include **stress**, illness, tiredness, exposure to sunlight, menstruation, fever, and diet.

Causes and symptoms

While anyone can be infected by the herpes virus, not everyone will show symptoms. The first symptoms of herpes occur within 2-20 days after contact with an infected person. Symptoms of the primary infection are usually more severe than those of recurrent infections. The primary infection can cause symptoms like other viral infections, including tiredness, headache, fever, and swollen lymph nodes in the neck.

People who experience outbreaks might have one or several blisters. Typically, 50-80% of persons who have outbreaks experience prodrome symptoms of oncoming disease of **pain**, burning, itching, or tingling at the site where blisters will form. This prodrome stage may last from a few hours, to one or two days. The herpes infection prodrome occurs in both the primary infection and recurrent infections.

In 95% of people with cold sores, the blisters occur at the outer edge of the lips, which is called the “vermillion border.” Less often, blisters form on the nose, chin, or cheek. Following the prodrome, the disease process is rapid. First, small red bumps appear which quickly form fluid-filled blisters. The painful blisters may either burst and form a scab or dry up and form a scab. Within two days of the first red bumps, all the blisters have formed scabs. The skin heals completely and without scarring within six to ten days. The virus then moves to nerve cells and remains in its resting state until the next outbreak, which can occur in the same or a nearby site.

Some children have a very serious primary (first episode) herpes infection called “gingivostomatitis.” This causes fever, swollen lymph glands, and numerous blisters inside the mouth, lips, and tongue that may form large, open sores. These painful sores may last up to three weeks and can make eating and drinking difficult. Because of this, young children with gingivostomatitis are at risk from **dehydration** (excessive loss of water from the body).

Most people experience fewer than two recurrent outbreaks of cold sores each year. Some people never experience outbreaks, while some have very frequent outbreaks, as often as every few weeks. In most people, the blisters form in the same area each time and are triggered by the same factors (such as stress, sun exposure, etc.).

Diagnosis

The typical appearance of HSV-1 often makes it an easy visual diagnosis. Health care professionals who are uncertain of the diagnosis can swab the infected area and send it to a lab for analysis. HSV-1 can be diagnosed and treated by family doctors, dermatologists (doctors who specialize in skin diseases), and infectious disease specialists. Sometimes, dentists or nurses are the first to see the signs of HSV-1. Other laboratory tests, including scrapings and **blood** tests, might be performed to look for the virus. These tests produce valid results only in the early stages of an outbreak and, sometimes, more than one test is needed.

Oral herpes may resemble a bacterial infection called “impetigo.” This skin infection is most commonly seen in

children and causes herpes-like blisters around the mouth and nose. Also, because oral herpes can occur inside the mouth, the blisters could be mistaken for common canker sores. Therefore, the doctor would need to determine whether the blisters are oral herpes, canker sores, or impetigo. The diagnosis and treatment of herpes infections should be covered by most insurance providers.

Treatment

There is no cure for herpes virus infections. There are **antiviral drugs** available, which have some effect in lessening the symptoms and decreasing the length of herpes outbreaks. There is evidence that some may also prevent future outbreaks. These antiviral drugs work by interfering with the replication of the viruses and are most effective when taken as early in the infection process as possible. For the best results, drug treatment should begin during the prodrome stage before blisters are visible. Depending on the length of the outbreak, drug treatment could continue for up to ten days or be used on an on-going basis as a method of prevention.

Acyclovir, famciclovir, and valacyclovir are oral antiviral medications developed to effectively treat herpes infections. In June 2000, the United States Food and Drug Administration approved the first over-the-counter ointment, called docosanol 10% cream, as a topical treatment for cold sores.

During an outbreak of cold sores, salty foods, citrus fruits (oranges, etc.), and other foods which irritate the sores should be avoided. The sores should be washed once or twice a day with warm, soapy water and patted gently dry. Over-the-counter lip products which contain the chemical phenol (such as Blistex Medicated Lip Ointment) and numbing ointments (Anbesol) help to relieve cold sores. Sometimes applying ice at the first sign of a cold sore diminishes the outbreak. A band-aid may be placed over the sores to protect them and prevent spreading the virus to other sites on the lips or face. Acetaminophen (Tylenol) or ibuprofen (Motrin, Advil) may be taken if necessary to reduce pain and fever.

Alternative treatment

Vitamin and mineral supplements and diet may have an effect on the recurrence and duration of cold sores. In general, cold sore sufferers should eat a healthy diet of unprocessed foods such as vegetables, fruits, and whole grains. Alcohol, **caffeine**, and sugar should be avoided.

An imbalance in the amino acids lysine and arginine is thought to be one contributing factor in herpes virus outbreaks. A diet that is rich in the amino acid lysine may help prevent recurrence of cold sores. Foods which con-

tain high levels of lysine include most vegetables, legumes, fish, turkey, and chicken. In one study, patients taking lysine supplements had milder symptoms during an outbreak, a faster healing time, and had fewer outbreaks than patients who did not take lysine. Patients should take 1,000 mg of lysine three times a day during a cold sore outbreak and 500 mg daily on an ongoing basis to prevent recurrences. Intake of the amino acid arginine should be reduced. Foods rich in arginine that should be avoided are chocolate, peanuts, almonds, and other nuts and seeds.

Vitamin C and bioflavonoids (a substance in fruits that helps the body to absorb and use vitamin C) have been shown to reduce the duration of a coldsore outbreak and reduce the number of sores. The **vitamin B complex** includes important **vitamins** that support the nervous system where viruses can hide out. B complex vitamins also can help manage stress, an important contributing factor to the outbreak of herpes viruses. Applying the oil in **vitamin E** capsules directly to cold sores may provide relief. **Zinc** lozenges appear to affect the reproduction of viruses and also enhance the immune system. Ointments containing lemon balm (*Melissa officinalis*) or licorice (*Glycyrrhiza glabra*) and peppermint (*Menthapiperita*) have been shown to help heal cold sores.

Prognosis

Oral herpes can be painful and embarrassing but it is not a serious condition. There is no cure for oral herpes but outbreaks usually occur less frequently with time. The spread of the herpes virus to the eyes is very serious. Herpes virus can infect the cells in the cornea and cause scarring which may impair **vision**. Those who are seriously ill, with compromised immune systems, are vulnerable to more severe and dangerous outbreaks.

Health care team roles

Registered nurses are often involved in helping to identify oral herpes. It is important that nurses then educate patients that cold sores caused by herpes simplex are highly contagious. Nurses need to teach patients not to touch their mouths and then other parts of their bodies, such as the eyes, because they can spread the virus to other parts of their bodies. Nurses should also inform patients that if the sore is indeed herpetic, patients might experience intense symptoms when the infection first appears and the sores and symptoms could last up to two weeks. Normally, subsequent outbreaks, if they occur, are shorter because people generally build up some immunity to the virus. Nurses should let patients know about factors, such as sun exposure, that can stimulate outbreaks, and educate them about over-the-counter and

KEY TERMS

Latent—A non-active virus that is in a dormant state within a cell. Herpes virus is latent in the nervous system.

Prodrome—Symptoms that warn of the beginning of disease. The herpes prodrome consists of pain, burning, tingling, or itching at a site before blisters are visible.

Recurrence—The return of an active infection following a period of latency.

prescription options, as well as things patients can do to alleviate their symptoms, such as applying ice at the first signs of an outbreak. While RNs educate patients about cold sores, nurse practitioners often diagnose and treat them just as a physician would.

Nurses can direct patients to many sites on the Internet that can help to answer their questions. For example, the American Academy of Dermatology at www.aad.org, www.herpes.org and www.herpeszone.com. The Herpes Resource Center, a public service of the American Social Health Association, provides educational pamphlets and a counseling line at 919-361-8488.

Prevention

The only way to prevent oral herpes is to avoid contact with those who are infected. This is not an easy solution because as many as 60% of those who are infected don't realize or admit that they may have herpes. As of 2001, there are no herpes vaccines available, although herpes vaccines, which will function to prevent infection in new patients, are being tested. The belief is that an effective vaccine is about three to five years away. Researchers are also attempting to reduce the rate of asymptomatic viral shedding to prevent transmission of the virus. Many say that a cure for herpes won't come for another seven to 10 years.

Several practices can reduce the occurrence of cold sores and the spread of virus to other body locations or people. These practices are:

- Avoidance of sun exposure to the face. Before getting prolonged exposure to the sun, apply sunscreen to the face and especially to the lips. Wearing a hat with a large brim is also helpful.
- Avoid touching cold sores. Squeezing, picking, or pinching blisters can allow the virus to spread to other parts of the lips or face, and infect those sites.
- Herpes can be transmitted via respiratory secretions, such as coughing or sneezing, so avoiding these situations is advised.
- Washing hands frequently. Persons with oral herpes should wash their hands carefully before touching others. An infected person can spread the virus to others, even when he or she has no obvious blisters.
- Avoid contact with others during active infection. Infected persons should avoid kissing and sexual contact with others until after the cold sores have healed.
- Wear gloves when applying ointment to a child's sore.
- Be especially careful with infants. Never kiss the eyes or lips of a baby who is under six months old.
- Be watchful of infected children. Do not allow infected children to share toys that may be put into the mouth. Toys that have been mouthed should be disinfected before other children play with them.
- Maintain good general health. A healthy diet, plenty of sleep, and **exercise** help to minimize the chance of getting a cold or the flu, which are known to bring on cold sores. Also, good general health keeps the immune system strong, which helps to keep the virus in check and prevents outbreaks.

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Lisette Hilton

Cold therapy *see* **Cooling treatments**

Colds *see* **Common cold**

Colon cancer *see* **Colorectal cancer**

Colonoscopy

Definition

Colonoscopy is an endoscopic (to visualize a hollow organ’s interior) medical procedure that uses a long, flexible, tubular instrument called a colonoscope to view the rectum and the entire inner lining of the colon (**large intestine**).

Purpose

A colonoscopy is generally recommended when the patient complains of rectal bleeding or has a change in bowel habits and other unexplained abdominal symptoms. The test is frequently used to look for **colorectal cancer**, especially when polyps or tumor-like growths have been detected by a **barium enema** examination and other diagnostic imaging tests. Polyps can be removed through the colonoscope, and samples of tissue (biopsies) can be taken to detect the presence of cancerous cells. In addition, colonoscopy can also be used to remove **foreign bodies**, control hemorrhaging, and excise tumors.

The test also enables physicians to check for bowel diseases such as ulcerative colitis and **Crohn’s disease** and is an essential tool for monitoring patients who have a past history of polyps or colon **cancer**. Colonoscopy is being used increasingly as a screening tool in both asymptomatic patients and patients at risk for colon cancer. It has been recommended as a screening test in all people 50 years or older.

Precautions

Patients who regularly take aspirin, **nonsteroidal anti-inflammatory drugs** (NSAIDs), **blood** thinners, or insulin should be sure to inform the physician prior to the colonoscopy. Patients with severe active colitis, extremely dilated colon (toxic megacolon), or severely inflamed bowel may not be candidates for colonoscopy. Patients requiring continuous ambulatory **peritoneal dialysis** are generally not candidates for colonoscopy due to a higher risk of developing intraperitoneal bleeding.

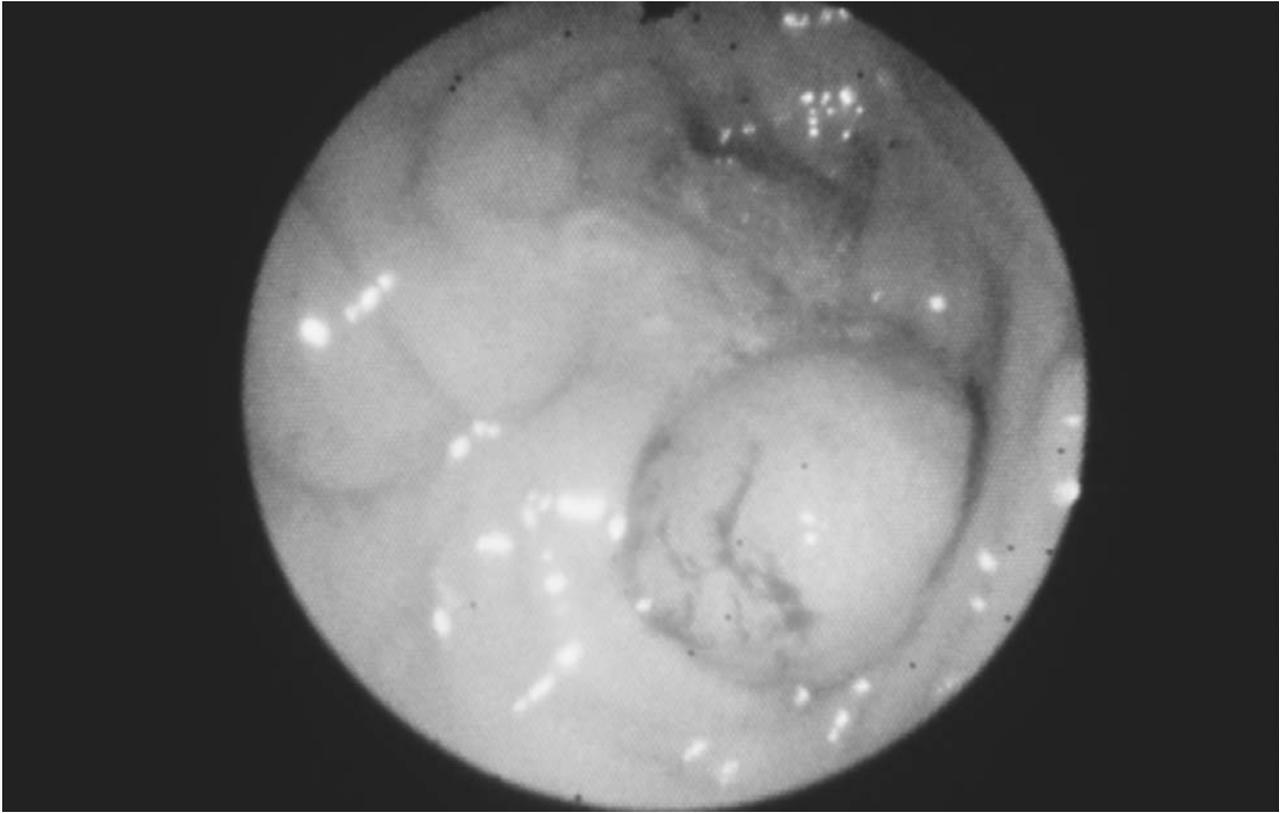
Description

Colonoscopy can be performed either in a physician’s office or in an endoscopic procedure room of a hospital. An intravenous (IV) line is inserted into a vein in the patient’s arm to administer, in most cases, a sedative and a pain-killer.

During the colonoscopy, patients are asked to lie on their sides with their knees drawn up towards the abdomen. The doctor begins the procedure by inserting a lubricated, gloved finger into the anus to check for any abnormal masses or blockage. A thin, well-lubricated colonoscope is then inserted into the anus and gently advanced through the colon. The lining of the intestine is examined through the colonoscope. Images are viewed by the physician on a television monitor, and the procedure can be documented using a video recorder. Still images can be recorded and saved on a computer disk or printed out. Occasionally air may be pumped through the colonoscope to help clear the path or open the colon. If excessive secretions, stool, or blood obstructs the viewing, they are suctioned out through the scope. The doctor may press on the abdomen or ask the patient to change position in order to advance the scope through the colon.

The entire length of the large intestine can be examined in this manner. If suspicious growths are observed, tiny biopsy forceps or brushes can be inserted through the colon and tissue samples can be obtained. Small polyps can also be removed through the colonoscope. For excising tumors or performing other types of surgery on the colon during colonoscopy, an electrosurgical device or laser system may be used in conjunction with the colonoscope. After the procedure, the colonoscope is slowly withdrawn and the instilled air is allowed to escape. The anal area is then cleansed with tissues.

The procedure may take anywhere from 30 minutes to two hours depending on how easy it is to advance the scope through the colon. Colonoscopy can be a long and uncomfortable procedure, and the bowel cleansing preparation may be tiring and can produce **diarrhea** and



Endoscopic view of a colonic polyp. (G-I Associates/Custom Medical Stock Photo. Reproduced by permission.)

cramping. During the colonoscopy, the sedative and the **pain** medications will keep the patient drowsy and relaxed. Some patients complain of minor discomfort and pressure from the colonoscope. However, the sedative and pain medication usually causes most patients to dose off during the procedure.

Preparation

The physician should be notified if the patient has **allergies** to any medications or anesthetics, bleeding problems, or is pregnant. The doctor should also be informed of all the medications that the person is currently taking and if the patient has had a barium enema x-ray examination recently. If the patient has had **heart** valves replaced, the doctor should be informed so that appropriate **antibiotics** can be administered to prevent **infection**. The risks are explained to the patient beforehand, and the patient is asked to sign a consent form.

The colon must be thoroughly cleansed before performing colonoscopy. Hence, for two or more days before the procedure, considerable preparation is necessary to clear the colon of all stool. The patient is asked to refrain from eating any solid food for 24 to 48 hours before the test. Only clear liquid such as juices, broth,

and Jello are allowed. Red or purple juices should be avoided, since they can cause coloring of the colon that may be misinterpreted during the colonoscopy. The patient is advised to drink plenty of water to avoid **dehydration**. A day or two before the colonoscopy, the patient is prescribed liquid, tablet, and/or suppository **laxatives** by the physician. In addition, commercial **enemas** may be prescribed. The patient is given specific instructions on how and when to use the laxatives and/or enemas.

On the morning of the colonoscopy, the patient is not to eat or drink anything. Unless otherwise instructed by the physician, the patient should continue to take all current medications. However, **vitamins** with **iron**, iron supplements, or iron preparations should be discontinued for a few weeks prior to the colonoscopy because iron residues in the colon can inhibit viewing during the procedure. These preparatory procedures are extremely important to ensure a thoroughly clean colon for examination.

After the procedure, the patient is kept under observation until the medications' effects wear off. The patient has to be driven home and can generally resume a normal diet and usual activities unless otherwise instructed. The

patient is advised to drink lots of fluids to replace those lost by laxatives and fasting.

For a few hours after the procedure, the patient may feel groggy. There may be some abdominal cramping and considerable amount of gas may be passed. If a biopsy was performed or a polyp was removed, there may be small amounts of blood in the stool for a few days. If the patient experiences severe abdominal pain or has persistent and heavy bleeding, it should be brought to the physician's attention immediately.

For patients with abnormal results, such as polyps, the gastroenterologist will recommend another colonoscopy, usually in another year or so.

Complications

The procedure is virtually free of any complications and risks. Rarely (two in 1000 cases) a perforation (a hole) may occur in the intestinal wall. Heavy bleeding due to the removal of the polyp or from the biopsy site occurs infrequently (one in 1000 cases). Some patients may have adverse reactions to the sedatives administered during the colonoscopy, but severe reactions are very rare. Infections due to a colonoscopy are also extremely rare. Patients with artificial or abnormal heart valves are usually given antibiotics before and after the procedure to prevent an infection.

Results

The results are normal if the lining of the colon is a pale reddish pink and there are no masses that appear abnormal in the lining.

Abnormal results indicate polyps or other suspicious masses in the lining of the intestine. Polyps can be removed during the procedure, and tissue samples can be biopsied. If cancerous cells are detected in the tissue samples, then a diagnosis of colon cancer is made. A pathologist analyzes the tumor cells further to estimate the tumor's aggressiveness and the extent of the disease. This is crucial before deciding on the mode of treatment for the disease. Abnormal findings could also be due to inflammatory bowel diseases such as ulcerative colitis or Crohn's disease. A condition called diverticulosis, which causes many small fingerlike pouches to protrude from the colon wall, may also contribute to an abnormal result in the colonoscopy.

Health care team roles

For otherwise healthy patients, colonoscopy is generally performed by a gastroenterologist in an office setting. It may also be performed in the endoscopy depart-

KEY TERMS

Barium enema—An x-ray test of the bowel after giving the patient an enema of a white chalky substance that outlines the colon and the rectum.

Biopsy—Removal of a tissue sample for examination under the microscope to check for cancer cells.

Colonoscope—A thin, flexible, hollow, lighted tube that is inserted through the anus and into the rectum and into the colon to enable the doctor to view the entire lining of the colon.

Crohn's disease—A chronic inflammatory disease that generally starts in the gastrointestinal tract and causes the immune system to attack one's own body.

Diverticulosis—A condition that involves the development of sacs that bulge through the large intestine's muscular walls but are not inflamed. It may cause bleeding, stomach distress, and excess gas.

Electrosurgical device—A medical device that uses electrical current to cauterize or coagulate tissue during surgical procedures. Often used in conjunction with laparoscopy.

Pathologist—A doctor who specializes in the diagnosis of disease by studying cells and tissues under a microscope.

Polyps—An abnormal growth that develops on the inside of a hollow organ such as the colon.

Ulcerative colitis—A chronic condition where recurrent ulcers are found in the colon. It is manifested clinically by abdominal cramping and rectal bleeding.

ment of a hospital, where patients with other medical conditions requiring hospitalization, more intensive physiologic monitoring, or **general anesthesia** can be better examined. Depending on the patient's condition, the colonoscopy may also be performed by a colorectal surgeon. In the gastroenterologist's office, a nurse and/or **nurse anesthetist** are necessary to provide patient sedation and analgesic medication, monitor the patient during the procedure, and assist the physician during the colonoscopy. In the hospital, colonoscopy performed under general anesthesia requires an anesthesiologist. Biopsied tissue samples are sent to a clinical laboratory, where they are analyzed by a pathologist.

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National Digestive Diseases Information Clearinghouse. 2 Information Way, Bethesda, MD 20892-3570. <<http://www.niddk.nih.gov>>.

Society of American Gastrointestinal Endoscopic Surgeons(SAGES). 2716 Ocean Park Boulevard, Suite 3000, Santa Monica, CA 90405. (310) 314-2404. <<http://www.sages.org>>.

Society of Gastroenterology Nurses and Associates Inc. 401 North Michigan Avenue, Chicago, IL 60611-4267. (800) 245-7462. <<http://www.sgna.org>>.

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Jennifer E. Sisk, M.A.

Color blindness

Definition

The term color blindness describes a deficiency in discriminating various colors. It is a misnomer because most color-blind people do, in fact, see colors. The deficiency is a lack of perceptual sensitivity to certain colors. A rare few may not see colors at all.

Description

Normal color **vision** requires the use of special cells, called cones. They are wavelength receptors located at

the back of the eye on the retina. Most of us are trichromats, which means that we have three types of cones, commonly called red, green, and blue cones. They are long, medium, and short wavelength receptors, respectively. The interplay among these cones enables us to see a large spectrum of colors. A defect in any of these types of cones will result in deficient color vision. Most color-deficient individuals are dichromats. They are not entirely blind to color, rather they get some colors confused with each other. For example, they may see certain colors (like red and green) as very similar, whereas people without the deficiency would easily be able to differentiate these colors.

The following are three basic types of color deficiency:

- Protanopia and deuteranopia (commonly called red/green color blindness). Red/green color blindness is the most common deficiency, affecting about 10% of Caucasian males and 0.5% of females. People with protanopia have fewer red cones; blue-green and red-purple appear gray to them. Deuteranopes have fewer green cones; green and purple-red appear gray to them.
- Tritanopia (commonly called Blue color blindness). People with tritanopia have fewer blue cones; blue and yellow appear as white or gray to them. Such people are very rare and have poor blue and/or yellow perception. As many females as males have this deficiency. It usually appears in people who have physical disorders, such as **liver** disease or **diabetes mellitus**.
- Achromatopsia (commonly called total color blindness). Total color blindness—vision only in black, white, and shades of gray—can be caused by monochromacy (a retina that has only one type of receptor) or from acquired **brain** damage. Monochromacy is a very rare hereditary disorder. It affects one person in 33,000 in the United States, males and females equally. They usually have poor visual acuity and extreme sensitivity to light. Their vision is significantly impaired and they protect their light-sensitive eyes by squinting in even ordinary light.

Causes and symptoms

The key symptom of color blindness is the long-term inability to distinguish colors or notice some colors entirely. Most cases of color blindness (in particular red/green) are inherited, and affect males almost exclusively.

Color blindness can be acquired by the following:

- Chronic illness. Illnesses that can lead to color blindness are: **Alzheimer's disease**, diabetes, **glaucoma**, leukemia, liver diseases, chronic **alcoholism**, **macular**

degeneration, multiple sclerosis, Parkinson's disease, sickle cell anemia, and retinitis pigmentosa.

- Trauma. Accidents or strokes that damage the eye can lead to color blindness.
- Medications. Some frequently used medications may cause color blindness. Some **antibiotics**, barbiturates, anti-tubercular drugs, high **blood pressure** medications, and a number of medications used to treat nervous disorders and psychological problems may lead to color blindness.
- Industrial toxins. Strong chemicals can cause color vision loss. Some include carbon monoxide, carbon disulfide, fertilizers, styrene, and lead-based chemicals.
- Aging. After age 60, changes occur in people's capacity to discriminate colors.

Diagnosis

Some of the tests available to detect color vision in the general public include:

- American Optical/Hardy, Rand, and Ritter (AO/H.R.R.) Pseudoisochromatic test. This is the test used most often to detect color blindness. A person with full color vision looking at a sample plate from this test would see a number, composed of blobs of one color, clearly located somewhere in the center of a circle of blobs of another color. A colorblind person is not able to distinguish the number.
- Ishihara test. The Ishihara test is made up of eight test plates similar to the AO/H.R.R. pseudoisochromatic test plates. The person being tested looks for numbers made up of various colored dots on each test plate.
- Titmus II Vision Tester Color Perception test. During this test, a person looks into a stereoscopic machine. The chin rests on a base, and the image comes on only when the forehead touches a pad on the top of the unit. Either a series of plates, or only one plate, can be used to test for color vision. The one most often used in doctors' offices is one that has six samples on it. Six different designs or numbers are on a black background, framed in a yellow border. While Titmus II can test one eye at a time, its value is limited because it only tests for red/green deficiencies and is not highly accurate.

Treatment

There is no treatment or cure for color blindness. Most color deficient persons compensate well for their defect and may even discover instances in which they can discern details and images that would escape normal-sighted persons. Colorblind people tend to look for outlines, not colors. Consequently, they are not easily confused by camou-

KEY TERMS

Acuity—Acuity is the clarity or sharpness of vision.

Cone cells—Cone cells are special cells in the retina and are responsible for color vision and fine visual discrimination.

Retina—The retina is the innermost lining of the eye, containing light sensitive nerve tissue composed of rod and cone cells.

Stereoscopic—Stereoscopic refers to vision in which things have a three-dimensional appearance.

flage. (Some colorblind people were used in World War II spy planes to spot camouflaged German camps.) Also, their night vision may be much better than average.

Health care team roles

Color blindness can be tested for and diagnosed by a general physician, ophthalmologist, or optometrist. Questions about color blindness may be addressed by nurses or **optometry** assistants.

Prognosis

Color blindness that is hereditary is present in both eyes and remains constant over time. Some cases of acquired color vision loss are not severe and last for only a short time. Other cases tend to be progressive, becoming worse over time.

Prevention

Hereditary color blindness cannot be prevented. In the case of acquired color blindness, if the cause of the problem is removed, the condition may improve with time. If not, damage may become permanent.

Resources

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ORGANIZATIONS

Achromatopsia Network. C/O Frances Futterman, P.O. Box 214, Berkeley, CA 94701-0214.
<http://www.achromat.org/how_to_join.html>.

American Academy of Ophthalmology. 1533 Shattuck Avenue, Berkeley, CA 94701. (847) 845-1059. <<http://www.geocities.com/Heartland/8833/coloreye.html>> and <<http://www.zipmall.com/mpm-art-colorbl.html>>.

National Society to Prevent Blindness. 500 East Remington Road, Schaumburg, IL 60173. (708) 843-2020 or (800) 331-2020. <<http://www.preventblindness.org>>.

Lorraine T. Steefel
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Colorectal cancer

Definition

The **digestive system** is made up of the esophagus (food pipe), **stomach**, and the small and large intestines. The upper 5–6 feet (1.5–1.8 m) of the **large intestine** is the colon, and the last 6–8 inches (15–20 cm) of the colon is the rectum. Colorectal **cancer** is a disease in which the cells of the tissues lining the colon and the rectum start to grow uncontrollably and form tumors.

Description

Colorectal cancer is the second most common cancer for both men and women, and the second leading cause of cancer deaths. There are 150,000 new cases each year, with more than 55,000 people dying annually. The average age at first diagnosis is between 60 and 65 and appears to be a disease that affects the latter years of life. Since it is slow growing, it may take years before the disease manifests.

The primary function of the colon is to absorb water and the nutrients from the food that is already digested by the stomach and the **small intestine**. The waste material that remains moves into the rectum. From there, it is excreted out of the body through the anus. The colon has four sections. The ascending colon moves upward to the hepatic flexure. It then becomes the transverse colon, moving across to the **liver**. When it reaches the spleen, the colon continues as the descending colon and moves down to the pelvic area. It is then called the sigmoid colon and extends to the rectum. Cancer can develop in any of the four sections or in the rectum. Cancers beginning in the different sections have different symptoms.

Colorectal cancers have a very high cure rate if found early. Unfortunately, most colorectal cancers are silent tumors, which means they grow slowly and often do not produce symptoms until they reach a large size. Therefore, diagnosis is often delayed. The cancer usual-

ly begins as a benign growth (polyp) in the lining of the intestine. Although most polyps are not cancerous, virtually every colorectal cancer case begins with these polyps. There are two kinds of polyps: hyperplastic polyps, which are small, completely benign, and never develop into cancers, and adenomas, which are polyps that do have the potential to become cancerous.

Causes and symptoms

Causes

The current consensus among the medical community is that most colorectal cancers have a genetic link. Abnormal genes have been found in all inherited colorectal cancers and in most sporadic colon cancers. Dietary and environmental factors also seem to play a role in colorectal incidence.

Several risk factors may make a person more susceptible to colorectal cancer. They include:

- **Family history:** Some conditions such as familial adenomatous polyps (FAP) and Lynch syndrome (a genetic condition that predisposes certain families to colon cancer, even when polyps are not present) occur in certain families and may make an individual more likely to develop cancer of the colon or the rectum.
- **History of colorectal cancer:** Even when colorectal cancer has been completely removed, new cancers may still develop in other areas of the colon and the rectum. The incidence of recurrence is every 10 years.
- **Recurrent intestinal polyps:** These are polyps that increase the risk of colorectal cancer, especially if they are large and there are many of them.
- **Inflammatory bowel disease:** Chronic ulcerative colitis, a condition in which the colon is inflamed over a long period of time and causes ulcers in the lining, can increase the risk of colon cancer.
- **Age:** About 90% of colorectal cancers are found in people over the age of 50.
- **Diet:** Eating foods that are high in fat and low in fiber may increase the risk of colorectal cancer. It is estimated that diet accounts for 35%–45% of disease incidence.
- **Physical inactivity:** A sedentary lifestyle and not enough physical activity has been reported to be associated with a higher risk of colorectal cancer.
- **Gender factors:** Women have a 38% higher risk of having upper-colon cancer than men.
- **Smoking:** There is strong evidence that smoking increases the risk of colorectal cancer, possibly causing 12% of all colorectal cancer deaths. The frequency,

amount, and duration of smoking over a lifetime are positively correlated with colon cancer. The more a person smokes over a long period of time, the greater the incidence of colon cancer.

- **Ethnicity:** Black, non-Hispanic people may have as much as a 24% increased risk in upper-colon cancer than other groups.
- **Co-morbid illnesses:** The presence of serious, life-threatening diseases like congestive **heart failure**, peptic ulcer, and **diabetes mellitus** may contribute up to a 28% increase in risk of colorectal cancer.

Symptoms

The earliest sign of colon cancer may be bleeding, though the amount is usually quite small. **Blood** can be detected by the **fecal occult blood test** (FOBT), which is a chemical testing of the feces for hidden (occult) blood.

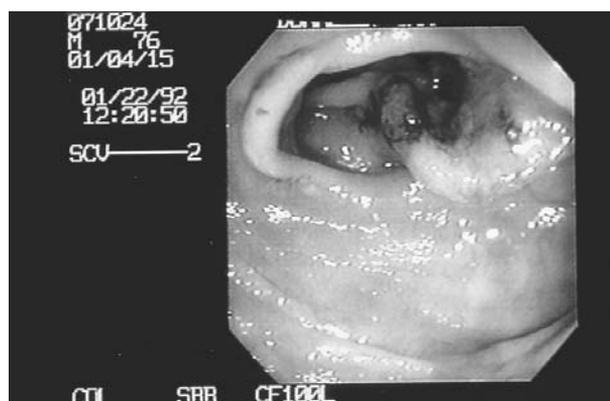
When tumors grow to a large size, they may cause a change in bowel habits. Stools may be very narrow in diameter, and there may be **diarrhea** or constipation. Other symptoms of general stomach discomfort may be present, such as a feeling of fullness or bloating, stomach cramps, or gas pains. Sometimes, the patient complains of a feeling that the bowel does not empty completely. Constant tiredness and weight loss with no known reason may be other warning signs. Even though many of these symptoms can be caused by conditions other than cancer, they must be evaluated by a doctor without delay.

Usually, there are no signs of colorectal cancer at all. That is why screening is essential. Polyps may be detected before they develop into cancers, and are easily removed.

Diagnosis

Regular screenings can identify colorectal cancer before symptoms manifest. Routinely, depending on the screening method used, this is done every one to five years, beginning at age 50. With higher risk populations (a family history of colorectal cancer or polyps, previous ulcerative colitis, or a specific ethnicity), screening may be initiated at an earlier age and conducted more often. Screening methods include a digital rectal examination, fecal occult blood testing (FOBT), a **sigmoidoscopy**, a **colonoscopy**, and a double-contrast **barium enema**.

If the physician suspects colon cancer, then a thorough **physical examination** will be conducted to check all symptoms and a complete medical history will be taken to assess any risk factors. A digital rectal examination will be done during the physical. In this procedure,



An endoscopic view of a colorectal tumor. (Custom Medical Stock Photo. Reproduced by permission.)

the physician inserts a gloved finger into the rectum to feel for anything abnormal. This simple test can help to detect many rectal cancers.

A fecal occult blood test may be ordered, in which a sample of stool is examined for blood. The test kit can be purchased at any local pharmacy. The test involves taking a sample of stool and smearing it on a slide. This is then sent to the laboratory or to the doctor's office to be chemically examined for the presence of red blood cells.

A sigmoidoscopy may be done to enable the physician to look inside the rectum and the lower half of the colon. In this procedure, a thin, flexible, hollow, lighted tube (sigmoidoscope) is inserted into the rectum. The physician then looks inside the scope for polyps. Since they may become cancerous, they are usually removed with the sigmoidoscope and examined for cancer cells. About half of all colon and rectal cancers are found using this procedure.

A colonoscopy will be ordered if the doctor wishes to examine the entire colon lining. A colonoscope is longer than a sigmoidoscope and is inserted through the rectum into the colon. It is connected to a video camera and a video display unit so that the physician can look at the inside of the colon. If a suspicious mass is detected, then the physician may cut out a small piece to examine it under a **microscope** for cancer cells. This procedure is called a biopsy.

Another test that is used to diagnose colon cancer is known as a double-contrast barium enema. The patient is given a barium sulfate enema through the anus. This is a chalky substance that partially fills and opens the colon. When the colon is about half full of barium, the patient is turned on the x-ray table so that the barium spreads throughout the colon. Air is then inserted into the colon to make it expand and x-ray films are taken. Usually, this procedure is done if the patient cannot tolerate a sigmoido-

doscopy, or a suspected mass prevents the penetration of the sigmoidoscope or the colonoscope.

Treatment

Treatment for colon and rectal cancers depends on the stage of the cancer, which refers to the extent to which it has spread (metastasized). The standard modes of treatment are surgery, radiation therapy, and **chemotherapy**.

Surgery is the primary treatment for colon cancer. If the cancer is found at a very early stage, the physician may be able to remove the cancer without cutting into the abdomen. Instead, the physician may insert a tube through the rectum into the colon and cut the tumor out. This procedure is called a local excision. If the cancer is found in a polyp, however, the operation is called a polypectomy. When the cancer is large but confined to a portion of the colon, the abdomen is opened up and the cancerous growth and a small piece of normal tissue from either side of the cancer are removed. This procedure is called segmental resection. If there is any likelihood of the cancer having metastasized to the nearby lymph nodes, they may be removed as well. The remaining sections of the colon are then reattached.

When the physician is unable to reattach the colon, an opening called a stoma will be surgically created on the outside of the body for the waste material to pass from the body. This procedure is called a **colostomy**. Sometimes, the colostomy is temporary, lasting until the colon is healed, and then the colostomy can be reversed. However, if the surgery involves taking out the entire lower colon, a permanent colostomy is required. The patient will need to wear a special bag to collect body wastes. The disposable bag attaches to the body around the opening (stoma). Hospital personnel will teach patients how to take care of the stoma and maintain colostomy bags.

In the case of rectal cancer, different surgical methods are used. When the cancer is found in polyps, a polypectomy is performed. Local excision is a procedure that can be used to remove small superficial cancers. A small amount of adjoining tissue is also removed from the inner layer of the rectum. If the cancer is in the deeper layers of the rectum, local full thickness resection is used. A cut is made through all the layers of the rectum to remove the invasive cancer as well as some surrounding normal rectal tissue. Electrofulguration is a procedure in which the cancer is burned away by passing an electric current through it. All of these methods may be done without cutting through the abdomen. However, a colostomy may still be necessary if the cancer is too

close to the anus, necessitating the removal of the sphincter muscles.

Radiation therapy involves the use of high-energy radiation to kill cancer cells. It can be applied to both colon and rectal cancers. External-beam radiation uses radiation from an external source that is focused on the tumor. Internal radiation therapy uses a small pellet of radioactive material that is implanted directly into the cancer. Radiation therapy is generally used as adjuvant therapy, that is, it is used after the surgery to destroy any cancerous material that may not have been removed during surgery. If the tumor is in a place that makes surgery difficult, then radiation may be used before surgery to shrink the tumor. In advanced cancers, in which surgery is not an option, radiation may be used to ease the symptoms such as **pain**, blockage, or bleeding.

In colorectal cancers, chemotherapy is generally used after surgery to destroy any cancerous cells that may have migrated from the original site and spread to other parts. The anti-cancer drugs are either given intravenously (through a vein) in the arm or orally in the form of pills. In the case of advanced cancers, chemotherapy may be given to alleviate symptoms.

Prognosis

The death rate from colorectal cancer has been going down for the past 20 years. This is due to advanced methods of early detection and improved treatment modes. If colorectal cancer is detected at an early stage and is treated appropriately, 92% of patients will survive five years or more. However, only a third of colorectal cancers are found at that early stage. Once the cancer has metastasized to nearby organs or lymph nodes, the five-year survival rate plummets to 64%. If the disease has metastasized to distant sites such as the liver or the lung, the outlook is bleak, with only 7% of the patients surviving five years after initial diagnosis. The American Cancer Society also notes that once colorectal cancer is detected and removed, another occurrence is highly probable in 10 years.

Health care team roles

Physicians, nurse practitioners, nurses, lab technicians, and radiology technicians all participate in the screening, diagnosing, and treating of colorectal cancers. Physicians and their nursing staff must educate patients in the necessity and urgency of complying with colorectal screening guidelines. Colorectal cancer, for many people, is a totally preventable disease. By exercising regularly, eating a high-fiber diet, and avoiding smoking many colorectal cancers can be prevented. For those with

a family history of polyps or colorectal cancer, participation in a screening program can detect polyps, and they can have them removed before they turn into cancerous growths.

Subsequently, all members of the medical health team will need to educate patients about early screening, the procedures involved, and any possible side effects. They will also need to provide information about diet and **exercise** and anti-smoking support groups. Physicians may need to prescribe medications to cope with nicotine withdrawal.

When cancer is detected, the entire medical team will need to educate the patient about treatment options and procedures, outcomes, and aftercare. Physicians and radiology technicians will perform additional tests. The gastroenterologist and surgeon will prepare the patient physically and psychologically for surgery. The surgeon will remove the cancer and prepare a stoma, if necessary. The gastroenterologist will recommend radiation and/or chemotherapy as a preventative. The nursing staff will educate the patient on the care of the stoma and the colostomy equipment.

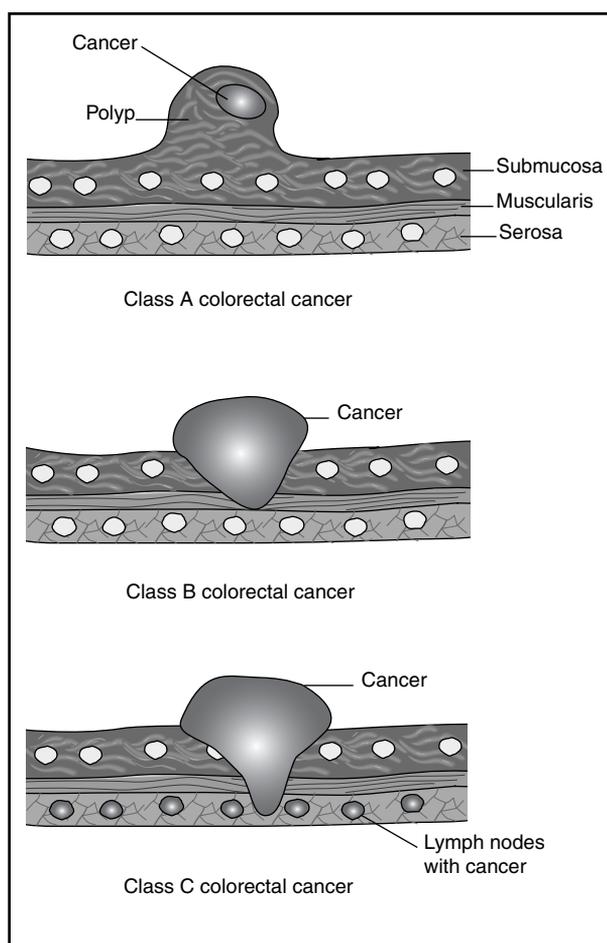
Prevention

Many colon and rectal cancers may be prevented by avoiding risk factors and following screening guidelines. The number of colorectal cancer cases can be lowered and, by detecting the disease at an earlier stage, the death rate can be reduced.

The American Cancer Society recommends that, beginning at age 50, both men and women follow a screening schedule for the early detection of colorectal cancer. One or more of the following tests should be performed: a yearly fecal occult blood test and a digital rectal examination, a flexible sigmoidoscopy every five years, a colonoscopy every five to 10 years (depending on the patient's risk factors), or a barium enema x ray every five to 10 years.

Proper diet and exercise go a long way in preventing colorectal cancer. The American Cancer Society recommends eating at least five servings of fruits and vegetables every day and six servings of food from plant sources that contain fiber, such as breads, cereals, grain products, rice, pasta, or beans. Reducing the consumption of high-fat, low-fiber foods such as red meat and processed foods is also advised. Achieving and maintaining an ideal body weight are recommended, and participating in at least 30 minutes of physical activity every day is advocated.

The addition of mineral supplements may also be helpful in preventing colorectal cancer. **Copper**, selenium,



Classes of colorectal cancer: class A, class B, and class C. (Delmar Publishers, Inc. Reproduced by permission.)

and **calcium** seem to be factors in colorectal cancer prevention. Eating foods rich in these **minerals** is recommended.

It is also recommended that individuals over 50 quit smoking as soon as possible. Besides the risks of other forms of cancer, there seems to be a correlation between the incidence of colorectal cancer and the amount of tobacco smoked and for how long.

It may not be possible to control risk factors such as a strong family history of colorectal cancer. However, by getting information about prevention and early detection, one can still beat the odds. People with a family history of colorectal cancer should start screening at a younger age, and the tests should be done more frequently. Certain genetic tests are now available that can help determine which members of certain families have inherited a high risk for developing colorectal cancer.

KEY TERMS

Adenomas—Polyp-like growths in the colon or the rectum that have the potential to turn cancerous.

Barium enema—An x-ray test of the bowel after receiving an enema of a white chalky substance that outlines the colon and the rectum, making them more visible in an x ray.

Benign—Tested tissue that is not cancerous and does not invade surrounding tissue or spread to other parts of the body.

Biopsy—Removal of a tissue sample for examination under the microscope to check for cancer cells.

Chemotherapy—Treatment with drugs that destroy cancerous tissue.

Colonoscopy—A medical procedure in which the physician looks at the colon through a flexible lighted instrument called a colonoscope.

Colostomy—An opening is created to provide a path for waste material to leave the body after the colon has been removed.

Crohn's disease—A chronic inflammatory disease in which the immune system starts attacking one's own body. The disease generally starts in the gastrointestinal tract.

Digital rectal examination—An exam to detect rectal cancer.

Familial adenomatous polypos (FAP)—An inherited condition in which hundreds of polyps develop in the colon and rectum.

Fecal occult blood test (FOBT)—A test in which the stool sample is chemically tested for hidden blood.

Flexible sigmoidoscopy—An examination in which the physician looks at the lower half of the colon.

Hyperplastic polyps—Benign polyps found in the colon or the rectum.

Lynch syndrome—A genetic condition that predisposes certain families to colon cancer, even when polyps are not present.

Polyp—An abnormal growth that develops on the inside of a hollow organ such as the colon.

Polypectomy—A surgical procedure that involves removal of the polyp.

Radiation therapy—Treatment using high-energy radiation from x-ray machines, cobalt, radium, or other sources.

Segmental resection—Surgical removal of a portion of the colon.

Stoma—The opening established in the abdominal wall by the colostomy procedure.

Ulcerative colitis—A chronic condition in which recurrent ulcers are found in the colon.

Resources

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ORGANIZATIONS

American Cancer Society (National Headquarters). 1599 Clifton Road, N.E., Atlanta, GA 30329. (800) 227-2345. <<http://www.cancer.org>>.

Cancer Research Institute (National Headquarters). 681 Fifth Avenue, New York, NY 10022. (800) 992-2623. <<http://www.cancerresearch.org>>.

National Cancer Institute. Public Inquiries Office, Building 31, Room 10A03, 31 Center Drive, MSC 2580, Bethesda, MD 20892. (800) 422-6237. <<http://www.nci.nih.gov>>.

Oncolink. University of Pennsylvania Cancer Center. <<http://cancer.med.upenn.edu>>.

United Ostomy Association, Inc. (UOA). 36 Executive Park, Suite 120, Irvine, CA 92612. (800) 826-0826.

OTHER

NCI/PDQ Patient Statement. "Colon Cancer." National Cancer Institute.

NCI/PDQ Patient Statement. "Rectal Cancer." National Cancer Institute.

Janie F. Franz

Colostomy

Definition

A colostomy is a surgical procedure that brings a portion of the **large intestine** through the abdominal wall to carry feces out of the body.

Purpose

A colostomy is created as a means to treat various disorders of the large intestine, including **cancer**, obstruction, inflammatory bowel disease, ruptured diverticulum, ischemia (compromised **blood** supply), or traumatic injury. Temporary colostomies are created to divert stool from injured or diseased portions of the large intestine, allowing rest and healing. Permanent colostomies are performed when the distal bowel (bowel at the farthest distance) must be removed or is blocked and inoperable. Although **colorectal cancer** is the most common indication for a permanent colostomy, only about 10–15% of patients with this diagnosis require a colostomy.

Description

Surgery will result in one of three types of colostomies:

- **End colostomy:** The functioning end of the intestine, the section of bowel that remains connected to the upper gastrointestinal tract, is brought out onto the surface of the abdomen to form a stoma (an artificial opening) by cuffing the intestine back on itself and suturing the end to the skin. The surface of the stoma is actually the lining of the intestine, usually appearing moist and pink. The distal portion of bowel (now connected only to the rectum) may be removed or sutured closed and left in the abdomen. An end colostomy is usually a permanent colostomy, resulting from trauma, cancer, or another pathological condition.

- **Double-barrel colostomy:** This colostomy involves the creation of two separate stomas on the abdominal wall. The proximal (nearest) stoma is the functional end that is connected to the upper gastrointestinal tract, and will drain stool. The distal stoma, connected to the rectum, drains small amounts of mucus material. This is most often a temporary colostomy, performed to rest an area of bowel and to be later closed.
- **Loop colostomy:** This colostomy is created by bringing a loop of bowel through an incision in the abdominal wall. The loop is held in place outside the abdomen by a plastic rod placed beneath it. An incision is made in the bowel to allow the passage of stool through the loop colostomy. The supporting rod is removed approximately seven to 10 days after surgery, after healing has occurred that will prevent the loop of bowel from retracting into the abdomen. A loop colostomy is most often performed for the creation of a temporary stoma to divert stool away from an area of intestine that has been blocked or ruptured.

Preparation

The physician will outline the procedure, possible side effects, and what the patient may experience after surgery. The physician or an enterostomal therapist will explain the general aftercare to the patient before surgery, so the patient has all of the information necessary to make an informed decision about surgery and medical care.

Blood and urine studies, along with various x rays and an electrocardiograph (EKG), may be ordered as necessary. If possible, the patient should visit an enterostomal therapist, who makes the decision about the appropriate place on the abdomen for the stoma and who offers pre-operative education on colostomy management.

To empty and cleanse the bowel, the patient may be placed on a low-residue diet for several days prior to surgery. A liquid diet may be ordered for at least the day before surgery. A series of **enemas** and/or oral preparations (GoLytely or Colyte) may be ordered to empty the bowel of stool. Oral anti-infectives (neomycin, erythromycin, or kanamycin sulfate) may be prescribed to decrease **bacteria** in the intestine and help prevent post-operative **infection**. On the day of surgery or during surgery, a nasogastric tube is inserted into the nose to connect it to the **stomach** to remove gastric secretions and prevent nausea and vomiting. A urinary catheter may also be placed to keep the bladder empty during surgery, giving more space in the surgical area and decreasing the risk of accidental injury.

KEY TERMS

Diverticulum—Pouches that project off the wall of the intestine.

Embolism—Blockage of a blood vessel by any small piece of material traveling in the blood.

Enema—Insertion of a tube into the rectum to infuse fluid into the bowel and encourage a bowel movement.

Intestine—Commonly called the bowels, divided into the small and large intestine, they extend from the stomach to the anus. The small intestine is about 20 feet (6 m) long; the large intestine is about 5 feet (1.5 m) long.

Ischemia—A compromise in blood supply delivered to body tissues that causes tissue damage or death.

Ostomy—A surgically created opening in the abdomen for elimination of waste products (urine or stool).

Preparation

Post-operative care for the patient with a new colostomy involves monitoring of **blood pressure**, pulse, respirations, and temperature. The patient is instructed how to support the operative site during deep breathing and coughing, and given **pain** medication as necessary. Fluid intake and output is measured, and the operative site is observed for color and amount of wound drainage. The nasogastric tube will remain in place, attached to low-intermittent suction until bowel activity resumes. For the first 24 to 48 hours after surgery, the colostomy will drain bloody mucus. Fluids and electrolytes are infused intravenously until the patient's diet can gradually be resumed, beginning with liquids. Usually within 72 hours, passage of gas and stool through the stoma begins. Initially the stool is liquid, gradually thickening as the patient begins to take solid foods. The patient is usually out of bed in eight to 24 hours after surgery and discharged in two to four days.

A colostomy pouch or bag will generally have been placed on the patient's abdomen, around the stoma, during surgery. During the hospital stay, the patient and the caregivers will be educated on how to care for the stoma and the colostomy bag. Determination of appropriate pouching supplies and a schedule of how often to change the pouch should be established. Regular assessment and meticulous care of the skin surrounding the stoma is important to maintain an adequate surface on which to

apply the pouch. Patients will be instructed in daily irrigation of the stoma about seven to 10 days after surgery. This results in the regulation of bowel function. Some patients with colostomies may need only a dressing or cap over the stoma and do not wear a colostomy pouch. Often, an enterostomal therapist will visit the patient at home after discharge to help with the patient's resumption of normal daily activities.

Complications

Potential complications of colostomy surgery include:

- excessive bleeding
- surgical wound infection
- thrombophlebitis (inflammation and blood clot in veins in the legs)
- pneumonia
- pulmonary embolism (blood clot or air bubble in the lungs' blood supply)
- cardiac **stress** due to allergic reaction to the general anaesthetic
- if the colostomy becomes blocked
- if the stoma extends too far out from the abdomen, presenting the potential for physical damage or infection

The physician should be made aware of any of the following problems after surgery:

- increased pain, swelling, redness, drainage, or bleeding in the surgical area
- flu-like symptoms such as headache, muscle aches, dizziness, or fever
- increased abdominal pain or swelling, constipation, nausea or vomiting, or black, tarry stools

Stomal complications to be monitored include:

- Necrosis (death) of stomal tissue. Caused by inadequate blood supply, this complication is usually visible 12 to 24 hours after the operation and may require additional surgery.
- Retraction (stoma is flush with the abdomen surface or has moved below it). Caused by insufficient stomal length, this complication may be managed by the use of special pouching supplies. Elective revision of the stoma is also an option.
- Prolapse (stoma increases length above the surface of the abdomen). Most often, this results from an overly large opening in the abdominal wall or inadequate fixation of the bowel to the abdominal wall. Surgical correction is required when blood supply is compromised.

- Stenosis (narrowing at the opening of the stoma). Often, this is associated with infection around the stoma or scarring. Mild stenosis can be removed under **local anesthesia**, while severe stenosis may require surgery for reshaping the stoma.
- Parastomal hernia (bowel-causing bulge in the abdominal wall next to the stoma). Usually, this is due to placement of the stoma where the abdominal wall is weak or the creation of an overly large opening in the abdominal wall. The use of a colostomy support belt and special pouching supplies may be adequate. If severe, the defect in the abdominal wall should be repaired surgically, and the stoma moved to another location.

Psychological complications may result from colostomy surgery because of the fear of the social stigma attached to wearing a colostomy bag. Patients also may be depressed and have feelings of low self-worth because of the change in their lifestyle and their appearance. Some patients may feel sexually unattractive and may worry that their spouse or significant other will no longer find them desirable. Counseling and education regarding surgery and the inherent lifestyle changes are often necessary.

Results

Complete healing is expected without complications. The period of time required for recovery from the surgery may vary, depending on the patient's overall health prior to surgery. The colostomy patient, without other medical complications, should be able to resume all daily activities once recovered from the surgery.

Health care team roles

A team of doctors, surgeons, specialists, technicians, and nurses are involved in the care of a patient who has a colostomy. While the skills of each health care provider are necessary, it is education and support that may be the most critical in affecting a successful outcome for the patient. Understanding what is involved in the procedure, what the results will be, and the ramifications of the surgery outcome are all considerations for the patient in order to make informed decisions. A thorough understanding of the implications of the surgical procedure and trust in the medical team enable the patient to face the change in lifestyle in a more positive fashion.

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Colostomy care

Definition

A **colostomy** is a surgically created opening in the abdominal wall through which digested food passes. It may be temporary or permanent. The opening is called a stoma from the Greek word meaning mouth. Stool passes through the stoma into a pouch attached to the stoma on the outside of the abdomen. The pouch, stoma, and skin surrounding the stoma require care and maintenance by the patient or caregiver.

Purpose

A pouch is worn over a colostomy to collect the stool passed through the stoma. There are a variety of pouches available for use with a colostomy. Over time the patient can determine which pouch type best suits his or her needs. A colostomy pouch is normally emptied one or more times daily. The pouch itself usually needs to be changed every four to six days. The stoma and surrounding skin need to be kept clean and sanitary.



Colostomy care and colostomy pouch replacement in a hospital. (Delmar Publishers, Inc. Reproduced by permission.)

Precautions

The nurse attending to a colostomy should wash his or her hands before and after the procedure, as well as wear latex gloves while performing care.

Description

A pouching system is normally worn over a colostomy stoma. Pouches can be obtained from several different manufacturers in both disposable and reusable varieties. The enterostomal therapy ET nurse can be an invaluable resource when helping patients select a pouch system.

Colostomy pouches may be either open ended or closed. Open-ended pouches require a clamp for closure. They can be drained simply and reused after they are emptied. Closed pouches are sealed at the bottom and are usually used by patients who irrigate their colostomies or who have a regular bowel elimination pattern. Two-piece pouch systems consist of a separate flange and pouch. The pouch has a closing ring that attaches to a matching piece on the flange. One-piece systems have a connected wafer and pouch that do not separate. The portion of the pouch that is applied to the abdomen is called a skin barrier wafer. Both two-piece and one-piece systems can be either closed or open ended.

Some patients with colostomies can irrigate their stomas using a procedure similar to an enema. This cleans the stool out of the colon through the stoma. A special irrigation system is used. Sometimes a special lubricant is used to prepare for the irrigation. Irrigating often leads to increased control over the timing of bowel movements.

Removing the colostomy appliance requires gently pushing away the skin surrounding the stoma and pulling the appliance downwards. Adhesive remover wipes are available to help in the removal of the wafer. The bag is then discarded in an appropriate waste container. The stoma should be cleaned with lukewarm water and dried with a soft towel. The stoma and surrounding skin should be assessed. The stoma should be pink or red and moist-looking, and may bleed slightly when cleansed. The stoma normally decreases in size slightly during the first weeks after surgery.

The opening in the wafer should fit snugly around the stoma. An opening that is too large will allow intestinal contents to leak onto the skin. Measuring guides come with the colostomy wafers so that the hole can be cut to the proper size. Skin barrier paste can be used to help create a better seal between the wafer and the patient's abdomen. Various skin preparation products are



A colostomy creates a stoma (opening) in the abdominal wall to which a section of the large intestine is attached. The surface of the stoma is the inside lining of the intestine, so it appears moist and pink or red. (Custom Medical Stock Photo. Reproduced by permission.)

also available to help protect the skin under the wafer and around the stoma. They also aid in the adhesion of the wafer. Using the fingertips, gentle pressure should be applied to put the wafer in place.

After the application of the barrier, the bag should be applied (if it is a two-piece system). If it is an open system, apply a clamp to the bottom of the new pouch.

Preparation

The nurse should instruct the patient and caregiver(s) about the procedure before it is performed. Many people feel anxious and nervous when first dealing with an ostomy. Encourage the patient to ask questions, and explain all steps as they are performed.

Aftercare

The nurse should assess the patient's tolerance of the procedure and response to teaching or education about the appliance.

Health care team roles

Although most members of the health care team will come into contact with patients having ostomies, it is the nurse who has the responsibility for providing ostomy care and instructing the patient and/or caregiver how to provide care independently. An enterostomal therapy (ET) nurse is specially educated in all aspects of ostomy care.

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Colposcopy

Definition

Colposcopy is a procedure that allows a physician to examine a woman's cervix and vagina using a special **microscope** called a colposcope. It is used to check for precancerous or abnormal areas.

Purpose

Colposcopy is used to identify or rule out the existence of any precancerous conditions in the cervical tissue. If a **PAP test** shows abnormal cell growth, a colposcopy is usually the first follow-up test performed. The physician will attempt to find the area that produced the abnormal cells and remove it for further study (biopsy) and diagnosis.

Colposcopy may also be performed if the cervix looks abnormal during a routine examination. It may also be suggested for women with genital warts and for DES daughters (women whose mothers took DES when pregnant with them). Colposcopy is also used in the emergency department to examine victims of sexual assault and abuse and document any physical evidence of vaginal injury.

Precautions

Women who are pregnant, or who suspect that they are pregnant, must tell their doctor before the procedure begins. Pregnant women can, and should, have a col-

poscopy if they have an abnormal PAP test. However, special precautions must be taken during biopsy of the cervix.

Description

A colposcopy is usually performed in a physician's office and is similar to a regular gynecologic exam. An instrument called a speculum is used to hold the vagina open, and the gynecologist looks at the cervix and vagina using a colposcope, a low-power microscope designed to magnify the cervix 10–40 times its normal size. Most colposcopes are connected to a video monitor, which displays the area of interest. Photographs are taken during the examination to document abnormal areas.

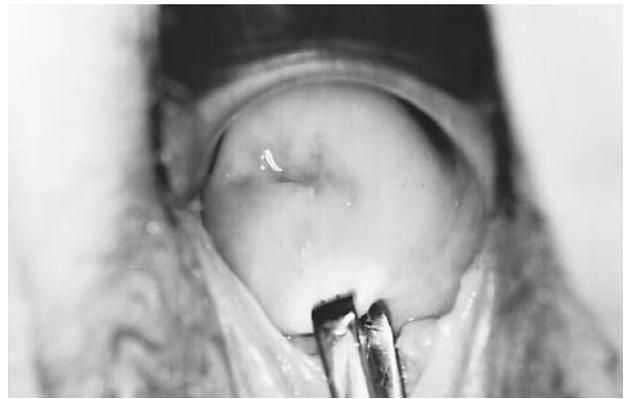
The colposcope is placed outside the patient's body and never touches the skin. The cervix and vagina are swabbed with dilute acetic acid (vinegar). The solution highlights abnormal areas by turning them white (instead of a normal pink color). Abnormal areas can also be identified by looking for a characteristic pattern made by abnormal **blood vessels**.

If any abnormal areas are seen, the doctor will take a biopsy of the tissue, a common procedure that takes about 15 minutes. Several samples might be taken, depending on the size of the abnormal area. A biopsy may cause temporary discomfort and cramping, which usually go away within a few minutes. If the abnormal area appears to extend inside the cervical canal, a scraping of the canal may be done. The biopsy results are usually available within a week.

If the tissue sample indicates abnormal growth (dysplasia) or is precancerous, and if the entire abnormal area can be seen, the doctor can destroy the tissue using one of several procedures, including ones that use high heat (diathermy), extreme cold (cryosurgery), or lasers. Another procedure, called a loop electrosurgical excision (LEEP), uses low-voltage, high-frequency radio waves to excise tissue. If any of the abnormal tissue is within the cervical canal, a cone biopsy (removal of a conical section of the cervix for inspection) will be needed.

Preparation

Patients should be instructed not to douche or have sexual intercourse for 24 hours before the colposcopy. Patients should empty their bladder and bowels before colposcopy for comfort. Colposcopy does not require any anesthetic medication because **pain** is minimal. If a biopsy is done, there may be mild cramps or a sharp pinching when the tissue is removed. To lessen this pain the doctor may recommend 800 mg of ibuprofen (Motrin) taken



A colposcopy makes it possible for a physician to view this healthy cervix without surgery. (Photograph by Dr. P. Marazzi, Custom Medical Stock Photo. Reproduced by permission.)

the night before and the morning of the procedure (no later than 30 minutes before the appointment). Patients who are pregnant or allergic to aspirin or ibuprofen can take two tablets of acetaminophen (Tylenol) instead.

Aftercare

If a biopsy was done, there may be a dark vaginal discharge afterwards. After the sample is removed, the doctor applies Monsel's solution to the area to stop the bleeding. When this mixes with **blood** it creates a black fluid that looks like coffee grounds. This fluid may be present for a couple of days after the procedure. It is also normal to have some spotting after a colposcopy. Pain-relieving medication can be taken to lessen any postprocedural cramping.

Patients should not use tampons or put anything else in the vagina for at least a week after the procedure, or until the doctor says it's safe. In addition, women should not douche or have sex for at least a week after the procedure because of the risk of **infection**.

Complications

Occasionally, patients may have bleeding or infection after biopsy. Bleeding is usually controlled with a topical medication prescribed by the physician or health care provider.

A patient should call her doctor right away if she notices any of the following symptoms:

- heavy vaginal bleeding (more than one sanitary pad an hour)
- fever, chills, or an unpleasant vaginal odor
- lower abdominal pain

Health care team roles

The colposcopy may be performed by a gynecologist or other qualified health care provider. Such examinations will normally be performed in the presence of a female nurse. In cases of sexual assault, a nurse practitioner or **registered nurse** may perform the procedure. If a biopsy is performed, a pathologist examines the tissue samples under a powerful microscope in the laboratory and sends the results to the health care provider who, in turn, informs the patient of the results.

Results

If visual inspection shows that the surface of the cervix is smooth and pink, this is considered normal. Areas that look abnormal may be normal variations; a biopsy will indicate whether the tissue is normal or abnormal.

Abnormal conditions that can be detected using colposcopy and biopsy include precancerous tissue changes (cervical dysplasia), **cancer**, and cervical warts (human papilloma virus).

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- Association of Women's Health, Obstetric, and Neonatal Nurses (AWHONN). 2000 L St., NW, Ste. 740, Washington, DC 20036. (800) 673-8499. <<http://www.awhonn.org>>.
- DES Action USA. 610 16th St., Ste. 301, Oakland, CA 94612. (510) 465-4011. <<http://www.desaction.org>>.
- Society of Gynecologic Oncologists. 401 North Michigan Ave., Chicago, IL 60611. (312) 644-6610. <<http://www.sgo.org>>.

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KEY TERMS

Biopsy—Removal of sample of abnormal tissue for more extensive examination under a microscope.

Cervix—The neck of the uterus.

Cryosurgery—Freezing and destroying abnormal cells.

DES—The abbreviation for diethylstilbestrol, a synthetic form of estrogen that was widely prescribed to women from 1940 to 1970 to prevent complications during pregnancy. It was linked to several serious birth defects and disorders of the reproductive system in daughters of women who took DES. In 1971 the FDA suggested it not be used during pregnancy and banned its use in 1979 as a growth promoter in livestock.

Diathermy—Also called electrocautery, this is a procedure that heats and destroys abnormal cells. It is gradually being replaced by cryosurgery, lasers, or LEEP.

Dysplasia—Development of abnormal tissue.

Human papilloma virus (HPV)—A virus that causes common warts of the hands and feet, as well as lesions in the genital and vaginal area. More than 50 types of HPV have been identified, some of which are linked to cancerous and precancerous conditions, including cancer of the cervix.

Loop electrosurgical excision (LEEP)—A procedure that can help diagnose and treat cervical abnormalities using a thin wire loop that emits a low-voltage high-frequency radio wave that can excise tissue. It is considered better than either lasers or electrocautery because it can both diagnose and treat precancerous cells or early stage cancer at the same time.

Monsel's solution—An aqueous solution of Monsel's salts with valuable styptic properties.

PAP test—The common term for the Papanicolaou test, a simple smear method of examining stained cells to detect cancer of the cervix.

Speculum—A retractor used to separate the walls of the vagina to make visual examination easier.

Coma

Definition

Coma, from the Greek word *koma*, meaning deep sleep, is a state of extreme unresponsiveness, in which an individual exhibits no voluntary movement or behavior. Furthermore, in a deep coma, even painful stimuli (actions which, when performed on a healthy individual, result in reactions) are unable to cause any response, and normal **reflexes** may be lost.

Description

The important characteristics of the conscious state is defined by two fundamental elements: awareness and arousal.

Awareness allows one to receive and process all the information communicated by the five senses. Awareness has both psychological and physiological components. The psychological component refers to an individual's mind and mental processes. The physiological component refers to the functioning of an individual's **brain**, and the physical and chemical condition of the brain. Awareness is regulated by cortical areas within the cerebral hemispheres, the outermost layer of the brain.

Arousal is regulated solely by physiological functioning and consists of more primitive responsiveness to the world, as demonstrated by predictable reflex (involuntary) responses to stimuli. Arousal is maintained by the reticular activating system (RAS), a network of brain structures, including the brainstem, the medulla, and the thalamus, and nerve pathways that function together to produce and maintain arousal.

Causes and symptoms

Coma is the result of something that interferes with the functioning of the cerebral cortex and/or the functioning of the structures that comprise the RAS. Several conditions can result in coma. Anatomic causes of coma are those conditions that disrupt the brain structures responsible for consciousness, either at the level of the cerebral cortex or the brainstem, while metabolic causes of coma consist of those conditions that change the chemical environment of the brain, thereby adversely affecting function.

There are many metabolic causes of coma, including:

- a decrease in the delivery to the brain of substances necessary for appropriate brain functioning, such as oxygen, glucose (sugar), and sodium

- the presence of certain substances such as drugs, alcohol, carbon dioxide, and ketones that disrupt the functioning of neurons
- changes in chemical levels in the brain caused by seizures

Diagnosis

History and examination form the cornerstone of diagnosis when an individual is in a coma. However, history must be obtained from family, friends, or emergency medical service personnel.

The Glasgow Coma Scale is a system of examining a comatose person. It evaluates the depth of the coma, tracks the person's progress, and predicts the ultimate outcome of the coma. The Glasgow Coma Scale assigns a different number of points for exam results in three different categories: opening the eyes, verbal response, and motor response (moving a part of the body). Fifteen is the largest possible number of total points, indicating the highest level of functioning, which would be demonstrated by individuals who spontaneously open their eyes, give appropriate answers to questions about their situations, and can carry out a command such as moving a specific limb when ordered. Three is the least possible number of total points, and would be given to a person for whom not even a painful stimulus is sufficient to provoke a response. In the middle are those people who may be able to respond, but who require an intense or painful stimulus, and whose response may demonstrate some degree of brain malfunctioning. When performed as part of the admission examination, a Glasgow score of three to five points often suggests that an individual has likely suffered fatal brain damage, while eight or more points indicates that the person's chances for recovery are good.

Expansion of the pupils and respiratory pattern are also important. Metabolic causes of coma are diagnosed from **blood** work and **urinalysis** to evaluate blood chemistry, drug screen, and blood cell abnormalities that may indicate **infection**. Anatomic causes of coma are diagnosed from computed tomography (CT) or **magnetic resonance imaging** (MRI) scans.

Treatment

Coma is a medical emergency, and attention must first be directed to maintaining an individual's respiration and circulation, using intubation and ventilation, administration of intravenous fluids or blood as needed, and other supportive care. If head trauma has not been excluded, the neck should be stabilized in the event of fracture. It is extremely important for a physician to quickly determine

the cause of a coma, so that potentially reversible conditions are immediately treated. These conditions may include an infection that can be treated with **antibiotics**, a **brain tumor** that can be removed, or brain swelling that can be reduced with certain medications.

Various metabolic disorders can be addressed by supplying an individual with the correct amount of oxygen, glucose, or sodium, by treating the underlying problem in **liver** disease, **asthma**, or diabetes, and by halting seizures with medication. Because of their low incidence of side effects and potential for prompt reversal of coma in certain conditions, glucose, the B-vitamin **thiamine**, and Narcan (to counteract any narcotic-type drugs) are routinely given.

Prognosis

Some conditions that cause coma can be completely reversed, restoring an individual to an original level of functioning. However, if areas of the brain have been sufficiently damaged due to the severity or duration of the condition that led to the coma, an individual may recover with permanent disabilities, either physical or mental, or may never regain consciousness. Short of death, the most severe types of brain injury result in states in which an individual loses all ability to function and remains deeply unresponsive. An individual who has suffered such a severe brain injury may remain in a coma indefinitely. This condition is termed a persistent vegetative state.

Outcome from a coma is therefore quite variable and depends a great deal on the cause and duration of the coma. In the case of drug poisonings, extremely high rates of recovery can be expected following prompt medical attention. Persons who have suffered head injuries tend to do better than do those whose coma was caused by medical illness. Besides those people whose coma results from drug **poisoning**, only about 15% of individuals who remain in a coma for more than just a few hours make a good recovery. Adult patients who remain in a coma for more than four weeks have almost no chance of eventually regaining their previous level of functioning. On the other hand, children and young adults have regained functioning after two months in a coma.

Health care team roles

Emergency medical team members are often first on the scene to provide a preliminary assessment of unconsciousness. In the hospital, a physician makes the diagnosis of coma, often with assistance from radiologists and laboratory technicians. Nurses provide supportive

KEY TERMS

Anatomic—Related to the physical structure of an organ or organism.

Metabolic—Refers to the chemical processes of an organ or organism.

Narcan—A drug that reverses the effects of narcotics.

Neuron—The cells within the body which comprise the nervous system.

Reticular activating system (RAS)—A network of structures, including the brainstem, medulla, and thalamus, and nerve pathways, which function together to produce and maintain arousal.

Stimulus—Action performed on an individual that predictably provokes a reaction.

care throughout the duration of a coma. Physical therapists provide range of motion and other therapeutic movements designed to preserve normal muscular functioning.

Prevention

Medical conditions known to cause comas should be monitored and promptly treated. Applicable safety precautions and rules should be followed when engaging in any activity that has the potential for serious **head injury**.

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Combat neurosis see **Post-traumatic stress disorder**

Community fluoridation see **Water fluoridation**

Common cold

Definition

The common cold is a viral **infection** of the upper **respiratory system**, including the nose, throat, sinuses, eustachian tubes, trachea, larynx, and bronchial tubes. Although over 200 different **viruses** can cause a cold, 30–50% are caused by a group of viruses known as rhinoviruses. Almost all colds clear up in less than two weeks without complications.

Description

Colds, sometimes called rhinovirus or coronavirus infections, are common, frequently occurring illnesses. It is estimated that the average person has more than 50 colds during a lifetime. Anyone can get a cold, although preschool and grade school children catch them more frequently than adolescents and adults because they have not been exposed to the cold viruses and developed immunity. Repeated exposure to the viruses that cause colds creates partial immunity.

Although most colds resolve on their own without complications, they are a leading cause of visits to the doctor and of time lost from work and school. Treating symptoms of the common cold has given rise to a multi-million dollar industry in over-the-counter medications.

Cold season in the United States begins in early autumn and extends through early spring. Colds occur more frequently during this period because people tend to spend more time indoors where it is easier for viruses to spread from one person to another. Although it is not true that getting wet or being in a draft causes a cold (a person has to come in contact with the virus to catch a cold), certain conditions may lead to increased susceptibility. These include:

- fatigue and overwork
- emotional **stress**
- poor nutrition
- smoking
- living or working in crowded conditions

Colds make the upper respiratory system less resistant to bacterial infection. Secondary bacterial infection may lead to otitis media (middle ear infection), bronchitis, **pneumonia**, sinus infection, or **strep throat**. Patients with chronic lung disease, **asthma**, diabetes, or a weakened **immune system** are more likely to develop these complications.

Causes and symptoms

Colds are caused by more than 200 different viruses. The most common groups are rhinoviruses and coronaviruses. Different viruses are more infectious at different seasons of the year, but determining the exact virus causing the cold is not important for purposes of treatment.

People with colds are contagious during the first two to four days of the infection. Colds pass from person to person in several ways. When an infected person coughs, sneezes, or speaks, tiny fluid droplets containing the virus are expelled. If these are inhaled by others, the virus may establish itself in their noses and airways.

Colds can also be passed through direct contact. If a person with a cold touches his runny nose or watery eyes, then shakes hands with another person, the virus is transferred to the uninfected person. When the uninfected person touches his mouth, nose, or eyes, the virus is transported to an environment where it can reproduce and produce symptoms of illness.

Finally, cold viruses can be spread through inanimate objects such as doorknobs, telephones, or toys that become contaminated with the virus. This is a common method of viral transmission in childcare centers. When a child with a cold touches his runny nose, then plays with a toy, the virus may be transferred to the toy. When another child plays with the toy a short time later, he may pick up the virus on his hands. When the second child touches his contaminated hands to his eyes, nose, or mouth the virus is once again in an environment conducive to replication.

Once acquired, the cold virus attaches itself to the mucosal lining of the nasal passages and sinuses. This causes the infected cells to release a chemical called histamine. Histamine increases **blood** flow to the infected cells, causing swelling, congestion, and increased mucus production. One to three days following infection, the affected individual begins to experience cold symptoms.

The first cold symptoms are **sore throat**, runny nose, and sneezing. The initial discharge from the nose is clear and thin. Later it changes to a thick yellow or greenish discharge. Most adults do not develop a **fever** when they contract a cold. Young children may develop fevers to 102°F (38.9°C).

Along with a runny nose and fever, symptoms of a cold include coughing, sneezing, nasal congestion, headache, myalgias (muscle aches), chills, sore throat, hoarseness, watery eyes, fatigue, and loss of appetite. The cough that accompanies a cold is usually intermittent and nonproductive (dry).

Most people begin to feel better four to five days after cold symptoms become noticeable. All symptoms are generally gone within ten days, except for a dry cough that may linger for up to three weeks.

Colds increase susceptibility to bacterial infections such as strep throat, middle ear infections, and sinus infections. Individuals with symptoms that do not begin to improve within a week; or those with chest **pain**, persistent fever (fever for longer than a few days), difficulty breathing, productive cough, skin rash, swollen glands, or whitish spots on the tonsils or throat should consult a health care practitioner. The health care practitioner will determine if these patients have acquired secondary bacterial infections that require treatment with **antibiotics**.

People who have **emphysema**, chronic pulmonary disease, diabetes, or a weakened immune system—either from diseases such as **AIDS** or leukemia, or as the result of immunosuppressive medications (**corticosteroids**, **chemotherapy** drugs)—should consult a health care practitioner when they experience cold symptoms. Patients with these chronic health problems are at greater risk for secondary infections.

Diagnosis

Colds are readily diagnosed using a focused history and **physical examination**. There are no laboratory tests readily available to detect or isolate the causative virus. When patients seek medical care, the health care practitioner (physician or mid-level practitioner) may perform a **throat culture** or blood test to rule out a secondary bacterial infection.

Though viruses cause both colds and **influenza** (flu), influenza is usually a more serious viral illness. A cold develops gradually over the course of a day or two. Patients may have a runny nose, sneezing, mild sore throat, headache and body aches, but usually they do not have fever or feel completely exhausted. Influenza symptoms develop suddenly. They are similar to cold symptoms, but usually more severe. Patients with influenza generally feel sicker than those with colds because the influenza virus produces symptoms throughout the body—muscle aches, weakness, fever, and chills.

Allergies also produce rhinitis (runny nose). Symptoms of allergic rhinitis—sneezing, nasal congestion, and itchy, runny nose—are commonly caused by

dust mites, animal dander, or indoor molds. Other environmental irritants such as smoke, pollen, pollutants, pesticides, and perfumes may also trigger allergic rhinitis. Allergies are usually more persistent than the common cold. An allergist can perform tests to determine if the persistent cold-like symptoms are attributable to an allergic reaction. Also, some people get a runny nose when they go outside in winter and breathe cold air. This type of runny nose, called vasomotor rhinitis, is not a symptom of a cold.

Treatment

There are no medicines that will cure the common cold. Given time, the body's immune system will make antibodies to fight the infection, and the cold will resolve without any intervention. Antibiotics are useless against a cold. There are, however, medications to provide symptom relief. Pharmaceutical companies in the United States promote an array of products designed to relieve cold symptoms. Most products contain **antihistamines**, decongestants, and/or pain relievers.

Antihistamines block the action of the chemical histamine that is produced when the cold virus invades the cells lining the nasal passages. Histamine increases blood flow and causes the cells to swell. Antihistamines relieve the symptoms of sneezing, runny nose, itchy eyes, and congestion. Side effects are dry mouth and drowsiness, especially with the first few doses. Patients should be advised against taking antihistamines if they intend to drive or operate dangerous equipment. The brand names of common over-the-counter antihistamines are Chlor-Trimeton, Dimetapp, Tavist, and Actifed. The generic names of two common antihistamines are chlorpheniramine and diphenhydramine.

Decongestants work to constrict the blood flow to the vessels in the nose. This can shrink the tissue, reduce congestion, and open inflamed nasal passages, making breathing easier. Decongestants can cause patients to feel jittery or prevent them from sleeping. They should not be prescribed for or used by patients with **heart** disease, high **blood pressure**, or **glaucoma**. The brand names of some common decongestants are Neo-Synephrine, Novafed, and Sudafed. The generic names of common decongestants are phenylephrine, phenylpropanolamine, pseudoephedrine, and in nasal sprays naphazoline, oxymetazoline, and xylometazoline.

Many over-the-counter medications are combinations of antihistamines and decongestants. They also may include an ache and pain reliever, such as acetaminophen (Datril, Tylenol, Panadol) or ibuprofen (Advil, Nuprin, Motrin, Medipren), and a cough suppressant (dextromethorphan). Common combination

medications include Tylenol Cold and Flu, Triaminic, Sudafed Plus, and Tavist D. Aspirin should not be given to children with colds because of its association with a risk of Reye's syndrome.

Nasal sprays and nose drops also are promoted to relieve nasal congestion. These usually contain a decongestant, but the decongestant can act more quickly and strongly than ones found in pills or liquids because it is applied locally, directly in the nose. Congestion usually returns after a few hours.

Patients may become dependent on nasal sprays and nose drops. If used for a long time, users may suffer withdrawal symptoms when the products are discontinued. This withdrawal condition is called rhinitis medicamentosa. Nasal sprays and nose drops should not be used for more than a few days. Patients should be instructed to adhere to product-specific recommendations about duration and frequency of use.

Individuals have varied reactions to different cold medications and may find some more helpful than others. A medication may be effective initially, then lose some of its effectiveness. Children sometimes react differently from adults. Patients should be cautioned against giving over-the-counter cold remedies to infants without first consulting a health care professional.

Care should be taken not to exceed the recommended dosages, especially when combination medications or nasal sprays are used. Individuals should determine whether they wish to use any of these medications based on their need for symptom relief, since none of them shorten the duration of a cold. Patients confused about the use of over-the-counter cold remedies should be encouraged to seek counsel from a health care practitioner, such as a physician, mid-level practitioner, nurse, or pharmacist.

Along with the optional use of over-the-counter cold remedies, there are some self-care steps that patients can take to ease their discomfort. These include:

- Drinking plenty of fluids, but avoiding acidic juices, which may irritate the throat.
- Gargling with warm salt water (made by adding one teaspoon of salt to 8 oz of water) for a sore throat.
- Not smoking.
- Getting plenty of rest.
- Using a cool-mist room humidifier to ease congestion and sore throat.
- Rubbing Vaseline or other lubricant under the nose to prevent irritation from frequent nose blowing.
- For babies too young to blow their noses, the mucus should be suctioned gently with an infant nasal aspira-

tor. It may be necessary to soften the mucus first with a few drops of salt water.

Many alternative health care practitioners believe that people contract colds because their immune systems are weak. They observe that everyone is exposed to cold viruses, but not everyone becomes ill. The difference seems to be in the ability of the immune system to fight infection. Prevention focuses on strengthening the immune system by eating a healthy diet low in sugars and high in fresh fruits and vegetables, practicing **meditation** to reduce stress, and getting regular moderate **exercise**.

There is some scientific evidence that phytochemicals, nutrients found in fruits and vegetables, may act to prevent viral infections such as colds. An herb, *Echinacea purpurea*, is widely used to prevent and treat colds. It is believed to act as a transient (brief) immunostimulant, however, patients with autoimmune diseases should not use it since continuous use had been linked to immunosuppression.

The use of **zinc** lozenges every two hours along with high doses of **vitamin C** is another alternative therapy. Some alternative practitioners also suggest eliminating dairy products for the duration of the cold because they contend that dairy products encourage production of mucus.

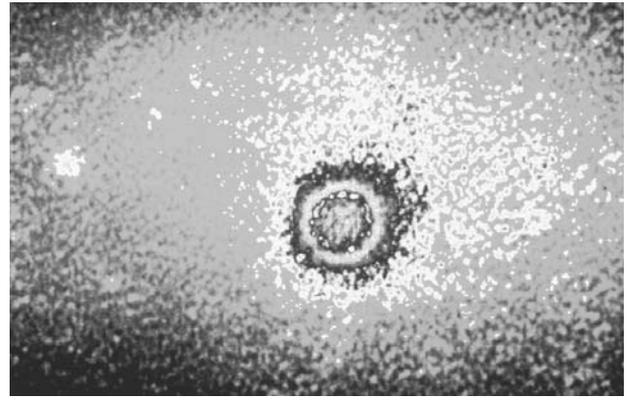
The use of zinc lozenges to treat cold symptoms remains controversial. Some studies evaluating the effectiveness of zinc gluconate lozenges found that using zinc in the first 24 hours after cold symptoms occurred shortened the duration of symptoms. Other studies refuted these findings.

Prognosis

Given time, the body will generate antibodies to the cold. Most colds last a week to ten days, and patients start feeling better within four or five days. Occasionally, a cold will lead to a secondary bacterial infection that causes strep throat, bronchitis, pneumonia, sinus infection, or a middle ear infection. These conditions usually resolve rapidly when treated with the appropriate antibiotic.

Health care team roles

Nearly all health care professionals encounter patients seeking advice about, or treatment for, cold symptoms. Physicians, mid-level practitioners, nurses, pharmacists, and health educators are often called upon to evaluate symptoms, instruct patients in self-care techniques, and reassure them that colds are self-limiting disorders that generally resolve without treatment.



Rhinovirus magnified 100,000 times. Rhinovirus causes the common cold. (CHSP/Custom Medical Stock Photo. Reproduced by permission.)

Patient education

Along with strategies to prevent the spread of cold viruses, it is vitally important for health care professionals to teach patients that antibiotics have no role in the treatment of the common cold. Antibiotics should not be prescribed for colds because, as of 2001, there are no antibiotics effective against the viruses that cause colds. Further, antibiotics should not be prescribed unnecessarily because they can produce side effects such as rash and **diarrhea**. Another dangerous **public health** consequence of overuse of antibiotics is the emergence of strains of **bacteria** that are resistant to these medications.

Prevention

It is not possible to prevent colds because the viruses that cause colds are common and highly infectious. There are, however, steps individuals can take to reduce their spread. These include:

- Washing hands well and frequently, especially after touching the nose and before handling food.
- Covering the mouth and nose when sneezing.
- Disposing of used tissues properly.
- Avoiding close contact with an infected individual during the first two to four days of their infection.
- Not sharing food, eating utensils, or cups with others.
- Avoiding crowded places where cold germs can spread.
- Eating a healthy diet and getting adequate sleep.

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KEY TERMS

Bronchial tubes—The major airways to the lungs and their main branches.

Coronavirus—A type of virus that causes respiratory disease and gastroenteritis.

Corticosteroids—A group of hormones produced naturally by the adrenal gland or manufactured synthetically. They are often used to treat inflammation. Examples include cortisone and prednisone.

Eustachian tube—A thin tube between the middle ear and the pharynx. Its purpose is to equalize pressure on either side of the ear drum.

Rhinovirus—A virus that infects the upper respiratory system and causes the common cold.

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Barbara Wexler

Community health programs

Definition

Community health programs are locally based education and treatment programs available typically to individuals who are living in poverty and/or do not have health insurance coverage. Community health programs are usually non-profit and seek funding through health department programs, donations, and government grants. Community-based health programs are typically found in communities where the services are needed the most, and the services are tailored to the populations of residents.

Description

Community health programs and clinics provide treatment, special clinics, education, and media campaigns that target a variety of issues affecting the health of a community. Many poor populations would have no other options for treatment without such neighborhood clinics and community health programs. Typical services include testing and treatment of sexually transmitted diseases; gynecological and obstetrical services; well-baby checks and immunizations; treatment of chronic diseases such as diabetes and high **blood pressure**; substance abuse programs; and general health promotion of good **nutrition** and weight management.

U.S. populations

Community-based programs will continue to be in demand to serve all populations from newborns to the elderly. Such programs are likely to become increasingly necessary to serve the growing number of immigrants moving to and living in the United States, the aging of the baby boomer generation, and the overall expansion of the population.

In the 21st century, the United States is expected to become increasingly diverse as the proportion of immigrants grows. In the next 25 years, the number of non-Hispanic white people living in the United States is expected to decrease from 72% to 62% due mostly to the increase in Hispanic populations.

Immigration also affects fertility rates because women in some immigrant populations tend to have more children. The need for **reproductive health** care and **pregnancy** prevention services are expected to increase at the community level.

The demand for services for the elderly will also increase as baby boomers age. As the health status of the elderly population improves, older adults are increasingly choosing to stay in their own homes and live independently. Senior citizens who live on a fixed income or who have limited health care coverage may be hard-pressed to pay for medications, monitoring, and treatment of age-related, chronic conditions such as diabetes, high **blood pressure**, declining eye sight, **hearing loss**, and **heart** disease.

Viewpoints

One point of debate within community health programs is the maximum income a person may earn and still be eligible for community health benefits. With limited funding, these agencies must follow guidelines for whom to offer services. In addition to those clearly living in poverty, the working poor and those with fixed

incomes may not otherwise be able to afford health care services.

The American Public Health Association (APHA) emphasizes that health care for all individuals is a basic human right. Every individual should be able to participate in his or her own health and wellbeing, and it is every citizen's responsibility to contribute to the wellbeing of all. Community-based health programs offers the opportunity to empower the community to enable all citizens to have access to optimum health. Community health directors can take the lead to promote these ends.

In collaboration with the APHA, the American Medical Association (AMA) has implemented seven goals, known as the Medicine/Public Health Initiative. They include: working to change the attitude within academic health centers; community health programs, insurance companies, and other health care delivery providers having a more health-centered approach; creating interdisciplinary teams to establish research-based programs that focus on relevant health problems; expanding the public's understanding of medicine, and, in turn, helping those in medicine understand public health; developing a common research agenda for public health; and developing a framework for integrating health promotion into clinical and community settings.

Professional implications

The AMA emphasizes that the success of health education and promotion lies with many disciplines collaborating and working cooperatively. Health care professionals, such as physicians, social workers, nurses, health educators, environmental health engineers, and behavioral health professionals, have their own unique training, skills, and tools. Public health is a multidisciplinary field. By contributing a population-based perspective on health and disease, public health practitioners can collaborate with medical professionals to optimize resources and ideas and contribute more effectively to improving the health of the community. Community-based health clinics and centers are in need of professionals who can lobby legislators to support funding for programs, in addition to lobbyists who can work with government agencies such as the **Health Care Financing Administration (HCFA)**, which oversees **Medicaid** funding.

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The Center for Community-Based Health Strategies. 1825 Connecticut Ave., NW, Washington, D.C. 20009. (202) 884-8862. <<http://www.healthstrategies.org>>.

U.S. Department of Health and Human Services, Offices of Disease Prevention and Health Promotion. 200 Independence Ave., SW, Washington, D.C. 20201. (202) 401-6295. <<http://odphp.osophs.dhhs.gov>>.

Meghan M. Gourley

Complementary nursing therapies

Definition

Complementary therapies are treatment modalities originating outside of Western medical practices that are used in addition to traditional Western medical practices. Alternative therapies are treatment modalities used in place of traditional Western medicine. The two terms are sometimes used interchangeably. The term integrative therapy may be used to describe the use of complementary and alternative (CAM) therapies with traditional Western medical practice. The National Center for Complementary and Alternative Medicine (NCCAM) at the National Institutes of Health defines complementary and alternative medical practices as “practices that are not currently an integral part of conventional medicine.”

Description

The NCCAM groups CAM practices into five categories:

- **Alternative medical systems.** This category includes acupuncture and traditional Chinese medicine (TCM), the ancient Indian practice of Ayurveda, **homeopathy**, naturopathy, and practices considered traditional to other cultures. The term medical system means that these practices incorporate the use of dietary recommendations, **exercise**, **meditation**, and/or herbal remedies as part of the total treatment plan.
- **Mind-body interventions.** These include biofeedback, prayer, meditation, hypnosis, dance, music and art ther-

apies, guided imagery, progressive muscle **relaxation**, and visualization. Many of these techniques aid in stress-reduction and can be taught to patients, either individually or in groups.

- Biologically based therapies. Included in this category are herbal remedies and supplements, special diets such as Dr. Dean Ornish's program (low-fat, vegetarian, meditation, exercise, and support group) for **cardiac rehabilitation** patients, vitamin therapy, or the use of laetrile or shark cartilage.
- Manipulative and body-based methods. Osteopathy, chiropractic, massage, and reflexology are considered manipulative therapies.
- Energy therapies. These practices are based on the philosophy that an energy field exists around the body. The goal of practices such as reiki, qi gong, and **therapeutic touch** (TT) is to reestablish a healthy energy field so that the body can then work to heal itself. The use of magnets to manipulate the energy field is another example.

Describing CAM practices using the vocabulary of Western medicine is often a challenge, as the concept of life force, or chi, does not exist. However, a health practitioner who has been with a dying patient will recognize that, when the patient has died, there is a physical difference in how the patient looks. They do not just look asleep, for that which made them alive is now gone. It is this rather ephemeral quality that is described as chi.

Acupuncture has existed for thousands of years. Treatment is based on the belief that the acupuncture points connect a system of meridians, or energy pathways, to the internal organs. When energy flows freely, health is experienced. Disease or illness represents a blockage of the flow of energy throughout the body. TCM uses acupuncture along with herbal remedies and diet to reestablish balanced energy. Acupuncture may use an herb called moxa to enhance the stimulation of the acupuncture points. **Acupressure** involves the stimulation of the meridian points by manual pressure rather than with the fine acupuncture needles. Acupuncture has been successfully used to treat dental **pain** and the nausea associated with **pregnancy**, postsurgical anesthesia, and **chemotherapy**. According to the NCCAM, the World Health Organization lists about 40 conditions for which acupuncture may be beneficial.

Ayurveda is a traditional Indian medical system based on the belief that disease and illness result when there is an imbalance of the three doshas, which represent qualities governing body type, as well as the seasons and the different times of day. Each body type is susceptible to its own set of illnesses. Treatment to reestablish balance involves diet, herbal supplements, **yoga**, meditation, and massage with certain herbal oils.

Homeopathy functions on the philosophy that substances causing illness can be used in very dilute quantities to reestablish health. The more the substance is diluted, the more potent it becomes. Homeopathic remedies come in tablet, liquid, and cream form, and are used for children as well as for adults. The Food and Drug Administration (FDA) regulates the manufacture of homeopathic remedies.

Mind-body therapies emphasize the healing power intrinsic within the human body. Biofeedback uses a machine that both records physical measurements, such as skin temperature and **blood pressure**, as well as giving visual or auditory cues to teach the individual to control these factors usually considered involuntary. Patients suffering from migraines may use biofeedback to learn to warm their hands and cool their foreheads, thus providing relief on demand. Patients may learn a meditation technique in order to control the effect of **stress** on the body, perhaps to decrease their high **blood** pressure. Many meditation techniques exist. In meditation, the individual tries to focus on a word, feeling, breathing pattern, or state of being in order to free the mind of other thoughts. Guided imagery is a technique encouraging individuals to utilize all their senses to create a peaceful, calming image in their mind. This technique works well with children, and can be used to distract from pain or **anxiety**. In progressive muscle relaxation, the individual tightens then relaxes the muscles of the body, starting with the feet and moving towards the head. This process helps the person become more aware of the feeling of tight versus relaxed muscles, and enables the body to achieve greater physical relaxation. Nurses can teach these techniques to their patients, empowering them with ways to manage the stress in their daily lives.

Herbal remedies and supplements are used for therapeutic purposes and may be a part of an alternative system, such as Chinese medicine or naturopathy. They may be taken in tablet form, drunk as a tea, applied in a carrier cream, or inhaled in a vapor. Aromatherapy uses essential oils to stimulate the **brain** through the sense of **smell** to bring about a physiological effect such as relaxation or mood elevation. While individual herbal remedies are being investigated, such as the use of garlic to reduce cholesterol levels, or the use of saw palmetto for benign prostatic hyperplasia (enlarged prostate), the interaction of herbs with standard medications has often not been thoroughly researched.

Infant massage can be taught to new parents to facilitate bonding, and to teach them how to soothe their newborn. Infant massage has been used with infants in the intensive care unit to reduce their level of stress from being in an over-stimulating, noisy environment, address

their emotional needs, foster weight gain, and enable earlier discharge.

Reflexology involves a directed massage of the feet or hands. Points on the hands and feet are believed to correspond with internal organs, similar to the connection between acupuncture points, meridians, and internal organs. In reflexology, the practitioner applies pressure to specific points on the feet or hands to stimulate or remove energy blockages, thereby promoting healing and restoring health.

Prayer and the use of support groups are other important methods that can have an impact on an individual's health. Individuals with **cancer** who attended support groups were found to live longer than those who did not attend a support group.

Therapeutic touch (TT) is an energy technique developed by a **registered nurse** and university professor, Dr. Dolores Kreiger. Practitioners use their hands to sense the energy around a patient, feeling for areas where the energy is stagnant, or blocked. The patient may feel a sense of warmth or tingling while the practitioner is working to rebalance the energy. The goal is to promote the patient's innate ability to self-heal by reestablishing free-flowing energy. TT has been used to decrease pain, allowing a patient to prolong the time period between pain medication, to accelerate the rate of wound healing, and to promote relaxation.

Viewpoints

A 1998 study reported that in 1997 an estimated \$21.2 billion was spent on CAM services, of which \$12.2 billion was spent out-of-pocket. This figure is greater than the amount spent for all hospitalizations in the United States in 1997. Nurses may choose to believe in the validity of CAM or to believe that these, or some of these, practices represent medical quackery. Regardless of their personal belief, nurses need to recognize that many of their patients will believe and/or follow these practices. Respect for a patient's belief system is fundamental to the practice of nursing. Because of this, nurses must become knowledgeable about CAM practices in order to provide better nursing care to their patients. As research studies using CAM practices report beneficial outcomes, the definition of which therapies are considered alternative and which are considered mainstream changes. For this reason, it may be best not to label a therapy as CAM in discussing its use with a patient. In addition, patients' cultural backgrounds affect which therapies are mainstream to them.

Professional implications

As patient interest in and use of CAM increases, nurses need to be aware of these practices, regardless of whether or not they have been scientifically proven to be effective. CAM and nursing intersect at many points, including:

- **History and assessment.** As the nurse documents the patient's pertinent medical history, CAM practices need to be included. Asking open-ended questions, such as "What do you use to help your migraine pain?", may elicit a different response from the patient than the question, "Do you use alternative medicine for your migraine pain?" A 1999 study of women with **breast cancer** reported that while 72% of the women were engaged in at least one form of complementary medicine, only 54% informed their health care professional of their CAM use, although 94% told their alternative practitioner what medical treatments they were receiving. Reasons cited included concern of ridicule and perceived lack of interest from the professional. Patients requiring surgery may take herbal remedies that could interact with anesthesia medications. Knowledge of all the medications and supplements that the patient is taking could be critical.
- **Triage.** Nurses may receive telephone calls from patients who want to know if a particular herbal remedy is effective for their or their child's condition. In addition, patients may call after taking a remedy and experiencing an adverse side effect. Knowledge of herbal remedies could facilitate proper diagnosis.
- **Nurse as practitioner.** Nurses may choose to study CAM practices, become proficient in their use, and integrate their use into an existing nursing practice. However, nurses must keep in mind the legal implications of adding CAM therapies to their existing practice, to ensure they continue to practice within the legal boundaries of their license.

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KEY TERMS

Chi, qi—Life-force energy existing in and around the body.

Osteopathy—A practice of medicine that focuses on the care of the total person with an emphasis on the musculoskeletal system.

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OTHER

National Center for Complementary and Alternative Medicine. NCCAM Clearinghouse, P.O. Box 8218, Silver Spring, MD 20907-8218. (888) 644-6226. <<http://nccam.nih.gov>>.

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Complete blood count

Definition

A complete **blood** count (CBC) is a series of tests used to evaluate the composition and concentration of the cellular components of blood. It consists of the following tests: red blood cell (RBC) count, white blood cell (WBC) count, and platelet count; measurement of hemoglobin and mean red cell volume; classification of white blood cells (WBC differential); and calculation of **hematocrit** and **red blood cell indices**. The hematocrit is the percentage of blood by volume that is occupied by the red cells (i.e., the packed red cell volume). Red blood cell indices are calculations derived from the red blood

cell count, hemoglobin and hematocrit that aid in the diagnosis and classification of anemia.

Purpose

The CBC provides valuable information about the blood and to some extent the bone marrow which is the blood-forming tissue. The CBC is used for the following purposes:

- As a preoperative test to ensure both adequate oxygen carrying capacity and hemostasis.
- To identify persons who may have an **infection**.
- To diagnose anemia.
- To identify acute and chronic illness, bleeding tendencies, and white blood cell disorders such as leukemia.
- To monitor treatment for anemia and other blood diseases.
- To determine the effects of **chemotherapy** and radiation therapy on blood cell production.

Precautions

The CBC requires a sample of blood collected from a vein. The nurse or phlebotomist performing the venipuncture should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. The collection tube must be filled completely, as under-filling increases the anticoagulant (EDTA) to blood ratio, which will crenate red blood cells. The tourniquet should be removed from the arm as soon as the blood flows to prevent hemoconcentration. If a fingerstick is used to collect the blood, care must be taken to wipe away the first drop, and not to squeeze the finger excessively as this causes the blood to be diluted by tissue fluid. The tests should be performed within four hours of collection or the sample must be refrigerated. Samples stored at 35-46°F (2-8°C) may be measured for up to 18 hours. Samples must be thoroughly mixed prior to measurement. Many drugs affect the results by causing increased or decreased RBC, WBC, and/or platelet production. Medications should be taken into account when interpreting results.

Description

The CBC is commonly performed on an automated hematology analyzer using well mixed whole blood anticoagulated with EDTA. A CBC is a group of tests used to quantify the number of RBCs, WBCs, and platelets, provide information about their size and shape, measure the hemoglobin content of RBCs, determine the percentage and absolute number of the five white blood cell types, and identify early and abnormal blood cells. These tests are

performed simultaneously, (usually in less than one minute), using an automated hematology analyzer. When the performance limit of the automated hematology analyzer is exceeded, sample dilution or pretreatment, manual smear review, or manual cell counts may be required. Such conditions include very low or elevated cell counts, and the presence of cold agglutinins, lipemia, and cell fragments. For example, a manual WBC count may be performed when the automated WBC count is below 500 per microliter. A manual microscopic evaluation of a stained blood film is performed when an abnormal cell population is encountered. Each laboratory has established rules for determining the need for manual smear review based upon specific CBC parameters. For example, a manual differential is always performed when nucleated red blood cells are found on an electronic cell count.

Electronic cell counting

Electronic blood cell counting is based upon the principle of impedance (i.e., resistance to current flow). Some hematology analyzers combine impedance counting with light scattering to measure platelets. A small sample of the blood is aspirated into a chamber (the WBC counting bath) and diluted with a balanced isotonic saline solution that is free of particles. The diluted blood sample is split into two parts, one for counting RBCs and platelets and the other for counting WBCs. The RBC portion is transferred to the RBC/platelet counting bath where it is diluted further. The other portion remains in the WBC bath and a detergent (lysing agent) is added to destroy (hemolyze) the red blood cells. A small portion of the diluted fluid in each bath is allowed to flow past a small aperture. An electrical current is produced in each aperture by two electrodes, one on the inside and the other on the outside of the aperture. The saline solution is responsible for conducting current between the electrodes. The cells move through the aperture one at a time. When a cell enters the aperture, it displaces a volume of electrolyte equal to its size. The cell acts as an electrical resistor, and impedes the flow of current. This produces a voltage pulse the magnitude of which is proportional to the size of the cell. Instrument electronics are adjusted to discriminate voltage pulses produced by different cells. These adjustments are called thresholds. For example, the threshold for counting a RBC is equivalent to a cell volume of 36 femtoliters or higher. Voltage pulses that are equivalent to volumes between 2-20 femtoliters are counted as platelets. This process is repeated two more times so that the RBC, WBC, and platelet counts are performed in triplicate. Each time frame for counting is several seconds and many thousands of cells are counted. The computer processes the counting data first by determining the

agreement between the three counts. If acceptable criteria are met the counts are accepted and used to calculate the result. The computer mathematically corrects the count for the random chance of two cells entering the aperture simultaneously. The voltage pulses for each cell type are sorted and displayed. The RBC and platelet sizes are plotted as a histogram, and the WBC sizes are plotted as a scattergram. This process produces cell counts with coefficients of variation that are on the order of tenfold lower than can be achieved by manual cell counting.

The hemoglobin concentration is measured optically using the solution in the WBC bath. The lysing agent contains potassium cyanide that reacts with the hemoglobin to form cyanmethemoglobin. The optical density of the cyanmethemoglobin is proportional to hemoglobin concentration. Source light from a small tungsten lamp or an LED that produces monochromatic light is directed through the sample contained in a small tube behind the bath. An interference filter on the other side of the tube transmits unabsorbed monochromatic light (e.g., 525 nm) to a photodiode. The photodiode current is proportional to the light it receives. This electronic signal is converted to an inverse log voltage that is proportional to the optical density of the solution. The optical density reading for the diluent is subtracted from the sample and the value is multiplied by a calibration factor (determined by measuring a calibrating solution) in order to calculate hemoglobin concentration.

The voltage pulses produced by the white blood cells depend upon the size of the cell and its nuclear density. Therefore, the pulses may be analyzed to differentiate between the types of WBCs found. For example, lymphocytes are the smallest WBCs and comprise the lower end of the size scale. Monocytes, prolymphocytes, and immature granulocytes comprise the central area of the WBC histogram, and mature granulocytes comprise the upper end. In addition to cell sizing, automated instruments may use any of three other methods to distinguish between subpopulations. These are radio frequency conductance, forward and angular light scattering, and fluorescent staining.

Red blood cell count

The red cells, the most numerous of the cellular elements, carry oxygen from the **lungs** to the body's tissues. They are released from the bone marrow into the blood in an immature form called the reticulocyte that still retains much of the cellular RNA needed for hemoglobin production. Reticulocytes may be counted on some automated analyzers and are an index to recovery from anemia. The average life span of RBCs in the circulation is approximately 110 days.

The red blood cell (RBC) count determines the total number of red cells (erythrocytes) in a sample of blood. Most **anemias** are associated with a low RBC count, hemoglobin, and hematocrit. Common causes include excessive bleeding; a deficiency of **iron**, **vitamin B₁₂**, or **follic acid**; destruction of red cells by antibodies or mechanical trauma; bone marrow malignancy and fibrosis; and structurally abnormal hemoglobin. The RBC count is also decreased due to **cancer**, kidney diseases, and excessive IV fluids. An elevated RBC count may be caused by **dehydration**, hypoxia, or polycythemia vera. Hypoxia may result from high altitudes, chronic obstructive lung diseases, and congestive **heart failure**.

Hematocrit and cell indices

The hematocrit is a test that measures the volume of blood in percent that is comprised of the red blood cells. Automated cell counters calculate the hematocrit by multiplying the RBC count by the mean red cell volume (see MCV below). A decrease in the number or size of red cells also decreases the amount of space they occupy, resulting in a lower hematocrit. Conversely, an increase in the number or size of red cells increases the amount of space they occupy, resulting in a higher hematocrit. Thalassemia minor is an exception in that it usually causes an increase in the number of red blood cells, but because they are small, it results in a decreased hematocrit.

The three RBC indices are used to determine the average size and hemoglobin content of the RBCs and they help determine the cause of anemia. The three indices are described below:

- Mean corpuscular volume (MCV)—the average size of the red blood cells expressed in femtoliters. MCV is calculated by dividing the hematocrit (as percent) by the RBC count in millions per microliter of blood, then multiplying by 10.
- Mean corpuscular hemoglobin (MCH)—the average amount of hemoglobin inside an RBC expressed in picograms. The MCH is calculated by dividing the hemoglobin concentration in grams per deciliter by the RBC count in millions per microliter, then multiplying by 10.
- Mean corpuscular hemoglobin concentration (MCHC)—the average concentration of hemoglobin in the RBCs expressed in percent. It is calculated by dividing the hemoglobin in grams per deciliter by the hematocrit, then multiplying by 100.

The mechanisms by which anemia occurs will alter the RBC indices in a predictable manner. Therefore, the RBC indices permit the physician to narrow down the

possible causes of an anemia. The MCV is an index of the size of the RBCs. When the MCV is below normal, the RBCs will be smaller than normal and are described as microcytic. When the MCV is elevated, the RBCs will be larger than normal and are termed macrocytic. RBCs of normal size are termed normocytic. Failure to produce hemoglobin results in smaller than normal cells. This occurs in many diseases including **iron deficiency anemia**, thalassemia (an inherited disease in which globin chain production is deficient), and anemias associated with chronic infection or disease. Macrocytic cells occur when division of RBC precursor cells in the bone marrow is impaired. The most common causes of macrocytic anemia are vitamin B₁₂ deficiency, folate deficiency, and **liver** disease. Normocytic anemia may be caused by decreased production (e.g., malignancy and other causes of bone marrow failure), increased destruction (hemolytic anemia), or blood loss. The RBC count is low, but the size and amount of hemoglobin in the cells is normal.

White blood cell count

The majority of CBCs include both a WBC count and an automated differential. A differential determines the percentage of each of the five types of mature white blood cells. An elevated WBC count occurs in infection, allergy, systemic illness, inflammation, tissue injury, and leukemia. A low WBC count may occur in some viral infections, **immunodeficiency** states, and bone marrow failure. The WBC count provides clues about certain illnesses, and helps physicians monitor a patient's recovery from others. The differential will reveal which WBC types are affected most. For example, an elevated WBC count with an absolute increase in lymphocytes having an atypical appearance is most often caused by infectious mononucleosis. The differential will also identify early WBCs which may be reactive (e.g., a response to acute infection) or the result of a leukemia.

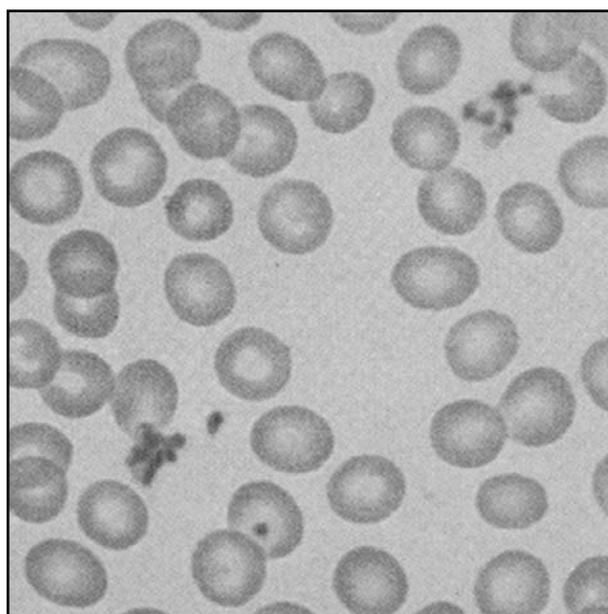
When the electronic WBC count is abnormal or a cell population is flagged, meaning that one or more of the results is atypical, a manual differential is performed. In that case, a wedge smear is prepared. This is done by placing a drop of blood on a glass slide, and using a second slide to pull the blood over the first slide's surface. The smear is air dried, then stained with Wright stain and examined under a **microscope** using oil immersion (1000x magnification). One hundred white cells are counted and identified as either neutrophils, lymphocytes, monocytes, eosinophils, or basophils based on the shape and appearance of the nucleus, the color of cytoplasm, and the presence and color of granules. The purpose is to determine if these cells are present in a normal distribution, or if one cell type is increased or decreased. Any atypical or immature cells also are counted.

In addition to determining the percentage of each mature white blood cell, the following tests are performed as part of the differential:

- Evaluation of RBC morphology is performed. This includes grading of the variation in RBC size (anisocytosis) and shape (poikilocytosis); reporting the type and number of any abnormal RBCs such as target cells, sickle cells, stippled cells, etc.; reporting the presence of immature RBCs (polychromasia); and counting the number of nucleated RBCs per 100 WBCs.
- An estimate of the WBC count is made and compared to the automated or chamber WBC count. An estimate of the platelet count is made and compared to the automated or chamber platelet count. Abnormal platelets such as clumped platelets or excessively large platelets are noted on the report.
- Any immature white blood cells are included in the differential count of 100 cells, and any inclusions or abnormalities of the WBCs are reported.

WBCs consist of two main subpopulations, the mononuclear cells and the granulocytic cells. Mononuclear cells include lymphocytes and monocytes. Granulocytes include neutrophils (also called polymorphonuclear leukocytes or segmented neutrophils), eosinophils, and basophils. Each cell type is described below:

- Neutrophils are normally the most abundant WBCs. They measure 12-16 μm in diameter. The nucleus stains dark purple-blue, and is divided into several lobes (usually three or four) consisting of dense chromatin. A neutrophil just before the final stage of maturation will have an unsegmented nucleus in the shape of a band. These band neutrophils may be counted along with mature neutrophils or as a separate category. The cytoplasm of a neutrophil contains both primary (azurophilic) and secondary (specific) granules. The secondary granules are lilac in color and are more abundant, almost covering the pink cytoplasm. Neutrophils are phagocytic cells and facilitate removal of **bacteria** and antibody-coated antigens. The neutrophilic granules are rich in peroxidase, and aid the cell in destroying bacteria and other ingested cells.
- Eosinophils are 14-16 μm in diameter and contain a blue nucleus that is segmented into two distinct lobes. The cytoplasm is filled with large refractile orange-red granules. The granules contain peroxidase, hydrolases, and basic **proteins** that aid in the destruction of phagocytized cells. Eosinophils are increased in allergic reactions and parasitic infections.
- Basophils, like eosinophils, are 14-16 μm in diameter and have a blue nucleus that is bilobed. The cytoplasm



Wright's stain of normal red blood cells and platelets.
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of the basophil is filled with large dark blue-black granules that may obscure the nucleus. These contain large amounts of histamine, heparin, and acid mucopolysaccharides. Basophils mediate the allergic response by releasing histamine.

- Lymphocytes are the second most abundant WBCs. They may be small (7-9 μm in diameter) or large (12-16 μm in diameter). The nucleus is dark blue and is nearly round or slightly indented and the chromatin is clumped and very dense. The cytoplasm is medium blue and usually agranular. An occasional lymphocyte will have a few azurophilic granules in the cytoplasm. Lymphocytes originate in the lymphoid tissues and are not phagocytic. They are responsible for initiating and regulating the **immune response** by the production of antibodies and cytokines.
- Monocytes are the largest WBCs, measuring 14-20 μm in diameter. They have a large irregularly shaped and folded blue nucleus with chromatin that is less dense than other WBCs. The cytoplasm is gray-blue, and is filled with fine dust-like lilac colored granules. Monocytes are phagocytic cells that process and present antigens to lymphocytes, an event required for lymphocyte activation.

Platelet count

Platelets are disk-shaped structures formed by the detachment of cytoplasm from megakaryocytes. They aid in the coagulation process by attaching or adhering to the

walls of injured **blood vessels**, where they stick together to form the initial platelet plug. A low platelet count may occur in patients with **AIDS**, viral infections, lymphoma, and lupus erythematosus, or in patients taking certain drugs, most notably quinine and quinidine. Decreased platelet production is also a cause of thrombocytopenia, and may be due to aplastic anemia, leukemia, lymphoma, or bone marrow fibrosis. A low platelet count can occur due to increased destruction. This can result from alloantibody production which is often drug-induced (heparin treatment being a prominent cause). Increased destruction also results from autoantibody production as occurs in idiopathic thrombocytopenic purpura (ITP) and thrombotic episodes that consume platelets such as occur in thrombotic thrombocytopenic purpura (TTP), disseminated intravascular coagulation (DIC), and hemolytic-uremic syndrome (HUS). Inherited (congenital) thrombocytopenia can be caused by Glanzmann's thrombasthenia, von Willebrand's disease, Fanconi syndrome, and Wiskott-Aldrich syndrome.

Thrombocytosis, an increased platelet count, is most often caused by a reaction to injury or inflammation. In these cases the platelet count increases transiently and is usually within the range of 400,000-800,000 per microliter. Persistent or higher counts are usually associated with myeloproliferative disease (malignant disease involving blood forming cells) such as chronic granulocytic (myelogenous) leukemia, polycythemia vera, or primary (essential) thrombocythemia.

The platelet count is most often measured by impedance counting but is performed manually when the platelet count is very low, platelet clumping is observed, or abnormally large (giant) platelets are present. Often these abnormalities and others such as cryoglobulinemia, cell fragmentation (hemolysis), and microcytic RBCs are signaled by abnormal RBC and platelet indices and abnormal population flags. An abnormal mean platelet volume or platelet histogram indicates that morphological platelet abnormalities are present and the platelets should be observed from a stained blood film to characterize the abnormality. The platelet count can be estimated using the Wright-stained blood smear used for a differential WBC count by multiplying the average number of platelets per oil immersion field by 20,000. Platelet estimates should correlate with actual counts. When they disagree, the platelet count should be repeated and a manual count performed if necessary.

Preparation

The CBC does not require fasting or any special preparation.

Aftercare

Discomfort or bruising may occur at the puncture site. Applying pressure to the puncture site until the bleeding stops helps to reduce bruising; warm packs relieve discomfort. Some people feel dizzy or faint after blood has been drawn and should be treated accordingly.

Complications

Other than potential bruising at the puncture site, and/or dizziness, there are no complications associated with this test.

Results

CBC values vary by age and sex. Normal values are ultimately determined by the laboratory performing the test. As a guide, the normal values for men and non-pregnant women are as follows:

- WBCs: 4500 to 11,000 per microliter for women and men, with neutrophils representing 50-70%, lymphocytes 25-35%, monocytes 4-6%, eosinophils 1-3%, basophils 0.4-1%, and bands 0-5%.
- RBCs: 4.2 to 5.0 million per microliter for women; 4.5 to 6.2 million per microliter for men.
- Hemoglobin: 12-15 g/dL for women; 13.6 to 17.2 g/dL for men.
- Hematocrit: 35-47% for women; 42-52% for men.
- Platelets: 150,000 and 350,000 per microliter.
- Reticulocyte count: 0.5-1.5%.

Normal adult results for red blood cell indices are as follows:

- MCV: 80-98 fl (femtoliters).
- MCHC: 32-36%.
- MCH: 27-31 pg (picograms).
- RDW: 11.5-14.5%.

In addition to normal values, critical values (alert, panic values) are established for hemoglobin (and hematocrit), WBC count, and platelet count. Precipitously low hemoglobin is associated with hypoxia that can have life-threatening complications. Extremely low WBCs indicates an inability to fight infection and a high risk of sepsis. A severely reduced platelet count predisposes the patient to spontaneous internal bleeding. Representative critical values are shown below.

- Hemoglobin: less than 5.0 g/dL.
- Hematocrit: less than 15%.
- Platelet count: less than 30,000 per microliter.

KEY TERMS

Anemia—A diminished oxygen carrying capacity caused by a decrease in the size, number, or function of red blood cells.

Capillaries—The smallest of the blood vessels that bring oxygenated blood to tissues.

EDTA—A colorless compound used to keep blood samples from clotting. Its chemical name is ethylenediaminetetraacetic acid. EDTA functions by binding the calcium in the blood sample.

Hematocrit—The volume of blood occupied by the red blood cells expressed in percent.

Hemoglobin—A protein inside red blood cells that carries oxygen to body tissues.

Hypochromic—A descriptive term applied to a red blood cell with a decreased concentration of hemoglobin.

Macrocytic—A descriptive term applied to a larger than normal red blood cell.

Mean corpuscular hemoglobin (MCH)—A measurement of the average weight of hemoglobin in a red blood cell.

Mean corpuscular hemoglobin concentration (MCHC)—The measurement of the average concentration of hemoglobin in a red blood cell.

Mean corpuscular volume (MCV)—A measure of the average volume of a red blood cell.

Mean platelet volume (MPV)—A measure of the average volume of a platelet.

Microcytic—A descriptive term applied to a smaller than normal red blood cell.

Normochromic—A descriptive term applied to a red blood cell with a normal concentration of hemoglobin.

Normocytic—A descriptive term applied to a red blood cell of normal size.

Red blood cell indices—Measurements that describe the size and hemoglobin content of red blood cells.

Red cell distribution width (RDW)—A measure of the variation in size of red blood cells.

Thrombocyte—Another name for platelet.

Thrombocytopenia—An abnormally low platelet count.

Thrombocytosis—An abnormally high platelet count. It occurs in polycythemia vera and other disorders in which the bone marrow produces too many platelets.

- WBC count: less than 2,500 per microliter and greater than 30,000 per microliter.

Abnormal blood count results are seen in a variety of conditions. One of the most common is anemia, which is characterized by a low RBC count, hemoglobin, and hematocrit. The category into which a person's anemia is placed is in part based upon the red blood cell indices provided. The indices provide a significant clue as to the cause of the anemia, but further testing is needed to confirm a specific diagnosis. The most common causes of macrocytic anemia (high MCV) are vitamin B₁₂ and folic acid deficiencies. Lack of iron in the diet, thalassemia (a type of hereditary anemia), and chronic illness are the most common causes of microcytic anemia (low MCV). Normocytic anemia (normal MCV) can be caused by kidney and liver disease, bone marrow disorders, leukemia, excessive bleeding, or hemolysis of the red blood cells. Iron deficiency and thalassemia are the most common causes of hypochromic anemia (low MCHC). Normocytic anemias are usually also normochromic and share the same causes. The red cell distribution width (RDW) is increased in anemias caused by deficiencies of

iron, vitamin B₁₂, or folic acid. Abnormal hemoglobins, such as in sickle cell anemia, can change the shape of red blood cells as well as cause them to hemolyze. The abnormal shape and the cell fragments resulting from hemolysis increase the RDW. Conditions that cause more immature cells to be released into the bloodstream, such as severe blood loss, will increase the RDW. The larger size of immature cells creates a distinct size variation.

Infections and leukemias are associated with increased numbers of WBCs. Increases or decreases in the percentage of each white cell can be associated with a number of diseases or conditions, including cancer, leukemia, anemia, **multiple sclerosis**, **allergies**, parasitic and viral diseases, infections, and tissue damage.

Health care team roles

The CBC is ordered by a physician. A nurse or phlebotomist usually draws the blood to be used for the test. A clinical laboratory scientist/medical technologist or clinical laboratory technician/medical laboratory technician performs the test. The laboratory personnel are

responsible for notifying the physician when a critical limit is encountered. A clinical pathologist may be consulted when abnormal findings that indicate a serious blood disease are noted, such as early cells or cells containing inclusions.

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Victoria E. DeMoranville

Computed radiography

Definition

Computed radiography, or CR, is a digital image acquisition and processing system for radiography that uses computers and laser technology. It was developed in the mid-1980s. CR images can be recorded on laser-printed film or transmitted and stored digitally. This technological change has a significant impact on hospital operating costs and efficiency because radiography is the most common method of diagnostic imaging. It accounts for 70% of all imaging procedures, in comparison to 10% for CT scans and 6% for MRIs.

Purpose

The purpose of CR is to produce accurate radiographic images without the use of film, thereby streamlining the storage, display, and transmission of patient data. Because CR allows the radiographer to correct images immediately following exposure, the need for retake exposures is dramatically reduced. In a CR system, corrections made in the image are relayed to the radiographer through an s number. This value tells the

radiographer whether the system had to brighten or darken the image, and to what degree, in order to produce a usable image. The adjusted image can then be printed on a film by a laser printer.

In addition to providing clear diagnostic images that can be adjusted before printing, CR simplifies the process of transmission for purposes of consultation. CR images can easily be sent to other physicians or facilities for consultation via computer networks. Furthermore, CR systems permit considerable reductions in the cost of storage space for diagnostic images. Given the rapid rise in operating costs of full-service radiology departments, many newer facilities and some larger hospitals have installed CR systems.

Precautions

Radiation levels

One problematic aspect of CR is that it requires a higher dose of radiation to produce an image comparable to those produced by the film-screen method. The higher dose is necessary because the plate speed is approximately half that of the current screens used in film-screen combinations. The speed of the plate is directly related to the amount of radiation needed to create the x-ray image. Keeping the patient's exposure to radiation "ALARA," or "as low as is reasonably achievable," has always been one of the goals of radiologic imaging. On the other hand, some radiologists note that patients may receive lower total dosages of radiation from CR imaging because fewer repeat exposures are required.

Performance considerations

A second problematic aspect of CR is that although its contrast resolution is better than that of conventional radiographic films, its spatial resolution is not as good. This drawback is especially apparent in mammograms and chest radiographs. One study that compared six different systems for chest radiography found that the CR system performed the least well, even though it was tested under the normal operating conditions for its setting.

Description

Computed radiography is an imaging technology in which a phosphor imaging plate replaces the older combination of film-screen radiography. Phosphors are substances that become luminescent (emit light) when they are excited by ultraviolet light or other forms of radiation. The imaging plate consists of either aluminum or a steel frame with honeycombed carbon fiber on one side. This side is the x-ray attenuating side. Inside is the phosphor

imaging plate, which replaces the older film-screen cassette. The plate is contained in standard-size radiographic cassettes that can be used in existing radiographic tables and stands.

The radiographer positions the patient and inserts the imaging plate cassette with the carbon-fiber side facing the x-ray tube. When the phosphor inside the imaging plate is exposed to x rays, its electrons are excited to higher energy levels. The radiographer then places the plate in a scanner, in which a helium-neon laser irradiates the excited electrons in the phosphor. The electrons emit light and return to a lower energy level. The light given off is converted first to an analog electrical signal which is then digitized, or converted into numerical data. The data can be recorded as an image on laser-printed film or transmitted and stored digitally.

Picture-archiving communications systems (PACS)

Picture-archiving communication systems, or PACS, are computer systems that allow several physicians to view radiographic images from multiple locations at the same time, whether in different departments of the same hospital or from remote facilities. CR images can be scanned, reviewed by the technologist for accuracy, and made available within three minutes to both the radiologist and the admitting physician. PACS improve hospital efficiency by eliminating the risk of losing or misplacing x-ray films as well as minimizing the need for storage space.

Complications

Systems conversion

One of the major challenges in the implementation of computed radiography in any institution is acceptance by the clinical staff. The task of retraining radiologists and technologists as well as ancillary staff can be daunting. Lastly, the increasing complexity of radiographic equipment requires greater cooperation between the engineers and scientists who develop the equipment and the health care personnel who use them. Gradual introduction of CR, along with smooth coordination of the technology experts and the clinical staff, is usually the best way of moving toward full departmental conversion.

Newer technology

An additional complication to implementing CR systems is that they no longer represent cutting-edge imaging technology. Within the past few years, a system called digital radiography, or DR, has been introduced. It

KEY TERMS

Cassette—The thin container that holds the film or the laser plate during radiographic exposure.

Digital radiography (DR)—A newer form of filmless imaging that produces digital images on a computer monitor without the use of cassettes.

Digital recording—A method of recording audio or visual data in which an input wave form is sampled thousands of times per second, and each sample is given a binary numerical value.

Film-screen—The combination of x-ray film and screens used in current conventional methods of radiographic imaging.

Phosphor—A substance that emits light when it is struck by light of a certain wavelength. Some phosphors are luminescent only when struck by ultraviolet light.

Picture-archiving communication system (PACS)—A digitized system for storing CR or DR images that replaces older film storage, manual filing, and manual routing systems.

Screen—The layer lining the cassette that changes the x-ray into light

resembles CR in that it transmits, displays, and stores images without the use of film, but it differs from CR in that it is strictly digital and does not use cassettes at all. While the advantages of CR include its portability and its lower production cost, DR offers superior contrast resolution, immediate image readout, and considerable time savings. The first productivity studies comparing the two imaging systems have found that a CR examination takes between three and four times as long as an examination using digital radiography. In one hospital near Boston, the average two-view chest radiograph required 9.9 minutes with a CR system but only 2.5 minutes with DR. Most of the time difference appears to be due to the steps required to process the CR cassettes. While some hospitals are using both CR and DR systems, others are concerned that CR technology may not have a long enough future in spite of its lower initial costs to justify implementing it at all.

Results

CR does, however, offer significant advantages in diagnostic quality over conventional film-screen methods. The latest enhancements for CR include energy sub-

traction, which makes it possible to view bone-only and soft tissue-only images of the chest, and dynamic range control, which makes it possible to study both bone and soft tissue on the same image. Another benefit of the CR system is that the images are available immediately on the monitor for evaluation and post-processing enhancement. In addition, the images can be evaluated by an off-site radiologist with a monitor hooked up to the hospital's system. Lastly, CR is a portable system that can be used at the patient's bedside or in the emergency room as well as in a radiology clinic.

Health care team roles

With computed radiography as with conventional film-screen technology, the exposures can be made by a radiologic technologist or a radiologist. The radiologist will interpret the images as part of the process of differential diagnosis. A PACS system will allow the radiologist to consult with colleagues in other parts of the hospital or other institutions.

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- Radiological Society of North America, Inc. 820 Jorie Boulevard, Oak Brook, IL 60523-2251. (630) 571-2670. Fax: (630) 571-7837. Web site: <<http://www.rsna.org>>.
- Society for Computer Applications in Radiology (SCAR). 10105 Cottesmore Court, Great Falls, VA 22066-3540. (703) 757-0054. Fax: (703) 757-0454. Web site: <http://www.scarnet.org>. The Society has published the *Journal of Digital Imaging* since 1988.

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Computed tomography equipment see **CT imaging equipment**

Computerized axial tomography see **CT scans**

Computers in health care

Definition

Once used primarily as back-office record keepers and financial calculators, computers and their networks now play increasingly significant roles in patient care. They are increasingly used by health-care practitioners for patient information, record keeping, communicating with colleagues, devising strategies for patient care, interpreting lab results, and research. The fast processors and large **memory** capacity of today's computers, along with the Internet and other networks, have expanded the role of computers into virtually every aspect of health care.

Description

From the moment a patient walks into a hospital, doctor's office or clinic, computers are involved in his or her care. Patient information is often entered electronically to generate an electronic chart. Some organizations integrate this information with practice management software, helping staff schedule patient procedures and manage the financial matters.

Computer workstations in exam rooms can now allow clinicians to access patient information, lab results, and educational material. Electrocardiograms and other lab and radiology tests are often analyzed initially by computer programs to save staff time. Some radiology departments have begun to use digital "filmless" imaging technologies, and computers are even slowly entering the chaotic environment of the operating room, where perioperative nurses use workstations to document procedures.

Computers are being used to help avert medical errors—a critical need, since, according to an Institute of Medicine report important, an estimated 44,000 to 98,000 Americans die each year from preventable errors. Computer systems in some hospitals monitor patients in intensive-care units or operating rooms, alerting clinicians to anything abnormal, such as a sharp decrease in hemoglobin levels, for example. Instead of writing prescriptions on paper, some clinicians now use computer-based systems that not only suggest **drug dosages** but



Computers can be used to view patient information, help with diagnoses, and communicate with colleagues at other facilities. (Custom Medical Stock Photo. Reproduced by permission.)

check for **allergies** and interactions as well. Some clinicians also use handheld computers to enter patient notes and check medical references.

In addition to computerizing individual hospital departments, computers are being used to tie disjointed departments together and to standardize health care information over the entire industry. Aside from promising monetary savings and improved efficiency, such departmental integration is expected to help hospitals adhere to insurance company and government requirements. The federal Health Insurance Portability and Accountability Act (HIPAA), designed to protect confidential health care information, has pushed health care organizations to use consistent standards in their dealings with patients and insurers. Such standardization also promises to improve research by allowing scientists to track **public health** records more accurately and to better identify both treatments for, and causes of, disease.

The Internet has quickly become an integral part of health care. Patients can check their **medical records**, research drug interaction information, or find information on clinical trials and experimental medical treatment. Health care practitioners use the Internet for research, to

gain continuing medical education (CME) credits, and to check patient information. To help manage this information overload, several websites provide customized health information and access to research tools such as the National Library of Medicine's Medline/PubMed, a search engine that provides access to millions of citations from research journals. The Internet can also educate people about disease prevention and help them adopt a healthy lifestyle. Specialty websites, whose topics range from mental health to infectious diseases, allow individuals to conduct disease screenings and lifestyle and quality-of-life assessments.

In addition, government health organizations, such as the Centers for Disease Control and Prevention, use the web to provide public health information to state and local health departments, health professionals, and the general public. The World Health Organization (WHO) and its member organizations have created a vast global computer network called the Library and Information Networks for Knowledge (LINK); the agency also supports an electronic database called WHOLIS. Both the library and the database support the WHO's mission to improve international public health. Once a communica-

ble disease outbreak has been confirmed, for example, information is placed on the web for the general public.

Several Internet applications can even provide telemedical services, such as long-distance mammograms to underserved women. Other applications help patients suffering from chronic diseases such as **asthma**, diabetes, and **heart** disease to monitor their conditions. Still another computer program allows diabetics to download data from a **blood** glucose meter, enter information about their medications, diet, and symptoms, and transmit this data to healthcare providers.

Viewpoints

Although computers have improved patient care, administrative efficiency, and disease tracking, their increasing use also poses several challenges. Consistent, standardized data coding is one example. Maintaining patient privacy is another concern. In an electronic world of integrated departments and shared databases, **patient confidentiality** can be difficult to maintain unless great care is taken with sensitive patient information (like HIV status or drug-abuse history), and staff is trained to protect the confidentiality and security of patient information. Another consideration: making sure technology is reliable enough to be trusted. Poorly designed pharmaceutical software could result in drug errors, for example.

Professional implications

Nurses, who have traditionally gathered, stored, and maintained patient information, have an especial need for computer training. Even beginning nurses should have basic word processor, database, spreadsheet, and E-mail skills, according to a panel of researchers affiliated with the American Nurses Association (ANA). As computers become ever-more integrated into patient care, disease prevention, and health promotion, as well as into medicine's administrative processes, nurses need information literacy as much as they need computer literacy. This means that they must be able to recognize when information is needed and know how to track down and use it appropriately, according to the ANA panel.

Reflecting this shift, some nurses have chosen to augment their training with courses in nursing informatics, a field that was officially recognized as a specialty for registered nurses by the American Nurses Association in 1992. This specialty is a combination of nursing science, information processing theory, and computer science.

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- American Nurses Association (ANA), 600 Maryland Avenue, SW, Suite 100 West, Washington, DC 20024. (800) 274-4ANA. <<http://www.nursingworld.org>>.
- AORN, Association of Perioperative Registered Nurses, 2170 South Parker Road, Suite 300, Denver, CO 80231. (800) 755-2676. <<http://www.aorn.org>>.
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Concussion

Definition

Concussion is a trauma-induced change in mental status, associated with confusion and amnesia, that may or may not be accompanied by a brief loss of consciousness.

Description

A concussion occurs when the head hits or is hit by an object, or when the **brain** is jarred against the **skull** with sufficient force to cause temporary loss of function in the higher centers of the brain. The injured person may remain conscious or briefly lose consciousness and become disoriented for some minutes after the blow. According to the Centers for Disease Control and Prevention, approximately 300,000 people sustain mild to moderate sports-related brain injuries each year, most of them young men between the ages of 16 and 25.

While a concussion usually resolves on its own without lasting effect, it can set the stage for a much more serious condition. “Second impact syndrome” occurs when a person with a concussion, even a very mild one, suffers a second blow before fully recovering from the first. The brain swelling and increased intracranial pressure that can result is potentially fatal. More than 20 such cases have been reported since the syndrome was first described in 1984.

Causes and symptoms

Causes

Most concussions are caused by motor vehicle accidents and **sports injuries**. In motor vehicle accidents, concussion can occur without an actual blow to the head. Instead, concussion occurs because the skull suddenly decelerates or stops, which causes the brain to be jarred against the skull. Contact sports, especially football, hockey, and boxing, are among those most likely to lead to concussion. Other significant causes include **falls**, collisions, or blows due to bicycling, horseback riding, skiing, and soccer.

The risk of concussion from football is extremely high, especially at high school level. Studies show that approximately one out of every five players suffers a concussion or more serious brain injury during their brief high-school careers. The rate at the collegiate level is approximately one person in 20. Rates for hockey players are not known with certainty but are believed to be similar.

A concussion is usually accompanied by another area of brain injury on the opposite side of the head from the initial blow. This is called a **contrecoup injury**. It is caused by the impact of the brain on the opposite side of the skull after the initial blow.

Concussion and lasting brain damage is an especially significant risk for boxers, since the goal of the sport is, in fact, to deliver a concussion to the opponent. For this reason, the American Academy of Neurology has called for a ban on boxing. Repeated concussions over months or years can cause cumulative **head injury**. The cumulative brain injuries suffered by most boxers can lead to permanent brain damage. Multiple blows to the head can cause “punch-drunk” syndrome or **dementia pugilistica**, as evidenced by Muhammed Ali, whose **Parkinson’s disease** is a result of his career in the ring.

Young children are likely to suffer concussions from falls or collisions on the playground or around the home. **Child abuse** is, unfortunately, another common cause of concussion.

Symptoms

Symptoms of concussion include:

- headache
- disorientation relative to time, date, or place
- amnesia for the events immediately preceding the blow
- confusion
- dizziness
- vacant stare or confused expression
- incoherent or incomprehensible speech
- incoordination or weakness
- nausea or vomiting
- double vision
- ringing in the ears (tinnitus)

These symptoms may last from several minutes to several hours. More severe or longer-lasting symptoms may indicate more severe brain injury. A person with a concussion may or may not lose consciousness from the blow. If consciousness is lost, the duration is usually brief, for several minutes at most. More prolonged unconsciousness indicates more severe brain injury.

The severity of concussion is graded on a three-point scale. This is used as a basis for treatment decisions.

- Grade 1: no loss of consciousness, transient confusion, and other symptoms that resolve within 15 minutes.

- Grade 2: no loss of consciousness, transient confusion, and other symptoms that require more than 15 minutes to resolve.
- Grade 3: loss of consciousness for any period of time.

Days or weeks after the accident, a person may show signs of:

- headache
- poor attention and concentration
- **memory** difficulties
- anxiety
- depression
- sleep disturbances
- light and noise intolerance

The occurrence of such symptoms is called “post-concussion syndrome.”

Diagnosis

It is very important for those attending a person with a concussion to pay close attention to the person’s symptoms and progression immediately after the accident. The duration of unconsciousness and degree of confusion are very important indicators of the severity of the injury and help guide the diagnostic process and subsequent treatment decisions.

A trained health professional may make an immediate assessment based on the severity of the symptoms; a neurological exam of the pupils, coordination and sensation; and brief tests of orientation, memory, and concentration. Persons with very mild concussions may not need to be hospitalized or have expensive diagnostic tests. Questionable or more severe cases may require a computed tomography scan (CT) or **magnetic resonance imaging** (MRI) scan to look for brain injury.

Treatment

The symptoms of concussion usually clear quickly and without lasting effect, if no further injury is sustained during the healing process. Guidelines for returning to sports activities are based on the severity of a concussion.

A grade 1 concussion (no loss of consciousness, transient confusion, and other symptoms that resolve within 15 minutes) can usually be treated with rest and continued observation alone. The person may return to sports activities the same day, but only after examination by a trained professional, and after all symptoms have completely resolved. If the person sustains a second concussion of any severity that same day, contact sports

should be discontinued and not resumed until there have been no symptoms, during both rest and activity, for one week.

A person with a grade 2 concussion (no loss of consciousness, transient confusion, and other symptoms that require more than 15 minutes to resolve) must discontinue sports activity for the day, should be evaluated by a trained professional, and should be observed closely throughout the day to make sure that all symptoms have completely cleared. Worsening of symptoms, or continuation of any symptoms beyond one week, indicates the need for a CT or MRI scan. Return to contact sports should only occur after one week with no symptoms, both at rest and during activity, and following examination by a physician. Following a second grade 2 concussion, the person should remain symptom-free for two weeks before resuming contact sports.

A person with a grade 3 concussion (involving any loss of consciousness, no matter how brief) should be examined by a medical professional either on the scene or in an emergency room. More severe symptoms may warrant a CT or MRI scan, along with a thorough neurological and physical exam. The person should be hospitalized if any abnormalities are found or if confusion persists. Prolonged unconsciousness and worsening symptoms require urgent neurosurgical evaluation or transfer to a trauma center. Following discharge from professional care, a person should be closely monitored for neurological symptoms that may arise or worsen. If headaches or other symptoms worsen or last longer than one week, a CT or MRI scan should be performed. Contact sports should be avoided for one week following unconsciousness of only seconds, and for two weeks following unconsciousness of a minute or more. A person receiving a second grade 3 concussion should avoid contact sports for at least a month after all symptoms have cleared, and then resume them only with the approval of a physician. If signs of brain swelling or bleeding are seen on a CT or MRI scan, an athlete should not return to the sport for the rest of the season at the earliest, if not indefinitely.

For someone who has sustained a concussion of any severity, it is critically important to avoid the possibility of another blow to the head until well after all symptoms have cleared to prevent second-impact syndrome. The guidelines above are designed to minimize the risk of this syndrome.

Prognosis

A concussion usually leaves no lasting neurological problems. Nonetheless, symptoms of post-concussion syndrome may last for weeks or even months.

Studies of concussion in contact sports have shown that the risk of sustaining a second concussion is even greater than for the first, if the person continues to engage in the sport.

Health care team roles

A doctor, nurse, athletic trainer, or emergency medical technician may provide an initial evaluation at the time of the concussion. These health care team members can usually evaluate a grade 1 or 2 concussion. A neurologist, neurosurgeon, or trauma specialist should evaluate a concussion in a hospital. A neurologist or neurosurgeon should provide follow-up for grade 3 concussions. A nurse may provide post-concussion supportive care. Radiologists may obtain and interpret CT or MRI scans.

Prevention

Many cases of concussion can be prevented by using appropriate protective equipment. This includes using seat belts and air bags in automobiles, and wearing helmets in all contact sports. Helmets should also be worn when bicycling, skiing, or horseback riding. Soccer players should avoid heading the ball when it is kicked at high velocity from close range. Playground equipment should be underlaid with soft material, either sand or special matting.

The value of high-contact sports such as boxing, football, or hockey should be weighed against the high risk of brain injury during a young person's participation in the sport. Steering a child's general enthusiasm for sports into activities less apt to produce head impacts may reduce the likelihood of brain injury.

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KEY TERMS

Amnesia—A loss of memory that may be caused by brain injury, such as concussion; the loss may be temporary or permanent.

Contrecoup injury—An injury, usually involving the brain, in which the tissue damage is on the side opposite the site of the trauma.

Parkinson's disease—A neurological disorder that includes a fine tremor, muscular weakness and rigidity, and an altered way of walking.

Tinnitus—A sensation of ringing in the ears in the absence of external sources of noise.

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- American College of Sports Medicine, 401 W. Michigan St., Indianapolis, IN 46202-3233. (317) 637-9200. Fax: (317) 634-7817. <<http://www.acsm.org>>. mkeckhaver@acsm.org.
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Confidentiality see **Patient confidentiality**

Consciousness disorders see **Coma**

Consciousness, levels of

Definition

The everyday meaning of the word “consciousness” corresponds fairly closely to how most psychologists use the term. To be conscious is to be aware.

Description

Most of the time, we are aware of whatever activity happens to be at the center of our current attentional focus. For example, in order to read this sentence the readers need to focus their attention on the appropriate line on the page, and concentrate on extracting meaning from what they are reading. Such conscious attention is, however, very selective. Research has demonstrated that a great deal of our mental activity is performed outside of conscious awareness. Consciousness is like the tip of an iceberg. It allows us to exert purposeful control over our current activities, and to communicate our mental states to others. We selectively attend to only a small fraction of the stimulation to which we are constantly exposed. We ignore many sources of external information, but can be made instantly aware of them. Upon reflection, it is obvious that we are operating at various levels of consciousness throughout the day. Do students daydream in class, and later wonder what the teacher said? When people brush their teeth, are they thinking about how clean they are getting them? There are a variety of states or lev-

els of consciousness that have been studied extensively by psychologists. A few of them are described below.

Sleep

Perhaps the most frequent and conspicuous altered state of consciousness is experienced during sleep. Sleep is typically studied by means of an electroencephalograph. It produces a visual record (called an EEG) of the changes in electrical activity in the **brain** that occur during sleep. Changes in muscle activity and eye movements are also monitored. There are four major stages of sleep that are distinguished from one another on the basis of the electrical activity associated with each. There is also a distinctive fifth stage, known as REM (rapid eye movement) sleep. During this phase the brain’s electrical activity is similar to that of the waking state. The sleeper’s eyes dart about rapidly, even though the lids remain closed. Apart from the occasional twitch, there is a total suppression of muscle movement. The sleeper is essentially paralyzed. Because the brain’s motor cortex is active during this stage, REM sleep is sometimes referred to as “paradoxical sleep.” There is considerable internal activity, but an external calmness. REM sleep is the stage during which almost all dreaming occurs. REM sleep is usually accompanied by genital arousal in both males and females, although such arousal is unrelated to dream content. Regardless of the stage of sleep, there is no evidence that any substantive learning can take place during sleep. Despite extravagant claims, listening to a foreign language while sleeping is not going to make someone bilingual.

Hypnosis

Most of us have seen Hollywood movies in which a hypnotist puts somebody in a trance and then ostensibly induces them to perform silly and sometimes dangerous activities. There are reports of criminal investigations having been assisted by witnesses whose memories have been hypnotically enhanced. “Age regression” demonstrations show hypnotized subjects apparently reliving experiences from their childhood. Are these memories accurate? Does hypnotism produce an altered state of consciousness? Can hypnosis cause people to act against their will?

There are two competing explanations of what goes on during hypnosis. The social-cognitive approach views hypnosis as a social phenomenon. According to this perspective, hypnosis is not a unique physiological state and the behaviors produced by hypnosis can also be produced by other means. Hypnotized people are simply in a heightened state of suggestibility. Most people know what is supposed to happen during a hypnosis session. If the hypnotist’s suggestions are believed to be irresistible,

then people will comply with them. It's not that people are being deliberately deceptive. Their behaviors are genuine enough but they reflect beliefs about hypnosis and the role of hypnotized subjects, rather than the skills of the hypnotist or an altered state of consciousness.

The dissociation approach views hypnosis as a procedure that produces a split between two basic functions of consciousness—the executive function that we use for controlling our own behavior, and the monitoring function that is used for observing it. Hypnosis is assumed to disconnect these two components of consciousness, thereby preventing hypnotic experiences from entering normal consciousness. The two approaches are not necessarily contradictory. Certainly there is abundant evidence that social scripts play a role in many hypnotically induced behaviors. Numerous studies have shown that normal subjects who are asked to pretend to be hypnotized produce behaviors that are indistinguishable from those of hypnotized subjects. In another study, hypnotized subjects were given what they were told was a blank piece of paper. In reality, the number 8 was written on it. After hypnosis, those who reported that the paper was blank were told that only fakers would say that. They were then asked to draw what had been on the paper. Almost all drew the number 8. As far as hypnotically enhanced memories are concerned, such testimony is rarely admissible in court. The problem is that hypnotically revived memories often combine fact with fiction. Under hypnosis, people are more likely to use their imagination to construct or retrieve their recollections. Consequently, there is a danger that people will confidently assert having a **memory** of something they never experienced.

Hypnosis continues to be an active area of research. It is used in **psychotherapy** and is sometimes useful in alleviating chronic **pain**. Regardless of what the underlying mechanism might be, there is no evidence that hypnosis produces exceptional psychological feats or behaviors.

Automatic and controlled processing

It's not easy for us to talk on the phone while simultaneously carrying on a conversation with somebody else in the same room. Such difficulty illustrates a fundamental principle of cognition, namely that our cognitive resources are limited. We simply do not have the mental wherewithal to focus on several different tasks at once. If so, how do we manage to execute two activities at the same time, for example reading the newspaper and listening to the radio? The answer is that there are two different levels of conscious control over our behavior. The first is referred to as “automatic processing” because it

requires relatively little conscious awareness, and makes little demand on limited attentional capacity. When a person drives a car while mentally reviewing the previous days' events, he is demonstrating automatic processing. Automatic processing develops with practice as the component parts of the activity become well learned.

“Controlled processing” refers to behaviors that require effortful and deliberate concentration. It requires substantial use of cognitive resources. Consequently tasks requiring controlled processing can usually only be performed one at a time. Automatic processing is rapid and effortless, but somewhat inflexible. Controlled processing is slower, effortful, but adaptable.

This distinction between automatic and controlled processing is directly relevant to the current controversy about the use of cell phones while driving. There is good evidence to suggest that such behavior poses significant risks. For most adults, driving a car is a relatively automatic activity. For this reason, talking on the phone while driving may seem like a victimless crime. However, driving is not always automatic. When the unexpected happens, concentration is required. A driver in the midst of an animated conversation may not recognize an impending emergency and/or may not be able to respond with appropriate speed when it is recognized.

Subliminal perception

To what extent can we be influenced by stimuli whose presence we are not even aware of? There are numerous laboratory studies that show that individual words can be processed, even when presented so quickly that the viewer has no awareness of the word's identity. There is also evidence that patients under **general anesthesia** can apparently remember information (i.e., words) presented while they are unconscious. But what about more extraordinary claims? Can we be induced to buy a product or change our behavior on the basis of images or directives that are presented outside of conscious awareness? In a word, no. Before changing one's habitual response to a stimulus, one would have to be aware of perceiving it. There is no evidence to suggest that people initiate actions on the basis of subliminally presented stimuli.

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Consumption see **Tuberculosis**

Contact lenses

Definition

Contact lenses are small, light-weight plastic devices worn on the eye that correct refractive errors in **vision**. While they appear to be worn in direct contact with the cornea, they actually float on a layer of tears that separates them from the cornea.

Purpose

Contact lenses correct or improve the vision of people with nearsightedness (**myopia**), farsightedness (**hyperopia**), **presbyopia**, and **astigmatism**. In recent years, some people also wear contact lenses not for medical reasons, but rather to change their eye color.

Precautions

People allergic to certain plastics should not wear contact lenses manufactured from that type of material.

Patients with dry eye or severe seasonal **allergies** may find contact lenses uncomfortable and may prefer **eye glasses**. A careful patient history needs to be taken by the physician or contact lens technician to make sure these problems are addressed.

Eye care professionals should ensure that contact lens patients who have disposable or planned replacement lenses keep strictly to their replacement schedules. Contact lenses wear out over time and can damage patients' eyes. Deposits also can build up on the lenses, leading to lid and eye infections.

Patients who have lenses they can sleep in (extended wear lenses) also are advised not to keep their contact lenses in their eyes for longer periods than directed by their physician. Adherence to the schedules recommended by their physicians helps patients avoid **infection** and long-term damage to the cornea.

People employed in certain occupations may be prohibited from wearing contact lenses, or may be required to wear safety eyewear over the contact lenses. Physicians and employers should be consulted for recommendations.

Description

Ophthalmologists (M.D.s) or optometrists (O.D.s) dispense contact lenses. The prices for lenses vary for the different types. Some physicians offer a "global fee" to their patients that includes the contact lens fitting, lenses, and follow-up visits.

Over 32 million people in the United States wear contact lenses. These lenses provide a field of view unobstructed by eyeglass frames. They do not fog-up or get splattered and are less noticeable than any eyeglass style. On the other hand, they take time to get accustomed to; require more measurements for fitting; require many follow-up visits to the eye doctor; can lead to complications such as infections and corneal damage (but only if not cared for properly or replaced as prescribed); and may not correct astigmatism as well as eye glasses.

Originally, hard contact lenses were made of a material called PMMA. Although still available, it is rarely used because it does not allow oxygen to pass through the lens. The more common types of contact lenses are:

- Rigid gas-permeable (RGP) daily-wear lenses are made of plastic that does not absorb water, but does allow oxygen to permeate from the atmosphere to the cornea. (This is important because the cornea has no **blood** supply and needs to acquire oxygen from the atmosphere through the film of tears that moves beneath the lens.) They must be removed and cleaned each night.
- Rigid gas-permeable (RGP) extended-wear lenses are made from plastic that also does not absorb water and is more permeable to oxygen than the plastic used for daily-wear lenses. They can be worn for up to a week, then cleaned, and reinserted.
- Daily wear soft lenses are made of plastic that is permeable to oxygen and absorbs water; therefore, they are soft and flexible. These lenses must be removed and cleaned each night, and they do not correct all vision problems. Many patients find it easier to become accustomed to soft lenses, but these lenses are more prone to ripping and do not last as long as rigid lenses.
- Extended-wear soft lenses are highly permeable to oxygen, are flexible by virtue of their ability to absorb water, and can usually be worn for up to one week. They do not correct all vision problems.

- Extended-wear disposable lenses are soft lenses worn continually for up to six days and then discarded, with no need for cleaning.
- One type of disposable soft lenses are worn for one day and then discarded by the patient. Doctors believe these lenses reduce the risk of infection due to poor cleaning habits or over-wearing lenses. They can be price prohibitive for some patients at \$1 a day.
- Planned-replacement soft lenses are daily wear lenses that are replaced on a regular schedule, most commonly every two weeks, monthly, or quarterly. They must also be cleaned.

Soft contact lenses come in a variety of materials. High Dk materials provide high oxygen permeability and allow greater comfort for patients. Advances in toric contact lenses also allow individuals with astigmatism to achieve better visual correction from contact lenses with more comfort.

There are also different kinds of RGP and soft multifocal contact lenses available. There are five basic designs and over one hundred brands that offer variations of these designs. The optics of bifocal contact lenses are improving dramatically, as baby boomers move into presbyopia and more research dollars are devoted to this area. Monovision, where one contact lens corrects for distance vision while the other corrects for near vision, also may be an option for presbyopic patients. However, monovision may affect depth perception and may not be appropriate for everyone. Contact lenses also come in a variety of tints. Soft contact lenses are available that can change eye color. Even though such lenses have no prescription, they must still be fitted and checked to ensure that an eye infection does not occur. People should never wear someone else's contact lenses. This can lead to infection or damage to the eye.

Preparation

Before contact lenses are prescribed, the patient's eyes are examined by an optometrist or an ophthalmologist. Contact lens technicians, ophthalmic nurses, and ophthalmic technicians also may assist with the exam, although frequently their findings are verified by the physician.

Eyeglass prescriptions, if necessary, are then given to patients. A separate contact lens-fitting exam is necessary if the patient wants contact lenses. This is sometimes performed by the doctor, but in many cases is completed by a contact lens technician.

Before prescribing contact lenses, a technician performs an evaluation. He or she conducts a written and oral interview with the patient to determine if the patient

is a viable contact lens candidate. The technician then assesses the technical aspects of the patient's ocular status, since good eye health is required to wear lenses. The patient's palpebral aperture and visual iris diameter is measured to determine the appropriate diameter for the contact lens. The technician also tests the patient's tear quantity. A poor tear film is a contraindication for contact lenses use. Using instrumentation and information gained from the patient's eye exam, the technician determines what type of lens is best for the patient. For example, RGPs are commonly given to astigmatic patients because they provide clearer vision for these patients.

The contact lens technician selects the lens material and design, then determines the best trial lens. Based on the patient's experience with the trial lenses, the technician then determines the lens parameters. The physician reviews these findings to make the recommendation for the proper contact lenses. He or she ascertains the proper fit, and measures visual acuity and over-refraction to determine the proper lens prescription. Because a contact lens is an FDA-approved medical device placed directly onto the eye (unlike eye glasses), it cannot be issued until the eye's proper health has been ascertained via a follow-up examination. Unlike eyeglass prescriptions, a contact lens prescription includes not only the prescription, but also the contact lens material, diameter, brand, and curvature.

Before the patient is sent home with the lenses, the technician will give a detailed demonstration of inserting, removing, and cleaning the lenses. A written list of detailed instructions is usually dispensed with the lenses.

Aftercare

The doctor and technician schedule several return visits for the patient to evaluate the lens fit and performance. At these visits, eye care professionals determine whether the lens design or material needs to be modified.

Patients may be allergic to certain solutions that are used to clean or lubricate the lenses. For that reason, physicians instruct patients not to change solutions without prior approval. Contact lens wearers also are advised to seek immediate attention if they experience eye **pain**, a burning sensation, red eyes, intolerable sensitivity to light, cloudy vision, or an inability to keep the eyes open.

To avoid infection, it is important for contact lens wearers to exactly follow the instructions for lens insertion, removal, and cleaning. Soft contact lens wearers should never use tap water to rinse their lenses or to make up solutions. All contact lens wearers should always carry a pair of glasses and a contact lens case with them,

KEY TERMS

Astigmatism—A vision condition that occurs when the cornea is slightly irregular in shape. This irregularity prevents light from focusing properly on the retina.

Cornea—The clear outer covering of the front of the eye.

Index of refraction—A constant number for any material that is an indicator of the degree of the bending of the light caused by that material.

Lens—A device that bends light waves.

Permeable—Capable of allowing substances to pass through.

Polycarbonate—A very strong type of plastic often used in safety glasses, sport glasses, and children's eye glasses. Polycarbonate lenses have approximately 50 times the impact resistance of glass lenses.

Polymer—A substance formed by joining smaller molecules. Examples of polymers include plastic, acrylic, cellulose acetate, cellulose propionate, nylon, etc.

Presbyopia—A condition affecting people over the age of 40 where the system of accommodation that allows focusing of near objects fails to work because of age-related hardening of the lens of the eye.

Retina—The inner, light-sensitive layer of the eye containing rods and cones; transforms the image it receives into electrical messages sent to the brain via the optic nerve.

Ultraviolet (UV) light—Part of the electromagnetic spectrum with a wavelength just below that of visible light. It is damaging to living material, especially eyes and DNA.

in case the contact lenses have to be removed due to eye irritation.

Complications

Wearing contact lenses increases the risk of corneal damage and eye infections, if the lenses are not properly cleaned, if the lenses are inserted or removed with dirty hands, or if the lenses are worn for a longer period of time than recommended. However, there is little increased risk of eye infection or damage if the lenses are

worn as instructed and cared for properly. Dry eye and seasonal allergy symptoms may be exacerbated by wearing contact lenses.

Results

The normal expectation is that people will achieve 20/20 vision while wearing corrective lenses.

Health care team roles

Nursing and allied health professionals play an important role in contact lens examination and fitting. With advances in technology, technicians now have duties that formerly only a physician performed.

Contact lens technicians take the lead role in the contact lens fitting by recording the pertinent patient history, measuring the eye for the proper lens fit, and testing the tear quantity.

Advanced and intermediate level ophthalmic technicians perform refractions and determine the patient's depth perception. These professionals also may perform corneal topography (mapping).

Some of these professionals seek certification through the American Board of Opticianry and the National Contact Lens Examiners or other organizations. These organizations offer seminars and testing that helps professionals keep current with technological advances.

Physicians have become increasingly dependent on these technicians and assistants as managed care dictates they see more patients per day. By delegating these task to qualified personnel, the physicians can see more patients per day without jeopardizing patients' ocular health.

Patient education

Technicians emphasize the importance of cleaning contact lenses and adhering to any planned replacement schedule. They stress that while patients may save money by wearing lenses longer or skimping on cleaning solution, these actions increase the risk of eye infections or damage. Younger patients also are cautioned that sharing colored contact lenses with others can lead to eye infections. The importance of inserting and removing contact lenses with clean hands also is emphasized to all contact lens wearers.

Training

Optometrists and ophthalmologists receive training in **optometry** schools or medical residencies for these procedures. Contact lens technicians may complete special training courses or be trained by the physician.

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American Optometric Association. 2420 North Lindbergh Boulevard, St. Louis, MO 63141. (800) 365-2219. <<http://www.aoanet.org>>.

Contact Lens Council. 8201 Corporate Drive, Suite 850, Landover, MD 20785. (800) 884-4CLC. <<http://www.contactlenscouncil.org>>.

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Mary Bekker

Continuous ambulatory electrocardiography see **Ambulatory electrocardiography**

Continuous passive motion device

Definition

Continuous passive motion (CPM) is a modality of postoperative treatment intended to assist recovery following joint surgery or injuries of upper or lower extremities. CPM equipment covers a range of mechanical devices designed to move the patient's joint or extremity without the use of the patient's muscles through a prescribed range of motion over extended periods of time. These devices were first introduced in the 1980s by Dr. Robert Salter, an orthopedic surgeon.

Purpose

CPM is used to reduce the adverse effects of trauma or immobilization following surgery. In physiological terms, synovial fluid is diffused without hindering tissue repair; the joint receives **nutrition**, the flow of venous **blood** is increased, and the cartilage is prevented from deteriorating. From a clinical perspective, joint swelling (**edema**) is decreased, range of motion (ROM) is maintained, tissue repair is accelerated, and the patient experiences less **pain**.

CPM devices are used as alternatives and adjuncts to conventional **physical therapy** following surgery or injury. CPM devices may also be used in bedridden surgical patients to reduce the incidence of deep vein thrombosis, to treat abnormal muscle shortening that occurs due to prolonged immobilization, and in patients with **burns** or joint sepsis.

Description

Typical CPM devices consist of a limb support resembling a splint or brace, a motor drive, and a control unit. CPM devices for the lower limb are used primarily after total knee replacement and ligament repair to provide flexion and extension of the joint. Configurations for exercising the hip, ankle, or toes are also available. Larger lower-limb CPM devices are typically designed to rest directly on the patient's bed; some are designed with the limb support suspended from an overhead traction frame. Upper-limb CPM devices are available mounted on stands that

KEY TERMS

Edema—An abnormal buildup of fluid in the tissues or joint capsules of the body, causing swelling of the involved area. Edema is a common cause of stiffness in the joints following injury or surgery.

Range of motion (ROM)—The extent to which a joint can be moved.

Sepsis—A local or generalized invasion of the body by disease microorganisms or their toxins.

Synovial fluid—A clear, viscous fluid secreted by membranes surrounding the joints. Synovial fluid helps to lubricate the joints.

Thrombosis—Coagulation or clotting of the blood inside a vein.

can be wheeled to the patient's bedside, in tabletop configurations, and as portable battery-powered units.

The motor drive of a CPM device is connected by a shaft to the limb support. The control unit contains adjustments for speed, motor reversal, and such range of motion parameters as degree of rotation, flexion, or extension. Some units are computerized and have remote control capabilities. Other units pause the continuous motion to allow for some active contraction by the patient or for the application of neuromuscular electrical stimulation.

Operation

The limb requiring CPM is strapped into the device's support. The range of motion parameters, speed, cycling time, and duration are then set. Most CPM devices have mechanical safety releases, resistance sensors, and/or automatic shut-offs for safety purposes. The most advanced CPM devices use microprocessors and load cells to measure resistance and automatically adjust parameters. Hospital patients may have 24-hour CPM operation. Patients using CPM at home may use the devices from four to six hours daily in hour-long sessions.

Patients on CPM devices should be monitored for problems with limb positioning and interference with device operation. For instance, bedsheets may become tangled in the device, or the patient's limb may become trapped, resulting in injury. Patients with urinary incontinence should be monitored carefully during CPM, because body fluids are an electrical hazard. All patients on CPM devices should be monitored for unnecessary

discomfort, pain, and chafing. Most manufacturers offer accessories or configurations to adjust for variations in patient limb size.

Maintenance

CPM devices are low-maintenance equipment since they are designed for continuous use. They do, however, require frequent checks for wear of moving parts and malfunctioning.

Health care team roles

The use of a CPM device is most often prescribed by a physician or orthopedic surgeon, and overseen by nursing, physical therapy, or rehabilitation staff.

Training

Manufacturers of CPM devices provide training for clinical staff. In addition, detailed user manuals are provided for reference during operation and maintenance. Patients using CPM devices at home should be given instructions regarding proper use of the device.

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American Academy of Physical Medicine and Rehabilitation. One IBM Plaza, Suite 2500, Chicago, IL 60611-3604. (313) 464-9700. <<http://www.aapmr.org>>.

American Physical Therapy Association. 1111 North Fairfax Street, Alexandria, VA 22314-1488. (703) 684-2782. <<http://www.apta.org>>.

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Continuous positive airway pressure see
Ventilation assistance

Contraception

Definition

Contraception is the use of a method, device, or medication to prevent **pregnancy** by interfering with ovulation, fertilization, and/or implantation. Another term for contraception is birth control.

Purpose

The purpose of contraception is to allow individuals to engage in sexual intercourse without it resulting in pregnancy.

Precautions

There are many methods of contraception. Factors to consider in choosing a method include:

- **Safety.** What are the risks of using this method? Can its use result in any damage to the female or male reproductive tract? Is its use associated with a higher risk of certain cancers? What are the consequences of its long-term use? Does its use affect future fertility?
- **Access.** Is a prescription needed to gain access to this method?
- **Cost.** How expensive is this method?
- **Insurance.** Is the cost of this method covered by my health insurance?

- **Effectiveness.** If this method is used as directed, what is the likelihood that it will fail to prevent a pregnancy?
- **Ease of use.** Is this method easy or difficult to use correctly?
- **Timing.** Is this method effective the first time it is used or put in place, or is it necessary to use it for a while before it will be effective?
- **Frequency.** How frequently will the individual engage in sexual intercourse?
- **Temporary versus permanent.** Does this method provide temporary birth control, or is it considered a permanent method? If permanent, could it be reversed in the future?
- **Ethics.** Is this method acceptable within the context of the individual's religious or ethical beliefs?
- **Benefits.** Other than its ability to provide contraception, does its use have any benefits to the individual's health?
- **Postpartum.** How soon after pregnancy can this method of birth control be used? Is it safe while breastfeeding? Does fertility return?

Description

During a woman's reproductive years, from its onset at menarche to its termination at **menopause**, an egg, or ovum, is released each month from one of her two ovaries, and it travels through the adjacent fallopian tube and into the uterus. If the egg is fertilized, it implants into the lining of the uterus and undergoes changes that eventually lead to the development of a fetus. In tandem with the release of the egg, the lining of the uterus, called the endometrium, undergoes changes that will enable it to support a pregnancy should the released egg become fertilized. When the egg is not fertilized, the endometrium that has built up in preparation for the pregnancy is shed. This tissue and the non-fertilized egg leave the uterus through the cervix and exit the body through the vagina in the form of menstrual secretions.

Birth control methods vary in targeting different aspects of this monthly process. The primary methods of birth control are hormonal, barrier, spermicides, intrauterine devices (IUDs), surgical, and periodic abstinence. In choosing a form of birth control it is important to understand how each method works, as well as its associated risks, benefits, and side effects.

- **Hormonal.** Hormonal methods of birth control include oral birth control pills. Birth control pills, sometimes called the Pill, come in two forms: combination, containing both estrogen and progestin, and progestin only, referred to as the mini-pill. Both forms suppress ovula-



Various contraceptives. (Photograph by Michael Keller. *The Stock Market*. Reproduced by permission.)

tion, thicken cervical mucus, and prevent implantation. Both require prescriptions. The hormone doses in the pills are kept as low as possible, while still being effective as a contraceptive. For this reason it is extremely important that they are taken on a daily basis. Skipping doses can put a woman at risk of becoming pregnant and she should supplement the pill with the use of a barrier method. In the first month a woman begins oral contraception, she may not be fully protected, so a barrier method should be used as a back-up. In a survey conducted by Planned Parenthood, only 28% of women take the Pill correctly, and only 42% actually take it on a daily basis. Because of the hormones used, women who suffer from migraines, diabetes, have had breast or uterine **cancer**, or who smoke, may need to choose another method. Women should always mention their use of birth control pills to their primary health care provider, as some medications prescribed for other conditions may interact with oral contraceptives. Use of the Pill can make other medications less effective, or exaggerate their effectiveness. Serious potential side effects of the combined pill include the formation of **blood clots**, **myocardial infarction**, and stroke. Because oral contraceptives suppress ovulation, their use can decrease a woman's risk of getting ovarian cancer. Some women find that their oral contraceptive improves skin problems. Hormonal contraception can be used by breastfeeding mothers, but usually not until the milk supply has been well established. In the case of the mini-pill, it can usually be started earlier, as it does not decrease milk volume. The combination pill can decrease the volume and lower the protein content of the breast milk. Oral contraceptives do not protect against any sexually transmitted diseases, so a condom should be used for that purpose in addition to taking the Pill.

- Depo-Provera and Lunelle are two brands of contraception given by injection. Depo-Provera is the trade name for the contraceptive depot medroxyprogesterone acetate (DMPA). Lunelle is a combination of estrogen and progesterone. They provide protection for about 12 weeks. They may be a good choice for women who have trouble remembering to take the Pill on a daily basis, for those for whom privacy of using a contraceptive is important, and for those engaging frequently in sexual intercourse. They work by suppressing ovulation, fertilization, and implantation. This method may not be a good choice for women who have had **breast cancer**, blood clots, **heart** attack or stroke, major depression, high cholesterol or **blood pressure**, diabetes, migraines, or abnormal results on **liver function tests**. If given within the first five days of a woman's menstrual cycle, they are considered protective against pregnancy during the first month of use. Side effects include irregular vaginal bleeding, loss of menstruation after one year of use, nausea, breast tenderness, depression, weight gain, vaginal dryness, and increased facial hair. After a woman stops using DMPA, it may take 18 months before a woman is able to become pregnant. They do not provide protection against sexually transmitted disease.
- Barrier methods. Barrier methods work by preventing the sperm from reaching and fertilizing the egg. Male and female condoms, diaphragms, and cervical caps work by creating a membrane through which the sperm cannot travel. Spermicides and the contraceptive sponge contain chemicals that decrease the sperm's ability to travel towards the egg. Condoms, diaphragms and caps should be used in conjunction with spermicides to increase overall effectiveness. Spermicides come in several forms: foam, cream, gel, sponge, and vaginal suppository. Condoms provide the most protection against sexually transmitted diseases. The diaphragm and cervical cap require fitting by a health care practitioner and a prescription. The other barrier methods are available without a prescription. Barrier methods are used at the time of sexual intercourse. They are less effective than hormonal methods of contraception. Individuals who have latex **allergies**, or who have had an allergic reaction to bananas, avocados or chestnuts, should speak with their health care provider before trying a condom, diaphragm, or cap. The allergic reaction may be mild, with symptoms such as runny nose, itching or a rash, or may be severe, resulting in **anaphylaxis** in which breathing can be obstructed by swelling. Early signs of anaphylaxis include rash, flushed skin, dizziness, or a tingling sensation. Medical help should be sought right away. A condition called toxic shock syndrome (TSS) has been

occasionally reported with diaphragm use. Signs of TSS include high **fever**, vomiting, **diarrhea**, flu-like symptoms such as aching joints or **sore throat**, dizziness, and rash. The diaphragm should be removed right away and the woman should call her practitioner. Diaphragm and cervical caps need to be refitted with weight gain or loss, and after a few years need to be replaced because the rubber begins to tear or decompose, rendering them ineffective.

- **Intrauterine devices (IUDs).** The IUD is a small, plastic device that is inserted by a health care practitioner into a woman's uterus. While in place it seems to prevent implantation by altering the endometrium. It is also thought that the consistency of the cervical mucus is changed, affecting sperm motility, preventing fertilization. It is easy to have it inserted and can be removed at any time by a practitioner. One brand contains **copper** and can be left in place for ten years, another contains progestin and needs to be replaced after one year. IUDs have a string attached at one end that hangs into the vagina. This not only assists in its ultimate removal, but also allows a woman to check periodically that it is still in its proper place. If the string appears to be shorter or longer than when inserted, the woman should have its placement checked by her practitioner. The string does not function as a wick, so it does not draw fluid up into the uterus. The IUD is not a good choice for a woman with a sexually transmitted disease or a history of pelvic inflammatory disease (PID). It is usually inserted during a menstrual period by a health care provider. Some practitioners may require the woman to have a negative **pregnancy test** done just prior to insertion. Some women may experience spotting between periods, or heavier periods with more cramping while using the copper IUD. Because the IUD was inserted through the cervix, a woman may be at a somewhat higher risk of **infection**, until the cervix closes tightly again (around three weeks). Two rare side effects can occur: the IUD imbedding into the uterus and the migration of the IUD into the abdominal cavity, requiring surgery to remove it. There is also a higher risk of pelvic inflammatory disease and infection of the reproductive organs, which could result in sterility, or require removal of the uterus. IUDs do not protect against sexually transmitted diseases.
- **Surgical sterilization.** Individuals who have completed their childbearing may choose a permanent form of contraception: surgical sterilization. In the male, this is known as a vasectomy. The vasectomy blocks the sperm from mixing with the seminal fluid. Sperm continue to be produced, but are reabsorbed by the body. Vasectomy does not affect the man's ability to have an erection, to ejaculate, nor does it affect the production

of male hormones. It is not effective immediately, as some sperm are still present in the unblocked portion of the tubes. A sperm analysis needs to be done to check for the presence of sperm. Until this process is completed, the man and his partner need to use another form of contraception to prevent a pregnancy. For the woman sterilization is known as tubal ligation, tubal sterilization, or having one's tubes tied. In tubal ligation the fallopian tubes are cut or blocked, preventing the egg from passing through towards the uterus. The ovum will continue to be released each month, but will be reabsorbed by the body after being blocked in the fallopian tube. Menstrual cycles continue as usual, and hormone production is not affected. It is effective immediately. Surgical sterilization is considered permanent and irreversible, although some individuals have been successful at having the process reversed. In a small percentage of cases, the surgery is not successful and the woman becomes pregnant. Both surgeries are done through small incisions, and on an outpatient basis. This form of birth control is not recommended for very young individuals, or those who have not yet had families. Because they involve surgery, complications associated with surgery, such as infection, bleeding, or a reaction to the anesthesia, can occur. Tubal ligation and vasectomy do not provide protection against sexually transmitted diseases. For the individual undergoing the sterilization, the surgery must be voluntary.

- **Periodic abstinence.** Periodic abstinence, or fertility awareness, is a technique of birth control based on abstaining from sexual intercourse on those days when a woman might become pregnant. The same techniques can be used by couples trying to conceive, by identifying the days when a woman is most likely to become pregnant. Using periodic abstinence often requires taking a class to learn the techniques used. The techniques employed are basal body temperature (BBT), cervical mucus identification, and a calendar method. The most effective use is the combination of all three techniques to predict which are the safe and which are the unsafe days for intercourse. Couples may then use this information to abstain from intercourse or use a barrier form of contraception on unsafe days. The calendar method keeps track of a woman's menstrual cycle. The cervical mucus identification method teaches the woman the differences in the vaginal secretions at various times of her cycle, which helps to identify when ovulation is most likely taking place. The BBT method charts the first temperature of the morning. Just prior to ovulation there is a slight dip in the basal temperature, followed by a slight temperature elevation when the woman ovulates. This method requires the use of a special **thermometer** that is more finely calibrated than one used

KEY TERMS

Anaphylaxis—A serious allergic response that can be fatal if not treated. In anaphylaxis the individual undergoes a hypersensitive reaction to a substance. Initial signs may include itching, wheezing, coughing and shortness of breath. If left untreated, the individual's respiratory passages may begin to swell, blocking the flow of air. Anaphylaxis is a medical emergency, and can result in death.

Ectopic pregnancy—A pregnancy that implants outside of the uterus, most commonly in a fallopian tube. An ectopic pregnancy can cause the fallopian tube to rupture, causing severe internal bleeding and pain. A woman with an ectopic pregnancy must seek medical care right away.

Triage—To organize or sort patients according to the degree or severity of their condition.

Vaginal suppository—Medication that is bullet-shaped, and is inserted into the vagina, where it melts and is absorbed.

for checking the presence of a fever. This combination of techniques requires that a woman's menstrual cycles are quite regular, that she has the ability to keep careful records, and that she and her partner(s) can abstain from intercourse or use a barrier method for much of the month. The readings are not accurate when the woman is sick, and may be affected by certain medications.

- Post-coital contraception. No method of contraception is 100% effective. If birth control was not used or if it failed during intercourse, or in the event of rape, the possibility of pregnancy exists. Some **reproductive health** centers and physicians offer emergency contraception that is used within 72 hours of unprotected sex, failed contraception, or rape. It involves taking oral doses of progestin or an estrogen-progestin combination, similar to that used in oral contraceptives. Some women experience dizziness or nausea and vomiting following the treatment. If a woman has had a positive pregnancy test and wishes to terminate the pregnancy, she may choose between surgical or medical abortion. Medical abortion involves the use of hormonal therapy, referred to in the United States as RU486. Planned Parenthood offers more information about these options through the telephone number listed below in Resources, and on their web site.

Preparation and aftercare

Preparation for the different contraceptive choices varies. Oral contraceptives need to be taken on a daily basis, and require a prescription, a thorough **health history**, and a visit to a health care provider. Injected hormonal contraception requires periodic visits for the injection. Barrier methods must be used every time there is intercourse, these methods differ in how long they may remain in the vagina, and whether ejaculation can be repeated without the use of a new barrier device. The IUD requires insertion and removal by a practitioner. Surgical sterilization is usually done in an outpatient facility. Patients will be given post-surgical instructions to follow, including which symptoms necessitate contacting their physician. Practitioners will want to be sure that this irreversible decision was made carefully and competently and that the patients are aware that there is a failure rate. Some follow-up care may be necessary. Periodic abstinence requires careful monitoring of a woman's fertility and the ability to abstain from intercourse or use barrier methods on unsafe days.

Complications

Complications of contraception vary according to the method used. Hormonal complications involve a response to the particular hormone and dosage used. Bleeding between periods or difficulty regaining regular menstruation or fertility following their discontinuance may occur. Oral contraceptives can interfere with the effectiveness of other medications. Women over 35 who smoke should not use oral contraceptives, as smoking places them at greater risk of heart attack or stroke. Barrier methods may produce a local reaction to the spermicide use. Spermicide packages should be checked for an expiration date. If used after expiration, they are not reliable. Diaphragm use is associated with the risk of toxic shock syndrome. Individuals unaware of their latex allergy may have a small allergic reaction, or could go into anaphylaxis. IUDs do have a serious but rare risk of puncturing the uterine wall, and also carry a risk of pelvic inflammatory disease with potential complications such as sterility if untreated. IUDs may be expelled from the uterus, so it is important to periodically check for the string that is attached to it. Women who become pregnant while using the IUD are at greater risk of an ectopic pregnancy. Surgical sterilization involves the risks of surgery, such as bleeding, or infection due to the anesthesia used. Vasectomy is only effective once all stored sperm has been ejaculated. Fertility awareness carries a higher risk of pregnancy, and if hands are not washed prior to checking the cervical mucus, **bacteria** could be introduced into the vagina and spread.

Results

The end result of effective contraception is prevention of pregnancy. Individuals choosing contraception must weigh the risks of the method against its ease of correct use and its success rate of preventing pregnancy. Hormonal methods are usually at least 95% effective. Barrier methods range from 60–80% effective. The IUD is considered 99% effective. Sterilization is about 99% effective. Fertility awareness is about 85% effective. Of course, effectiveness depends on consistent, careful use.

Health care team roles

Pharmacists are involved in filling the prescriptions of various forms of birth control. Having prescriptions filled at the same pharmacy provides protection against the possibility of interactions between different medications. Nurses provide education to patients on the various forms of birth control the individual is considering. Nurses are also involved in the care of patients seeking surgical contraception, as well as triaging calls from patients when they call their health care providers with questions and concerns about possible side effects. If a patient suspects an IUD has been dislodged, a radiology technician may take an imaging scan to locate the IUD.

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- Planned Parenthood Federation of America. 810 Seventh Ave. New York, NY 10019. (212) 541-7800. (800) 230-PLAN (7526). (888) NOT-2-LATE.

Esther Csapo Rastegari, R.N., B.S.N., Ed.M.

Conversion disorder see **Somatoform disorders**

Cooling treatments

Definition

Cooling or cold treatments are used to decrease **pain**, minimize swelling, and slow the inflammatory response secondary to injury (usually acute). Cold treatments slow the local physiological activity of the tissues, decrease nerve transmission, and decrease muscle guarding and spasm, thus minimizing potential damage to tissues when injury has occurred. Another name for cold or cooling treatments is cryotherapy.

Purpose

The most common reasons for cooling treatments are sprains, bruises, **burns**, eye injuries, and muscle spasms. Cooling treatments are used to help alleviate the resulting swelling, pain, and discoloration of the skin. They also help to cool the body if **fever** or hyperthermia exists. The body can sustain temperatures up to 104°F (40°C) with relative safety, however temperatures above 104°F (40°C) are more likely to cause damage to the **brain**, muscles, **blood**, and **kidneys**.

Cooling treatments slow chemical reactions within the body. For this reason, cooling tissues below normal body temperature (98.6°F [37°C]) can prevent injury from inadequate oxygen or **nutrition**. Interestingly, cold water drowning victims suffering from hypothermia (cooling of the body below its normal temperature) have been successfully resuscitated after long periods underwater without medical complications because of this effect. For the past 40 years, **heart** surgeons have been experimenting with hypothermia to protect tissues from lack of blood circulation during an operation. Neurosurgeons are also working with hypothermia to protect the very sensitive brain tissues during periods of absent or reduced blood flow. However, the major use for cooling treatments is to alleviate pain and swelling after acute injury.

Precautions

Before using cryotherapy nurses and other allied health team members need to make sure patients do not have sensation deficits or circulatory problems.



A technician uses a hose that blows cold, dry air directly onto goalkeeper Carlos Roa's injury. (Photograph by Oscar Pipkin. AP/Wide World Photo. Reproduced by permission.)

Description

There are many types of cooling treatments that offer relief of pain and decrease inflammation during acute injury:

- Ice bags: For application of deep cold. A very simple and inexpensive method.
- Ice massage: Simply rubbing ice on the skin, usually in a circular motion.
- Cryo-compression units: Usually a pad that fits around the affected area. Tubes or lines provide constant (cold) fluid under pressure from a mechanical device.
- Vapocoolant sprays: Either Ethel chloride or Fluoromethane type sprays that provide local pain relief and decreased muscle spasm.
- Gel packs: Packs are stored in the freezer until needed, and they contain a gel that can be refrozen any time.
- Immersion: Placing the limb, area, or joint in a bin of ice water.
- Cold bags (chemical): Bags with separate pouches containing chemicals within. The pouches are broken by squeezing the entire bag, the chemicals mix by means of an endothermic chemical reaction, and yield cold.

Preparation

Cooling treatments are prepared a number of ways:

- Ice bags: Plastic bags filled with ice applied over a towel for 20 minutes.
- Ice massage: Usually performed with a Styrofoam cup filled with water that has been frozen. Treatment lasts until skin is numb.
- Cryo-compression units: These units provide both cooling and mechanical compression of the affected area. A large pad or cuff is placed around the area.
- Vapocoolant sprays: An aerosol spray is usually used for treating trigger points (local muscular spasm with high sensitivity).
- Gel packs: Reusable gel packs are stored in a freezer until gel is completely frozen. Use with caution and less time than ice bags.
- Immersion: Usually, ice is frozen and placed in a bib of water, providing a very complete cold treatment. They should be used for about 15–20 minutes.
- Cold bags (chemical): Kept at room temperature until needed with no need for freezing. They do not provide intense cold; more of a cooling treatment. Can be used for up to 30 minutes.

Aftercare

Nurses and other allied health professionals should realize that there are three to four stages of cold sensation perceived by the patient: The first is the feeling of cold followed by (second stage) the patient feeling a burning sensation. The third stage is a dull aching over the area and finally (fourth stage) the patient reports feeling numbness. Removal of the cold treatment occurs when the skin feels numb. Sometimes the dull aching, or third stage, is not felt.

Complications

Nurses and allied health professionals also need to be aware that in instances where vaso constriction is contraindicated, cryotherapy should not be used. Furthermore, some patients may be oversensitive to cold and have an allergic type reaction. Excessive duration of cooling treatments may cause sensitivity.

Results

Cold treatments are usually the optimum treatment for acute injuries such as strains, sprains, bruises, and trigger points. Cryotherapy is one of the easiest and

effective treatments in decreasing pain, swelling, and muscle spasms.

Health care team roles

Nurses and other allied health team members should use the RICE principle when treating an acute injury: rest the area, ice the area, apply compression, and elevate the area.

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Mark Damian Rossi, Ph.D, P.T., C.S.C.S.

Coombs' test see **Antiglobin tests**

Coordination tests see **Balance and coordination tests**

COPD see **Emphysema**

Copper

Description

Copper is an essential mineral that plays an important role in **iron** absorption and transport. It is considered a trace mineral because it is needed in very small amounts. Only 70–80 mg of copper are found in the body of a normal healthy person. Even though the body needs

very little of it, copper is an important nutrient that holds many vital functions in the body.

Copper is essential for normal development of the body because it:

- Participates in a wide variety of important enzymatic reactions in the body.
- Is a component of or a cofactor for approximately 50 different enzymes. These enzymes need copper to function properly.
- Is essential for iron absorption and transport. Iron is needed to make hemoglobin, a main component of red **blood** cells. Therefore, copper deficiency is often linked to iron-deficiency anemia.
- Is required to build elastin and collagen, which are an important components of bones and connective tissues. Therefore, copper is believed to protect the bones and joints against degeneration and **osteoporosis**.
- Is required for melanin production. People with copper deficiency may have pale skin and hair.
- Is a key mineral for the **immune system**. Copper promotes wound healing. Studies show that **premature infants** or children with genetic copper defects are at high risk of getting infections and would significantly improve with copper supplementation.
- Attacks free radicals. Copper is a strong antioxidant. It works by attaching itself to the enzyme Superoxide dismutase (SOD). Copper also binds to a protein to form ceruloplasmin, which is an antioxidant.
- Helps the body produce energy. Copper participates in many oxidative reactions that break down **fats** in fat tissue to produce much needed energy. Copper deficiency has been associated with high cholesterol levels.
- Is necessary for normal functioning of insulin. Copper deficiency is also associated with poor blood glucose control.
- Is needed for normal functioning of the cardiovascular system.
- Protects the structure and function of the nervous system, including the **brain**. Copper protects nerve fiber by maintaining myelin, the insulating sheath that surrounds nerve cells. It also aids the transmission of nerve signals in the brains.

General use

Copper supplements may be beneficial in treating or preventing copper deficiency. Copper deficiency used to be relatively rare because the body requires so little of it, only about 2 mg per day. In addition, it is available naturally in a variety of foods such as whole grains, shellfish,

nuts, beans, and leafy vegetables. Additional sources of copper are the copper water pipes that run through homes or the copper cookware in the kitchen. These sources leach copper into the water we drink and the food we eat. The level of copper in drinking water is sometimes so high that it becomes a public concern. However, scientists now realize that copper deficiency, especially borderline cases, is more common than once thought. Copper deficiency is currently on the rise due to a decrease of whole foods in the diet and high consumption of fatty and processed foods.

Besides dietary causes, certain diseases or conditions may reduce copper absorption, transport, or increase its requirements, resulting in abnormally low copper blood levels. Increased copper intake through diet or supplementation may be necessary in the following conditions:

- premature infants fed only cow's milk
- pregnant women
- malnutrition
- celiac disease, sprue, **cystic fibrosis**, or short-bowel syndrome (These diseases cause poor absorption of dietary copper.)
- kidney disease
- high consumption of **zinc** or iron (These **minerals** interfere with copper absorption.)
- highly processed foods (Copper is stripped away during food processing.)
- Menkes syndrome (In this disease, copper deficiency is caused by genetic defects of copper transport. Menkes syndrome patients cannot use copper supplied by the diet efficiently.)

Symptoms of copper deficiency include:

- anemia
- malnourished infants
- prominently dilated veins
- pale hair or skin
- poorly formed bones
- nervous system disorders
- high cholesterol levels
- **heart** disease
- loss of **taste**
- increased susceptibility to infections
- infertility
- birth defects

Exceeding the daily requirement is dangerous, however, because copper toxicity commonly occurs. Copper

toxicity is a very serious medical problem. Acute toxicity due to ingestion of too much supplement, for example, may cause nausea, vomiting, abdominal **pain**, **diarrhea**, dizziness, headache, and a metallic taste in the mouth. Chronic toxicity is often caused by genetic defects of copper **metabolism**, such as Wilson's disease. In this disease, copper is not eliminated properly and is allowed to accumulate to toxic levels. Copper is therefore present at high concentration where it should not be, such as in the **liver**, the lens of the eye, **kidneys**, or brain.

Disease prevention

Copper is a good antioxidant. It works together with an antioxidant enzyme, superoxide dismutase (SOD), to protect **cell membranes** from being destroyed by free radicals. Free radicals are any molecules that are missing one electron. Because this is an unbalanced and unstable state, a radical is desperately finding ways to complete its pair. Therefore, it reacts to any nearby molecules to either steal an electron or give away the unpaired one. In the process, free radicals initiate chain reactions that destroy cell structures. Like other antioxidants, copper scavenges or cleans up these highly reactive radicals and changes them into inactive, less harmful compounds. Therefore, it can help prevent **cancer** and many other degenerative diseases or conditions such as premature aging, heart disease, autoimmune diseases, arthritis, **cataracts**, **Alzheimer's disease**, or diabetes.

Osteoporosis

Copper may play a role in preventing osteoporosis. **Calcium** and **vitamin D** have long been considered the mainstay of osteoporosis treatment and prevention. However, a recent study has shown that they can be even more effective in increasing bone density and preventing osteoporosis if they are used in combination with copper and two other trace minerals, zinc and manganese.

Rheumatoid arthritis

Copper has been a folklore remedy for rheumatoid arthritis since 1500 B.C. in ancient Egypt. Some people believe that wearing jewelry made of copper may relieve arthritic symptoms. To evaluate the effect of copper for the treatment of rheumatoid arthritis, Dr. Walker and his colleagues conducted a study of 77 arthritic patients. Patients were divided into two groups: treatment group wearing copper jewelry and placebo group wearing nothing or aluminum jewelry. In this study, patients who wore copper bracelets felt significantly better than those in the placebo group. In addition, patients in the treatment group reported recurrences of symptoms after the bracelets were removed. To explain the effects of the cop-

per bracelets, these researchers suggested that copper contained in the bracelets was dissolved in sweat and then absorbed through the skin. They suspected that copper's effectiveness may be related to its role as an antioxidant. They also believe that copper may function as both an anti-inflammatory agent and as an antioxidant. Thus, it is possibly effective in reducing inflammatory response to such conditions as rheumatoid arthritis.

Preparations

Copper is contained in many multivitamin/mineral preparations. It is also available as a single ingredient in the form of tablets. These tablets should be swallowed whole with a whole cup of water preferably with meals to avoid **stomach** upset. A person may choose any of the following preparations: copper gluconate, copper sulfate, or copper citrate. However, copper gluconate may be the least irritant to the stomach.

Zinc and copper compete with each other for absorption in the gastrointestinal tract. As a result, excessive copper intake may cause zinc deficiency, and vice versa. Therefore, a person should take zinc and copper supplements together in ratios of 10:1 or 15:1.

Precautions

Take heed to the following:

- Persons who take copper supplements should inform their doctors for proper instruction and monitoring of side effects. Copper toxicity due to excessive doses of copper supplements have been reported.
- Although there currently is no recommended daily allowance RDA established for copper, 2 mg of copper per day is considered sufficient and safe. Nausea and vomiting may occur in persons taking more than 20 mg of copper daily.
- It is not known if copper supplementation may harm a growing fetus. However, as with any drugs, pregnant or nursing women should not take copper or any other supplements or drugs without first consulting their doctors.
- In certain areas, drinking water may contain high levels of copper. Periodic checks of copper levels in drinking water may be necessary.
- Because individual antioxidants often work together as a team to defend the body against free radicals, the balance between copper, zinc, and iron must be maintained. Excessive intake of one nutrient might result in a deficiency of other minerals and decrease resistance to infections and increase risk of heart disease, diabetes, arthritis, and other diseases.

KEY TERMS

Antioxidants—Antioxidants are nutrients that deactivate reactive molecules (free radicals) and prevent harmful chain reactions.

Minerals—Inorganic chemical elements that are found in plants and animals and are essential for life. There are two types of minerals: major minerals, which the body requires in large amounts, and trace elements, which the body needs only in minute amounts.

Side effects

A person should stop taking copper supplements and seek medical help immediately if having the following signs or symptoms:

- anemia
- nausea
- vomiting
- abdominal pain

Interactions

Factors that increase copper concentrations

Certain disorders have been known to increase copper levels. Persons with these conditions should not take copper supplements as they may cause copper toxicity.

- recent heart attacks
- lupus erythematosus
- cirrhosis of the liver
- schizophrenia
- leukemia and some other forms of cancer
- viral infections
- ulcerative colitis (This inflammatory bowel disease may cause accumulation of copper in the body. Excessive amount of copper may worsen many symptoms of this disease by increasing susceptibility to infections and inhibiting wound healing.)
- Wilson's disease (This disease causes accumulation of copper in the tissues. As a result, these patients have liver disease, mental retardation, tremor, and poor muscle coordination. They also have copper deposits in the cornea of the eyes. To manage this disease, patients are put on a low-copper diet and given penicillamine, a drug that attaches itself to copper and increases its excretion.)

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Mai Tran

Copper deficiency see **Mineral deficiency**

Coronary angiography see **Cardiac catheterization**

Coronary artery disease

Definition

Coronary artery disease is a stenosis (narrowing) or blockage of the arteries and vessels that provide oxygenated **blood** to the **heart**. It is caused by atherosclerosis (hardening of the arteries), an accumulation of fatty plaque on the inner linings of arteries. The resulting blockage restricts blood flow through the coronary arteries. When blood flow is completely cut off, the result is **myocardial infarction** (heart attack).

Description

Coronary artery disease, also called coronary heart disease or atherosclerotic heart disease, is the leading cause of death for men and women in the United States. According to the American Heart Association, in 1998

one in every five deaths in the United States was caused by coronary artery disease. About every 29 seconds one American will have a heart attack; about every minute one American will die from a heart attack. Fourteen million Americans have active symptoms of coronary artery disease. Many millions more have asymptomatic (silent) coronary disease, the first indication of which can be sudden death.

Coronary artery disease occurs when the coronary arteries become partially blocked or clogged, thereby depriving the heart muscle of oxygen (myocardial ischemia). When the blockage is temporary or partial, angina (chest **pain** or pressure) may occur. When the blockage completely and suddenly cuts off the flow of blood, the result is myocardial infarction.

Healthy coronary arteries are clean, smooth, and slick. The artery walls are flexible and can expand to let more blood through when the heart needs to work harder. Atherosclerosis is thought to begin with an injury to the linings of the inner walls of the arteries. This injury makes them susceptible to atherosclerosis and thrombosis (blood clots).

Causes and symptoms

Coronary artery disease is usually caused by atherosclerosis. Cholesterol and other fatty substances accumulate on the inner wall of the arteries. This attracts fibrous tissue, blood components, and **calcium**, which harden into flow-obstructing plaques. If a blood clot suddenly forms on one of these plaques it can convert a partial obstruction to a total occlusion. This is known as coronary thrombosis. Congenital defects and spasms of a coronary artery may also block blood flow. There is evidence that **infection** from organisms such as chlamydia **bacteria** may be responsible for some cases of coronary artery disease.

A number of major contributing factors increase the risk of developing coronary artery disease. Some risk factors can be modified and others cannot. Persons with more of these risk factors are at greater risk of developing coronary artery disease.

Major risk factors

Major risk factors significantly increase the chance of developing coronary artery disease. Risk factors that cannot be changed include:

- Heredity. People whose parents have coronary artery disease, particularly those who develop it at younger ages, are more likely to be diagnosed with it. African-Americans are also at increased risk because they expe-

rience a higher rate of severe **hypertension** than whites.

- **Gender.** Men under the age of 60 years of age are more likely to have myocardial infarctions than women of the same age. Over age 60, however, women have coronary artery disease at a rate equal to that of men.
- **Age.** Men over age 45 and women over age 55 years are more likely to have coronary artery disease. Occasionally, coronary disease affects individuals in the 30s. Older adults (those over 65) are more likely to die of a myocardial infarction. Older women are twice as likely as older men to die within a few weeks of a myocardial infarction.

Major risk factors that can be changed are:

- **Smoking.** Smoking greatly increases both the risk of developing coronary artery disease and resulting mortality. Smokers have two to four times the risk of non-smokers for sudden cardiac death and are more than twice as likely to have a myocardial infarction. They are also more likely to die within an hour of a heart attack. Second-hand smoke may also increase risk.
- **High cholesterol.** Cholesterol is produced by the body, and obtained from eating animal products such as meat, eggs, milk, and cheese. Age, gender, heredity, and diet affect cholesterol level. Risk of developing coronary artery disease increases as blood cholesterol levels increase. When combined with other factors, the risk is even greater. Total cholesterol of 240 mg/dL or more poses a high risk, and 200–239 mg/dL a borderline high risk. For LDL (low-density lipoprotein) cholesterol, high risk starts at 130–159 mg/dL, depending on other risk factors. Low levels of HDL (high-density lipoprotein) increases the risk of coronary disease; high HDL protects against it.
- **Hypertension (high blood pressure).** High blood pressure makes the heart work harder, and over time, weakens it. It increases the risk of myocardial infarction, stroke, kidney failure, and congestive **heart failure**. Blood pressure of 140 over 90 or above is considered high. When hypertension is combined with **obesity**, smoking, high cholesterol, or diabetes, the risk of myocardial infarction or stroke increases several times.
- **Sedentary lifestyle and lack of physical activity.** Inactivity increases the risk of coronary artery disease. Even modest physical activity is beneficial if done regularly.
- **Diabetes mellitus.** The risk of developing coronary artery disease is significantly increased for diabetics. More than 80% of diabetics die of some type of cardiovascular disease.

Contributing risk factors

Contributing risk factors have been linked to coronary artery disease, but their precise contribution to the development of disease is not known yet. Contributing risk factors are:

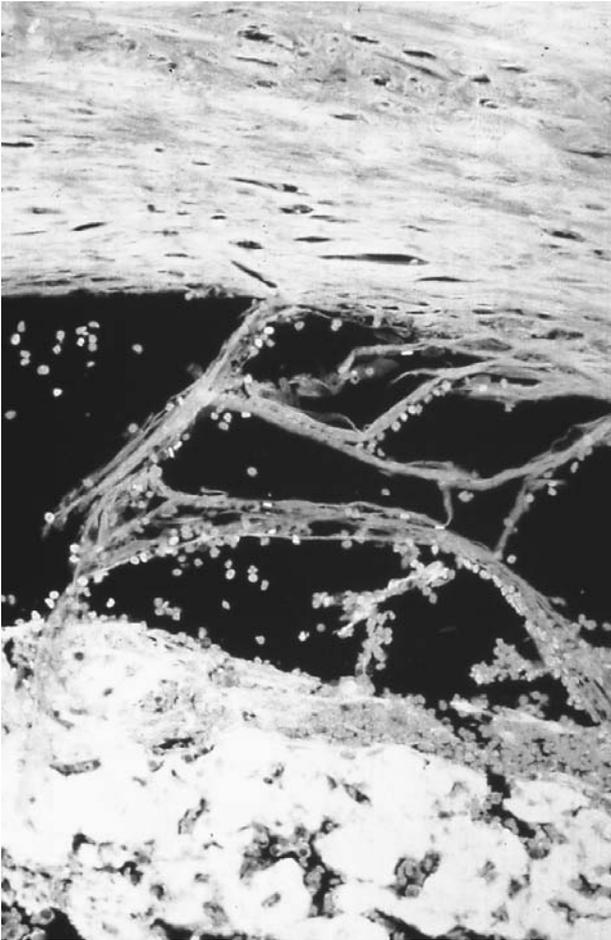
- **Obesity.** Excess weight increases the strain on the heart and increases the risk of developing coronary artery disease, even if no other risk factors are present. Obesity increases both blood pressure and blood cholesterol, and can lead to diabetes.
- **Stress and anger.** Stress and anger can produce physiological changes that contribute to the development of coronary artery disease, in part by increasing the risk of thrombosis. Stress, the mental and physical reaction to life's irritations and challenges, increases heart rate and blood pressure and can injure the lining of the arteries. Evidence shows that anger increases the risk of dying from heart disease. The risk of heart attack is more than double after an episode of anger.

Angina (chest pain) is the main symptom of coronary heart disease but it is not always present. Symptoms of angina typically include chest pain that may be described as heaviness, tightness, a burning sensation, squeezing, or pressure behind the breastbone. This pain may radiate to the left arm, neck, or jaw. Many people have no symptoms of coronary artery disease before having a heart attack; 63% of women and 48% of men who died suddenly of coronary artery disease had no previous symptoms of the disease, according to the American Heart Association.

Diagnosis

The diagnosis of coronary artery disease is made by the physician after a medical history, **physical examination**, and basic screening tests have been performed. The diagnostic work-up includes evaluation of body weight, blood pressure, blood lipid levels, and fasting blood glucose levels. Other diagnostic tests include resting and **exercise** electrocardiogram (ECG), **echocardiography**, radionuclide scans, and coronary **angiography**. A treadmill exercise (stress) test also may be used as a screening test for patients with significant risk factors but are asymptomatic.

An ECG may reveal if a patient has had a previous myocardial infarction (MI) or is having a MI. An ECG taken on a patient with coronary artery disease, who is not having chest pain during the ECG and has not had a prior MI, may be completely normal. An ECG technician places electrodes on the patient's chest, arms, and legs. These electrodes send impulses of the heart's activity through an oscilloscope (a monitor) to a recorder that traces them on



A fluorescent microscopy of a fresh thrombus of the coronary artery. (Photograph by J.L. Carson, Custom Medical Stock Photo. Reproduced by permission.)

paper. The test takes about 10 minutes and is performed in a physician's office. A definite diagnosis cannot be made from **electrocardiography**. About 50% of patients with significant coronary artery disease have normal resting electrocardiograms. Another type of electrocardiogram, known as an exercise **stress test**, measures how the heart and **blood vessels** respond to exertion when the patient is exercising on a treadmill or a stationary bike. This test is performed in a physician's office or an exercise laboratory. It takes 15-30 minutes. Like many medical tests, it does not have 100% accuracy. It sometimes gives a normal reading when the patient has a heart problem or an abnormal reading when the patient does not.

If the electrocardiogram reveals a problem or is inconclusive, the next step is exercise echocardiography or nuclear myocardial scanning (radionuclide angiography). Echocardiography, cardiac ultrasound, uses sound waves to create an image of the heart's chambers and valves. A technician presses a hand-held transducer

against the patient's chest to obtain an image that can be displayed on a monitor. It does not visualize the coronary arteries, but can detect abnormalities in heart wall motion caused by coronary disease. Performed in a cardiology outpatient diagnostic laboratory, the test takes about 30-60 minutes.

Nuclear myocardial scanning enables physicians to see if the myocardium (heart muscle) is being adequately perfused by the coronary arteries. Performed by radiologists and radiology technicians, nuclear scans involve injecting a small amount of radiopharmaceutical, such as thallium or sestamibi, into a vein. A camera that uses gamma rays to produce an image of the radioactive material records pictures of the heart. A radionuclide scan is comparable, in terms of radiation exposure, to a **chest x ray**. The tiny amount of radioactive material used disappears from the body in a few days. Radionuclide scans cost about four times as much as exercise stress tests but provide more information.

In nuclear myocardial scanning, a camera passes back and forth over the patient who lies on a table. Usually performed in a hospital's nuclear medicine department, the procedure takes 30-60 minutes.

Nuclear myocardial scanning is usually performed in conjunction with an exercise stress test. When the stress test is completed, thallium or sestamibi is injected. The patient resumes exercise for one minute to absorb the thallium. For patients who cannot exercise, cardiac blood flow and heart rate may be increased by intravenous dipyridamole (Persantine) or adenosine. Thallium or sestamibi scanning is done twice, immediately after injecting the radiopharmaceutical and again four hours (and maybe 24 hours) later. Usually performed in a hospital's nuclear medicine department, each scan takes about 30-60 minutes.

Coronary angiography is the gold standard (most accurate method) for establishing the diagnosis of coronary artery disease, but it is also the most invasive. During coronary angiography the patient is awake but sedated. ECG electrodes are placed on the patient's chest and an intravenous line is inserted. A local anesthetic is injected into the site where the catheter will be inserted. The invasive cardiologist inserts a catheter into a groin artery and guides it into the aorta. A contrast dye is injected directly into the coronary arteries to determine whether they are obstructed. Coronary angiography is performed in a **cardiac catheterization** laboratory either in an outpatient or inpatient surgery unit. It takes from 30 minutes to two hours.

Treatment

Coronary artery disease can be treated many ways. The choice of treatment depends on the severity of the disease. Treatments include lifestyle changes and drug therapy, percutaneous transluminal coronary **angioplasty**, and coronary artery bypass surgery. Coronary artery disease is a chronic disease requiring lifelong care. Angioplasty or bypass surgery is not a “cure.”

Patients with less severe coronary artery disease may gain adequate control through lifestyle changes and drug therapy. Many of the lifestyle changes that prevent disease progression—a low-fat, low-cholesterol diet, weight loss if needed, exercise, and not smoking—also help prevent the disease from developing.

Drugs such as nitrates, beta-blockers, and calcium-channel blockers relieve chest pain and complications of coronary artery disease, but they cannot clear blocked arteries. Nitrates (nitroglycerin) improve blood flow to the heart. Beta-blockers (acebutelol, propranolol) reduce the amount of oxygen required by the heart during stress. One type of calcium-channel blocker (verapamil, diltiazem hydrochloride) helps keep the arteries open and reduces blood pressure. Aspirin helps prevent blood clots from forming on plaques, reducing the likelihood of myocardial infarction. Cholesterol-lowering medications are also indicated in most cases.

Percutaneous transluminal coronary angioplasty and bypass surgery are invasive procedures to improve blood flow in the coronary arteries. Percutaneous transluminal coronary angioplasty, usually called coronary angioplasty or PTCA, is a non-surgical procedure. A catheter tipped with a balloon is threaded through an artery in the groin into the blocked coronary artery. The balloon is inflated, compressing the plaque to enlarge the blood vessel and open the blocked artery. The balloon is deflated, and the catheter is removed. Coronary angioplasty is performed by an invasive cardiologist in a hospital and generally requires a stay of one or two days. Coronary angioplasty is successful about 90% of the time, but one-third of the time the artery restenoses (narrows again) within six months. The procedure can be repeated. It is less invasive and less expensive than coronary artery bypass surgery.

In coronary artery bypass surgery, a healthy vein from an arm, leg, or the internal mammary artery is used to build a detour (bypass) around the coronary artery blockage. Bypass surgery is appropriate for those patients with blockages in two or three major coronary arteries, those with severely narrowed left main coronary arteries, and those who have not responded to other treatments. It is performed in a hospital under **general anesthesia**. A heart-lung machine is used to support the

patient while the healthy vein or artery is attached past the blockage to the coronary artery. About 70% of patients who have bypass surgery experience complete relief from angina; about 20% experience partial relief. Only about 3-4% of patients per year experience a return of symptoms. Survival rates after bypass surgery decrease over time. At five years after surgery, survival expectancy is 90%; at 10 years about 80%, at 15 years about 55%, and at 20 years about 40%.

Three newer surgical procedures for unblocking coronary arteries are currently being evaluated. Atherectomy is a procedure in which the cardiologist shaves off and removes strips of plaque from the blocked artery. In laser angioplasty, a catheter with a laser tip is inserted into the affected artery to burn or break down the plaque. A metal coil, called a stent, may be implanted permanently to keep a blocked artery open. Stenting is gaining popularity as an alternative to more invasive surgery.

Prognosis

In many cases, coronary artery disease can be successfully treated. Advances in medicine and healthier lifestyles have caused a substantial decline in death rates from coronary artery disease since the mid-1980s. New diagnostic techniques enable doctors to identify and treat coronary artery disease in its earliest stages. New technologies and surgical procedures have extended the lives of many patients who would otherwise have died. Research on coronary artery disease continues.

Health care team roles

Patients with coronary artery disease are most often treated by primary care physicians with consultation from cardiologists and cardiovascular surgeons when needed. Nurses, ECG technicians, laboratory technologists, and other allied health professionals have important roles in the diagnosis of coronary artery disease as well as in the institution of timely treatment. Nurses and other practitioners involved in triage or screening in the emergency department must accurately assess patients with chest pain or other indications of coronary artery disease.

ECG technicians, radiology technicians, and laboratory technologists are responsible for performing the diagnostic imaging studies, ECG and blood chemistries, to confirm the diagnosis of coronary artery disease. During the hospitalization, nurses, dietitians, respiratory and physical therapists collaborate to plan a **cardiac rehabilitation** program and provide patient and family education.

KEY TERMS

Angina—Chest pain that happens when diseased blood vessels restrict the flow of blood to the heart. Angina is often the first symptom of coronary artery disease.

Atherosclerosis—A process in which the walls of the coronary arteries thicken due to the accumulation of plaque in the blood vessels. Atherosclerosis is the cause of coronary artery disease.

Beta-blocker—A drug that blocks some of the effects of fight-or-flight hormone adrenaline (epinephrine and norepinephrine), slowing the heart rate and lowering the blood pressure.

Calcium-channel blocker—A drug that blocks the entry of calcium into the muscle cells of small blood vessels (arterioles) and keeps them from narrowing.

Coronary arteries—The main arteries that provide blood to the heart. The coronary arteries surround the heart like a crown, coming out of the aorta, arching down over the top of the heart, and dividing into two branches. These are the arteries in which coronary artery disease occurs.

HDL cholesterol—High-density lipoprotein cholesterol is a component of cholesterol that helps protect against heart disease. HDL is nicknamed “good” cholesterol.

LDL cholesterol—Low-density lipoprotein cholesterol is the primary cholesterol molecule. High levels of LDL increase the risk of coronary heart disease. LDL is nicknamed “bad” cholesterol.

Plaque—A deposit of fatty and other substances that accumulate in the lining of the artery wall.

Triglyceride—A fat that comes from food or is made from other energy sources in the body. Elevated triglyceride levels contribute to the development of atherosclerosis.

Patient education

Nurses, physical therapists and dieticians work together to educate patients and their families. Patients are taught to recognize and accurately describe symptoms such as pain, pressure, or heaviness in the chest, left arm, or jaw. Patients are advised to report any changes in the intensity or quality of their pain to nurses or other health care professionals while in the hospital. When

necessary, they are counseled by nursing or pharmacy technicians about the use of sublingual (under the tongue) nitroglycerin to relieve chest pain. They are instructed to seek medical attention immediately should serious symptoms return after they have been discharged.

Along with instruction about medication, follow-up care, and the importance of participating in cardiac rehabilitation, patients are informed about ways to reduce their risk for myocardial infarction or other complications of coronary artery disease. This education is tailored to the individual patient’s needs. It may include referral to a smoking cessation program; nutritional counseling to reduce dietary fat and sodium and achieve a desirable body weight; and recommendations to increase physical activity. **Patient education** also addresses treatment of any coexisting illnesses such as diabetes; and instruction about ways to more effectively manage stress and anger.

Prevention

A healthy lifestyle can help prevent coronary artery disease and help keep it from progressing. A heart-healthy lifestyle includes eating right, regular exercise, maintaining a healthy weight, no smoking, moderate drinking, no recreational drugs, controlling hypertension, and managing stress. Cardiac rehabilitation programs are excellent to help prevent recurring coronary problems for patients at risk and those with a history of coronary events and procedures.

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- American Heart Association. National Center. 7272 Greenville Avenue, Dallas, TX 75231-4596. (214) 373-6300. <<http://www.arhrt.org/>>.

National Heart, Lung, and Blood Institute. P.O. Box 30105, Bethesda, MD 20824-0105. (301) 496-4236. <<http://www.nhlbi.nih.gov/nhlbi/nhlbi.htm>>.

Texas Heart Institute Heart Information Service. P.O. Box 20345, Houston, TX 77225-0345. (800) 292-2221. <<http://www.tmc.edu/thi/his.html>>.

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Barbara Wexler

Coronary disease see **Coronary artery disease**

Coronary heart disease see **Coronary artery disease**

Coronary thrombosis see **Myocardial infarction**

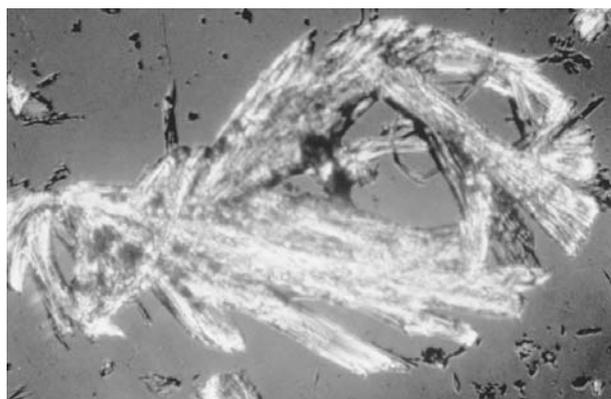
Corticosteroids

Definition

A group of natural and synthetic analogues of the hormones secreted by the hypothalamic-anterior pituitary-adrenocortical (HPA) axis, more commonly referred to as the **pituitary gland**. These include glucocorticoids, which are anti-inflammatory agents with a large number of other functions; mineralocorticoids, which control salt and water balance primarily through action on the **kidneys**; and corticotropins, which control secretion of hormones by the pituitary gland.

Purpose

Glucocorticoids have multiple effects, and are used for a large number of conditions. They affect glucose utilization and fat **metabolism**, bone development, and are potent anti-inflammatory agents. They may be used for replacement of natural hormones in patients with pituitary deficiency (Addison's disease), as well as for a wide number of other conditions including but not limited to arthritis, **asthma**, anemia, various cancers, and skin inflammations. Additional uses include inhibition of nausea and vomiting after **chemotherapy**, treatment of **sep-**



Photograph of cortisone. (Michael Siegel/Phototake NYC. Reproduced by permission.)

tic shock, treatment of **spinal cord** injuries, and treatment of hirsutism (excessive hair growth). The choice of drug will vary with the condition. Cortisone and hydrocortisone, which have both glucocorticoid and mineralocorticoid effects, are the drugs of choice for replacement therapy of natural hormone deficiency. Synthetic compounds, which have greater anti-inflammatory effects and less effect on salt and water balance, are usually preferred for other purposes. These compounds include dexamethasone, which is almost exclusively glucocorticoid in its actions, as well as prednisone, prednisolone, betamethasone, trimacinolone, and others. Glucocorticoids are formulated in oral dosage forms, topical creams and ointments, oral and nasal inhalations, rectal foams, and ear and eye drops.

Mineralocorticoids control the retention of sodium in the kidneys. In mineralocorticoid deficiency, there is excessive loss of sodium through the kidneys, with resulting water loss. Fludrocortisone (Florinef) is the only drug available for treatment of mineralocorticoid deficiency, and is available only in an oral dosage form.

Corticotropin (ACTH, adrenocorticotrophic hormone) stimulates the pituitary gland to release cortisone. A deficiency of corticotrophic hormone will have the same effects as a deficiency of cortisone. The hormone, which is available under the brand names Acthar and Actrel, is used for diagnostic testing, to determine the cause of a glucocorticoid deficiency, but is rarely used for replacement therapy since direct administration of glucocorticoids may be easier and offers better control over dosages.

Recommended dosage

Dosage of glucocorticoids varies with drug, route of administration, condition being treated, and patient. Consult specific references.

KEY TERMS

Hallucination—A false or distorted perception of objects, sounds, or events that seems real. Hallucinations usually result from drugs or mental disorders.

Hormone—A substance that is produced in one part of the body, then travels through the bloodstream to another part of the body where it has its effect.

Inflammation—Pain, redness, swelling, and heat that usually develop in response to injury or illness.

Ointment—A thick, spreadable substance that contains medicine and is meant to be used on the outside of the body.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies; or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies; or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

Fludrocortisone, for use in replacement therapy, is normally dosed at 0.1 mg/day. Some patients require higher doses. It should normally be administered in conjunction with cortisone or hydrocortisone.

ACTH, when used for diagnostic purposes, is given as 10 to 25 units dissolved in 500 ml of 5% Dextrose Injection infused IV over eight hours. A long-acting form, which may be used for replacement therapy, is given by subcutaneous (SC) or intramuscular (IM) injection at a dose of 40 to 80 units every 24–72 hours.

Precautions

The most significant risk associated with administration of glucocorticoids is suppression of natural corticosteroid secretion. When the hormones are administered, they suppress the secretion of ACTH, which in turn reduces the secretion of the natural hormones. The extent of suppression varies with dose, drug potency, duration of treatment, and individual patient response. While sup-

pression is seen primarily with drugs administered systemically, it can also occur with topical drugs such as creams and ointments, or drugs administered by inhalation. Abrupt cessation of corticosteroids may result in acute adrenal crisis (Addisonian crisis) which is marked by **dehydration** with severe vomiting and **diarrhea**, hypotension, and loss of consciousness. Acute adrenal crisis is potentially fatal.

Chronic **overdose** of glucocorticoids leads to Cushingoid syndrome, which is clinically identical to Cushing's syndrome and differs only in that in Cushingoid, the excessive steroids are from drug therapy rather than excessive glandular secretion. Symptoms vary, but most people have upper body **obesity**, rounded face, increased fat around the neck, and thinning arms and legs. In its later stages, this condition leads to weakening of bones and muscles with rib and spinal column **fractures**.

The short term adverse effects of corticosteroids are generally mild, and include indigestion, increased appetite, insomnia, and nervousness. There are also a very large number of infrequent adverse reactions, the most significant of which is drug-induced paranoia. Delirium, depression, menstrual irregularity, and increased hair growth are also possible. Consult detailed reviews for further information.

Long-term use of topical glucocorticoids can result in thinning of the skin. Oral steroid inhalations may cause fungal overgrowth in the oral cavity. Patients must be instructed to rinse their mouths carefully after each dose. Corticosteroids are **pregnancy** category C. The drugs have caused congenital malformations in animal studies, including cleft palate. Breastfeeding should be avoided.

Because fludrocortisone has glucocorticoid activity as well as mineralocorticoid action, the same hazards and precautions apply to fludrocortisone as to the glucocorticoids. Overdose of fludrocortisone may also cause **edema**, **hypertension**, and congestive **heart failure**.

Corticotropin has all the same risks as the glucocorticoids. Prolonged use may cause reduced response to the stimulatory effects of corticotropin.

Warnings and contraindications

Use corticosteroids with caution in patients with the following conditions:

- osteoporosis or any other bone disease
- current or past **tuberculosis**
- glaucoma or **cataracts**

- infections of any type (virus, **bacteria**, fungus, amoeba)
- sores in the nose or recent nose surgery (if using nasal spray forms of corticosteroids)
- underactive or overactive thyroid
- liver disease
- stomach or intestine problems
- diabetes
- **heart** disease
- high **blood pressure**
- high cholesterol
- kidney disease or **kidney stones**
- myasthenia gravis
- systemic lupus erythematosus (SLE)
- emotional problems
- skin conditions that cause the skin to be thinner and bruise more easily

Interactions

Corticosteroids have many **drug interactions**. Consult specific references.

Resources

ORGANIZATIONS

American Academy of Allergy, Asthma and Immunology. 611 East Wells Street, Milwaukee, WI 53202. (414) 272-6071. <<http://www.aaaai.org>>.

Asthma and Allergy Foundation of America. 1125 15th Street NW, Suite 502, Washington, DC 20005. (800) 727-8462. <<http://www.aafa.org>>.

National Heart, Lung and Blood Institute. National Institutes of Health, P.O. Box 30105, Bethesda, MD 20824-0105. (301) 251-1222. <<http://www.nhlbi.nih.gov/nhlbi/nhlbi.htm>>.

Samuel Uretsky, PharmD

Cortisol tests *see* **Adrenocortical hormone tests**

Cosmetic dentistry

Definition

Cosmetic, or aesthetic, dentistry focuses on improving appearance and facial self-image by correcting the alignment, shape, and color of teeth. Dental professionals

who offer cosmetic options can improve the appearance of stained, chipped, and misshapen teeth, and correct uneven gums and replace old fillings with nearly invisible filling materials. Cosmetic dentistry procedures are elective and, therefore, often not covered by insurance.

Description

The most popular option in cosmetic dentistry is tooth bleaching, an area that is experiencing a 15 to 20% growth a year. Most dental practices offer tooth bleaching, which involves the use of at-home and in-office supervised whitening systems that brighten stained, discolored, or dull-looking teeth.

Veneers are the second most popular cosmetic dentistry option. Used to correct chipped, cracked or worn teeth, veneers are ultra thin tooth coverings, sometimes made of porcelain or composite materials. Bonding is another process also used to correct chipped, cracked, or worn teeth.

Crowns, dental bridges, and dental implants can be used to replace missing teeth or correct bite dysfunction. Today's newer technology includes porcelain and ceramic tooth replacements that look real and blend with existing teeth.

Cosmetic dentists can correct excessive or uneven gums with cosmetic surgery. Many patients with old or unsightly fillings also can opt to have them replaced by a dentist, who can use resin and porcelain filling materials or crowns to eliminate the look of the previous fillings.

Causes and symptoms

Anyone who is unhappy with his or her smile is a candidate for cosmetic dentistry. The reason might be a general displeasure with the look of one's teeth or a specific aesthetic dental concern. While the reasons for improvement vary, the most common causes are staining due to aging, tobacco use, coffee intake, **fluorosis**, and tetracycline use. Patients also often want to improve the shape and position of their teeth. Diastemas (spaces between teeth), slight rotations, and malformation of the teeth (e.g., peg laterals, barrel shape teeth) are common reasons for correcting the shape and the position of the teeth.

Diagnosis

The diagnosis of an aesthetic problem involves looking at the entire face; the color of the eyes, skin, and lips often influence the appearance of teeth. The face evaluation is usually divided into imaginary thirds: the first section goes from the hairline to eyebrows, the second from eyebrows to the base of the nose, and the third from the

KEY TERMS

Bleaching—Tooth whitening using a chemical such as carbamide peroxide or hydrogen peroxide.

Bridge—A fixed or removable dental appliance used to replace missing teeth and to restore the mouth to function.

Caries—Demineralization or calcified tooth tissue, which, if left untreated, results in soft, discolored areas, pain, and eventual loss of the tooth.

Crown—A gold, porcelain, or stainless steel cover used to replace a tooth structure that has been lost to decay, accident, or injury.

Dental implant—A fixed dental appliance that replaces missing teeth.

Diastema—An abnormally large space between two teeth.

Periodontitis—Inflammation and infection of gingival tissue, ligaments, and alveolar bone that support teeth.

Veneers—Porcelain or composite laminates that are bonded to the surface teeth to improve aesthetics and function.

base of the nose to the lower border of chin. Aesthetic smiles are diagnosed by the dentist, who looks for asymmetry and mobility of the upper and lower lips; midline in relation to the front teeth; gumline; tooth and gum contours; tooth color; tooth to length proportion and relationships; and, finally, restorations. Several factors must be taken into account when assessing these variables, including age, gender, race, and personality.

When examining the tooth shade, specifically, certain factors should be considered, such as the light source and surrounding colors. Bleaching of teeth will change the shade of the tooth structure only, which can pose a problem if the patient has several tooth-colored restorations.

Treatment

Minor corrections in shape and positions can be done with direct resin bonding and ceramic veneers. If the problem is related to position and is considered to be moderate to severe, it is possible to correct it through the placement of veneers, full crowns, or by orthodontic treatment.

Bonding involves applying an enamel-like material to the tooth's surface and sculpting it to an aesthetically

pleasing shape. Once it hardens, the dentist polishes and refines the new tooth. One of the advantages of direct resin bonding over ceramic veneers is that bonding can be done in one session without laboratory involvement, which helps to control cost. The major advantage of direct composite resin restorations is conservation of the tooth structure because, in some cases, little or no enamel removal is required. Longevity, the main advantage of ceramic veneers, is superior to resin bonding.

Discoloration caused by extrinsic staining, such as coffee, tea, red wine, tobacco, aging, and some types of medications, are usually yellow or brown in color and can be improved by vital bleaching, using a 10% carbamide peroxide solution. The concentration may be slightly higher or lower, depending on the stains. Discoloration caused by intrinsic staining, such as after root canal treatment, pulp bleeding, tetracycline medication, fluorosis, and some types of inherited disease, are usually blue, gray, or brown and often requires a non-vital bleaching treatment. Non-vital bleaching treatment is done internally to the tooth structure, meaning the bleaching agent is placed inside the tooth crown.

Prognosis

The term aesthetics takes into consideration the psychological interpretation of beauty. Because of this subjectivity, it is extremely important to establish a common goal and line of communication between the dentist and the patient. Communication is particularly important when the patient's expectations exceed the reality of what is possible to achieve. Studies support significant differences among the preferences of dentists and patients for cosmetic dentistry.

The results of aesthetic dentistry vary according to the different procedures. It should be noted that the results of the bleaching treatment are not predictable, since it varies according to each case. For the most part, it is possible to lighten the tooth shade on the first few days of treatment.

The success of any restoration depends on patient compliance. It is important that the patient be informed about maintenance of his or her treatments, and understand that the results of bleaching are not permanent. Explanations of the etiology of oral diseases, risk factors, and preventive measures are also warranted; these may help to motivate patients keep their new smiles healthy.

Health care team roles

Identification of imperfections in patients' smiles might be done by dental hygienists during care. They may refer patients to the dentist for cosmetic dentistry.

Trained dental hygienists can coordinate patients' bleaching procedures. Dental assistants help explain what is involved in the cosmetic dental solutions and inform the patient that, in most cases, insurance does not reimburse for cosmetic dentistry. Dental assistants also work with dentists during cosmetic dental procedures and can assist patients and dentists in selecting tooth shades.

Prevention

Patients can help to keep their teeth healthy and white with good nutritional and lifestyle habits. Preventive measures to reduce or eliminate dental disease, including caries, **periodontitis**, and **oral cancer**, are essential to obtaining and maintaining an optimal dental health and aesthetic appearance.

Maintenance remains important after cosmetic dentistry. The proper maintenance of tooth color restorations is important to improve and increase the lifetime of the restorations. This includes cessation or decrease in tobacco use, and cessation or decrease in the intake of **caffeine** products and stain-producing foods and beverages. Acidic products can also cause erosion of the tooth structure. The use of soft toothbrushes and non-abrasive toothpaste will avoid unnecessary tooth abrasion. Some types of whitening toothpaste can have large particle size, which can act as an abrasive on the restoration surface.

Resources

ORGANIZATIONS

Academy of General Dentistry, 211 East Chicago Ave., Chicago, IL 60611. (312) 440-4800. <<http://www.agd.org>>.

American Academy of Cosmetic Dentistry, 2810 Walton Commons West, Suite 200, Madison, Wisconsin 53718. 800-543-9220. <<http://www.aacd.com>>.

American Dental Assistants Association, 203 North LaSalle Street, Suite 1320, Chicago, IL 60601-1225. (312)541-1550. <<http://www.dentalassistant.org>>.

American Dental Association, 211 East Chicago Avenue, Chicago, IL 60611 (312) 440-2500. <<http://www.ada.org>>

OTHER

Gordan, Valeria V., DDS, MS. Assistant Professor. University of Florida, College of Dentistry, Operative Dentistry Department, Gainesville, FL. Interview with Lisette Hilton.

Lisette Hilton

CPAP see **Ventilation assistance**

CPR see **Cardiopulmonary resuscitation (CPR)**

Creatine kinase test see **Cardiac marker tests**

Creatinine test see **Kidney function tests**

Creutzfeldt-Jakob disease

Definition

Creutzfeldt-Jakob disease (CJD) is a transmissible, rapidly progressing, fatal neurodegenerative disorder related to "mad cow disease."

Description

Before 1995, Creutzfeldt-Jakob disease was little known outside the medical profession. Indeed, most physicians did not know much about the disease, and few had ever seen a patient with the disease. But with the discovery of a "new variant" form, the possibility that those with the disease became infected simply by eating beef, and the radical theory that the infectious agent is a rogue protein, CJD has become one of the most talked about diseases in the world, and has taken on a significance far beyond the small number of deaths it currently causes each year.

First described in the 1920s, CJD is a neurodegenerative disease causing a rapidly progressing **dementia** which ends in death, usually within eight months of the onset of symptoms. It is also a very rare disease, affecting only about one in every million people in the population worldwide. In the United States, CJD is thought to affect about 250 people each year. CJD affects adults of all ages, but is rare in young adults and most common between ages 50 and 75.

Spongiform encephalopathies

The most obvious pathologic feature of CJD is the formation of numerous, fluid-filled spaces in the **brain** (vacuoles), giving the brain a sponge-like appearance. CJD is one of several human spongiform encephalopathies, diseases that produce this characteristic change in brain tissue. Others include kuru; Gerstmann-Straussler-Scheinker disease, predominantly characterized by cerebellar ataxia; and fatal familial insomnia, associated with progressive insomnia, autonomic system dysfunction, and weakness caused by motor system dysfunction.

Kuru was prevalent among the Fore people in Papua New Guinea. The disease was spread from infected individuals after their deaths through the practice of ritual

cannibalism, in which the relatives of the dead person honored him by consuming his organs, including the brain. Discovery of the infectious nature of kuru won the Nobel Prize for Carleton Gajusek in 1976 and also alerted the medical world to the possibility of slow-acting infectious agents, collectively termed slow-virus diseases. The incubation period for kuru was four to 30 years or more. While kuru has virtually disappeared following the cessation of cannibalistic practices, several new cases continue to arise each year.

Cases of CJD have been grouped into three types: familial, iatrogenic, and sporadic.

- Familial CJD, representing 5–15% of cases, is inherited in an autosomal dominant manner, meaning that either parent may pass along the disease to a child, who may then develop CJD later in life.
- Iatrogenic CJD occurs when a person is infected during a medical procedure, such as organ donation and transplantation, **blood** transfusion, or brain surgery. The rise in organ donation has increased this route of transmission. Grafts of infected corneas and dura mater (the tissue covering the brain) have been linked with the transmission of CJD. Another source is hormones concentrated from the pituitary glands of cadavers, some of whom carried CJD, for use in people with growth hormone deficiencies. Iatrogenic **infection** represents a small fraction of all cases. The incubation period between exposure to the infectious agent is very long and is estimated to be from less than 10 to more than 30 years.
- Sporadic CJD represents at least 85% of all cases. Sporadic cases have no identifiable source of infection. Death usually follows the appearance of the first symptoms within eight months.

Animal forms and “mad cow disease”

Six different forms of spongiform encephalopathy are known to occur in other mammals: scrapie in sheep, recognized for more than 200 years; chronic wasting disease in elk and mule deer in Wyoming and Colorado; transmissible mink encephalopathy; exotic ungulate encephalopathy in some types of zoo animals; feline spongiform encephalopathy in domestic cats; and bovine spongiform encephalopathy (BSE) in cows. All of these are classified as slow-virus diseases.

BSE was first recognized in Britain in 1986. Besides the spongiform changes in the brain, BSE causes dementia-like behavioral changes. This is the origin of the name “mad cow disease.” BSE is thought to be an altered form of scrapie that was transmitted to cows when sheep offal (slaughterhouse waste) was included in their feed.

The use of slaughterhouse offal in animal feed has been common in many countries and has been practiced for at least 50 years. The trigger for the BSE epidemic in Britain seems to have come in the early 1980s, when the use of organic solvents for preparation of offal was halted there. It seems likely that these solvents had destroyed the scrapie agent, thereby preventing infection. The change in preparation procedure opened the way for the agent to “jump species” and cause BSE in cows that consumed scrapie-infected meal. The slaughter of infected (but not yet visibly sick) cows at the end of their useful farm lives, and the use of their carcasses for feed, spread the infection rapidly and widely. For at least the first year after BSE was initially recognized in British herds, infected bovine remains continued to be incorporated into feed, spreading the disease still further. It is thought that most cows with BSE became infected as a result of eating meal containing offal from other cows, not sheep. Although milk from infected cows has never been shown to contain or pass the infectious agent, passage from infected mother to calf has occurred through unknown means.

Beginning in 1988, the British government took steps to stop the spread of BSE, banned the use of bovine offal in feed and other products, and ordered the slaughter of infected cows. By then, the slow-acting agent had become epidemic in British herds. In 1992, it was diagnosed in over 25,000 animals (1% of the British herd). By mid-1997, the cumulative number of BSE cases in the United Kingdom had risen to more than 170,000. The feeding ban apparently did slow the spread of the epidemic. The number of new cases each week fell from a peak of 1,000 in 1993 to fewer than 300 two years later.

The export of British feed and beef to member countries was banned by the European Union, but cases of BSE had developed in Europe by then. About 1,000 cases were identified in Europe by 1997. In 1989, the United States banned the import of British beef and began monitoring U.S. herds in 1990. As of 2001, the U.S. Department of Agriculture reports that BSE has not been detected in the United States. One case has been reported in Canada in a cow imported from Britain.

New-variant CJD: the jump to humans

From the beginning of the BSE epidemic, scientists and others in Britain feared that BSE might jump species again to infect humans who had consumed infected beef. In 1995, this fear seemed to be realized with the first cases of a new variant of Creutzfeldt-Jacob disease, termed nvCJD. Its victims, 81 as of the beginning of 2001, tend to be much younger than the 60–65 average for CJD, and the time from symptom onset to death has

averaged 12 months instead of eight. EEG abnormalities characteristic of CJD are not typically seen in nvCJD.

Evidence is growing stronger that nvCJD is in fact caused by BSE.

- The majority of cases have occurred in Britain, the location of the original BSE epidemic
- BSE injected into monkeys produces a disease very similar to nvCJD
- BSE and nvCJD produce the same brain lesions after the same incubation period when injected into laboratory mice
- Brain **proteins** isolated from nvCJD victims, but not from the other forms of CJD, share similar molecular characteristics with brain proteins of animals that died from BSE.

While definitive proof is still lacking as of 2001, many researchers feel that the connection between BSE and nvCJD has been strongly established.

Assuming that BSE is the source, the question that has loomed from the beginning is the number of people that will eventually be affected. Epidemiological models of infectious disease produce estimates ranging from less than 100 to tens of thousands, depending on the assumptions used by those creating the mathematical models. The incubation period of nvCJD in humans is not known, nor are the genetic and environmental risk factors that influence susceptibility. The quantity of infectious agent needed to cause the disease is not known with precision. It is estimated that humans have eaten between one and two million infected cattle, most in the earliest stages of the epidemic. Estimates cannot be based on the very few cases that have developed to date. These cases could represent the very few people with the right combination of exposure and susceptibility to a relatively fast-developing infection, or they could be the first few victims of a slower-acting, more highly infectious agent. Only time will tell.

Causes and symptoms

Causes

It is clear that Creutzfeldt-Jakob disease is caused by an infectious agent, but it is not yet clear what type of agent that is. Originally assumed to be a virus, evidence is accumulating that, instead, CJD is caused by a protein called a “prion,” (proteinaceous infectious particle) that is transmitted between persons who have CJD. The other spongiform encephalopathies are also hypothesized to be due to prion infection.

If this hypothesis is proved true, it would represent one of the most radical new ideas in biology since the discovery of DNA. All infectious diseases, in fact, all

life, use nucleic acids—DNA or RNA—to code the instructions needed for reproduction. Inactivation of nucleic acids destroys the capacity to reproduce. However, when these same measures are applied to infected tissue from spongiform encephalopathy victims, infectivity is not destroyed. Furthermore, purification of infected tissue to concentrate the infectious fraction yields protein, not nucleic acid. While it remains possible that some highly stable nucleic acid remains hidden within the purified protein, this appears less and less likely as further experiments are done. The “prion hypothesis,” as it is called, is now widely accepted, at least provisionally, by most researchers in the field. The most vocal proponent of the hypothesis, Stanley Prusiner, was awarded the Nobel Prize in 1997 for his work on prion diseases.

A prion is an altered form of a normal brain protein. The normal protein has a helical shape along part of its length. In the prion form, a sheet structure replaces the helix. According to the hypothesis, when the normal form interacts with the prion form, its helical part is converted to a sheet, thus creating a new prion capable of transforming other normal forms. In this way, the disease process resembles crystallization more than typical viral infection, in which the virus commands the host’s cellular machinery to reproduce more of the virus. Build up of the sheet form causes accumulation of abnormal protein clumps and degeneration of brain cells, causing dementia and ultimately death.

The brain protein affected by the prion, called PrP, is part of the membrane of brain cells, but its exact function is unknown. It is composed of about 250 subunits, called amino acids, coded for by a gene on chromosome 20. Slight genetic differences, called polymorphisms, give rise to two slightly different normal protein forms: subunit 129 is a “methionine” in one form, but is “valine” in the other. A person may have all of one, all of the other, or a mixture of the two, depending on the individual’s genetic inheritance. Both forms have the normal helical structure, and function normally. However, susceptibility to prion conversion is influenced by subunit 129: a person with a mixture of forms is more resistant to conversion, and a person with all valine appears to be somewhat more susceptible than one with all methionine. Exposure to the infectious agent is, of course, still required for disease development. Prion diseases are not contagious in the usual sense, and transmission from an infected person to another person requires direct inoculation of infectious material.

Familial CJD, on the other hand, does not require exposure but develops through the inheritance of other, more disruptive mutations in the gene for the normal PrP protein. Researchers believe these mutations increase the likelihood that the protein will spontaneously “flip” to the sheet form; once created, these abnormal proteins can

then convert other normal-form molecules. The other two inherited human prion diseases, Gerstmann-Straussler-Scheinker disease and fatal familial insomnia, involve different mutations in the same gene.

The large majority of CJD cases are sporadic, meaning they have no known route of infection or genetic link. Causes of sporadic CJD are likely to be diverse and may include spontaneous genetic mutation, spontaneous protein changes, or unrecognized exposure to infectious agents. It is highly likely that future research will identify more risk factors associated with sporadic CJD.

Symptoms

About one in four people with CJD begin their illness with weakness, changes in sleep patterns, weight loss, or loss of appetite or sexual drive. A person with CJD may first complain of visual disturbances, including double **vision**, blurry vision, or partial loss of vision. Some visual symptoms are secondary to cortical blindness related to death of nerve cells in the occipital lobe of the brain responsible for vision. This form of visual loss is unusual in that patients may be unaware that they are unable to see. These symptoms may appear weeks or months before the onset of dementia.

The most characteristic symptom of CJD is rapidly progressing dementia, or loss of mental function. Dementia is marked by:

- **memory** losses
- impaired abstraction and planning
- language and comprehension disturbances
- poor judgment
- disorientation
- decreased attention and increased restlessness
- personality changes and psychosis
- hallucinations

Muscle spasms and jerking movements, called myoclonus, are also a prominent symptom of CJD. Balance and coordination disturbance (ataxia) is common in CJD and is more pronounced in nvCJD. Stiffness, difficulty moving, and other features characteristic of **Parkinson's disease** may develop and can progress to akinetic mutism, or a state of being unable to speak or move.

Diagnosis

CJD is diagnosed by a clinical neurological exam and **electroencephalography** (EEG), which shows characteristic spikes called triphasic sharp waves. **Magnetic resonance imaging** (MRI) or computed tomography scans (CT) should be performed to exclude

other forms of dementia. CJD typically shows atrophy or loss of brain tissue. Lumbar puncture, or spinal tap, may be done to rule out other causes of dementia and to identify elevated levels of marker proteins known as 14-3-3. Cell count, chemical analysis, and other routine tests are normal in CJD. Another marker, neuron-specific enolase, may also be increased in CJD. A conclusive diagnosis of CJD can only be accomplished after death using material obtained from a brain **autopsy**.

Treatment

There is no cure for CJD. There is no treatment that slows the progression of the disease. Drug therapy and nursing care are intended to minimize psychiatric symptoms and increase comfort for affected persons. However, the rapid progression of CJD frustrates most attempts at treatment, since ever-worsening cognitive deficits and more prominent behavioral symptoms develop so quickly. Despite the generally grim prognosis, a few individuals with CJD progress more slowly and live longer than the average. For these persons, treatment will be more satisfactory.

Prognosis

Creutzfeldt-Jakob disease is invariably fatal, with death following symptom onset by an average of eight months. About 5% of patients live longer than two years. Death from nvCJD has averaged approximately 12 months after onset.

Health care team roles

Physicians are usually involved in initial identification of CJD. Nurses may provide supportive care. Radiologists obtain CT and MRI scans. Surgeons or physicians obtain spinal fluid. Pathologists and laboratory technicians process samples of bodily fluids and tissues.

Prevention

There is no known way to prevent sporadic CJD, by far the most common type. Not everyone who inherits the gene mutation for familial CJD will develop the disease, but at present, there is no known way to predict who will and who won't succumb. The incidence of iatrogenic CJD has fallen with recognition of its sources, the development of better screening techniques for infected tissue, and the use of **sterilization techniques** for **surgical instruments**, which inactivate prion proteins.

Strategies for preventing nvCJD are a controversial matter, as they involve a significant sector of the agricultural industry and a central dietary element in many

countries. The infectious potential of contaminated meat is unknown, because the ability to detect prions within meat is limited. Surveillance of North American herds strongly suggests that no cases of BSE have been confirmed as of 2001. Strict regulations on imports of European livestock make future outbreaks highly unlikely. Therefore, avoidance of all meat originating in North America simply on grounds of BSE risk is a personal choice unsupported by current data. The ban on the export of British beef continues in countries of the European Union, although some herds in these countries have developed low levels of infection as well.

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- American Academy of Neurology, 1080 Montreal Avenue, St. Paul, MN 55116. (651) 695-1940. Fax: (651) 695-2791. <<http://www.aan.com/>>. info@aan.org.

KEY TERMS

Autosomal dominant inheritance—A pattern of inheritance in which a trait is expressed if the gene is inherited from either parent.

Encephalopathy—A brain disorder characterized by memory impairment and other symptoms.

Iatrogenic—Caused by a medical procedure.

Nucleic acids—The cellular molecules DNA and RNA, which act as coded instructions for the production of proteins and which are copied for transmission of inherited traits.

Centers for Disease Control and Prevention, 1600 Clifton Road, Atlanta, GA 30333. (404) 639-3534 or (800) 311-3435.
<<http://www.cdc.gov/ncidod/eid/vol7no1/brown.htm>>.
<<http://www.cdc.gov/netinfo.htm>>.

Creutzfeldt-Jakob Disease Foundation, P.O. Box 611625, Miami, FL 33261-1625. (305) 891-7579. Fax: (954) 436-7591. <<http://cjd.foundation.org/>>. crjakob@aol.com.

Creutzfeldt-Jakob Disease Support Network, Birchwood, Heath Top, Ashley Heath, Market Drayton, Shropshire, England. (011) 0163-067-3993.
<<http://glaxocentre.merseyside.org/cjd1.html>>. E-mail: Gill Turner, 106703.141@compuserve.com.

National Creutzfeldt-Jakob Disease Surveillance Unit, Western General Hospital, Crewe Road, Edinburgh, EH4 2XU, UK. 011-0131-537-2128. Fax: 011-0131-343-1404.
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L. Fleming Fallon, Jr., MD, PhD, DrPH

Crohn's disease

Definition

Crohn's disease is a type of inflammatory bowel disease (IBD) caused by inflammation along any portion of the alimentary canal (the mouth to the anus).

Description

Although Crohn's disease may involve any part of the alimentary canal, it most commonly affects the **small intestine**. There is evidence that the inflammation is an autoimmune response—when products of the **immune system** attack the body itself instead of attacking a foreign substance such as a virus or **bacteria**.

The part of the small intestine most commonly affected is the last part of the ileum, also known as the terminal ileum. The colon (**large intestine**) is less commonly involved. Inflammation may also occur in other areas of the alimentary canal, less frequently affecting the mouth, esophagus, or **stomach**.

Crohn's disease differs from ulcerative colitis, the other major type of IBD, in the following ways:

- The inflammation of Crohn's disease may be discontinuous, meaning that areas of involvement in the intestine may be separated by normal, unaffected segments of intestine. The affected areas are called "regional enteritis," while the normal areas are called "skip areas."
- The inflammation of Crohn's disease is transmural; this means it affects all the layers of the intestinal wall, while ulcerative colitis affects only the lining of the intestine.
- Ulcerative colitis does not usually involve the small intestine; in rare cases it involves the terminal ileum (so-called "backwash" ileitis).

In addition to inflammation, Crohn's disease causes ulceration. These ulcers occur because the inflammation has caused areas of tissue destruction.

Crohn's disease may be diagnosed at any age, although most diagnoses are made between the ages 15-35. About 0.02-0.04% of the population suffers from this disorder. It affects equal numbers of males and females. Whites are more frequently affected than other racial groups, and people of Jewish origin are between three and six times more likely to suffer from IBD. IBD runs in families; an IBD patient has a 20% chance of having other relatives who are fellow sufferers.

Crohn's disease is a chronic disorder. Though symptoms can be effectively controlled, patients are not completely cured of the underlying disease.

Causes and symptoms

The cause of Crohn's disease is unknown. No infectious agent has been positively identified as the cause of Crohn's disease. Some researchers have theorized that a certain bacterium may have originally been responsible for triggering the immune system, resulting in the abnormal activation of the immune system in the intestines that occurs in Crohn's disease.

Symptoms of Crohn's disease depend on which section of the alimentary canal is affected. Symptoms may include **diarrhea**, **fever**, abdominal **pain**, loss of appetite, weight loss, and fatigue. Some patients experience severe pain that mimics **appendicitis**. Unlike patients with ulcerative colitis, it is rare for patients with Crohn's disease to notice **blood** in their bowel movements. Because Crohn's disease severely limits the ability of the affected intestine to absorb the nutrients from food, a patient may have signs of malnutrition, depending on the amount of intestine affected and the duration of the disease.

The combination of severe inflammation, ulceration, and scarring that occurs in Crohn's disease can result in serious complications, including intestinal obstruction, intra-abdominal **abscess** formation, and fistula formation.

An obstruction is a mechanical blockage in the intestine. This obstruction, called a stricture, prevents the intestinal contents from passing beyond the point of the blockage. The intestinal contents "back up," resulting in constipation, vomiting, and intense pain. Although rare in Crohn's disease (because of the increased thickness of the intestinal wall due to swelling and scarring), severe bowel obstruction can result in an intestinal wall perforation (a hole in the intestine). A hole in the intestinal wall would allow the intestinal contents, containing bacteria, to enter the abdominal cavity, causing a severe, life-threatening **infection** known as peritonitis.

Abscess formation is the development of a walled-off pocket of pus. A patient with an abscess in the abdomen will have fever, abdominal pain, and may have a lump or mass that can be palpated (felt) through the wall of the abdomen.

Fistula formation is the formation of abnormal channels. These channels may connect one loop of the intestine to a neighboring section of intestine. Fistulas may connect an area of the intestine to the vagina or urinary bladder, or may drain an area of the intestine through the skin. Abscesses and fistulas commonly affect the area

around the anus and rectum. These abnormal connections allow the bacteria normally present in the intestine to enter other areas of the body, causing potentially serious infections.

Patients suffering from Crohn's disease are at increased risk of other disorders. Some of these may relate specifically to the intestinal disease, and others appear to have some relationship to the compromised immune system. The faulty absorption of the bowel can result in gallstones and **kidney stones**. Inflamed areas in the abdomen may compress and block the ureter (the tube that drains urine from the kidney to the bladder) causing failure of the kidney on the affected side. Patients with Crohn's disease also frequently suffer from extraintestinal manifestations such as:

- arthritis (inflammation of the joints)
- spondylitis (inflammation of the vertebrae, the bones of the spine)
- ulcers of the mouth and skin
- erythema nodosum (painful, red bumps on the skin)
- inflammation of several eye areas
- inflammation of the **liver**, gallbladder, and/or the ducts that carry bile between and within the liver, **gallbladder**, and intestine

The risk of developing **cancer** of the intestine is greater than average among patients with Crohn's disease, although the cancer risk is not as high as it is for patients with ulcerative colitis.

Diagnosis

Diagnosis is first suspected based on a patient's symptoms. Blood tests may reveal an increase in white blood cells, an indication that some type of inflammation is occurring in the body. The blood tests may also reveal anemia and other signs of malnutrition due to malabsorption, such as low blood protein; low **calcium**, potassium, and magnesium present in the blood; and indications of liver inflammation. Stool samples may be examined to rule out various infectious agents, and to see if the stool contains blood.

During a colonoscopic exam, a physician passes a flexible tube with a tiny, fiber-optic camera (called an **endoscope**) through the rectum and into the colon. The physician carefully examines the lining of the intestine for signs of inflammation and ulceration that might suggest Crohn's disease. A biopsy of the intestine can also be taken through the colonoscope, and the tissue will be examined under a **microscope** for evidence of Crohn's disease.

X rays can be helpful for diagnosis, and to determine how much of the intestine is involved in the disease. For these x rays, the patient must either drink a chalky solution containing barium, or receive a **barium enema**. Barium helps to "light up" the intestine, allowing more detail to be seen on the resulting x rays.

Crohn's disease and ulcerative colitis are similar, but they are distinct conditions. Although it may be difficult to determine whether a patient has Crohn's disease or ulcerative colitis, it is important to make every effort to distinguish between these two diseases because the long-term complications of the diseases are different, as is the treatment.

Treatment

Treatment for Crohn's disease aims to reduce the underlying inflammation, the resulting malabsorption/malnutrition, and relieve symptoms of abdominal pain and diarrhea. Treatment is also intended to prevent potential complications such as obstructions, abscesses, and fistulas.

Inflammation can be treated with a drug called sulfasalazine. Sulfasalazine is in part related to the sulfa **antibiotics**; its other component is a form of the anti-inflammatory chemical, salicylic acid (related to aspirin). Sulfasalazine is not well absorbed from the intestine, so it remains largely within the intestine, where it is broken down into its components. It is believed that the salicylic acid component actively treats Crohn's disease by fighting inflammation. Some patients do not respond to sulfasalazine and require **corticosteroids** such as prednisone. Corticosteroids, however, must be used carefully to avoid the various complications of these drugs, including an increased risk of infection and **osteoporosis** (weakening of the bones).

Patients with intra-abdominal abscesses or those with disease in the large bowel or ileum may be given antibiotics such as metronidazole or ciprofloxacin. Potent immunosuppressive drugs, such as 6-mercaptopurine, azathioprine, cyclosporine, and infliximab, which block the immune system and thereby reduce inflammation, may be prescribed for patients who do not respond to corticosteroids.

Serious cases of malabsorption/malnutrition may require treatment with nutritional supplements. These supplements must be in a form that can be absorbed from the damaged, inflamed intestine. Some patients find that certain foods are hard to digest, including milk, large quantities of fiber, and spicy foods. When patients are suffering from an obstruction, or during periods of time when symptoms of the disease are at their worst, they

KEY TERMS

Abscess—A walled-off pocket of pus caused by infection.

Endoscope—An instrument that can be passed into an area of the body (the bladder or intestine, for example) to allow examination of that area. The endoscope usually has a fiber-optic camera, which allows a greatly magnified image to be shown on a television screen viewed by the operator. Many endoscopes also allow the operator to retrieve a biopsy of the area examined.

Fistula—An abnormal channel that creates an open passageway between two structures that do not normally connect.

Gastrointestinal tract—The entire length of the digestive system, running from the mouth to the stomach, through the small intestine, large intestine, rectum, and anus.

Immune system—The body system responsible for combating infection by viruses, bacteria, fungi, and other foreign invaders. In autoimmune disease, these cells and chemicals turn against the body itself.

Inflammation—The result of the body's attempts to fight off and wall off an area that is infected. Inflammation results in the classic signs of redness, heat, swelling, and loss of function.

Obstruction—A blockage.

Ulceration—A pitted area or break in the continuity of a surface such as skin or mucous membrane.

may need to drink specially formulated, high-calorie liquid supplements. Those patients who are severely ill may need total **parenteral nutrition** (TPN). TPN patients receive their **nutrition** intravenously, or through a catheter inserted directly into a major vein in the chest.

A number of medications are available to help decrease the cramping and pain associated with Crohn's disease. These include loperamide, tincture of opium, and codeine. Fiber preparations (methylcellulose or psyllium) are helpful for some patients; others do not tolerate them well.

The first step in treating an obstruction involves general efforts to decrease inflammation with sulfasalazine, steroids, or immunosuppressive drugs. A patient with a severe obstruction is given no food or

drink by mouth, allowing the bowel to “rest.” Abscesses and other infections require antibiotics. Surgery may be required to repair an obstruction that does not resolve on its own, to drain an abscess, or to repair a fistula. Such surgery may involve the resection (removal) of the diseased length of the intestine.

In extremely severe cases of Crohn's disease that do not respond to treatment, patients may require a **colostomy**. In this procedure, a piece of the remaining small intestine is pulled through an opening in the abdomen. This segment of intestine is fashioned surgically to allow a special bag to be placed over it. This bag collects the stool, which can no longer pass through the large intestine and out of the anus.

Prognosis

Crohn's disease is a chronic, lifelong illness. The severity of the disease may vary, and patients may experience periods of time when the disease is not active and they are symptom free. Still, the complications and risks of Crohn's disease tend to increase over time. More than 60% of all patients with Crohn's disease will require surgery, and about half of these will require more than one operation over time. Approximately 5-10% of all Crohn's patients die of their disease, primarily due to massive infection.

Health care team roles

Crohn's disease is often diagnosed by primary care practitioners or gastroenterologists. In many instances, patients require surgical intervention. Imaging studies to assist in diagnosis are performed by x-ray technologists, and laboratory technologists may be involved in obtaining blood and stool samples for analysis.

Nurses, dieticians, and nutritional counselors have important roles in teaching patients about dietary changes to manage symptoms. Nurses, social workers, and ostomy specialists may also be involved in educating patients pre- and postoperatively about ostomy care.

Prevention

Presently, there is no way to prevent the development of Crohn's disease.

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ORGANIZATIONS

Crohn's & Colitis Foundation of America, Inc. 386 Park Avenue South, 17th Floor, New York, NY 10016-8804. (800) 932-2423.

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Cross infection

Definition

Cross **infection** is the physical movement or transfer of harmful **bacteria** from one person, object, or place to another, or from one part of the body to another (such as touching a staph-infected hand to the eye). When this cross infection occurs in a hospital or long-term care facility it is called a nosocomial infection. Community-acquired infections are those contracted anywhere *except* a hospital or long-term care facility.

Description

Cross infection accounts for half of all major complications of hospitalization; the rest are medication errors, patient **falls**, and other noninfectious events. In American hospitals, cross infection affects between 5–10% of patients at a cost in excess of \$4.5 billion. Further, with the advent of HMOs and incentives for outpatient care, hospitals now have a concentrated population of seriously ill patients, and an even greater risk of cross infection.

On one hand, trends toward same-day surgery, shorter hospital stays, and less-invasive surgical techniques will limit patients' exposure to hospital pathogens and invasive devices. On the other, long-term inpatients are likely to be older and sicker, requiring the use of invasive devices in treatment or management of their illness. This places them at increased risk of cross infection, a risk that is higher for public and larger hospitals and teaching institutions.

Statistics show that about 35 million patients are admitted to 7,000 acute-care institutions in the United States each year. This means that 1.75 million to 3.5 million patients are infected yearly in the United States. If 10% of all cross infections involve the bloodstream, then

175,000 to 350,000 patients acquire these life-threatening septicemic infections each year.

Causes and symptoms

Cross infections are caused by bacteria, **viruses**, **fungi**, or parasites that may already be present in the patient's body, or they may come from the environment, contaminated hospital equipment, health care workers, visitors, or other patients. A localized infection is limited to a specific part of the body and has local symptoms. An infected surgical site, for example, would exhibit an area that is red, hot, and painful. A generalized infection that enters the bloodstream causes general systemic symptoms such as **fever**, chills, low **blood pressure**, **boils** all over the body, or mental confusion.

Cross infections can occur from surgical procedures, catheters placed in the urinary tract, intravenous fluid sites, or when moisture droplets from the nose or mouth are inhaled into the **lungs**. The most common cause of cross infection is the failure of health care workers to wash their hands after taking off latex gloves or before donning a new pair. The most frequent types of cross infections occurring in facilities are urinary tract infections (UTIs), **pneumonia**, surgical site infections (SSIs), and **blood** stream infections (BSIs).

While all patients within a health care facility are vulnerable to cross infection, some patients are at greater risk than others because certain risk factors alter their susceptibility to infection. Intrinsic risk factors are those present in the patient and include age (the very young or the elderly), presence of chronic disease, or a compromised **immune system**. Extrinsic risk factors are types of interventions performed within the health care facility and the mix of patients present.

Fever is often the first sign of infection; other symptoms include rapid breathing, mental confusion, low blood pressure, reduced urine output, painful joints and muscles, and a high white blood cell count. If there is a skin break it may be red and swollen. Patients with a UTI may have **pain** when urinating along with cloudy or bloody urine. Symptoms of pneumonia include difficulty breathing, chronic deep coughing, and reluctance to lie flat because it makes breathing difficult. A localized infection causes swelling, redness, and tenderness at the site of infection.

Common cross infections

URINARY TRACT INFECTIONS. Urinary tract infections (UTIs), the most common type of cross infections, usually occur after catheterization, the placement of a catheter through the urethra into the bladder. This proce-

sure is done to empty urine from the bladder, relieve pressure in the bladder, measure urine in the bladder, put medicine into the bladder, or for other medical reasons. While there can be bacteria in or around the urethra, a healthy urinary bladder is sterile: it does not normally have any bacteria or other microorganisms in it. When a catheter is inserted, bacteria can be picked up from the urethra and carried into the bladder unless both the area and equipment are properly prepared; once in the bladder, bacteria can multiply. Infections can also arise if health care personnel fail to follow proper sterile technique when emptying the collection bag. Bacteria from the intestinal tract are the most common cause of UTIs, although fungi called *Candida albicans* are often implicated. Although UTIs are common, they are generally the least severe and least costly type of cross infection.

PNEUMONIA. Nosocomial pneumonia is the second most common type of cross infection; it is defined as an infection of the lungs that develops 48 or more hours after admittance. (Any infection that occurs within the first two days after admission is presumed to have come in with the patient.) Patients requiring invasive **respiratory therapy** may have infection rates seven to 21 times higher than those who don't need artificial ventilation. These infections occur because bacteria and other microorganisms are easily introduced into the throat by procedures such as respiratory intubation, suctioning of material from the throat and mouth, tracheostomy, and mechanical ventilation. The microorganisms can come from contaminated equipment, the hands of health care workers, or, depending on the physical health of the patient, from the patient's own bacteria. The introduced microorganisms quickly colonize the throat area, but do not yet cause an infection. Once the throat is colonized, it is easy for a patient to inhale the microorganisms into the lungs; most nosocomial pneumonia develops within two days of the infecting procedure. This is especially true for patients who cannot cough or gag very well. The occurrence of pneumonia can prolong a hospital stay by at least three or four days at considerable cost.

SURGICAL SITE INFECTIONS. Since surgery is a direct invasion of the patient's body, the natural barrier of the skin is broken, giving bacteria entrance into the normally sterile interior of the body. Surgical site infections (SSIs) can be acquired from contaminated surgical equipment, health care workers who use improper technique to change bandages postoperatively, intubations, and a depressed immune system that permits the body's natural bacteria to colonize. Other **wounds** from trauma, **burns**, and ulcers can also become infected for similar reasons.

BLOOD STREAM INFECTIONS. Many patients in health care facilities need an intravenous (IV) catheter

placed in a vein for the infusion of fluids for hydration, medications, and/or nutrients. This can cause blood stream infections (BSIs) by transmission from the surroundings, contaminated equipment, or health care workers' hands via the site of catheter insertion. A local infection can develop in the skin around the catheter, or more seriously, bacteria can enter the bloodstream through the vein and cause a generalized infection. The longer a catheter is in place, the greater the risk of infection. BSIs are the most severe of the cross infections, resulting in the most deaths, greatest prolongation of stay, and highest cost. Other procedures that put patients at risk for cross infections are gastrointestinal procedures, obstetric procedures, and kidney or **peritoneal dialysis**.

Diagnosis

An infection is suspected any time a hospitalized or home health care patient develops a fever that cannot be explained by a known illness. Some patients, however, especially the elderly, may not develop a fever. In these patients, the first signs of infection may be rapid breathing, pale clammy skin, or mental confusion.

Diagnosis of a cross infection is based on:

- signs and symptoms of the infection
- examination of wounds and catheter entry sites
- review of procedures that might have led to infection
- laboratory test results, including blood studies, **urinalysis**, and culture of any suspicious wound sites

A complete **physical examination** is conducted by the physician, nurse practitioner, or **registered nurse** caring for the individual in order to determine if an infection is present. Wounds and catheter insertion sites are examined for redness, swelling, the presence of pus, an **abscess**, or any area of exaggerated tenderness that might indicate an abscess. The registered nurse reports findings to the physician or nurse practitioner who reviews the patient's record of procedures performed to determine if any posed a risk for infection.

Medical technicians perform laboratory tests ordered by the physician or nurse practitioner to look for signs of infection. A **complete blood count** reveals the white blood cell count, a measure of macrophages whose increasing numbers indicate infection. White blood cells, blood, or "casts" (mineral crystals) may be present in the urine with a UTI as well. Cultures of blood, urine, sputum, other body fluids, or tissue are examined for infectious microorganisms, which must be identified to provide proper treatment. These cultures are obtained by taking a swab of an area or a sample of fluid, blood, or tissue and placing it in a special sterile medium that promotes bacte-

rial growth. Other tests can be done on blood and body fluids to find and identify bacteria, fungi, viruses, or other microorganisms responsible for the infection. If a patient has symptoms suggestive of pneumonia, a **chest x ray** is done to look for infiltrates—white blood cells and other inflammatory substances in the lung tissue.

Treatment

Upon identification of the infection, the patient is treated with **antibiotics** or other medications that destroy the responsible organism. Although many different antibiotics are available, bacteria strains resistant to specific antibiotics have become increasingly prevalent. In one 1998 U.S. report, only 56% of pneumococcal strains of bacteria were still sensitive to penicillin while 16% were highly resistant. At the present time, resistance is highest to penicillin, but resistance to other antibiotics such as cephalosporins, tetracyclines, and erythromycin is also rapidly increasing. Fortunately, most pneumococci are still sensitive to vancomycin, but an increasing number of vancomycin-resistant bacteria have been reported. Newer groups, called fluoroquinolones, are being used to treat resistant bacteria, as are imipenem/cilastatin (Primaxin), a carbapenem combination, and sanfetrinem, a tricyclic beta-lactam antibiotic. These are powerful new antibiotics that can combat a wide spectrum of bacteria that have become resistant to standard drugs. Unfortunately, some newer studies show that patients with infections resistant to cephalosporins may also have a cross-resistance to the fluoroquinolones. Repeated exposure even to these antibiotics, however, will eventually result in bacterial resistance. It is essential, therefore, that patients who require antibiotics be rigorous about completing their regimen and that those caring for them adhere to **aseptic technique** rigidly.

At highest risk for antibiotic-resistant pneumococci are children under two who live in areas of high antibiotic use and who have used antibiotics in the previous year. Efforts to reduce the number of resistant bacteria include teaching both the public and health care workers that a conservative approach is best when it comes to antibiotics use: not every infection needs medication. A program in Finland, for example, has nearly halved the incidence of erythromycin-resistant bacteria by limiting the use of penicillin and similar antibiotics to only serious infections. Many infections, in fact, are viral, and do not respond to antibiotic therapy.

Fungal infections are treated with antifungal medications, such as amphotericin B, nystatin, ketoconazole, itraconazole, and fluconazole, but many of these drugs have negative interactions with other medications that the patient may be using. A number of **antiviral drugs**

have been developed that slow the growth or reproduction of viruses, and these include acyclovir, ganciclovir, foscarnet, and amantadine.

Prognosis

Cross infections are serious illnesses that can cause death in about 1% of all cases. Blood stream infections in intensive care unit (ICU) patients have a mortality rate of almost 35%. Rapid diagnosis and identification of the responsible microorganism are necessary so that specific antimicrobial therapy can be started as quickly as possible.

Health care team roles

In all cases, medication for cross infection is administered by a registered nurse in a health care facility, by an intravenous infusion nurse who does home health care, or by a **licensed practical nurse** in a nursing home. These nurses must be extremely careful that the medication is given exactly as ordered and that they use sterile technique to prevent any additional cross infection. The nurse must also remain alert to additional complications or symptoms that may be significant and report these to the physician or nurse practitioner. Laboratory personnel must be very careful in utilizing sterile technique when drawing blood, as should respiratory therapists who may provide breathing treatments or suction for patients with pneumonia.

Patient education

If possible, the registered nurse can use the time during treatments to teach the patient how cross infection occurs. This is especially important when the patient is immunocompromised and, therefore, more susceptible to further infection. The nurse could explain the importance of taking medications exactly as ordered and why antibiotics are sometimes not given for illnesses. All health care personnel should explain procedures as they are performed and include the reasons for the particular treatment. The patient's family may be included in the session to further enforce the necessity of the treatment as well as the appropriate way to perform it.

Prevention

Hospitals and other health care facilities have developed extensive infection-control programs to identify all possible sources of infection, including medical procedures, that put patients at risk. The first infection-control committees and policies were developed in the late 1950s and early 1960s when a pandemic of highly virulent antibiotic-resistant *Staphylococcus aureus* swept through American hospitals. In response, the Centers for Disease

KEY TERMS

Abscess—A localized pocket of pus at a site of infection.

Candida albicans—A yeast-like fungal organism.

Catheter—A thin, hollow tube inserted into the body at specific points in order to inject or withdraw fluids.

Culture—The reproduction of microorganisms or of living tissue cells in special media that encourages their growth.

Generalized infection—An infection that has entered the bloodstream and has general systemic symptoms such as fever, chills, and low blood pressure.

Incubating—The development of an infectious disease from time of the entrance of the pathogen to the appearance of clinical symptoms.

Intubation—Placement of a tube inside the body to keep a lumen open, especially the trachea.

Localized infection—An infection that is limited to a specific part of the body.

Nosocomial infection—An infection acquired during or after hospitalization and that was not present or incubating at the time of the patient's admission. It includes any infection acquired in a facility that appears after discharge and any newborn infection that is the result of passage through the birth canal.

Peritoneal dialysis—A procedure for cleaning the blood when a patient's kidneys have failed. A catheter implanted in the patient's abdomen is used to add and remove cleansing fluid that removes waste and impurities from the bloodstream. Unlike hemodialysis, peritoneal dialysis can usually be done at home.

Systemic—Affecting the whole body.

Tracheostomy—The creation of an opening into the trachea (windpipe) through the neck, with insertion of an indwelling tube to facilitate passage of air or evacuation of secretions.

Control and Prevention (CDC; then the Communicable Disease Center) in Atlanta recommended that hospitals determine the sources of infection in hospital patients, so they could develop and apply preventive measures. One result of this was a CDC-sanctioned maximum of 250 beds for each **infection control** nurse. They further

noted that programs were most successful when data were communicated effectively to hospital staff.

Further recommendations that resulted from these initiatives included analyzing procedures with high risk of contamination, such as urinary catheterization. To minimize cross infection, it was recommended that these procedures be performed only when necessary, and that catheters or other medical devices be left in for as little time as possible. Medical instruments and equipment should be properly sterilized, with appropriate documentation and check devices, to ensure they were not contaminated. Frequent hand washing by health care workers and visitors is absolutely essential to prevent transferring infectious microorganisms to patients, and was cited as the procedure most important for prevention. Patients should be encouraged to ask their health care provider if they washed their hands before allowing them to proceed with an examination. Antibiotics should only be used when necessary because their use not only creates favorable conditions for infection with the fungal organism *Candida albicans* but their overuse has helped develop antibiotic-resistant bacteria.

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Linda K. Bennington, CNS

Crowns see **Dental crowns, inlays, and bridges**

Crutches and crutch walking

Definition

Crutches are orthopedic devices created to assist in weight bearing when a patient has a leg injury or weakness in the lower extremities.

Purpose

Wooden or aluminum axillary (under the arm) crutches are used to assist in weight bearing when a patient has sustained an injury to the leg, knee, ankle, or foot, such as a fracture or severe sprain. Crutches are also used following surgery on the leg, knee, ankle, or foot. Forearm crutches are used to provide stability and moderate support when a patient has generalized weakness in the lower extremities, such as for a patient with **cerebral palsy**.

Description

Axillary crutches can be either wooden or aluminum. Each crutch is comprised of two pieces of wood or aluminum that are connected at the top and middle by a crossbar and join to a third piece that extends to the floor. The top cross bar is slightly concave in shape and fits just 1-2 inches (2.54–5 cm) below the axilla. It is covered with a soft rubber pad and is used to brace the crutches against the body. The middle cross bar is round and covered with a rubber grip. It is adjusted to hand level for gripping the crutches with the hands. The third piece connects the two upper pieces, extends to the floor, and is covered by a rubber tip on the end that meets the floor. Crutches are used in pairs to provide balance and support. Aluminum crutches are lighter and easier to use. Wooden crutches are generally less expensive than aluminum crutches.

Forearm crutches are comprised of two pieces of aluminum tubing that are telescoped one within the other to adjust to the correct height of the client. They are fitted with attached, swivel-action arm cuffs that fit partially around the forearm, and with handgrips that are covered with a rubber grip. There is a rubber tip at the end of each crutch where it meets the floor.

Operation

Wooden or aluminum axillary crutches come in several sizes. The appropriate size crutches should be selected based on the patient's height. With the patient standing straight upright, one crutch is held against the patient's side. The nut bolt which attaches to the bottom piece is loosened and removed. The crutch is then adjust-

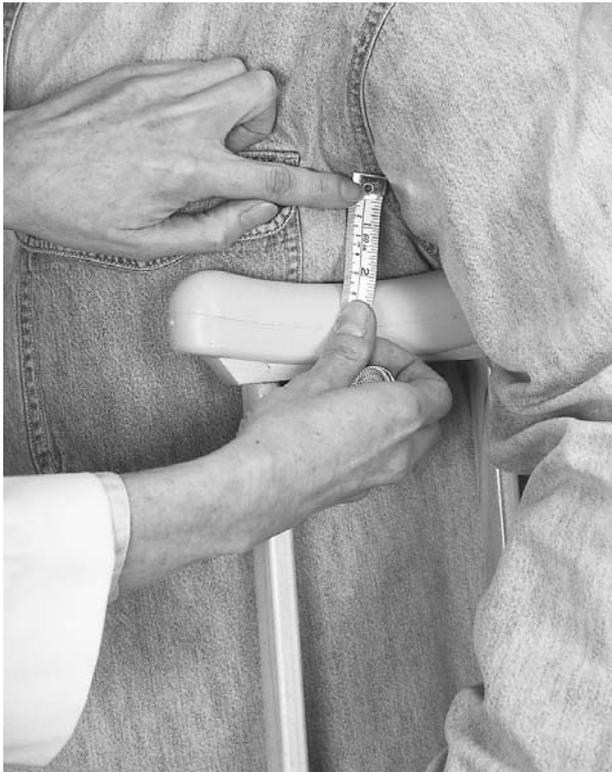
ed until it is 1-2 inches (2.54–5 cm) below the patient's axilla. The bolt is placed in the appropriate hole, and the nut wing is tightened securely to hold it in place. The patient then holds his hand down with the elbow slightly bent. The bolt and nut wing for the handgrip are loosened and moved to the correct position for the patient. The hand should be resting at the hip line with the elbow slightly bent. The bolt is placed in the appropriate hole, and the nut wing is tightened securely. The rubber tip, rubber axillary padding, and rubber handgrip are checked to ensure placement and security. The client sits back down, and the other crutch is adjusted at the base and the hand grip to exactly match the measured crutch.

Aluminum forearm crutches come in several sizes. The appropriate size crutches should be selected based upon the patient's height. With the patient standing, one crutch is adjusted by pushing in the locking mechanism and moving the height up until the forearm portion of the crutches can slip comfortably onto the patient's arm. The crutches are locked by moving the mechanism until the lock clicks securely. The arm cuff is adjusted if necessary. The crutch is checked for stability by pushing down on it. The vinyl padding on the arm cuff, the rubber handgrip, and the rubber tip at the end of the crutch are examined to be sure they are in place and secure. The client then sits back down, and the other crutch is adjusted to exactly match the measured crutch.

The patient should not attempt to use the crutches until they are fitted and all of the nut wings or locking mechanisms are secure. The hands and arms bear the patient's weight, not the axilla. The patient is instructed not to lean on the axillary pads because this can pinch the axillary nerve and cause numbness of the hands and arms. The patient is instructed on crutch safety, how to walk with crutches, how to go up and down stairs with crutches, how to sit, and how to stand up using the crutches. The patient demonstrates competency with the crutches before discharge. The patient is given written instructions about crutch walking and safety to review later after discharge.

Maintenance

The screw bolts and nut wings that hold the base of the crutches and the handgrip of the crutches should be checked daily to be sure they are securely tightened. Rubber tips that become worn or tear should be replaced at once to prevent slipping. Rubber handgrips that are torn or worn should be replaced promptly to prevent blisters on the hands or slipping of the hands. Worn or torn rubber padding at the top of axillary crutches should be replaced to prevent pressure injuries. New rubber tips or handgrips can be purchased at most drug stores. Crutches



A patient is measured for crutches. (Delmar Publishers, Inc. Reproduced by permission.)

that are kept in good repair can be reused if well maintained but should be re-measured and adjusted for each client. Forearm crutches should be checked daily before use to be sure that the height adjustment pegs are secure, the swivel-action arm cuffs fit correctly, the rubber tips are intact, and the handgrips are secure.

Health care team roles

It is most often the responsibility of a licensed nurse or physical therapist to fit crutches and teach crutch walking/safety to the patient in the health care setting. Non-professionals such as orthopedic technicians or ER staff can receive special training to fit crutches and teach crutch walking/safety in some medical settings. Patients must always be instructed on the proper use and safety factors involved in crutch walking prior to discharge with crutches.

Training

Instructing a patient about the safe use of crutches should include the following information:

- **Crutch walking:** The crutches are placed under both arms close to the body. The hands are placed firmly upon the handgrips. Both crutches and the injured limb are moved forward about 12 inches (30 cm). With the crutches braced against the body, the strength of the hands and forearms are used to push down on the handgrips as the good leg swings through and about 12 inches (30 cm) ahead of the crutches. The patient's weight is placed on the uninjured leg and the process is repeated. A slow steady rhythm is used when walking. The patient is instructed not to go too fast or swing his leg too far forward because this can cause a loss of balance. The body and head are kept upright. The patient is instructed not to lean forward or put his weight on the axillary pads. The patient is told to look ahead to where he is going and not to look at his feet. The patient practices walking forward, turning, and walking back until he has developed a rhythm and balance with the crutches.
- **Sitting:** The patient is instructed to back up against the chair until he feels the chair on the back of his legs. The patient's weight is placed on the uninjured leg, and the injured leg is advanced slightly forward. Both crutches are placed side by side on the uninjured side, beside the patient's body but not under the arm. The patient holds both handgrips together and reaches back for the armrest of the chair and the crutch handgrips as support, the patient slowly moves his injured leg forward and lowers himself into the chair. The crutches are placed nearby. Standing them on the axillary pads, when possible, makes it less likely that they will tip over and fall away from the patient.
- **Standing:** When in bed, the patient moves first to a sitting position to get his balance. The patient then inches forward to the edge of the bed or the chair. Both crutches are then placed upright and side-by-side on the uninjured side. The patient grips both handgrips firmly in his hand and rises up on his uninjured leg. The crutches are placed on either side of the body and the patient holds the handgrips. Instruct the patient to take a few minutes to get his balance. Be sure that the patient's body is upright, the crutches are positioned correctly, and his head is looking forward before beginning to walk.
- **Climbing up stairs:** Climbing stairs with crutches requires strength and flexibility. If the patient is unsure of his strength, he should be instructed to turn around and sit on the stairs and scoot himself up one stair at a time using his uninjured leg to propel him. The patient should be instructed to keep his crutches in one hand and bring them up with him. When climbing stairs with crutches, the patient leads with his uninjured leg and brings the injured leg and crutches up behind him. If the stairway has a handrail, the patient should place both crutches under the arm opposite the handrail and grip the handgrips together in one hand. The patient places his weight on the handrail and the handgrips, leans

slightly forward, and brings his uninjured leg up one step. He then brings the crutches and the injured leg up the step and advances his hand up the handrail. Once the patient has regained his balance, the process is repeated. The patient should be instructed to take his time and rest halfway up the stairs if necessary. To climb stairs with no handrail, the patient leans slightly forward and puts his weight on the handgrips of the crutches. The patient moves the uninjured leg up the step. He then shifts his weight to the uninjured leg and brings the crutches and injured leg up the step. His foot and crutch tips are kept in the middle of the step, away from the edge to avoid slipping. The patient is instructed to take his time, rest as needed, and ask for help if necessary. Having someone walk behind the patient up the stairs can add a sense of security, and the person can assist the patient into a sitting position if he becomes fatigued.

- **Going down stairs:** Going down stairs with crutches requires strength and flexibility. If the patient is unsure of his strength, he should sit down and scoot down the stairs one at a time, bracing himself with his good leg. The patient should keep his crutches in one hand and bring them down with him. When going down stairs with crutches, the patient should lead with his injured leg and crutches then bring his uninjured leg down behind him. If the stairway has a handrail, the patient should place both crutches under the arm opposite the handrail and grip the handgrips together in one hand. With his weight on his uninjured leg, the patient moves the crutches and the injured leg down one step. Then the patient places his weight on the handrail and the handgrips and brings his uninjured leg down the step. The patient should take time to regain his balance and repeat the process. The patient should be instructed to take his time and rest halfway down the stairs if necessary. To go down stairs with no handrail, the patient puts his weight on his uninjured leg and moves the crutches and injured leg down one step. The patient shifts his weight onto the handgrips of the crutches and brings the uninjured leg down the step. The patient keeps his foot and the crutch tips in the middle of the step, away from the edge to avoid slipping. The patient should be instructed to take his time, rest as needed, and ask for help if necessary. Having someone walk in front of the patient as he walks down the steps can add a sense of security, and the person can assist the patient into a sitting position if he becomes fatigued.
- **Daily maintenance:** The nut wings or locking mechanisms should be checked daily to be sure they are tightened securely. The rubber tip at the bottom of the crutches should also be checked to be sure it is secure. The tip should be replaced if it shows signs of wearing



This woman walks with aluminum crutches after her left calf and foot were removed. (Stock Boston, Inc. Reproduced by permission.)

or tearing. The rubber handgrips or vinyl arm cuffs should also be examined to be sure they are intact. They should be replaced if they show signs of wearing or tearing. The rubber axillary padding should be examined and replaced if it shows signs of wearing or tearing. New rubber tips or handgrips can be purchased at most drug stores.

- **General tips:** Items that may cause the patient to trip and fall, such as scatter rugs or extension cords, should be removed. Spilled liquids should be wiped up to avoid slipping. Items the patient needs with him can be carried in a fanny pack, apron with pockets, or knapsack to keep his hands free to grip the crutches. A non-skid bath mat should be used in the shower or tub. A tennis shoe or other flat, rubber-soled shoe should be worn on the patient's uninjured foot to avoid slipping. The patient should be careful when going through doorways to be sure that the door does not shut on his crutches. The patient should seek help to hold the door

KEY TERMS

Axillary—A term used to refer to the area in or around the axilla or armpit.

if necessary. The patient should avoid walking through water or on icy surfaces with crutches.

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Cryoglobulin test see **Autoimmune disease tests**

Cryotherapy see **Cooling treatments**

CSF analysis see **Cerebrospinal fluid (CSF) analysis**

CT-myelogram see **Myelography**

CT imaging equipment

Definition

CT imaging equipment includes conventional, spiral, multi-slice, and electron-beam computed tomography full-body scanners, which use x rays to acquire cross-sectional images and computer workstations to

reconstruct acquired image data for display on a viewing monitor or printed on film. Also referred to as computerized axial tomography (CAT) scanning equipment.

Purpose

Computed tomography is an x-ray imaging modality used for a variety of clinical applications. CT imaging equipment is used for spine and head imaging, gastrointestinal imaging, vascular imaging (e.g., signs of stroke, detection of **blood** clots), **cancer** staging and **radiotherapy** treatment planning, screening for cancers and **heart** disease, rapid imaging of trauma and pediatric patients, measuring bone mineral density for diagnosing **osteoporosis**, imaging of musculoskeletal disorders, detection of signs of infectious disease, and guidance of certain interventional procedures (e.g., biopsies). CT is the preferred imaging exam for diagnosing several types of cancers. CT scanners are also used to perform noninvasive angiographic imaging to assess the large **blood vessels**. Three-dimensional (3-D) image reconstruction, a feature available on many CT scanners, allows surgical procedure simulation and planning, postoperative evaluation, 3-D **angiography**, and virtual **colonoscopy**. Because computed tomography can clearly image soft tissue, bones, the **lungs**, and blood vessels, and can be used to diagnose so many diseases and conditions, CT scanners are often considered the backbone of a radiology department, and large hospitals may have multiple scanners to meet imaging demand. Because CT scanners are valuable in aiding in the evaluation of trauma and other emergency medical conditions, hospitals with large emergency volumes and major trauma centers may have a CT scanner located in and dedicated to the emergency department.

Some types of CT scanners (electron-beam and multislice, see below) have begun to be used for whole-body scanning for preventive screening purposes; that is, asymptomatic individuals can have a full-body scan to see if heart disease, cancer, or other conditions are present. This application is primarily offered by independent imaging centers and is not reimbursed by insurance companies.

Description

In general, a computed tomography scanner consists of a gantry, an x-ray system, a patient table, and a computer workstation. The gantry is a large square unit with an opening in the center through which the patient is moved during the scan. The gantry contains the x-ray system, which includes an x-ray tube, detectors, x-ray beam collimators, circuitry, and an x-ray generator. In some older CT scanners, the x-ray generator may be separate from the gantry. The patient table is designed for

both vertical and horizontal motion to accommodate various types of patient positions during the scan.

During a CT scan, the x-ray generator supplies power to the x-ray tube. X rays are produced by the x-ray tube and emitted as it is rotated around the patient. The x rays pass through the patient's body to the detectors, which, depending on the CT scanner type and model, may consist of xenon gas ionization chambers or solid-state crystals (such as cesium-iodide or cadmium-tungstate). During each rotation, the detector produces electrical signals, which are generated after exposure to the x rays. These electrical signals are transferred to the computer, processed, and reconstructed into images using preprogrammed algorithms. Each rotation of the x-ray tube and detectors is reconstructed into an image that is referred to as a slice. The slice represents a cross-section of anatomical detail, and allows the inside of anatomical structures to be visualized, which is not possible with general radiography. Collimators are located near the x-ray tube and at each detector to minimize scatter radiation and to properly define the x-ray beam for the scan. The height of the collimators determines the slice thickness.

There are several types of CT scanners currently in use that differ in configuration and scanning features. Conventional CT scanners, which were introduced in the 1970s, have cables attached to a detector array, and therefore, at the end of one x-ray tube rotation, the assembly must reverse to avoid tangling the cables. Conventional scanners, then, have the slowest scanning speed. Spiral CT scanners, also called helical or volumetric scanners, have a slip-ring configuration that allows continuous one-way rotation. In spiral scanning, the patient table is moved through the gantry while the x-ray tube and detector rotate in a spiral around the patient. Scanning speed is faster, thinner slices are acquired, and shorter patient breathholds are required than for conventional CT. Spiral CT scanners were introduced in 1989, and have since been considered a revolutionary advance in CT imaging due to the improvements in scanning speed and image quality that were possible compared to conventional CT scanners.

Multislice scanners, which were introduced in 1998 and are considered the next revolution in CT imaging, have multiple rows of detectors that allow acquisition of multiple image slices during one x-ray tube rotation. Depending on the model and manufacturer, a multislice scanner may be up to eight times faster than a single-slice spiral scanner, and slices half as thin as those acquired on a spiral scanner are attainable. Multislice technology was still under development as of 2001.

Electron-beam CT scanners, also called ultrafast CT scanners, use a different scanning technology than other CT scanners, where x-ray tube rotation is mechanical. Electron-beam CT scanners have no moving parts, which makes such a fast scanning speed possible. An electron gun produces a focused electron beam that generates a rotating x-ray fan beam after being steered along tungsten target rings. Scan times are approximately ten times faster than multislice scanners because only the electron beam moves during scanning. Electron beam CT scanners were introduced in the mid-1980s and were designed for cardiac imaging and imaging of other moving structures (e.g., lungs, colon) due to their fast scanning speed.

CT imaging equipment is often supplied with image archiving devices (e.g., compact disk jukebox, tape drive), image hard copy devices (e.g., x-ray film processor, laser imager), and networking capabilities, depending on the needs of the facility. Because CT is a digital modality, CT scanners are frequently networked with other digital equipment, such as ultrasound and **magnetic resonance imaging** (MRI) systems, to facilitate comparison of images on viewing monitors.

In small hospitals or hospitals in rural areas, a CT scanner may not be installed; rather, a mobile CT scanning service may be contracted. A spiral CT scanner is installed in a specially designed trailer, which is driven to the hospital contracting the service. Prescheduled **CT scans** are then performed for the day or days the scanner is available at the hospital. Obviously, mobile CT only accommodates imaging in cases where the exam is not urgent.

Operation

After the technologist properly preps and positions the patient on the scanning table, the technologist goes to the adjacent control room and begins the scan using the control computer workstation. Usually, the computer has preprogrammed scanning protocols for common types of scans (e.g., abdomen and pelvis, chest, head) and some computers allow customized scan protocols to be entered. During scanning, the technologist instructs the patient via an intercom system regarding breathholds and positioning. The controlling computer automatically moves the patient table according to the scanning parameters selected. The scan itself may only take five to 15 minutes, but total examination time may be up to 30 minutes, since the patient must be prepped and positioned.

When the examination is completed, the technologist processes the image data using the computer workstation. Depending on the facility, images may be sent to an x-ray film processor or laser imager to be printed as hard copy and taken to a reading room, or they may be put on a



Computed tomography (CT) equipment uses x rays to obtain cross-sectional images of soft tissues of the body. (Pete Salutos/Custom Medical Stock Photo. Reproduced by permission.)

computer diskette or transferred via a digital image management system (picture archiving and communication system) for interpretation on a viewing monitor.

Before the patient is moved off the table, the radiologic technologist should review the acquired images to be sure they are of sufficient diagnostic quality. Motion artifacts, which are streaks, blurs, or other inconsistencies in the image, may occur if the patient moves during the scan or when imaging moving structures (e.g., heart, lungs). Decreasing the acquired image slice thickness, changing the timing of the contrast material injection, and shortening the patient's breathhold time can help reduce the occurrence of motion artifacts.

The radiologic technologist should choose the scanning protocol that will provide optimal image quality with minimal radiation dose. Typical radiation doses for a CT scan are approximately equal to the amount of natural background radiation the average person is exposed to over a year. The patient radiation dose from a CT scan is slightly higher than that of a typical x-ray procedure. Newer multislice scanners may deliver a significantly higher radiation dose than single-slice spiral scanners; this higher dose is of special concern for pediatric

patients. The American Society of Radiologic Technologists (ASRT) has issued a statement regarding scanning protocols for pediatric scanning and recommends that specific scanning protocols be developed for pediatric patients and that CT equipment manufacturers develop a range of suggested parameters for pediatric patients based on weight. In addition, ASRT encourages technologists to be aware of radiation doses for their pediatric cases by using radiation shielding when necessary, adjusting patient positioning, using special dose filters, and increasing the pitch ratio (the table speed per gantry rotation) on spiral scans.

Maintenance

Due to its high cost (\$500,000 to over \$1,000,000) and technical sophistication, CT imaging equipment is usually purchased with a service contract from the manufacturer or third party service provider that covers x-ray tube and other parts replacement and emergency service repair. The facility's **biomedical engineering** department and medical physicist may also conduct annual preventive maintenance checks, as well as monthly calibration, image quality testing, and radiation dose moni-



A technologist stays at computer controls while the patient is scanned with CT equipment. (Custom Medical Stock Photo. Reproduced by permission.)

KEY TERMS

Angiography—Imaging of the blood vessels of the body conventionally performed using an x-ray system and invasive catheterization, but that is performed on some CT scanners as a noninvasive alternative, since only an intravenous injection of contrast material is required.

Contrast material—A chemical mixture injected intravenously, swallowed, or administered by enema before and/or during a CT scan to enhance imaging of the area of interest.

Digital image management system; picture archiving and communication system—Systems of computer networking that allow exchange of images over the network or Internet, archiving of images for on-line access, and viewing of patient images and other data on a display monitor. These may encompass just the radiology department or an entire facility. CT scanners are frequently networked as part of these larger systems.

Gantry—The large square unit that houses the x-ray system and related components and has an opening in the center through which the patient table is moved.

Laser imager—A device that uses laser technology to produce hard copies of CT images; used instead of an x-ray film processor.

toring. A comprehensive quality control program that includes evaluation of image resolution, patient radiation dose, accuracy, image processing, patient table movement, and other overall system performance and image quality features should be followed. The radiologic technologist may be required to assist engineering staff with maintenance checks and service repairs.

Most CT manufacturers offer remote diagnostic features on their equipment that facilitate repair of system problems. Communication via modem and telephone with service personnel and diagnostic software allows, for example, ordering of replacement parts, downloading of software to fix a problem, or immediate notification of an operational problem to repair personnel.

Health care team roles

A radiologic technologist trained in computed tomography positions the patient on the table, administers any contrast material (intravenously, oral, or by

enema), and operates the CT scanner and computer workstation. Before administering any contrast material, the technologist will screen the patient for any **allergies** to medications or iodine and take a medical history to determine whether the patient has any medical condition (e.g., diabetes, **asthma**, heart disease, kidney or thyroid problems) that may interfere with CT imaging or indicate a higher risk of reaction to the contrast material. In addition, the technologist will ask female patients whether there is a possibility of **pregnancy**. The technologist will position lead aprons on appropriate areas of the patient to minimize unnecessary radiation exposure and provide lead aprons and other shielding for any individuals who must remain in the scan room (e.g., parents with children, staff monitoring a critical patient).

During the CT scan, the technologist controls the imaging scan parameters using the computer workstation, and communicates instructions to the patient via an intercom system. The technologist is responsible for acquiring the requested images and ensuring that they are of diagnostic quality. A radiologist will interpret the CT images and compile a report that is sent to the requesting physician.

Depending on the condition of the patient, other clinical staff may be present during the CT scan. Because CT is frequently used for trauma imaging, emergency medicine staff (nurses, **emergency medical technicians**) may be required to transport and monitor the patient.

Training

Radiologic technologist education programs include specialized training on CT principles of operation, radiation dose, patient positioning and anatomy, and CT imaging techniques. Specific training for a particular CT scanner is provided by the manufacturer upon installation and/or a workshop at the manufacturer facility. Usually, training for technologists and physicians is included in the cost of the CT system and consists of three to four days of technical and clinical instruction. The manufacturer often provides follow-up on-site visits after installation.

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American College of Radiology. 1891 Preston White Drive, Reston, VA 20191-4397. (800)227-5463. <<http://www.acr.org>>.

American Registry of Radiologic Technologists. 1255 Northland Drive. St. Paul, MN 55120-1155 (651) 687-0048. <<http://www.arrt.org>>.

American Society of Radiologic Technologists (ASRT). 15000 Central Avenue SE, Albuquerque, NM 87123-2778. (800) 444-2778. <<http://www.asrt.org>>.

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CT scans

Definition

Computed tomography (CT) scans are completed with the use of a 360-degree x-ray beam and computer production of images. These scans allow for cross-sectional views of body organs and tissues.

Purpose

CT scans are used to image a wide variety of body structures and internal organs. Since the 1990s, CT equipment has become more affordable and available. In some diagnoses, CT scans have become the first imaging exam of choice. Because the computerized image is so sharp, focused, and three-dimensional, many tissues can be better differentiated than on standard x rays. Common CT indications include:

- **Sinus studies.** The CT scan can show details of sinusitis, and bone **fractures**. Physicians may order CT of the sinuses to provide an accurate map for surgery.
- **Brain studies.** Brain scans can detect hematomas, tumors, and strokes. The introduction of CT scanning, especially spiral CT, has helped reduce the need for more invasive procedures such as cerebral angiography.

- **Body scans.** CT scans of the body will often be used to observe abdominal organs, such as the **liver, kidneys, adrenal glands**, spleen, and lymph nodes, and extremities.
- **Aorta scans.** CT scans can focus on the thoracic or abdominal aorta to locate aneurysms and other possible aortic diseases.
- **Chest scans.** CT scans of the chest are useful in distinguishing tumors and in detailing accumulation of fluid in chest infections.

Precautions

Pregnant women or those who could possibly be pregnant should not have a CT scan unless the diagnostic benefits outweigh the risks. Pregnant patients should particularly avoid full body or abdominal scans. If the exam is necessary for obstetric purposes, technologists are instructed not to repeat films if there are errors. Pregnant patients receiving CT or any x-ray exam away from the abdominal area may be protected by a lead apron; most radiation, known as scatter, travels through the body and is not blocked by the apron.

Contrast agents are often used in CT exams and the use of these agents should be discussed with the medical professional prior to the procedure. Patients should be asked to sign a consent form concerning the administration of contrast media. One common ingredient in contrast agents, iodine, can cause allergic reactions. Patients who are known to be allergic to iodine (or shellfish) should inform the physician prior to the CT scan.

Description

Computed tomography, also called CT scan, CAT scan, or computerized axial tomography, is a combination of focused x-ray beams, a detector array, and computerized production of an image. Introduced in the early 1970s, this radiologic procedure has advanced rapidly and is now widely used, sometimes in the place of standard x rays.

CT equipment

A CT scan may be performed in a hospital or outpatient imaging center. Although the equipment looks large and intimidating, it is very sophisticated and fairly comfortable. The patient is asked to lie on a narrow table that slides into the center of the scanner, called the gantry. The scanner looks like a square doughnut with a round opening in the middle, which allows the x-ray beam to rotate around the patient. The scanner's gantry section

may also be tilted slightly to allow for certain cross-sectional angles.

CT procedure

The patient will feel the table move very slightly as the precise adjustments for each sectional image are made. A technologist watches the procedure from a window and views the images on a monitor.

It is essential that the patient lie very still during the procedure to prevent motion blurring. In some studies, such as chest CTs, the patient will be asked to hold his or her breath during image capture.

Following the procedure, films of the images are usually printed for the radiologist and referring physician to review. A radiologist can also interpret CT exams on a special viewing console. The procedure time will vary in length depending on the area being imaged. Average study times are from 30 to 60 minutes. Some patients may be concerned about claustrophobia but the width of the gantry portion of the scanner is narrow enough to preclude problems with claustrophobia, in most instances.

The CT image

While traditional x rays image organs in two dimensions, with the possibility that organs in the front of the body are superimposed over those in the back, CT scans allow for a more three-dimensional effect. Some have compared CT images to slices in a loaf of bread. Precise sections of the body can be located and imaged as cross-sectional views. The technologist's console displays a computerized image of each section captured by the x-ray beam and detector array. Thus, various densities of tissue can be easily distinguished.

Contrast agents

Contrast agents are often used in CT exams and in other radiology procedures to demonstrate certain anatomic details which, otherwise, may not be easily seen. Some contrast agents are natural, such as air or water. Other times, a water-based contrast agent is administered for specific diagnostic purposes. Barium sulfate is commonly used in gastrointestinal procedures. The patient may drink this contrast medium, or receive it in an enema. Oral and rectal contrast are usually given when examining the abdomen or gastrointestinal tract, and not used when scanning the brain or chest. Iodine based contrast media are the most widely used intravenous contrast agents and are usually administered through an antecubital (in front of the elbow) vein.

If contrast agents are used in the CT exam, these will be administered several minutes before the study begins. Abdominal CT patients may be asked to drink a contrast medium. Some patients may experience a salty taste, flushing of the face, warmth or slight nausea, or **hives** from an intravenous contrast injection. Technologists and radiologists have equipment and training to help patients through these minor reactions and to handle more severe reactions. Severe reactions to contrast are rare, but do occur.

Spiral CT

Spiral CT, also called helical CT, is a newer version of CT scanning which is continuous in motion and allows for three-dimensional recreation of images. For example, traditional CT allows the technologist to take slices at very small and precise intervals one after the other. Spiral CT allows for a continuous flow of images, without stopping the scanner to move to the next image slice. A major advantage of spiral CT is the ability to reconstruct images anywhere along the length of the study area. The procedure also speeds up the imaging process, meaning less time for the patient to lie still. The ability to image contrast more rapidly after it is injected, when it is at its highest level, is another advantage of spiral CT's high speed.

Some facilities will have both spiral and conventional CT available. Although spiral is more advantageous for many applications, conventional CT is still a superior and precise method for imaging many tissues and structures. The physician will evaluate which type of CT works best for the specific exam purpose.

Preparation

If a contrast medium must be administered, the patient may be asked to fast from about four to six hours prior to the procedure. Patients will usually be given a gown (like a typical hospital gown) to be worn during the procedure. All metal and jewelry should be removed to avoid artifacts on the film.

Aftercare

No aftercare is generally required following a CT scan. Immediately following the exam, the technologist will continue to watch the patient for possible adverse contrast reactions. Patients are instructed to advise the technologist of any symptoms, particularly respiratory difficulty. The site of contrast injection will be bandaged and may feel tender following the exam. Hives may develop later and usually do not require treatment.

Complications

Radiation exposure from a CT scan is similar to, though higher than, that of a conventional x ray. Although this is a risk to pregnant women, the exposure to other adults is minimal and should produce no effects. Although severe contrast reactions are rare, they are a risk of many CT procedures. There is also a small risk of renal failure in high-risk patients.

Results

Normal findings on a CT exam show bone, the most dense tissue, as white areas. Tissues and fat will show as various shades of gray, and fluids will be gray or black. Air will also look black and darker than fat tissue. Intravenous, oral, and rectal contrast appear as white areas. The radiologist can determine if tissues and organs appear normal by the different gradations of the gray shadows. In CT, the images which can cut through a section of tissue or organ provide three-dimensional viewing for the radiologist and referring physician.

Abnormal results may show different characteristics of tissues within organs. Accumulations of **blood** or other fluids where they do not belong may be detected. Radiologists can differentiate among types of tumors throughout the body by viewing details of their makeup.

Sinus studies

The increasing availability and lowered cost of CT scanning has led to its increased use in sinus studies, either as a replacement for a sinus x ray or as a follow-up to an abnormal sinus radiograph. The sensitivity of CT allows for location of areas of sinus **infection**, particularly chronic infection, and is useful for planning prior to functional endoscopic sinus surgery. CT scans can show the extent and location of tiny fractures of the sinus and nasal bones. **Foreign bodies** in the sinus and nasal area are also easily detected by CT. CT imaging of the sinuses is important in evaluating trauma or disease of the sphenoid bone (the wedge-shaped bone at the base of the **skull**). Sinus tumors will show as shades of gray indicating the difference in their density from that of normal tissues in the area.

Brain studies

The precise differences in density allowed by CT scanning can clearly show tumors, strokes, or other lesions in the brain area as altered densities. These lighter or darker areas on the image may indicate a tumor or hemorrhage within the brain and skull area.



A computerized axial tomography (CAT) scan of the human brain. (Custom Medical Stock Photo. Reproduced by permission.)

Different types of tumors can be identified by the presence of **edema**, by the tissue's density, or by studying blood vessel location and activity. Congenital abnormalities in children, such as hydrocephalus, may also be confirmed with CT. Hydrocephalus is suggested by enlargement of the fluid structures called ventricles of the brain.

Body scans

The body scan can identify abnormal body structures and organs. Throughout the body, a CT scan may indicate tumors or cysts, enlarged lymph nodes, abnormal collections of fluid, blood, or fat, and metastasis of **cancer**. Fractures or damage to soft tissues can be more easily seen on the sensitive images produced by CT scanning, though CT is not usually done for these types of examinations because of cost. Liver conditions, such as cirrhosis, **abscess**, and fatty liver, may be observed with a CT body scan.

KEY TERMS

Aneurysm—The bulging of the blood vessel wall. Aortic aneurysms are the most dangerous. Aneurysms can break and cause bleeding.

Contrast (agent, medium)—A substance injected into the body that illuminates certain structures that would otherwise be hard or impossible to see on the radiograph (film).

Gantry—A name for the portion of a CT scanner which houses the x-ray tube and detector array used to capture image information and send it to the computer.

Hematoma—A collection of blood that has escaped from the vessels. It may clot and harden, causing pain to the patient.

Hydrocephalus—A collection of fluid on or around the brain. The pressure from the spinal fluid causes the ventricles to widen.

Metastasis—Secondary cancer, or cancer that has spread from one body organ or tissue to another.

Radiologist—A medical doctor specially trained in radiology (x-ray) interpretation and its use in the diagnosis of disease and injury.

Spiral CT—Also referred to as helical CT, this method allows for continuous 360-degree x-ray image capture.

Thoracic—Refers to the chest area. The thorax runs between the abdomen and neck and is encased in the ribs.

CT of the aorta

CT provides the ability to see and measure the thickness of the aortal wall, which is very helpful in diagnosing aortic aneurysms. The use of contrast will help define details within the aorta. In addition, increased areas of density can identify calcification, which helps differentiate between acute and chronic problems. An abnormal CT scan may indicate signs of aortic clots. Aortic rupture is suggested by signs such as a hematoma around the aorta or the escape of blood from its cavity.

Chest scans

In addition to those findings which may indicate aortic aneurysms, chest CT studies can show other problems in the **heart** and **lungs**. The computer will not only show differences between air, water, tissues, and bone, but will

also assign numerical values to the various densities. Mass lesions in the lungs may be indicative of **tuberculosis** or tumors. CT will help distinguish between the two. Enlarged lymph nodes in the chest area may indicate lymphoma. Spiral CT is particularly effective at identifying pulmonary emboli (clots in the lung's **blood vessels**).

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American College of Radiology. 1891 Preston White Drive, Reston, VA 20191-4397. (800)ACR-LINE. <<http://www.acr.org>>.

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Cultural sensitivity

Definition

Cultural sensitivity begins with a recognition that there are differences between cultures. These differences are reflected in the ways that different groups communicate and relate to one another, and they carry over into interactions with health care providers. Cultural sensitivity does not mean, however, that a person need only be *aware* of the differences to interact effectively with people from other cultures. If health care providers and their patients are to interact effectively, they must move beyond both cultural sensitivity and cultural biases that create barriers. Developing this kind of culturally competent attitude is an ongoing process.

A culturally competent clinician views all patients as unique individuals and realizes that their experiences, beliefs, values, and language affect their perceptions of clinical service delivery, acceptance of a diagnosis, and compliance.

Description

Cultural competence is an important component of nursing care. This is especially true given America's increasingly diverse patient population and the disparities in the health status of people from different racial, ethnic,

socioeconomic, religious, and cultural backgrounds. To value this diversity a clinician must respect the differences seen in other people, including customs, thoughts, behaviors, communication styles, values, traditions, and institutions.

Recognizing differences among cultures is important, but the clinician should also be aware that differences also exist *within* cultures. The assumption that a common culture is shared by all members of a racial, linguistic, or religious group is erroneous. The larger group may share common historic and geographic experiences, but individuals within the group may share nothing beyond that.

Culture greatly influences how people view their health and the health care services they receive. Clinicians should be aware of these differences, respect them, and work within the parameters set by the patient's values. Clinicians must also recognize their own cultural values and draw parallels where possible; they should also identify any prejudices and stereotypes that prevent them from communicating effectively with patients from different cultures.

The language barrier

Language differences between the clinician and the patient are a further barrier to optimum health care. Where possible, hospital or local school translators should be used, since it's not always in the client's best interest to have a family member act as an interpreter. The client may feel uncomfortable discussing personal matters in front of a relative. In addition the interpreter may lack a medical vocabulary, or may reinterpret what the patient says in an effort to "help." Role conflicts may further hinder translation. For example, a child or a person of the opposite sex may be embarrassed by the information or feel it improper to convey the message intended.

When using an interpreter the clinician should:

- Try to find an unrelated interpreter of the same sex as the patient, who is able to translate medical information clearly.
- Schedule more time for the appointment, if possible. Discuss the focus of the session with the interpreter before the patient arrives; be clear about what the interpreter should convey to the patient.
- Have the interpreter meet with the patient before the session to assess his or her educational level. This will determine how complex the discussion can become. If the patient has already met the clinician, the interpreter should be presented as a member of the healthcare team.

- Speak in short sentences or phrases, to make translating easier for the interpreter. Make sure the patient understands what he or she has been told by asking for him/her to repeat the message in his/her own words.
- Remember who the patient is—keep the focus on the patient, not the interpreter.
- Be sensitive to cultural differences when using nonverbal communication. For example, a touch has many cultural meanings. Clinicians must be aware that personal space has different boundaries in different cultures.

Viewpoints

One of the biggest debates about cultural competence is whether the health care provider should be of the same culture or speak the same language as the patient. Many clinicians from racial, ethnic, or cultural minorities believe very strongly that providers should be of the same culture as the patient. Others believe this is unnecessary and wrongly maligns people who aren't members of that specific group.

Another area of disagreement is whether training programs, such as diversity workshops, affect cultural competence. The argument against them is that cognitive information does not necessarily change attitudes or behavior.

Professional implications

In order to be culturally competent clinicians need not possess full knowledge of every cultural practice and belief. Instead they should be sensitive to others' preferences and values, and should not assume that one person's preferences and values apply to everyone in that same group. Patients are often willing to share their customs with those who seek to understand them. Genuine concern about what is important to the client is the best way to insure that culturally competent care will be provided.

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Cultural Assessment Interview Guide

Name: _____

Nickname or other names or special meaning attributed to your name: _____

Primary language:

When speaking _____

When writing _____

Date of birth: _____

Place of birth: _____

Educational level or specialized training: _____

To which ethnic group do you belong? _____

To what extent do you identify with your cultural group? _____

Who is the spokesperson for your family? _____

Describe some of the customs or beliefs that you have about the following:

Health _____

Life _____

Illness _____

Death _____

How do you learn information best?

Reading

Having someone explain verbally

Having someone demonstrate

Describe some of your family's dietary habits and your personal food preferences. _____

Are there any foods forbidden from your diet for religious or cultural reasons? _____

Describe your religious affiliation. _____

What role do your religious beliefs and practices play in your life during times of good health and bad health? _____

Who do you rely on for health care services or healing and what type of cultural health practices have you been exposed to? _____

Are there any sanctions or restrictions in your culture that the person taking care of you should know? _____

Describe your current living arrangements. _____

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Barb Chandler

Cultures for sexually transmitted diseases
see **Sexually transmitted diseases cultures**

Cuts see **Wounds**

CVA see **Cerebrovascular accident**

CVS see **Chorionic villus sampling**

Cyanocobalamin see **Vitamin B₁₂**

Cyanosis

Definition

Cyanosis is a physical state characterized by bluish discoloration of the skin and mucus membranes.



This elderly woman's lips turned purple due to central cyanosis, a condition most commonly due to slow blood circulation, leading to a bluish skin coloration. (Photo Researchers, Inc. Reproduced by permission.)

Description

Cyanosis is a physical sign, rather than a diagnosis. The abnormal coloring of a cyanotic patient is due to a low oxygen content of the circulating red **blood** cells. Typically the abnormal bluish coloring is most noticeable in the nailbeds, lips, ears, and cheeks.

Causes and symptoms

One of the many important functions of blood is to pick up oxygen from the air sacs of the **lungs** and deliver it to sites around the body in need of oxygen. To carry oxygen, red blood cells (RBCs) contain a pigment called hemoglobin. When hemoglobin is carrying its full capacity of oxygen, it will cause the RBC to appear bright red. After the oxygen has been delivered, the RBC has a darker, bluish cast. If the darker-colored RBCs predominate, this gives the skin and mucus membranes the characteristic blue appearance of cyanosis.

There are two basic types of cyanosis: central and peripheral. Central cyanosis means that the arterial blood simply does not contain normal levels of oxygen (hypoxemia). This can happen because of lung disease, **heart** defects, and certain problems with the hemoglobin itself. Peripheral cyanosis means that venous blood (or blood that has unloaded its oxygen) is contributing to skin color more than arterial (or oxygen-rich) blood. A patient may have normal oxygen levels in arterial blood, but still have the bluish color of cyanosis expressed in some part(s) of his body. With peripheral cyanosis the underlying condition may be exposure to the cold, or decreased output from the heart, or local disruptions in the flow of arterial or venous blood.

KEY TERMS

Hemoglobin—A colored substance (pigment) in the red blood cell that carries oxygen to tissues and gives blood its red color.

Pulse oximeter—A painless device which uses a beam of light directed through the patient's finger, toe or earlobe to assess oxygen saturation of the blood.

Patients may or may not have symptoms with cyanosis, depending on its cause. With central cyanosis patients are often short of breath, dizzy, or even unconscious. With a peripheral cause of cyanosis, patients may have complaints localized to the affected parts of the body.

Diagnosis

Cyanosis is a subjective observation, so there is no test to confirm it. A patient's skin pigmentation and the presence or absence of anemia can make cyanosis more or less obvious. But there are objective tests to verify the presence or absence of hypoxemia (or low oxygen content of the blood). A non-invasive **pulse oximeter** can be used by a nurse or respiratory therapist to give a fairly accurate approximation of arterial oxygenation, and arterial **blood gases** can be drawn by a physician or respiratory therapist if detailed information is needed. If the arterial oxygen level is low, the cyanosis is central; if the oxygen level is normal, the cyanosis is peripheral in nature. If the affected body parts regain normal color with massage and warming, the cause was peripheral. Occasionally cyanosis has both central and peripheral elements.

Treatment

Treatment of cyanosis is based on identifying and treating its cause, and restoring normal flow of oxygenated blood.

Prognosis

Prognosis is dependent on the disease process underlying the cyanosis. If the underlying condition (such as heart or lung disease) can be properly treated, the skin will return to its normal coloring.

Health care team roles

Health care team members should be alert to cyanosis as a warning sign, particularly as a new devel-

opment in a given patient. Prompt recognition and treatment could be very important to clinical outcome.

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Erika J. Norris

Cybermedicine

Definition

Cybermedicine, also known as e-health, involves the provision of health care services using the Internet for communication.

Description

The growth of the Internet since the early 1990s, from a small network used in academia and government to a global infrastructure, has radically affected the delivery of health care. The health care industry has begun the complex process of linking previously disparate computer databases and patient-management applications together via the Internet. It is also adopting Internet-ready technologies, such as hand-held computers, Web cameras, decision-support and voice-recognition software, and wireless-transmission technology. The loftiest hope for cybermedicine is that it will create a fertile ground for patient-clinician partnerships as well as allow for more efficient management of health-related information. However, many issues of concern remain before the benefits of cybermedicine can be maximized while closely protecting the privacy and confidentiality rights of patient and clinician.

The strongest advocates of cybermedicine currently are consumers who use the Internet as a health-research tool. As of 2001, nearly one-third of the 250 million annual searches on the Medline Web site managed by the National Library of Medicine were conducted by patients and the general public. Thousands of public- and private-sector health Web sites exist; some target specific diseases such as **prostate cancer**, while others provide general health information. Some of these sites allow individuals to conduct disease screenings, or lifestyle and

quality-of-life assessments. Government health organizations, such as the Centers for Disease Control and Prevention, take advantage of the Internet's large audience by using the Internet as a public-health information bulletin board. Similarly, the World Health Organization reports communicable-disease outbreaks on the Internet.

The Internet is also increasingly used for telemedicine, which is cybermedicine involving the provision of care over the Internet. Patients with access to computers and the Internet may consult with their physicians online, receiving a diagnosis, treatment plan, and drug prescriptions for relatively simple disorders without face-to-face meetings. Computer-based decision-support software and videoconferencing technology are also used to provide telemedicine to chronically ill patients at home, and to help people with chronic diseases to self-monitor their conditions. People with diabetes, for example, may download data from a blood-glucose meter, record information about their medications, diet, and symptoms, and transmit these data to their health care providers. Teleradiology has been in operation for years but has vastly improved with the ability to transfer large amounts of data quickly. Genetics specialists are using telemedicine for genetic evaluations and services in rural areas. The future of telemedicine is projected to include long-distance robotic surgeries and quick tests of patients' DNA.

Remote surgery is an application of interest. Using a Web camera, a live transmission is sent from the operating room, where the patient is, to the office of a specialist, in another location. The specialist guides the on-site surgeon through the procedure.

One of the fastest growing applications of cybermedicine is in health business-support services. For example, WebMD, Medscape, and the American Medical Association's Medem are gradually moving traditional, office-based medical practices to the Web by offering online services for physicians, including the electronic transmission and storage of patient information, claims processing, billing procedures, and access to medical databases.

Viewpoints

Since e-mail and other tools of cybermedicine are more impersonal than face-to-face communication, critics observe that cybermedicine may challenge the ability of patients and clinicians to make emotional connections, such as to foster trust; physicians may find it too easy to dehumanize patients, thereby lessening patients' involvement in decision making. As regards remote surgery, critics question what happens if the Internet service fails during a crucial transmission. Perhaps the major issue of

concern is how to protect patient privacy/confidentiality over the Internet.

Proponents of cybermedicine point out that the ability to improve the flow of information between patients and clinicians gives significant potential to improve patient health. E-mail allows patients and clinicians to transmit detailed medical information and may increase opportunities for clinicians to provide social support to patients. Cybermedicine offers the potential to empower patients because patients may access the same on-line medical information as clinicians, thereby making the clinician-patient relationship potentially more democratic. Patients armed with accurate medical information may not be able to treat themselves, but they will be better informed and better able to assist in treatment decision making.

Another concern about cybermedicine is the difficulty of ensuring that Internet health content is both accurate and unbiased toward any product brands, thus maintaining the integrity of the line between e-health and e-commerce. To address this issue, many health-information Web sites are establishing ethical guidelines addressing issues such as commercial advertising, privacy, and accuracy of information. The American Telemedicine Association and the American Medical Informatics Association have established ethical and clinical guidelines for health care Web sites, health-related e-mail, and home-based telemedicine.

Professional implications

All indications suggest that cybermedicine practices will only increase. Health care practitioners should learn how to take advantage of this technology while recognizing its potential drawbacks, including concerns about individual patients' ability to assess symptoms and relate status effectively and clearly via the Internet. There is research suggesting that patients with chronic diseases such as diabetes or **asthma** and other chronic obstructive pulmonary disease (COPD) tend to underestimate the severity of their symptoms and to overestimate the degree of control that exists. Patients with breathing difficulties, for instance, cannot be adequately or accurately assessed without physical evaluation of the **lungs** and trachea and without in-office pulmonary-function tests. People with diabetes may find ways to modify results or underplay symptom reports via e-mail, so medications will not be changed.

Practitioners will also need to stay abreast of legal developments in cybermedicine. One legislative development expected to play a role in cybermedicine is the Health Insurance Portability and Accountability Act of 1996 (HIPAA). This act calls for protection of patient

health information, and it allows patients to access their **medical records**, which in the context of cybermedicine will probably be done electronically. In December of 2000, the HIPAA Privacy Rule was issued. It gives patients greater access to their own medical records and allows them to control how personal health information is used.

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ORGANIZATIONS

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- American Medical Association. The Council on Ethical and Judicial Affairs. 515 North State Street, Chicago, IL 60610. (312) 464-4823. <<http://www.ama-assn.org/ama/pub/category/2498.html>>.
- American Medical Informatics Association. 4915 St. Elmo Avenue, Suite 401, Bethesda, MD 20814 (301) 657-1291. <<http://www.amia.org>>.
- American Telemedicine Association. 910 Seventeenth Street NW, Suite 314, Washington, DC 20006. (202) 223-3333. <<http://www.atmeda.org>>.
- ANA, American Nurses Association, 600 Maryland Avenue SW, Suite 100 West, Washington, DC 20024. (800) 274-4ANA. <<http://www.nursingworld.org>>.
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Ann Quigley

Cystic fibrosis

Definition

Cystic fibrosis (CF) is an inherited disease that affects the **lungs**, **digestive system**, and sweat glands, and causes **infertility** in males. Its name derives from the fibrous scar tissue that develops in the **pancreas**, one of the principal organs affected by the disease.

Description

Cystic fibrosis affects the body's ability to move salt and water in and out of cells. This defect causes the lungs and pancreas to secrete thick mucus, an inflammatory response that blocks passageways—particularly airway passages—and therefore prevents proper functioning of the affected areas.

CF affects approximately 30,000 children and young adults in the United States, where approximately 3,000 babies are born with CF every year. CF primarily affects people of white northern-European descent. Rates of CF are much lower in nonwhite populations.

Many of the symptoms of CF can be treated with drugs or nutritional supplements. Close attention to and prompt treatment of respiratory and digestive complications have dramatically increased the expected life span of a person with CF. Several decades ago, most children with CF died by the age of two years. By the end of the twentieth century, about one-half of all people with CF lived past 31 years of age. That median age is expected to grow as new treatments are developed. It is estimated that a person born in 2001 with CF has a median expected life span of about 40 years.

Genetic profiles

Cystic fibrosis is a genetic disease, meaning it is caused by a defect passed on through the genes. Genes, found in the nucleus of all body cells, control cell function by serving as the blueprint for the production of **proteins**. Proteins carry out a wide variety of functions within cells. The cystic fibrosis transmembrane conductance regulator (CFTR) gene, when defective, causes CF. A simple defect in this gene leads to all the consequences of CF. There are more than 500 known defects in the CFTR gene that can cause CF. However, mutation delta F508 in exon 10 is present in about 70% of CF chromosomes worldwide.

Genes can be thought of as long strings of chemical words, each made of chemical letters called nucleotides. Just as rearranging its letters can change a word and changing a word can change a sentence, genes can be

mutated, or changed, by changes in the sequence of their nucleotide letters. The gene defects in CF are called point mutations, meaning that the gene is mutated only at one small spot along its length. In other words, the delta-F508 mutation is a loss of one “letter” out of thousands within the CFTR gene. As a result, the CFTR protein made from its blueprint is made incorrectly and cannot properly perform its function.

The CFTR protein helps to produce mucus. Mucus is a complex mixture of salts, water, sugars, and proteins that cleanses, lubricates, and protects many passageways in the body, including those in the lungs and pancreas. The role of the CFTR protein is to allow chloride ions to exit from mucus-producing cells. When the chloride ions leave these cells, water follows, thinning the mucus. In this way, the CFTR protein helps to keep mucus from becoming thick and sluggish, thus allowing the mucus to be moved steadily along the passageways to aid in cleansing.

In CF the CFTR protein does not allow chloride ions out of the mucus-producing cells. With less chloride leaving, less water leaves, and the mucus becomes thick and sticky. It can no longer move freely through the passageways, so they become clogged. In the pancreas, clogged passageways prevent secretion of digestive enzymes (including insulin) into the intestine, causing serious impairment of digestion, especially of **fats**, which may lead to malnutrition. Mucus in the lungs may plug the airways, preventing good air exchange and, ultimately, leading to **emphysema** or COPD. The mucus is also a rich source of nutrients for **bacteria**, leading to frequent infections such as sinusitis, bronchitis, and **gastritis**.

Inheritance factor

To understand the inheritance pattern of CF, it is important to realize that genes actually have two functions. First, they serve as the blueprint for the production of proteins. Second, they are the material of inheritance: parents pass on characteristics to their children by combining the genes in egg and sperm to make a new individual.

Each person actually has two copies of each gene, including the CFTR gene, in each of their body cells. During sperm and egg production, however, these two copies separate, so that each sperm or egg contains only one copy of each gene. When sperm and egg unite, the newly created cell once again has two copies of each gene.

The two gene copies may be the same or they may be slightly different. For the CFTR gene, for instance, a person may have two normal copies, or one normal and one mutated copy, or two mutated copies. A person with two mutated copies will develop cystic fibrosis. A person

with one mutated copy is said to be a carrier. A carrier will not have symptoms of CF but can pass on the mutated CFTR gene to children.

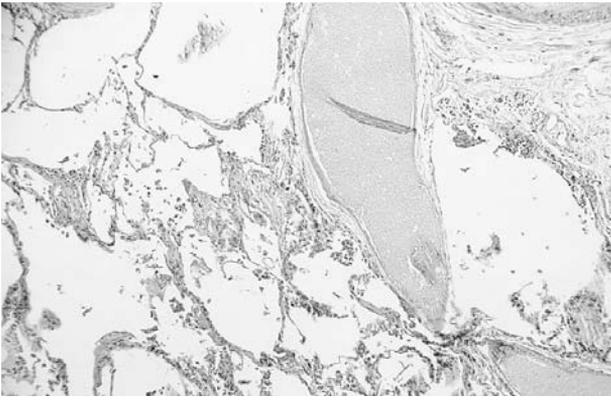
When two carriers have children, they have a one-in-four chance of having a child with CF each time they conceive, a two-in-four chance of having a child who is a carrier, and a one-in-four chance of having a child with two normal CFTR genes.

There are large differences in the frequency of mutated CF genes among different ethnic populations. For example, the frequency is highest in populations of northern-European descent—approximately one in every 25 Americans of northern-European descent is a carrier of the mutated CF gene, while only one in 17,000 African Americans and one in 30,000 Asian Americans are carriers. Since carriers are symptom-free, very few people know whether or not they are carriers unless there is a family history of the disease. Two white Americans with no family history of CF have a one-in-2,500 chance of having a child with CF.

It may seem puzzling that a mutated gene with such harmful consequences would remain so common. One might expect that the high mortality rate for CF patients before reaching childbearing age would quickly lead to the loss of the mutated gene from the population. It appears, however, that carriers may be protected from the intense **diarrhea** and eventual death by **dehydration** caused by cholera and typhoid **fever**. (This so-called “heterozygote advantage” is seen in some other genetic disorders, including sickle-cell anemia.) Some researchers believe that when these epidemics spread through early European populations, which were then much smaller, they would wipe out vast numbers in that population. However, people who carried one copy of the CF gene would have a greater chance of survival and so, therefore, would the defective gene. The incidence of the gene, then, would increase to a high level within that population. In hot climates, where dehydration from chronic excessive salt loss (perspiring) caused more deaths than occasional bouts of life-threatening diarrhea, the CF gene never gained the foothold it did in the colder European countries. Also, some researchers propose that CF heterozygotes are more resistant to **asthma**.

Causes and symptoms

The most severe effects of cystic fibrosis are seen in two body systems: the gastrointestinal (digestive) system, and the respiratory tract from the nose to the lungs. CF also affects the sweat glands and male fertility. Symptoms develop gradually; gastrointestinal symptoms are often the first to appear.



Lung tissue from a patient with cystic fibrosis. (Custom Medical Stock Photo. Reproduced by permission.)

Gastrointestinal system

Ten to fifteen percent of babies who inherit CF have meconium ileus at birth. Meconium is the first dark stool that a baby passes after birth. Ileus is an obstruction of the digestive tract. The meconium of a newborn with meconium ileus is thickened and sticky due to the presence of thickened mucus from the intestinal mucus glands. Meconium ileus causes abdominal swelling and vomiting, and often requires surgery immediately after birth. Presence of meconium ileus is considered highly indicative of CF. Borderline cases may be misdiagnosed, however, and attributed instead to a “milk allergy.”

Other abdominal symptoms are caused by the inability of the pancreas to supply digestive enzymes to the intestine. During normal digestion, as food passes from the **stomach** into the **small intestine**, it is mixed with pancreatic secretions (including insulin) that help break down the nutrients for absorption. While the intestines themselves also provide some digestive enzymes, the pancreas is the major source of enzymes for the digestion of all types of foods, especially fats and proteins.

In CF, thick mucus blocks the already inflamed pancreatic duct. Eventually, the duct becomes completely closed off by subsequent scar tissue formation, leading to a condition known as pancreatic insufficiency. Without pancreatic enzymes large amounts of undigested food pass into the **large intestine**. Bacterial action on this rich food source can cause gas and abdominal swelling. The large amount of fat remaining in the feces makes it bulky, oily, and foul-smelling.

Because nutrients are poorly digested and absorbed, a person with CF is often ravenously hungry, underweight, and shorter than expected for a given age. When CF is not treated for a longer period, a child may develop symptoms of malnutrition, including anemia, bloating, and—paradoxically—appetite loss. The rib cage

may eventually become barrel-shaped as the patient struggles with breathing and with the formation of emphysema-like symptoms.

Diabetes becomes increasingly likely as a person with CF ages. Scarring of the pancreas slowly destroys those pancreatic cells that produce insulin, producing type I, or insulin-dependent, **diabetes mellitus**.

Gall stones affect approximately 10% of adults with CF. **Liver** problems are less common, but can be caused by the buildup of fat within the liver. Complications of liver enlargement may include internal hemorrhaging, abdominal fluid (ascites), spleen enlargement, and liver failure.

Other gastrointestinal symptoms can include a prolapsed rectum, in which part of the rectal lining protrudes through the anus; intestinal obstruction; and rarely, intussusception (telescoping), in which part of the intestinal tube slips over an adjoining part, cutting off **blood** supply.

Somewhat less than 10% of people with CF do not have gastrointestinal symptoms. Most of these people do not have the delta-F508 mutation, but rather a different one, which presumably allows at least some CFTR-induced proteins to function normally in the pancreas.

Respiratory tract

The respiratory tract includes the nose, throat, trachea (or windpipe), main bronchus, bronchi (that branch off from the main stem bronchus within each lung), the smaller bronchioles, and the blind sacs called alveoli in which **gas exchange** takes place between air and blood through the capillaries feeding the alveoli.

Swelling of the sinus mucus membrane lining is common in people with CF. This usually shows up on x ray and may aid the diagnosis of CF. However, this swelling, called pansinusitis, rarely causes problems unless there is blockage and **infection**. Children with CF have a high rate of infection of the sinuses, requiring antibiotic therapy to prevent the infection from proceeding to the lungs.

Nasal polyps, or growths, affect about one in five people with CF. These growths are not cancerous and do not require removal unless they block nasal drainage enough to cause chronic sinus infections. However, they are usually treated medically before surgery is considered. While nasal polyps appear in older people without CF, especially those with **allergies**, they are rare in children without CF.

The lungs are the site of the most life-threatening effects of CF. The hyperinflammatory state of the membranes causes production of a thick, sticky mucus (that is actually the body’s attempt to soothe the affected area).

However, this mucus increases the likelihood of infection, decreases the ability to protect against infection, and causes further blockage of normal functioning in the airways. This blockage, in turn, exacerbates the inflammation and swelling. The functional capacity of the lungs is therefore severely compromised and may ultimately lead to emphysema. People with CF will live with chronic obstructive pulmonary disease (COPD) or bacterial residence in their lungs. Lung infection is the major cause of death for those with CF.

The bronchioles and bronchi normally produce a thin, clear mucus that traps foreign particles, including bacteria and **viruses**. Tiny hair-like projections, called cilia, on the surface of these passageways slowly move mucus out of the lungs and up the bronchus to the trachea and the back of the throat, where it may be swallowed or coughed up. This “mucociliary escalator” is one of the principal defenses against lung infection.

The thickened mucus of CF prevents ciliary movement of debris out of the lungs and increases the irritation and existing inflammation of airways and lung tissue. This inflammation swells the passageways, partially closing them down, further hampering the movement of mucus. A person with CF is likely to cough more frequently and more vigorously as their lungs attempt to clean themselves out.

At the same time, infection becomes more likely, since the mucus is a rich source of nutrients. Bronchitis, bronchiolitis, and **pneumonia** are frequent in CF. The most common infecting organisms are the bacteria *Staphylococcus aureus*, *Haemophilus influenzae*, and *Pseudomonas aeruginosa*. A small percentage of people with CF have infections caused by *Burkholderia cepacia*, a bacterium that is resistant to most current **antibiotics** (*Burkholderia cepacia* was formerly known as *Pseudomonas cepacia*). The fungus *Aspergillus fumigatus* may infect older children and adults.

The body’s response to inflammation and infection is to increase mucus production; white blood cells fighting the infection thicken the mucus even further as they break down and release their cell contents. These white blood cell constituents serve as messengers to enhance the production of both inflammatory and antiinflammatory cells and mediators.

As mucus accumulates it can plug up the smaller passageways in the lungs, decreasing functional lung volume. Inhaling enough air (oxygen) can become difficult; fatigue, shortness of breath, and intolerance of **exercise** become more common. Because air passes obstructions more easily during inhalation than during exhalation, over time, air becomes trapped in the smallest chambers of the lungs, the alveoli. As millions of

alveoli gradually expand, the chest takes on the enlarged, barrel-shaped appearance typical of emphysema.

For unknown reasons recurrent respiratory infections or impairment lead to “digital clubbing,” in which the last joint of the fingers and toes becomes slightly enlarged and the distal fingernail edges curl around and over the enlarged fingertip.

Sweat glands

The CFTR protein helps to regulate the amount of salt in perspiration. People with CF have perspiration with a higher salt content than normal, and measuring the saltiness of a person’s sweat is a key diagnostic test for CF. Parents may notice that their infants taste salty when they kiss them. Excess salt loss is not usually a problem, except during prolonged exercise or heat. While most older children and adults with CF compensate for this extra salt loss by eating more salty foods, infants and young children are in danger of suffering its effects (such as heat prostration), especially during summer, and require electrolyte supplementation. Heat prostration is marked by lethargy, weakness, and loss of appetite, and should be treated as an emergency condition, especially in children and the elderly.

Fertility

Ninety-eight percent of men with CF are sterile due to complete obstruction or absence of the vas deferens, the tube carrying sperm out of the testes. While boys and men with CF form normal sperm and have normal levels of sex hormones, sperm are unable to leave the testes, and fertilization is not possible. Most women with CF are fertile, though they often have more difficulty conceiving than women without CF. In both boys and girls, **puberty** is often delayed, most likely due to the effects of poor **nutrition** or chronic lung infection. Women with CF who have good lung health usually have no problems with **pregnancy**, while those with ongoing lung infection often do poorly. The potential for digestive disruption from intestinal displacement may also pose problems, regardless of lung function.

Diagnosis

The decision to test a child for cystic fibrosis may be triggered by concerns about recurring gastrointestinal or respiratory symptoms, or salty sweat. A child born with meconium ileus will be tested before leaving the hospital. Families with a history of CF may wish to have all children tested, especially if one child has already manifested the disease. Some hospitals now require routine screening of newborns for CF.

Sweat test

The sweat test is both the easiest and most accurate test for CF. In this test, a small amount of the drug pilocarpine is placed on the skin. A very small electrical current is then applied to the area, which drives the pilocarpine into the skin. The drug stimulates sweating in the treated area. The sweat is absorbed onto a piece of filter paper and analyzed for its salt content. A person with CF will have salt concentrations that are one and one-half to two times greater than normal. The test can be done on persons of any age, including newborns, and its results can be determined within an hour. Virtually every person who has CF will test positively on it, and virtually everyone who does not have the disease will test negatively.

Genetic testing

The discovery of the CFTR gene mutation in 1989 allowed the development of an accurate genetic test for CF. Genes from a small blood or tissue sample are analyzed for specific mutations; presence of two copies of the mutated gene confirms the diagnosis of CF in all but a very few cases. However, since there are so many different possible mutations, and since testing for all of them would be too expensive and time consuming, it is important to remember that a negative gene test cannot rule out the possibility of CF.

Couples planning a family may decide to have themselves tested if one or both have a family history of CF. Prenatal **genetic testing** is possible through **amniocentesis**. Many couples who already have one child with CF decide to undergo prenatal screening in subsequent pregnancies and use the results to determine whether to terminate the pregnancy. Siblings in these families are also usually tested, both to determine if they will develop CF and if they are carriers. This aids in their own family planning. If the sibling has no symptoms, determining carrier status is often delayed until the teen years or later, when persons are closer to needing the information to make decisions.

Newborn screening

Some states now require screening of all newborns for CF using a test known as the IRT test—a blood test that measures the level of immunoreactive trypsinogen. Babies with CF generally have higher levels of IRT; however, this test is not an accurate predictor as it gives many false positive results immediately after birth. A second test is therefore required several weeks later for validation. A second positive result indicates the need to conduct a sweat test.

Treatment

There is no cure for cystic fibrosis. Treatment has advanced considerably since the mid-1900s, increasing both the life span and the quality of life for most people affected by CF. Early diagnosis is important to prevent malnutrition and infection from weakening a young child. With proper management, many people with CF may participate in the full range of school and sports activities.

Nutrition

People with CF usually require high-calorie diets and vitamin supplements. Height, weight, and growth of a person with CF are regularly monitored. Most people with CF need to take pancreatic enzymes to supplement or replace the inadequate secretions of the pancreas. Tablets containing pancreatic enzymes are taken with every meal; depending on the size of the tablet and the meal, as many as 20 tablets may be needed at a time. Because of incomplete absorption even with pancreatic enzymes, a person with CF needs to take in about 30% more food than a person without CF. Low-fat diets are not recommended, except in special circumstances, since fat is a source of both essential fatty acids and abundant calories, but the high calorie diet does not include increased fat intake (above normal).

Some people with CF cannot absorb enough nutrients from the foods they eat, even with specialized diets and enzymes. For these people, tube feeding is an option. Nutrients can be introduced directly into the stomach through a tube inserted either through the nose (a nasogastric tube) or through the abdominal wall (a gastrostomy tube). A jejunostomy tube, inserted into the small intestine, is also an option. Tube feeding can provide nutrition at any time, including at night while a person is sleeping, allowing constant intake of high-quality nutrients. The feeding tube may be removed or temporarily occluded during the day, allowing the patient to take food by mouth.

Respiratory health

The key to maintaining respiratory health in a person with CF is regular monitoring and early treatment. Pulmonary function tests are done frequently to track changes in functional lung volume and respiratory effort. Sputum samples are analyzed to determine the types of bacteria present in the lungs. Chest x rays are usually taken at least once a year. Lung scans are performed with the patient inhaling radioactive contrast gas that helps define areas on the lungs not visible with x rays. Pulmonary circulation may be monitored by injection of a radioactive substance into the bloodstream.

People with CF live with chronic bacterial colonization. This means that their lungs are constantly host to several species of bacteria. Good general health, especially good nutrition, may keep the **immune system** functioning well, decreasing the frequency with which the resistant bacterial colonies multiply and cause infection or attack lung tissue. Exercise is also important to promote pulmonary health, and people with CF are encouraged to maintain a regular exercise program.

Clearing mucus from the lungs also helps prevent infection, and mucus control is an important aspect of CF management. Bronchial drainage (postural drainage) allows gravity to aid the mucociliary escalator. For this technique the patient lies on a tilted surface with head downward (Trendelenburg); alternately on the stomach, back, or side, depending on the section of lung to be drained. An assistant performs respiratory percussion techniques with varying strokes, rhythms, and hand positions, moving systematically over the patient's chest, rib cage, and upper back to help loosen secretions. A device called a "flutter" offers another way to loosen secretions: it consists of a stainless steel ball in a tube. When a person exhales through it, the ball vibrates, sending vibrations back through the air in the lungs. Some special breathing techniques, such as diaphragmatic breathing, and rib cage expansion and locking that allows the diaphragm freedom of movement, may also help clear the lungs.

Several drugs are available to prevent the airways from becoming clogged with mucus. Bronchodilators can help open up the airways, steroids reduce inflammation, and mucolytics loosen secretions. Surfactants are used to reduce the surface tension of the mucus, like a detergent breaks the surface tension of water and oils. Acetylcysteine (Mucomyst) has been used as a mucolytic for many years but now is less frequently prescribed, while DNase (Pulmozyme) is a newer product gaining in popularity. DNase is an enzyme that helps break down the DNA from dead white blood cells and bacteria found in thick mucus.

People with CF may contract cross-infected bacteria from other persons with CF. This is especially true of *Burkholderia cepacia*, which is not usually found in people without CF. While the ideal recommendation from a health standpoint might be to avoid contact with others who have CF, this is not always practical (since CF is a familial disease and CF clinics are a major site of care), nor does it meet the psychological and social needs of patients. At a minimum, CF centers recommend avoiding prolonged close contact between people with CF, and the use of scrupulous hygiene techniques, including frequent hand washing. Some CF clinics schedule appointments

on different days for those with and without *B. cepacia* colonies.

Some doctors choose to prescribe antibiotics for patients with CF only during an infection, while others prefer long-term prophylactic antibiotic treatment against *S. aureus*. The choice of antibiotic depends on the particular organism or organisms found. Some antibiotics are given as aerosols directly into the lungs. Antibiotic treatment for patients with CF, by necessity, may be prolonged and aggressive.

Supplemental oxygen may be needed as lung disease in CF progresses. In some cases, **respiratory failure** episodes require the temporary use of a ventilator to perform the work of breathing until the patient can begin to regain control and be weaned from the machine.

Lung transplantation is another option for people with CF, although the number of people who receive them is still much lower than those who need them. Transplantation is not a cure, however, and has been likened to trading one disease for another because long-term immunosuppression is required, increasing the likelihood of contracting opportunistic infections. About 50% of adults and more than 80% of children with CF who receive lung transplants live longer than two years posttransplant. Liver transplants may also be required for people with CF whose livers have been damaged by fibrosis.

Long-term use of ibuprofen as an antiinflammatory agent has been shown to help some people with CF. Close medical supervision is necessary, however, since the effective dose for patients with CF is high and not everyone benefits. Ibuprofen at these higher doses interferes with kidney function and, if taken together with aminoglycoside antibiotics, may cause kidney failure.

A number of experimental treatments are under research. Some evidence indicates that aminoglycoside antibiotics may help overcome the genetic defect in some CF mutations, allowing the protein to be made normally. While promising, these results would apply to only about 5% of those with CF.

Gene therapy has become the most ambitious approach to curing CF. In this set of techniques, copies of the healthy CFTR gene are delivered to affected cells, where they are accepted and used to create the CFTR protein. While elegant and simple in theory, gene therapy has met with a large number of difficulties in trials so far, including immune resistance, very short life-cycle duration of the introduced gene, and inadequately widespread distribution.

KEY TERMS

Carrier—In CF, a person with one copy of a defective gene who does not have the disease it causes but can pass along the defective gene to offspring.

Chronic obstruction pulmonary disease (COPD)—A progressive disease process that commonly stems from smoking. COPD is characterized by difficulty breathing, wheezing, and a chronic cough.

Cystic fibrosis transmembrane conductance regulator (CFTR)—The protein responsible for regulating chloride movement across cells in some tissues. When a person has two defective copies of the CFTR gene, cystic fibrosis is the result.

Emphysema—A pathologic accumulation of residual air in organs or tissues. This term is especially applied to the condition when in the lungs.

Gastrostomy tube—A tube that is inserted through a small incision in the abdominal wall and that extends through the stomach wall into the stomach for the purpose of introducing parenteral feedings.

Jejunostomy tube—A tube inserted through the abdominal wall and into the small intestine for the purpose of introducing parenteral feeding.

Lung surfactant—A surface active agent that renders the alveolar surfaces hydrophobic and prevents the lung filling with water by capillary action.

Meconium ileus—Obstructed bowel due to impacted, tenacious, meconium (infant's first stool).

Mucociliary escalator—The coordinated action of tiny projections on the surfaces of cells lining the respiratory tract that moves mucus up and out of the lungs.

Mucolytic—An agent that dissolves or destroys mucin, the chief component of mucus.

Nasogastric tube—A tube inserted through the nose, extending through the pharynx and esophagus, and into the stomach for the purpose of introducing parenteral feeding.

Pancreatic insufficiency—Reduction or absence of pancreatic secretions into the digestive system due to scarring and blockage of the pancreatic duct.

Alternative treatment

In homeopathic medicine the primary goal is to address the symptoms of CF in order to enhance quality of life. It is not yet possible to treat the cause, owing to the genetic basis of the disease. Homeopathic medicine seeks to treat the whole person, however, and in cystic fibrosis, this approach may include:

- mucolytics to help thin the mucous
- supplementation of pancreatic enzymes to assist in digestion
- addressing respiratory symptoms to open lung passages
- hydrotherapy techniques (such as nighttime mist tents) to help ease respiratory symptoms and help the body eliminate mucus from the lungs
- immune enhancements (such as vitamin supplementation) to help prevent development of secondary infections
- dietary enhancements and adjustments to treat digestive and nutritional problems

Prognosis

Approximately half of all people with CF live past the age of 30 years; however, because of earlier intervention and enhanced treatment, a person born in 2001 with CF may be expected, on average, to live to 40 years of age.

People with CF may lead relatively normal lives. Careful consideration of the effects pregnancy may have on a woman with CF is essential before beginning a family. Issues of parental longevity and the potential for the child to be a carrier are also concerns. Although most men with CF are functionally sterile, new procedures for removing sperm from the testes are being attempted that may offer more men suffering from CF the chance to become fathers.

Health care team roles

A pediatrician usually makes the initial diagnosis of CF. Family physicians, internists, and pulmonologists can manage persons with CF. Radiologists take images to document the extent of CF. Nurses, respiratory therapists, physical therapists, and nutritionists provide symptomatic treatments and supportive services. Surgeons are needed if transplantation is required.

Prevention

As of 2001 there was no way to prevent the development of CF in a person with two defective copies of

the relevant gene from both parents. Adults with a family history of CF may obtain a genetic test of their carrier status for purposes of family planning. Prenatal testing is also available to determine the genetic status of the infant with regard to CF.

Resources

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ORGANIZATIONS

- American Lung Association, 1740 Broadway, New York, NY 10019. (212) 315-8700. <<http://www.lungusa.org/diseases/lungtb.html>>.
- American Thoracic Society, 1740 Broadway, New York, NY 10019. (212) 315-8700. <<http://www.thoracic.org>>.
- Canadian Cystic Fibrosis Foundation, 2221 Yonge Street, Suite 601, Toronto, Ontario, M4S 2B4. (416) 485-9149. <<http://www.ccff.ca/home.cfm>>.
- Cystic Fibrosis Foundation, 6931 Arlington Road, Bethesda, Maryland 20814. (301) 951-4422 or (800) 344-4823. <<http://www.cff.org>>.
- International Association of Cystic Fibrosis Adults. <<http://ourworld.compuserve.com/homepages/FAntognin/iacfa.htm>>.

OTHER

- American Association for Respiratory Care. <http://www.aarc.org/patient_education/iq_tests/cf/cf_form.html>.
- CF Web. <<http://www.cf-web.org>>.
- Cystic-L. <<http://cystic-l.org>>.
- Merck Manual. <<http://www.merck.com/pubs/mmanual/section19/chapter267/267a.htm>>.
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Cystometry

Definition

Cystometry is a test of bladder function in which pressure and volume of fluid in the bladder is measured during filling, storage, and voiding.

Purpose

A cystometry study is performed to diagnose problems with urination, including incontinence, urinary retention, and recurrent urinary tract infections. The urinary bladder stores urine produced by the **kidneys**. The main muscle of the bladder wall, the detrusor, relaxes to allow expansion of the bladder during filling. The ure-

KEY TERMS

Anticholinergics—Drugs that prevent the action of acetylcholine, a compound released by nerve endings.

Cholinergics—Drugs that mimic the action of acetylcholine, a compound released by nerve endings.

Detrusor—Muscle of the bladder wall.

Residual urine volume—Amount of urine remaining after voiding.

Sphincter—Ring of muscle between the bladder and the urethra that functions to close off the urethra.

Urethra—Tube which empties urine from the bladder to the exterior of the body.

thra, the tube through which urine exits, is held closed by a ring of muscle known as the urethral sphincter. As volume increases, stretching of the detrusor and pressure on the sphincter sends signals to the **brain**, indicating the need for urination, or voiding. Voluntary relaxation of the sphincter and automatic contractions of the detrusor allow successful and virtually complete voiding.

Urinary difficulties may occur because of weak or hyperactive sphincter or detrusor, or non-coordination of their two activities. **Infection** of the bladder or urethra may cause incontinence, as can obstruction of the urethra from scar tissue, prostate enlargement, or other benign or cancerous growths. Loss of sensation due to nerve damage can lead to chronic overfilling.

Precautions

The mild irritation of the urinary tract necessary for insertion of the catheter may occasionally cause flushing, sweating, and nausea. Cystometry is contraindicated in patients with urinary tract infection because of the potential for false results and the possibility of exacerbating the infection.

Description

The patient begins by emptying the bladder as much as possible. A thin plastic catheter is then gently inserted into the urethra until it reaches the bladder. Measurements are taken of the residual urine volume and bladder pressure. Pressure measurements may require a

rectal probe to account for the contribution of the abdominal muscles to the pressure recording.

The bladder is then gradually filled with either warm water, room temperature water, saline solution, carbon dioxide gas, or a contrast solution for x-ray analysis, depending on the type of study being done. The patient is asked to describe sensations during filling, including temperature sensations and when the first feeling of bladder fullness occurs. Once the bladder has completely filled, the patient is asked to begin voiding, and pressure and volume measurements are again taken, as well as flow rate. It is important to instruct the patient not to strain while voiding during the test. Straining can alter the test results.

Preparation

There are no special food or fluid restrictions needed to prepare for this test. The patient may be asked to stop taking certain medications in advance of the test, including sedatives, cholinergics, and anticholinergics.

Aftercare

Cystometry may be somewhat uncomfortable. Urinary frequency or urgency and some hematuria (reddish urine), may last for a day. Increasing fluid intake helps to flush out the bladder. Caffeinated, carbonated, or alcoholic beverages are discouraged, because they may irritate the bladder lining. A warm bath or sitz bath may be recommended to soothe the patient.

Risks

There is a risk of upper or lower urinary infection due to tearing of the urethral lining. Although extremely rare, in some male patients, infection of the epididymis (tubules at the back of the testis) can occur and lead to **infertility**. Damage to the urethra or bladder sometimes occurs but usually heals without treatment. Rarely an allergic reaction may occur due to the contrast dye or medications.

Patients should notify their health care provider if they develop any of these symptoms:

- blood in the urine beyond several voidings
- fever or chills
- lower back pain

Results

The normal bladder should not begin contractions during filling and should initially expand without resistance. A feeling of fullness occurs with a volume of 100-

200 ml. Adult bladder capacity varies dependent on gender. Normal adult female bladder capacity ranges between 250 to 550 ml, and normal adult male capacity ranges from 350 to 750 ml. The sphincter should relax and open when the patient wills it, accompanied by detrusor contractions. During voiding, detrusor contraction should be smooth and lead to a steady urine stream.

Inability of the bladder to relax during filling, or low bladder volume, may indicate interstitial cystitis, prostate enlargement, or bladder **cancer**. Contraction of the bladder during filling may be due to irritation from infection or cysts, obstruction of the bladder outlet, or neurological disease such as stroke, **multiple sclerosis**, or **spinal cord injury**. Diminished sensation may occur with nerve lesions, peripheral neuropathy, or chronic overfilling.

Health care team roles

A cystometry may be performed in the hospital, doctor's office, or outpatient facility by a physician or nurse.

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Society of Urologic Nurses and Associates. National Headquarters, East Holly Avenue, Box 56, Pitman, NJ 08071-0056. (888) TAP-SUNA. <<http://www.suna.org/>>.

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Kidney Information Clearing House. <<http://www.renalnet.org/>>.

Maggie Boleyn, R.N., B.S.N.

Cystoscopy

Definition

Cystoscopy (cystourethroscopy) is a diagnostic procedure that uses an **endoscope** especially designed for urological use to examine the bladder, lower urinary tract, and prostate gland. It can also be used to collect urine samples, perform biopsies, and remove small stones.

Purpose

Cystoscopy is performed by urologists to examine the entire bladder lining and take biopsies of any questionable areas. Cystoscopy may be prescribed for patients who display the following:

- **blood** in the urine (hematuria)
- inability to control urination (incontinence)
- urinary tract **infection**
- signs of congenital abnormalities in the urinary tract
- suspected tumors in the bladder
- bladder or **kidney stones**
- signs or symptoms of an enlarged prostate
- **pain** or difficulty urinating (dysuria)
- disorders of or injuries to the urinary tract
- symptoms of interstitial cystitis

Blood and urine studies, in addition to x rays of the **kidneys**, ureters, and bladder, may be performed before a cystoscopy to obtain as much diagnostic information as possible. During the cystoscopy, a retrograde pyelogram may also be performed to examine the kidneys and ureters.

Precautions

Cystoscopy is a commonly performed procedure, but it is an invasive technique that involves small yet significant risk. If anesthesia is required, there is additional risk, particularly for people who are obese, smoke, or are in poor health. Those undergoing anesthesia must inform the doctor of any medications they are taking.

Description

A cystoscopy typically lasts from 10 to 40 minutes. The patient is asked to urinate before surgery. A well-lubricated flexible or rigid cystoscope (urethroscope) is inserted through the urethra into the bladder where a urine sample is taken. Fluid is then injected to inflate the bladder and allow the urologist to examine the entire bladder wall. The cystoscope uses a lighted tip for guidance and enables biopsies to be taken or small stones to be removed through a hollow channel in the cystoscope.

During a cystoscopy, the urologist may remove bladder stones or kidney stones, gather tissue samples, and perform x-ray studies. To remove stones, an instrument that resembles a tiny basket or grasper is inserted through the cystoscope so that small stones can be extracted through the scope's channel. For a biopsy, specially designed forceps are inserted through the cystoscope to

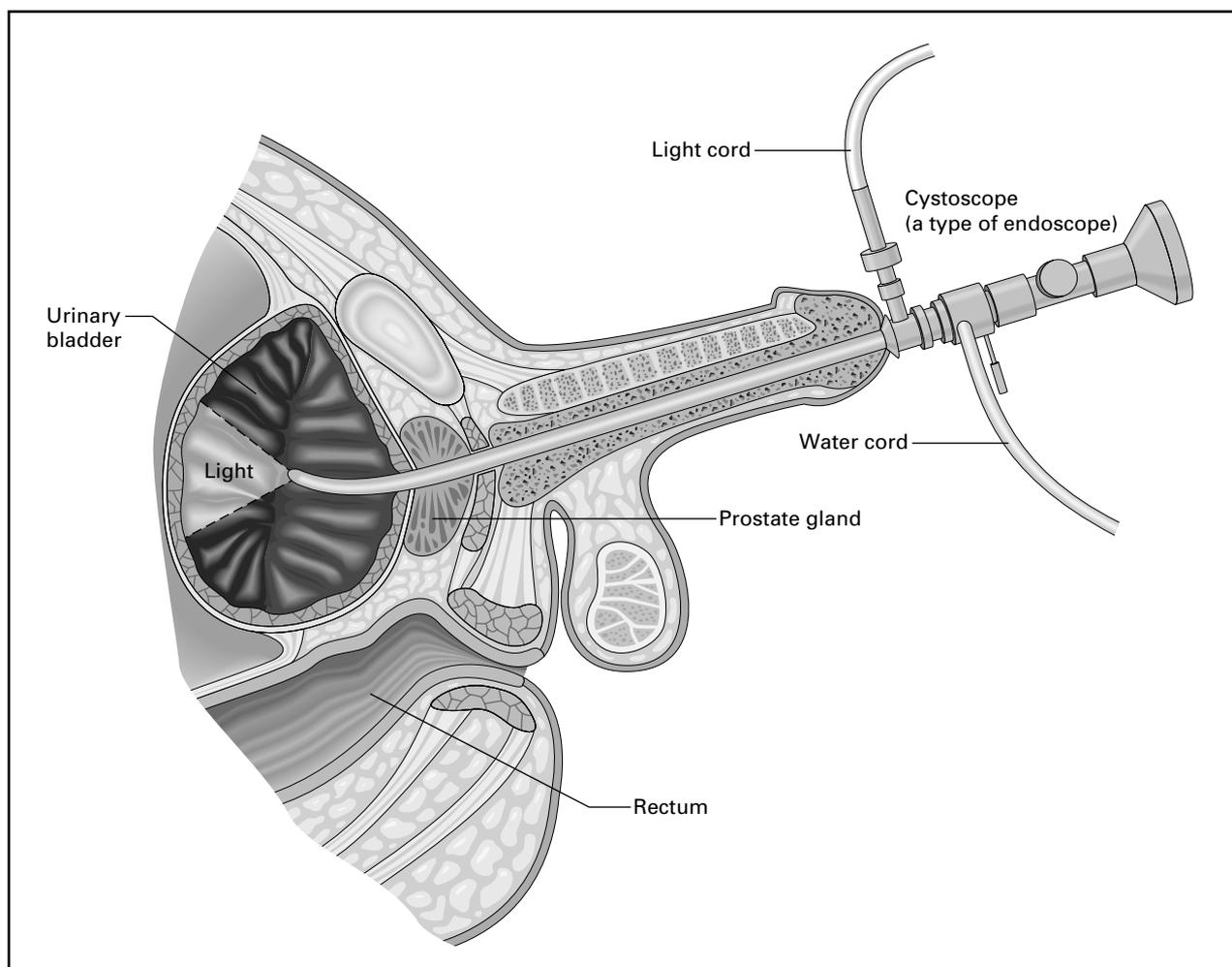


Illustration of cystoscopy procedure. (Delmar Publishers, Inc. Reproduced by permission.)

pinch off a tissue sample. Alternatively, a small brush-like instrument may be inserted to scrape off some tissue. To perform x-ray studies such as a retrograde pyelogram, a dye is injected into the ureters by way of a catheter passed through the cystoscope. After completion of all needed tests, the cystoscope is removed.

Preparation

Cystoscopy can be performed in a hospital, doctor's office, or outpatient surgical facility. Spinal or **general anesthesia** may be used for the procedure. Distension of the bladder with fluid is particularly painful, and if it needs to be done, as in the case of evaluating interstitial cystitis, general anesthesia is required. Cystoscopy is typically performed on an outpatient basis, but up to three days of recovery in the hospital is sometimes required.

Aftercare

Patients who have undergone a cystoscopy are instructed to:

- take warm baths to relieve pain
- rest and refrain from driving for several days, especially if general anesthesia was needed
- expect any blood in the urine to clear up in one to two days
- avoid strenuous **exercise** during recovery
- postpone sexual relations until the urologist determines that healing is complete

Patients may be prescribed pain relievers and **antibiotics** following surgery. Minor pain may also be treated with over-the-counter, non-prescription drugs such as acetaminophen.

Complications

As with any surgical procedure, there are some risks involved with a cystoscopy. Complications may include profuse bleeding, a damaged urethra, a perforated bladder, a urinary tract infection, or an injured penis.

Patients should contact their physician if they experience any of the following symptoms following the procedure: pain, redness, swelling, drainage or bleeding from the surgical site; signs of generalized infection, which may include headache, muscle aches, dizziness or an overall ill feeling and **fever**; nausea or vomiting; or difficult or painful urination.

Results

A successful cystoscopy includes a thorough examination of the bladder and collection of urine samples for cultures. If no abnormalities are seen, the results are indicated as normal.

Cystoscopy allows the urologist to detect inflammation of the bladder lining, prostatic enlargement, or tumors. If these are seen, further evaluation or biopsies may be needed. Cystoscopy with bladder distention can also evaluate interstitial cystitis. Bladder stones, urethral strictures, diverticula, or congenital abnormalities can also be detected.

Health care team roles

Cystoscopy is performed in a hospital operating room, cystoscopy suite, or urologist's office, depending on the condition of the patient and the anesthesia required. If general anesthesia is required, an anesthesiologist is necessary to administer the anesthesia and monitor the patient. The cystoscopy procedure is performed by a urologist, urologic surgeon, or urogynecologist, with assistance from nurses experienced in urologic procedures. If x rays are taken during the procedure, a uroradiologist or radiologic technologist is required to operate the x-ray equipment. Biopsy tissue samples are sent to the clinical laboratory for examination by a pathologist.

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KEY TERMS

Diverticula—A pouch or sac occurring normally or from a herniation or defect in a membrane. Cystoscopy can detect diverticula in the urinary tract.

Endoscopy—A minimally invasive procedure that involves examination of body organs or cavities using an endoscope (a lighted optical instrument used to see inside body cavities). A cystoscope is a type of endoscope.

Interstitial cystitis—A chronic inflammatory condition of the bladder involving symptoms of bladder pain, frequent urination, and burning during urination. Diagnosis is confirmed by cystoscopy with the bladder distended by fluid.

Retrograde pyelogram—A pyelography or x-ray technique in which radiopaque dye is injected into the kidneys through the ureters.

Ureter—The tube that carries urine from the kidneys to the bladder.

Urethra—The tube that carries urine from the bladder to outside the body. In females, the urethral opening is between the vagina and clitoris; in males the urethra travels through the penis, opening at the tip.

Urogynecologist—A physician that specializes in female medical conditions concerning the urinary and reproductive systems.

Uroradiologist—A radiologist who specializes in diagnostic imaging of the urinary tract and kidneys.

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ORGANIZATIONS

- American Urological Association. 1120 North Charles Street, Baltimore, MD 21201. (410) 727-1100. <<http://www.auanet.org>>.
- Interstitial Cystitis Association. 51 Monroe Street, Suite 1402, Rockville, MD 20850. (301) 610-5300. <<http://www.ichelp.org>>.
- Society of Urologic Nurses and Associates. East Holly Avenue, Box 56, Pitman, NJ 08071-0056. (609) 256-2335. <<http://suna.inurse.com/>>.

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Jennifer E. Sisk

Cytogenetic tests see **Genetic testing**

Cytomegalovirus antibody screening test

Definition

Cytomegalovirus (CMV) is a common human virus. When first exposed to CMV, a healthy person’s **immune system** is triggered and quickly makes antibodies to fight the virus. Specialized screening tests can be done to document the presence or absence of antibodies specific to the cytomegalovirus. Antibodies to CMV can be evidence of a current or a past **infection**.

Purpose

Up to 85% of people have antibodies to CMV by the time they are 40 years old. In a healthy, nonpregnant person, CMV infection is almost never serious. Symptoms, if present, are mild, often resembling infectious mononucleosis caused by the Epstein-Barr virus. However, consequences of CMV infection can be devastating to the fetus, transplant patients, patients with human **immunodeficiency** virus (HIV) and other patients with suppressed immune systems. People with weakened immune systems are vulnerable to infection from several routes, including from another person, from a donated organ or transfused **blood**, or from reactivation of a past infection. CMV is related to the herpes simplex and varicella (chickenpox) **viruses** in that it remains dormant in the body but can resurface with or without symptoms.

Antibody screening helps control the infection risk for high risk groups. For instance, before a transplant, both the recipient and donor are usually tested for antibodies. A recipient who has never had CMV (negative for antibodies) should not receive an organ from a donor who has had CMV (positive for antibodies) because active infection could be acquired by the recipient. CMV infection in this context can be associated with organ rejection, or can cause illness such as **pneumonia**, hepatitis, or death. In some transplant patients, particularly after bone marrow transplantation, testing may be done as often as every week to screen for new or recurrent infection.

Women who do not have evidence of previous CMV infection (i.e. antibody screen negative) should try to avoid exposure to CMV in **pregnancy**. CMV infection is the most common congenital infection (existing at birth). The infection, passed from mother to baby, can cause permanent mental or physical damage, or death. However, CMV antibody screening is not routinely ordered as part of **prenatal care**.

Blood is usually screened for CMV antibodies before being transfused into a person with a weakened immune system. CMV infection can be very similar to illness due to Epstein-Barr virus. If there is a need to know the specific source of a patient’s symptoms, antibody screening distinguishes between these two infections.

Precautions

Tests for CMV are performed on serum or biopsied tissue. Blood is collected by venipuncture by a nurse or phlebotomist. When collecting blood or handling tissue the health care provider should observe **universal precautions** for the prevention of transmission of blood-borne pathogens. Tests for immunoglobulin M (IgM) antibodies to CMV may be falsely positive in persons with rheumatoid arthritis. It is important to remember that an antibody screening test may not be useful in a person without an intact immune system. People with weak immune systems may not generate antibodies against CMV. A suspected infection in a transplant patient or a person with **AIDS** is confirmed with other tests, such as a viral culture, examination of biopsied material for cytopathic effects, or a viral DNA assay such as the polymerase chain reaction.

Description

The most frequently used antibody test for CMV is an enzyme linked immunosorbent assay (ELISA). In this test, CMV antigens are attached to the bottom of the wells of a microtiter plate. An initial dilution of the patient’s serum is added to a well of the plate and incubated. If antibodies to the CMV virus are present they attach to the CMV antigens in the well. The plate is washed and antihuman immunoglobulin G (IgG) or IgM conjugated to alkaline phosphatase is added. This antibody will attach to any antigen-antibody complexes in the wells. The plate is washed again, and substrate (e.g., p-nitrophenylphosphate) is added. The plate is incubated to allow the enzyme to split the phosphate from the substrate, which results in production of a yellow color. After incubating, a reagent (strong alkali) is added to stop the enzyme reaction and the optical density of the wells is measured. The test is interpreted as positive if the optical density of the patient’s sample is equal to or high-

er than the low-level standard. Multiple calibrators can be used to quantify the amount of anti-CMV in the patient's sample. Tests that measure a specific type of antibody help differentiate between a current and a past infection. IgM antibodies appear at the beginning of an infection and last only weeks. IgG antibodies appear 10-14 days later and can last a lifetime. A person suspected of having a current infection should be tested at the beginning of the infection and again 10-14 days later. The CMV antibody screening test is also called the transplant reaction screening test.

Preparation

This test requires 5 mL of blood. Collection of the sample takes only a few minutes.

Aftercare

Discomfort or bruising may occur at the puncture site, or the person may feel dizzy or faint. Pressure to the puncture site until the bleeding stops reduces bruising. Applying warm packs to the puncture site relieves discomfort.

Complications

The most common complication is a bruise at the site of the puncture or excessive bleeding. The patient can apply moist warm compresses if there is any discomfort.

Results

A person without previous exposure to CMV will test negative. A positive test for CMV antibodies means the person is infected or has been infected previously with the virus. An antibody titre that is significantly higher at the end of the illness than at the beginning, or the presence of IgM antibodies, indicates a recent or current first-time infection. A positive antibody test does not mean that the person has lifetime immunity. After an infection, this virus, like all members of the herpesvirus group, can stay dormant inside a person and cause infection if the person's immune system later weakens and antibody protection decreases. In fact, reactivation of such latent infection is not uncommon and usually occurs without symptoms.

KEY TERMS

Antibodies—Proteins made by the body to attach to foreign molecules called antigens and aid in their destruction.

Antigen—A marker on the surface of a molecule which stimulates an immune response and can be identified using the specific antibody formed against it.

Titre—A term denoting the concentration of an antibody. The titre is defined as the reciprocal of the highest dilution of the sample that gives a positive reaction.

Health care team roles

CMV antibody tests are ordered and interpreted by a physician. The sample is usually collected by a nurse or phlebotomist. Testing is performed by clinical laboratory scientists/medical technologists. Nurses, nurse practitioners, and physician assistants will educate patient about the purpose of the test, the nature of the CMV infection, and the consequences specific to the individual's situation.

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Erika J. Norris

Cytomegalovirus test see **TORCH test**

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D-dimer test *see* **Fibrin degradation products test**

D-Xylose tolerance test *see* **Malabsorption tests**

Dance therapy

Definition

Dance therapy is a type of **psychotherapy** that uses movement to further the social, cognitive, emotional, and physical development of the individual. Dance therapists work with people who have many kinds of emotional problems, intellectual deficits, and life-threatening illnesses. They are employed in psychiatric hospitals, day care centers, mental health centers, prisons, special schools, and private practice. They work with people of all ages in both group and individual therapy. Some also engage in research.

Dance therapists try to help people develop communication skills, a positive self-image, and emotional stability.

Origins

Dance therapy began as a profession in the 1940s with the work of Marian Chace. A modern dancer, she began teaching dance after ending her career with the Denishawn Dance Company in 1930. In her classes, she noticed that some of her students were more interested in the emotions they expressed while dancing (loneliness, shyness, fear, etc.) than the mechanics of the moves. She began encouraging them by emphasizing more freedom of movement rather than technique.

In time, doctors in the community started sending her patients. They included antisocial children, people

with movement problems, and those with psychiatric illnesses. Eventually, Chace became part of the staff of the Red Cross at St. Elizabeth's Hospital. She was the first dance therapist employed in a formal position by the federal government. Chace worked with the emotionally troubled patients at St. Elizabeth's and tried to get them to reach out to others through dance. Some of them were schizophrenics and others were former servicemen suffering from **post-traumatic stress disorder**. Success for these patients meant being able to participate with their class in moving to rhythmic music. "This rhythmic action in unison with others results in a feeling of well-being, **relaxation**, and good fellowship," Chace said once.

Chace eventually studied at the Washington School of Psychiatry and began making treatment decisions about her patients along with other members of the St. Elizabeth's medical team. Her work attracted many followers, and the first dance therapy interns began learning and teaching dance therapy at St. Elizabeth's in the 1950s.

Other dancers also began using dance therapy in the 1940s to help people feel more comfortable with themselves and their bodies. These dancers included Trudi Schoop and Mary Whitehouse. Whitehouse later became a Jungian analyst and an influential member of the dance therapy community. She developed a process called "movement in-depth," an extension of her understanding of dance, movement, and depth psychology. She helped found the contemporary movement practice called "authentic movement." In this type of movement, founded on the principles of Jungian analysis, patients dance out their feelings about an internal image, often one that can help them understand their past or their current life struggles. One of Whitehead's students, Jane Adler, furthered Whitehead's work in authentic movement by establishing the Mary Starks Whitehouse Institute in 1981.

In 1966, dance therapy became formally organized and recognized when the American Dance Therapy Association (ADTA) was formed.

Benefits

Dance therapy can be helpful to a wide range of patients—from psychiatric patients to those with **cancer** to lonely elderly people. Dance therapy is often an easy way for a person to express emotions, even when his or her experience is so traumatic he or she can't talk about it. It is frequently used with rape victims and survivors of sexual abuse and incest. It can also help people with physical deficits improve their self-esteem and learn balance and coordination.

Dance therapists also work with people who have chronic illnesses and life-threatening diseases to help them deal with **pain**, fear of death, and changes in their body image. Many people with such illnesses find dance therapy classes to be a way to relax, get away from their pain and emotional difficulties for a while, and express feelings about taboo subjects (such as impending death).

Dance therapy is suitable even for people who are not accomplished dancers, and may even be good for those who are clumsy on the dance floor. The emphasis in dance therapy is on free movement, not restrictive steps, and expressing one's true emotions. Children who cannot master difficult dances or can't sit still for traditional psychotherapy often benefit from free-flowing dance therapy. Even older people who cannot move well or are confined to wheelchairs can participate in dance therapy. All they need to do is move in some way to the rhythm of the music.

Dance therapy can be useful in a one-on-one situation, where the therapist works with only one patient to provide a safe place to express emotions. Group classes can help provide emotional support, enhanced communication skills, and appropriate physical boundaries (a skill that is vital for sexual abuse victims).

Description

There are currently more than 1,200 dance therapists in 46 states in the United States and in 29 foreign countries. Like other mental health professionals, they use a wide range of techniques to help their patients. Some of the major "schools of thought" in dance therapy include the Freudian approach, Jungian technique, and object relations orientation. Many therapists, however, do not ascribe to just one school, but use techniques from various types of dance therapy.

The authentic movement technique is derived from the Jungian method of analysis in which people work with recurring images in their thoughts or dreams to derive meaning in their life. Instead of asking the patient to dance out certain emotions, the therapist instructs the patient to move when he or she feels "the inner impulse."

The moves are directed by the patient and the therapist is a noncritical witness to the movement. The moves are supposed to emerge from a deep level within the patient.

In Freudian technique, dance therapists work with patients to uncover feelings hidden deep in the subconscious by expressing those feelings through dance.

In object relations technique, the therapist often helps the patient examine problems in his or her life by considering the primary initial relationship with the parents. Emotions are expressed in a concrete, physical way. For instance, a patient would work out his fears of abandonment by repeatedly coming close to and dancing at a distance from the therapist.

Dance therapists sometimes use other types of therapy along with dance, such as art or drama. Therapists also discuss what happens during a dancing session by spending time in "talk therapy." Dance therapists use visualizations during sessions, too. For example, the therapist might instruct patients to imagine they are on a beautiful, peaceful beach as they dance.

In one frequently used technique, the therapist mirrors the movements of the patient as he or she expresses important emotions. This is especially powerful in private one-on-one therapy. It is thought that this device provides a sense of safety and validates the patient's emotions.

The underlying premise of dance therapy is that when people dance, they are expressing highly significant emotions. A fist thrust out in anger into the air or a head bent in shame has deep significance to a dance therapist. Through dance therapy, the theory goes, patients are able to more easily express painful, frightening emotions, and can progress from there. After experiencing dance therapy, they can talk about their feelings more freely and tear down the barriers they have erected between themselves and other people. The hope is that eventually they can go on to live more psychologically healthy lives.

Preparations

People who want to use dance therapy should find a qualified therapist. The ADTA provides lists of qualified therapists. The person should begin dance therapy with an open mind and a willingness to participate so he or she can get the most benefit.

Precautions

A qualified dance therapist should have completed a graduate program in dance therapy approved by the ADTA and should be registered with the ADTA. He or

she should not just be a dancer, but should also have extensive training in psychology.

Side effects

No known side effects.

Research and general acceptance

Dance therapy was once dismissed as simply an ineffective, “feel good” treatment, but it is now more respected. Many research studies have proven that dance therapy can be an effective tool to help people overcome psychological problems.

In a 1993 study, older people with cognitive deficits showed that dance therapy could significantly increase their functional abilities. Patients improved their balance, rhythmic discrimination, mood, and social interaction.

In 1999, a pilot study of 21 university students showed that those who took a series of four to five group dance therapy sessions in a period of two weeks significantly reduced their test **anxiety** as measured by a well-known exam called the Test Anxiety Inventory. Afterwards, the subjects reported that their dance movement experience was positive and provided them with psychological insight. The researchers concluded that dance therapy could be a viable method of treatment for students who suffer from overwhelming test anxiety, and should be researched further.

In another 1999 study presented at the ADTA national conference in November 1999, dance therapist Donna Newman-Bluestein reported success in using techniques of dance therapy with cardiac patients. In a **stress** reduction class, health professionals used dance therapy methods to teach body awareness, relaxation, self-expression, creativity, and empathy. According to Newman-Bluestein, the dance therapy techniques helped the patients deal with such stressful emotions as anger, increased their self-awareness, made them more relaxed, and helped them adjust emotionally to having **heart** disease.

Training and certification

Dance therapists should have dance experience and a liberal arts background with coursework in psychology for their undergraduate degree. Professional dance therapy training takes place on the graduate level. A qualified dance therapist has received a graduate degree from a school approved by the ADTA, or has a master’s degree in dance or psychology and has taken additional dance therapy credits.

KEY TERMS

Authentic movement—A type of movement that is influenced heavily by Jungian analysis, and works by analyzing the internal images of the patient. Patients are also urged to dance only when they feel the “impulse” to move.

Freudian analysis—A type of psychological treatment where the therapist seeks to help the patient resolve conflicts and traumas buried in the subconscious.

Jungian analysis—A method of psychological treatment where the patient strives to understand the internal, often mythic images in his or her thoughts and dreams.

Psychotherapy—A medical treatment that seeks to resolve psychological traumas and conflicts, often by discussing them and emotionally reliving difficult events in the past.

Test anxiety—A name for the stress and anxiousness that commonly occur in students before they take exams.

After graduation, dance therapists can become registered with the ADTA, meaning that they are qualified to practice. After two years they may receive an additional recognition when they become an Academy of Dance Therapist Registered. They can then teach dance therapy and can supervise interns.

Dance therapists can also obtain psychological credentials by taking a test and becoming registered by the National Board for Certified Counselors, Inc.

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Barbara Boughton

Deafness see **Hearing loss**

Death and dying

Definition

Death is the end of life, a permanent cessation of all vital functions. Dying refers to the body’s preparation for death, which may be very short in the case of accidental death, or can last weeks or months in some **cancer** patients.

Description

Quality and method of death differs between cultures, circumstances and degrees of preparation. For many years, the terminally ill did not have choices in their manner of death, often enduring excruciating **pain** before the inevitable end of life. In recent years changes have been made to allow for a better quality for end of life, such as hospice care and preparatory actions by the patient.

It is important to recognize the differences in the ways people grieve. Each culture socializes a person in a certain way to deal with death. Death affects a person cognitively, behaviorally and socially. The death and grieving attitudes of a person affect the subjects of death, dying, bereavement, suicide and **euthanasia**. While a person may be able to verbalize feelings about death, internal contradictory feelings of anxiousness are common. Each person handles the subject individually, and seeking appropriate assistance will help the person to come to terms with the event in his or her own time and way.

Hospice care

A diagnosis of terminal illness is a sad and traumatic circumstance. Hospice care provides quality, caring services for both the patient and his or her loved ones. Most communities have a variety of hospice providers. A physician or hospital patient services can assist with provider names. The yellow pages of the phone book, or referral services from United Way, the local council on aging, Visiting Nurse Association or the American Cancer Society are other information sources.

While the patient should be the one to choose hospice care, it is always appropriate to discuss all care options. Hospice staff are sensitive to concerns of both patient and family members and assist in the planning process as requested. Most physicians are aware of the services provided by hospice and will cooperate fully.

The hospice program will work closely with the physician to optimize the patient’s care. The patient will sign consent and insurance forms, which are similar to those signed for hospital admission. There is also a form that states the patient’s understanding that hospice care is aimed at pain relief and symptom control (palliative), rather than curative. Should a patient’s condition improve and hospice services are no longer necessary, or the patient is in remission, services can be discontinued and the patient may return to regular care options. There is no obligation to remain with hospice care if it is not necessary. Should the patient need readmission to the program, medical insurance and **Medicare** may allow additional funding for this purpose.

Once hospice services are approved, the provider will perform a needs assessment, then assist in locating the equipment necessary for the patient’s care. Quite often, the earlier needs are minimal, increasing as the illness becomes more serious. The purpose of hospice care is to make the home environment a comfortable haven for the patient.

The hospice team prepares a plan of care that is tailored to the patient. This will address the amount of care necessary to maintain the patient’s comfort and well-being. The staff visits the home regularly and provides instruction on patient care, as well as answers medical questions and supports the caregivers.

As the illness progresses, care becomes more difficult. Hospice plans provide staff around the clock to consult by phone or to make visits if deemed appropriate. Respite care is also available for exhausted caregivers, so that the home can remain functional.

Hospice patients are cared for by a team of doctors, nurses, counselors, social workers, clergy, and volunteers, among others. Each provides assistance based on

area of expertise. Additionally, **hospices** provide supplies, equipment, medications and other services related to the terminal illness. Hospice does not hasten nor does it delay the death process. However, hospices do provide specialized care that eases some of the **anxiety** and worry that accompany oncoming death.

The management of pain is very often an issue in terminal illness. The mission of hospice is to address all types of pain, not only the physical. Support is available to assist the patient in achieving the highest quality of life possible under individual circumstance. This may include physical and occupational therapists to keep the patient as self-sufficient and mobile as possible. Music therapy, **art therapy**, massage and diet counseling are available. The latest medications and devices for relief from pain and other symptoms is available. Also, counselors, some of whom are clergy members, assist both the patient and the family as needed/requested. However, hospice programs are not affiliated with religious groups and do not expect participants to adhere to any particular belief system.

The goal of the hospice program is to keep the patient both as pain free and alert as possible. Constant communication with the patient and caregivers assist in the high success rate of the hospice program. After the loved one's death, hospice programs provide both individual and group support for caregivers for at least one year, longer if necessary.

Preparing for death legally

An advance directive is a way to allow caregivers to know a patient's wishes, should the patient become unable to make a medical decision. People who are admitted to hospitals must be told about advance directives at the time of admission. Description of the type of care for different levels of illness should be in an advance directive. For instance, a patient may wish to have or not to have a certain type of care in the case of terminal or critical illness or unconsciousness. An advance directive will protect the patient's wishes in these matters.

A living will is one type of advance directive and may take effect when a patient has been deemed terminally ill. Terminal illness in general assumes a life span of six months or less. A living will allows a patient to outline treatment options without interference from an outside party.

A durable power of attorney for health care (DPA) is similar to a living will; however, it takes effect any time unconsciousness or inability to make informed medical decisions is present. A family member or friend is stipulated in the DPA to make medical decisions on behalf of the patient.

While both living wills and DPAs are legal in most states, there are some that do not officially recognize these documents. However, they may still be used to guide families and doctors in treatment wishes.

Do-not-resuscitate (DNR) orders can be incorporated into an advance directive or by informing hospital staff. Unless instructions for a DNR are in effect, hospital staff will make every effort to help patients whose hearts have stopped or who have stopped breathing. DNR orders are recognized in all states and will be incorporated into a patient's medical chart if requested. Patients who benefit from a DNR order are those who have terminal or other debilitating illnesses. It is recommended that this be discussed with a physician by a patient who has not already been considered unable to make sound medical decisions.

None of the above documents are complicated. They may be simple statements of desires for medical care options. If they are not completed by an attorney, they should be notarized and a copy should be given to the doctor, as well as a trusted family member.

Viewpoints

In the Hague, Netherlands, euthanasia was legalized in April 2001, and the country became the first in the world to allow doctors to end the lives of patients with painful, terminal illnesses. The Dutch Senate voted 46-28 in favor of the law, which took effect in the summer of 2001.

Prior to the vote, Health Minister Els Borst assured the legislators that euthanasia would not be abused by doctors because of the strict supervision that would accompany the measure. The practice has been discreetly practiced in the Netherlands for decades, and preliminary guidelines were established by the country's Parliament in 1993.

In the United States, Oregon has permitted doctors to perform assisted suicides since 1996.

Mourning and grieving among cultures

The death of a loved one is a severe trauma, and the grief that follows is a natural and important part of life. No two people grieve exactly the same way, and cultural differences play a significant part in the grieving process. For many, however, the most immediate response is shock, numbness and disbelief. Physical reactions may include shortness of breath, **heart** palpitations, sweating and dizziness. At other times, there may be reactions such as loss of energy, sleeplessness or increase in sleep, changes in appetite, or **stomach** aches. Susceptibility to

common illnesses, nightmares, and dreams about the deceased are not unusual during the grieving period.

Emotional reactions are as individual as physical reactions. A preoccupation with the image of the deceased, feelings of fear, hostility, apathy and emptiness, even fear of one's own death may occur. Depression, diminished sex drive and anger at the deceased, as well as extreme sadness may occur. Bereavement may cause short- or long-term changes in the family unit and other relationships of the bereaved.

It is important for the bereaved to work through their feelings and not avoid emotions. If this does not occur through family, friends, or primary support group methods, then a therapist should be consulted to assist with the process.

Various cultures and religions view death in different manners and conduct mourning rituals according to their own traditions. In the Christian faith, bodies of deceased are normally on view at a funeral parlor for one or more days before the actual funeral service. Specific hours are given for visitation or viewing.

Visitors come to express their condolences to the family and to bid farewell to the deceased. At times, funeral services are private. Various ethnic groups host a gathering after the funeral for those who attended. If it is held at the family's home, very often relatives and others will bring food and drink. Others choose to hold this event at a restaurant or some other public venue. It is common for these events to become a celebration of the life of the deceased, which also helps the bereaved to begin the mourning process positively. Memories are often exchanged and toasts made in memory of the deceased. Knowing how much a loved one is cherished and remembered by friends and family is a comfort to those who suffer the loss. Other methods of condolences include sending flowers to the home or the funeral parlor; sending a mass card (for Catholics); sending a donation to a charity that the family has chosen; bringing a meal to the family during the weeks after the death.

In the Jewish culture, bodies are buried as soon after death as possible, even as early as sundown of the day after death. For the Jewish population, this marks a sign of respect to the deceased. A seven-day period of mourning follows, which is called *Shiva* or sitting *Shiva*. Friends and community visit the family and often bring food, so that the family does not have to worry about meals. Normal activities are suspended for the family of the deceased at this time, so that the bereaved can focus fully on their grief, thus enabling them to re-enter life a bit easier after the period of mourning. The first meal that is served after return from the cemetery is called *seudat havrach*, prepared by friends and neighbors. Eggs and

other round objects are traditionally served. These are objects that are symbolic of life, hope and the full circle of life, which ends in death. Flowers are not traditional; however, donations to charities chosen by the family are acceptable in memory of the deceased.

In the Muslim faith, everyone accompanies the funeral procession to the gravesite. The permitted mourning period for a deceased Muslim is three days, except for a widow, who is permitted to mourn her spouse for four months and 10 days. Traditionally, people leave the gravesite after offering condolences and offering assistance. However, some families do hold gatherings at home. Friends and neighbors bring food and drink to alleviate the family from the worry of providing refreshments. Flowers are often sent after the funeral to the family's home.

Buddhists normally hold a funeral within a week after the death. Flowers or a donation to a charity in the deceased's name are appropriate signs of respect. Caskets are often open, and guests are expected to view the deceased and bow slightly toward it. Friends are invited to call at the deceased's home after the funeral service but not before. The funeral service itself is usually held within 24 hours after the death. Then the body is kept at home until the traditional cremation ceremony. Flowers are acceptable from visitors and are placed at the feet of the deceased. Fruit is also a customary gift to bring to the family.

Professional implications

The primary concern of health care workers in most cases is preserving the life and health of an individual. Severely ill patients may be given **nutrition** and fluids intravenously or have their breathing supported by a ventilator. In cases in which the heart stops, **CPR (cardiopulmonary resuscitation)** is performed. In the case of terminally ill, dying patients, the role of health care professionals is to provide palliative care, to ensure that proper arrangements are made for the person after death, and to address the concerns of family members.

Physical signs

The causes of death vary greatly. Injuries, illness and more violent deaths occur routinely. However, as the time of death grows near for the dying, certain signs are common as their bodies begin to shut down. The time variable is as much as a few days and as little as a few hours. There is no particular order of events and not everyone experiences all of them. Support and caring by those surrounding the dying person are essential to make the passing as comfortable and with as little **stress** as possible.

The health care professional should keep the patient comfortable. Eggshell mattresses or foam cushions can prevent bedsores, as can changing the patient's position in bed. Sheets should be changed at least twice a week. Helping the patient with mouth care often makes him or her feel better.

There will be less interest in eating and drinking. Refusal of food indicates a readiness to die. Fluid intake may be reduced to only as much as will keep the mouth from feeling dry. At this time it is important for caretakers to offer food, drink, and medications, but they should not be forced. Pain may not be an issue when the end is near, so the patient may not feel the need for the medication.

The patient will begin to sleep more and begin to detach from his or her surroundings. The caregiver should not interfere, except to make the patient as comfortable as possible. The caregiver's presence is the most important factor.

Mental confusion may occur as less oxygen reaches the **brain**. Loss of **hearing** and **vision** may occur. The patient may complain of strange dreams. The caregiver should gently remind the patient of the day and time, who is present, and where the patient is at the moment. This should be done in a conversational manner. The caregiver should speak louder than normal if that is necessary, but not draw attention to the patient's loss of senses.

The room should be kept at the light and temperature that the patient requests. All conversations should be carried on as if the patient were aware. Hearing is the last of the senses to leave entirely, even in the case of stroke victims who sometimes appear completely unaware. However, many patients are able to speak even just a few minutes before death and are reassured by loving words.

Secretions may collect at the back of the throat. This may cause a gurgling sound as the patient breathes and possibly tries to cough up mucus. A cool mist humidifier in the room may help. If not, it may be advisable to turn the patient on his or her side, propped up with pillows, so that secretions can drain out of the mouth. The caregiver can cleanse the mouth with glycerin-dipped swabs, mineral oil, or cool water.

Near the end, there may be periods of non-breathing or irregular breathing. As death comes nearer, breathing may resume regularity but become shallow and mechanical. The patient may become agitated, try to get out of bed, hallucinate or pull at the bed linens. The caregiver should calmly reassure the patient and try to prevent the patient from falling if an attempt is made to get out of bed. A massage or soothing music may help.

As circulation slows down, the patient may lose the ability to realize his or her body temperature. The arms will become cool and begin to turn a bluish color. The underside of the body may darken. The caretaker should provide additional blankets or remove them as necessary. The patient should be kept as comfortable as possible.

Loss of control of the bladder and bowel may occur at the time of death. Breathing and heartbeat will stop. The jaw may sag open slightly as it relaxes. The eyelids may close partially, but the eyes will be fixed.

After a patient dies, health care staff allow family members time to grieve with the body before starting post-mortem procedures.

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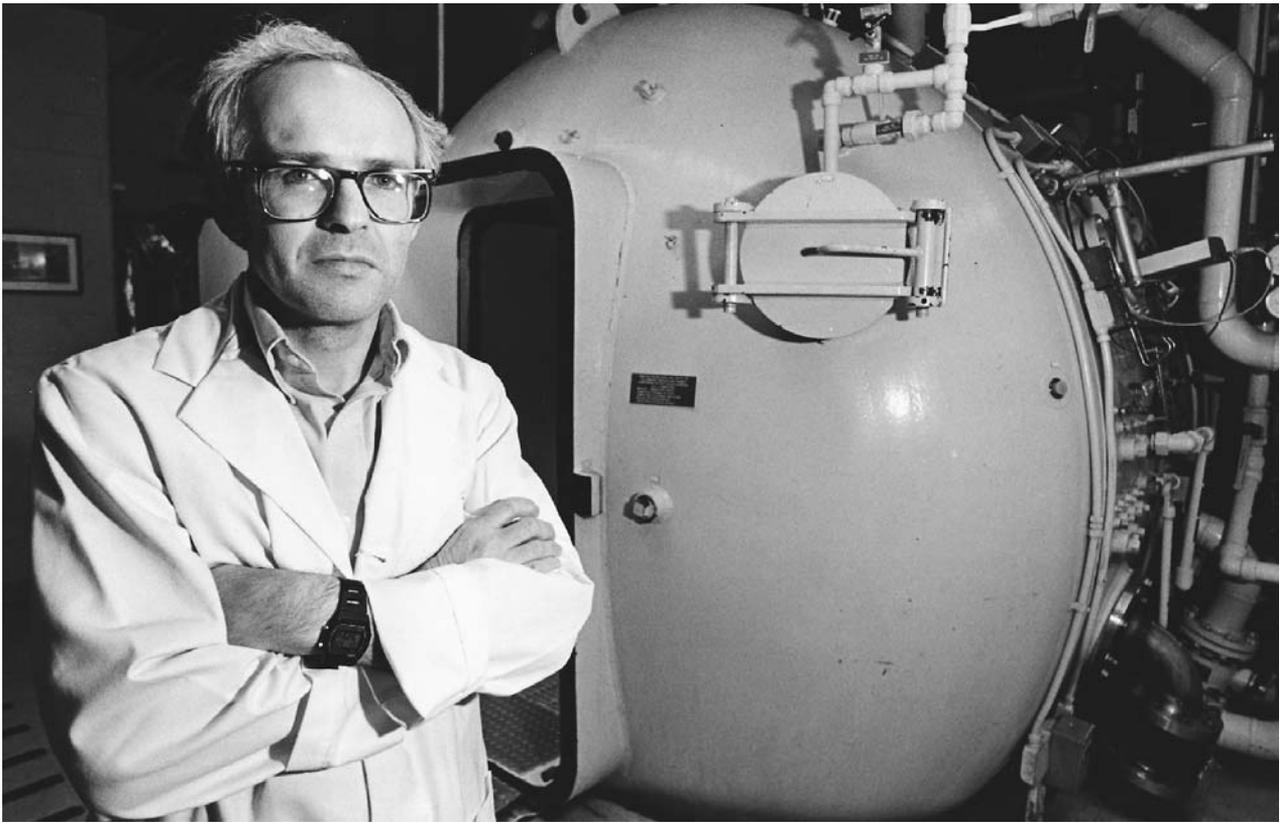
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Jacqueline N. Martin, M.S.

Decompression sickness

Definition

Decompression sickness (DCS) is a dangerous and occasionally lethal condition caused by nitrogen bubbles that form in the **blood** and other tissues of scuba divers who surface too quickly. It also occurs in the blood of tunnelers or miners who work in conditions of increased pressure and return to normal atmospheric pressure too quickly.



A hyperbolic chamber is used to treat patients for decompression sickness, or “the bends.” (AP/Wide World Photos. Reproduced by permission.)

Description

According to the Divers Alert Network (DAN), a worldwide organization devoted to safe-diving research and promotion, fewer than 1% of divers fall victim to DCS or the rarer bubble problem called **gas embolism**, air embolism, or arterial gas embolism (AGE). A study of the U.S. military community in Okinawa, where tens of thousands of sport and military dives are made each year, identified 84 cases of decompression sickness and 10 instances of arterial gas embolism between 1989 and 1995. These numbers included 9 deaths. Translated, this provides an estimated incidence of one case of decompression sickness in every 7,400 dives and one death in every 76,900 dives. Since symptoms of decompression sickness can be quite mild, many cases go unnoticed by divers; thus this estimate is probably understated.

Different terminology is used in discussing decompression sickness and it can be confusing. Sometimes the term illness is used instead of sickness. Others treat decompression illness as a term that encompasses both decompression sickness and arterial gas embolism. An older term for decompression sickness is caisson disease.

This term was coined in the nineteenth century, when bridge construction crews working at the bottom of lakes and rivers in large pressurized enclosures (caissons) were found to experience joint **pain** (a typical symptom of decompression sickness on returning to the surface).

Causes and symptoms

The air we breathe is mostly a mixture of two gases, nitrogen (78%) and oxygen (21%). Unlike oxygen, nitrogen is a biologically inert gas, meaning that it is not metabolized (converted into other substances) by the body. For this reason, most of the nitrogen we inhale is expelled when we exhale, but some is dissolved into the blood and other tissues. During a dive, however, the **lungs** take in more nitrogen than usual. This happens because the surrounding water pressure is greater than the air pressure at sea level (twice as great at 33 ft [10 m], for instance). As the water pressure increases, so does the pressure of the nitrogen in the compressed air inhaled by the diver. Because increased pressure causes an increase in gas density, the diver takes in more nitrogen with each breath than would occur at sea level. But instead of being exhaled, the extra nitrogen safely dissolves into the tis-

sues, where it remains until the diver begins the return to the surface. Under some circumstances, the extra dissolved nitrogen can cause nitrogen narcosis, although this condition is different from decompression sickness. On the way up, decompression occurs; in other words, the water pressure drops. With the decrease in pressure, the extra nitrogen gradually diffuses out of the tissues and is delivered by the bloodstream to the lungs, which expel it from the body. If the diver surfaces too quickly, potentially dangerous nitrogen bubbles can form in the tissues and cause decompression sickness. These bubbles can compress nerves, obstruct arteries, veins, and lymphatic vessels, and trigger harmful chemical reactions in the blood. The precise reasons for bubble formation remain unclear.

How much extra nitrogen enters the tissues varies with the dive's depth and the duration of the dive. Dive tables prepared by the U.S. Navy and other organizations specify how long most divers can safely remain at a particular depth. If the dive table limits are exceeded, the diver must pause on the way up, to allow the nitrogen to diffuse out of tissues and into the bloodstream without forming bubbles. These pauses are called decompression stops and are carefully calibrated. Decompression sickness can occur, however, even when a diver obeys safe-diving rules. In such cases, the predisposing factors include fatigue, **obesity**, **dehydration**, hypothermia, and recent alcohol use. People who fly or travel to high-altitude locations without letting 12–24 hours pass after their last dive are at risk for DCS, because their bodies undergo further decompression. This is true even when flying in commercial aircraft, since the cabin pressure in commercial aircraft is set much lower than the pressure at sea level. At 30,000 ft (9,144 m), for instance, cabin pressure is usually equivalent to the pressure at 7,000–8,000 ft (2,133–2,438 m) above sea level, a safe level for everyone except people who have recently been diving. Exactly how long a diver should wait before flying or traveling to a high-altitude location depends on how much time has been spent diving. If there is uncertainty about the appropriate waiting period, the sensible course of action is to let a full 24 hours pass.

Since the nitrogen bubbles that cause decompression sickness can affect all body tissues, many different symptoms are possible. Symptoms can appear minutes after a diver returns to the surface. The appearance of symptoms occurs within eight hours in about 80% of cases. Pain is often the only symptom. This is sometimes called “the bends,” although many people incorrectly use that term as a synonym for decompression sickness. Pain, which ranges from mild to severe, is usually limited to the joints, but can be felt anywhere. Severe itching (pruri-

tus), skin rashes, and skin mottling (*cutis marmorata*) are other relatively common symptoms. All of these are sometimes classified as manifestations of Type 1 or “mild” decompression sickness. Type 2 or “serious” decompression sickness can result in **paralysis**, **brain damage**, **heart** attack, and death. Many persons with decompression sickness experience both Type 1 and Type 2 symptoms.

Diagnosis

Diagnosis is determined by taking a thorough medical history and conducting a **physical examination**.

Treatment

Decompression sickness is treated by giving the affected person oxygen and placement in a hyperbaric chamber. A hyperbaric chamber is an enclosure in which the air pressure is first gradually increased and then gradually decreased. This shrinks the bubbles and allows the nitrogen to safely diffuse out of the tissues. Hyperbaric chamber facilities exist throughout the United States. No matter how mild symptoms may appear, immediate transportation to a facility with a hyperbaric chamber is essential. Treatment is necessary even if the symptoms clear up before the facility is reached, because bubbles may still be in the bloodstream and still pose a threat. The Divers Alert Network maintains a list of facilities and a 24-hour hotline that can provide advice on handling decompression sickness and other diving emergencies.

Prognosis

People suffering from decompression sickness who undergo chamber treatment within a few hours of symptom onset usually enjoy a full recovery. If treatment is delayed, the consequences are less predictable, although many people have been helped even after several days have passed. A 1992 report on diving accidents indicated that full recovery following chamber treatment was immediate in about 50% of divers. Some people, however, suffer numbness, tingling, or other symptoms that last for weeks, months, or even a lifetime. In another study, 6 out of 94 (6.4%) persons experienced long-lasting symptoms even after repeated chamber treatments.

Health care team roles

Paramedics often make the initial diagnosis of decompression sickness. Physicians supervise treatment in a hyperbaric chamber, while RNs provide support and monitor the patient during the period of decompression.

KEY TERMS

Cutis marmorata—Skin that has a marbled appearance due to conspicuous veining of small vessels.

Gas embolism—The presence of a gas bubble in the bloodstream that obstructs circulation.

Hyperbaric chamber—A sealed compartment in which air pressure is gradually increased and then gradually decreased, allowing nitrogen bubbles to shrink and the nitrogen to safely diffuse out of body tissue.

Lymphatic vessels—Vessels that carry a plasma-like fluid called lymph from tissues to the bloodstream.

Nitrogen narcosis—Also called “rapture of the deep,” the condition is caused by increased nitrogen pressure at depth and is characterized by symptoms similar to alcohol intoxication.

Pruritus—The symptom of itching or an uncontrollable sensation leading to the urge to scratch.

Prevention

The obvious way to minimize the risk of decompression sickness is to follow the rules of safe diving and air travel after a dive. People who are obese, suffer from lung or heart problems, or are otherwise in poor health should not dive. Because the effect of nitrogen diffusion on the fetus remains unknown, diving while pregnant is not recommended.

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Divers Alert Network, The Peter B. Bennett Center, 6 West Colony Place, Durham, NC 27705. (919) 684-8111. Fax: (919) 490-6630. <<http://www.diversalertnetwork.org/contact/>>. dan@diversalertnetwork.org.

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Decubitus ulcer see **Pressure ulcer**

Defibrillator, automatic see **Implantable cardioverter-defibrillator**

Defibrillators, portable

Definition

A portable defibrillator is a device, often automated and generally weighing less than 5 lbs (2.2 kilograms), that is commonly used in non-hospital settings to administer a shock and re-establish a regular heartbeat to treat sudden cardiac arrest.

Purpose

Rapid defibrillation is the most significant factor in the survival of the abrupt disruption of the **heart** function known as sudden cardiac arrest (SCA). In non-hospital

settings, the most common method of administering such a shock is by using a portable defibrillator, also known as an automated external defibrillator (AED). AEDs are now common equipment in airports, malls, casinos, golf courses, businesses, hotels, schools, on airplanes, and through various emergency response groups such as the police, fire departments, and paramedic squads.

Contrary to the perception portrayed by television and movies, defibrillation is not effective in treating hearts showing a flat-line electrocardiogram (ECG). Instead, defibrillation is most effective in reversing arrhythmias (abnormal rhythms of the heart) such as those that can cause SCA. This condition is often characterized by ventricular fibrillation, a rapid, nonproductive contraction of the ventricles. To treat this problem, the shock stops the chaotic electrical activity and allows the natural pacemaker of the heart, the sinoatrial node, to regain control of the beat.

SCA is the cause of death of more than 350,000 Americans per year, striking persons of all ages and in both sexes equally. Unlike a heart attack, SCA often occurs without warning symptoms. The American Heart Association estimates that nearly 300 persons per day would be saved if everyone who suffered from SCA had access to treatment with an AED within 10 minutes. AED models are now available for treatment of adults, children, and infants.

Because many AEDs include an ECG display, the device can also be used during cardiac emergencies to monitor and record the heart's electrical signals before, during, and after any given treatment. This is true even when the person suffers from a heart condition that does not warrant administering a shock, as determined by the device's automatic analysis of the heart problem.

Description

AED devices include an ECG to monitor the heartbeat of the patient, software and voice prompting to guide the operator, other software to analyze the advisability of administering a shock, and a shock generator to administer a shock of set duration and power. The device itself is enclosed in a case that includes a display, a speaker, leads running to two pad-shaped electrodes, and two buttons (power and shock). More sophisticated versions of this device can include manual over-rides (for control by trained medical personnel of the power and duration of the shock) and pacing abilities.

Generally, defibrillators are available that produce two types of shocks, monophasic and biphasic. Monophasic shocks move from one electrode to the other, while biphasic shocks move from one electrode to the other, and then reverse direction. Biphasic shocking



A portable defibrillator is used in an attempt to revive a man who suffered a heart attack before he is transported to an emergency room. (Photograph by Adam Hart-Davis. Science Source/Photo Researchers. Reproduced by permission.)

is usually more effective than monophasic in taking a heart out of fibrillation and is associated with less post-treatment heart or **brain** dysfunction. Biphasic shocking, combined with pre-shock impedance measurements, is a method particularly successful in treating obese patients, a situation that can be a challenge to other types of defibrillation therapies.

The analysis of the heartbeat is done using an algorithm (a sequence of mathematical steps) that compares the electrical output of the patient's heart to known heartbeats to determine if a shock should be administered. The four characteristics of the output examined are rate, conduction, stability, and amplitude. Rate is measured in beats per minute (bpm), with normal being between 60 and 100. Increased rate is characteristic of many common arrhythmias. Conduction is evaluated by looking at the characteristics of the R wave of the ECG, which is the portion of the electrical signal of the heart where there is a tall, narrow spike. Rounded wide R waves can indicate problems with conduction.

Stability of the heartbeat is evaluated by comparing one heartbeat signal to the next. In healthy hearts, the beats repeat themselves with a regular pattern. Unhealthy hearts have varied beat signals, an indication of instability. Finally, the algorithm looks at the amplitude (height) of the electrical signal put out by the heart. Lowered amplitude is a characteristic of an unhealthy heart.

KEY TERMS

Algorithm—A sequence of mathematical steps used by an automated external defibrillator to evaluate whether a shock is appropriate treatment for the patient attached to the machine's electrodes.

Biphasic—A term to describe a defibrillation shock that travels from one electrode to another and back again.

Monophasic—A term to describe a defibrillation shock that travels from one electrode to the other.

Additionally, many AEDs have systems to filter out artifacts, electrical signals that do not come from the heart of the patient being evaluated and that may interfere with the evaluation process.

Operation

The operation of an AED is as straightforward as possible so a person can use the machine correctly even without training. When in automatic mode, the machine provides voice and display prompts to guide the operator through its use. Many models have only two buttons, a green power button and an orange or other brightly-colored shock button.

The use of a defibrillator to treat SCA is one part of a four-step program known as the chain of survival. The four critical steps include early access to emergency care (by calling 911 or another emergency number), early **cardiopulmonary resuscitation (CPR)**, early defibrillation, and early advanced cardiac support. Thus, before using an AED, the operator should have someone call 911 and then begin CPR, if possible.

AEDs should only be used on individuals who are unresponsive, not breathing, and have no pulse. On activation, the machine asks the operator to confirm that these conditions are present. Next, the operator is directed to place the electrode pads on the collapsed person. The two pads are placed on the chest, one on the patient's upper right chest area, and the other below the ribs on the patient's left side. Often, there is a diagram on the machine to aid in electrode placement. At this point, the machine directs the operator to plug in the electrodes, guided by a light. Some machines skip this step, as the electrodes are permanently attached.

The machine then directs everyone to stand clear of the patient so that the heartbeat can be evaluated. If the

condition can be treated with a shock, the operator is directed to both visually and verbally clear the area around the patient and then push the shock button. After the shock is delivered, the machine automatically checks the heartbeat for change and, if further shocks are needed, the machine directs their delivery.

Maintenance

Older AEDs require periodic maintenance and calibration by using external devices, sending the machine to the factory, or service contracts with outsource providers of maintenance. However, newer machines have internal maintenance programs that carry out the required routine performance checks and function adjustments. Many will check the ability of the machine's shock function on a daily basis. The internal maintenance functions, combined with heavy-duty, easy-to-carry external casings, facilitate the use of AEDs as emergency equipment in non-health care settings. Wall mountings such as those that are used for fire extinguishers are available to keep the equipment in sight but protected.

Health care team roles

AEDs are specifically designed to be used by people who have no medical training. Indeed, a study using AEDs showed that sixth grade students, without the benefit of training or ability to ask questions, took only 30 seconds longer to administer a shock than trained emergency technicians.

In a hospital setting, portable defibrillators are often available for use by hospital personnel in order to assure quick access to defibrillation equipment in intensive care units and other areas of the hospital where SCA might occur. The manual settings found on more sophisticated units can be used by health care providers such as doctors, nurses, paramedics, and **emergency medical technicians** who have training in advanced life support techniques. Their training allows them to identify specific abnormal rhythms that may require different energy settings for the most effective correction.

Training

When an AED program is implemented, for example, by a business, training for the employees is often accomplished using a four-hour course, with refreshers suggested every three months. Training programs are available from the company that manufactures the AED or from organizations such as the American Red Cross.

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Degenerative arthritis see **Osteoarthritis**

Dehydration

Definition

Dehydration is the excessive loss of water from body tissues accompanied by an imbalance in essential electrolytes, such as sodium, potassium, and chloride.

Description

Dehydration occurs when the body loses more fluid than it takes in. Dehydration can be caused by illness, injury, **infection**, prolonged exposure to sun or high temperatures, inadequate water intake, or overuse of diuretics or other medications that increase urination.

Water is distributed throughout three compartments in the body: inside the cells (intracellular), in the tissue (interstitial), and in the bloodstream (intravascular). Each compartment contains differing amounts of electrolytes that must remain in balance in order for body organs and systems to function correctly. Dehydration upsets this delicate balance. Total body water also varies in relation to age, gender, and amount of body fat. Adult males have approximately 60% water content, adult females have

50%, infants have an estimated 77%, and the elderly have 46% to 52%. An increase in body fat causes a decrease in the percent fluid content because fat does not contain significant amounts of water.

Causes and symptoms

Different types of dehydration have different causes. When managing patients with dehydration, the type of water loss must be determined to ensure appropriate treatment. In addition, water and sodium levels in the body are closely related; if one is abnormal, the other often is too.

Isotonic dehydration is an equal loss of water and sodium. Isotonic means that the number of particles contained on one side of a permeable membrane is the same as on the other side, thus there is no fluid shift in either direction. The amount of intracellular and extracellular water remains in balance. This can be caused by a complete fast, vomiting, and **diarrhea**.

Hypertonic dehydration occurs when water loss is greater than sodium loss. **Blood** sodium levels may be >145 mmol/l (normal range=135 to 145 mmol/l). Higher blood sodium levels combined with decreased water in the intravascular space increases the osmotic pressure in the bloodstream, which, in turn, pulls more fluid out of the cells. This type of dehydration is usually caused by extended **fever** with limited oral rehydration. Mortality is more likely to occur from hypertonic than from isotonic dehydration.

Hypotonic dehydration occurs when sodium loss is greater than water loss. Blood sodium levels may be less than 135 mmol/l; and the osmotic pressure is greater inside the cells, which pulls more fluid out of the intravascular space into the intracellular space. This type of dehydration occurs with overuse of diuretics, which causes excessive sodium and potassium loss. Potassium depletion affects respiration, increases nausea, and, if severe enough, may cause respiratory arrest or **central nervous system** (CNS) seizures. Potassium depletion may also cause arrhythmias (an alteration in the heart-beat). As a result, patients are told to take diuretics with orange juice or to eat a banana, both of which are high in potassium.

Strenuous activity, excessive sweating, prolonged time in the sun, and extended vomiting or diarrhea cause fluid loss. Elderly people who move to warm, dry climates frequently become dehydrated because of the climate change combined with a tendency to not drink enough water. Large amounts of fluid can also be lost from prolonged fever. Healthy people require about 1 milliliter of water for each calorie their body metabo-

lizes; but during a fever the metabolic rate increases by seven percent for each 1°F rise in body temperature. Fever also increases the respiratory rate, resulting in additional water loss from the **lungs**. Further causes of fluid loss that may be overlooked include **caffeine** and alcohol consumption, which increase urination and fluid excretion.

Decreased oral intake of fluids is a common cause of dehydration and often occurs during times of appetite loss from illness or after oral surgery or injury. The elderly are at high risk for decreased intake because their thirst mechanism may no longer function or they may be physically unable to get a drink. Infants, another high-risk group, are more likely to develop dehydration than adults because they have a higher metabolic rate and their immature **kidneys** have difficulty concentrating urine. Children who do not wet their diapers for three hours or more are dehydrated. Dehydration is also associated with disorders of the **adrenal glands**, which regulate water-electrolyte balance; **diabetes mellitus**; eating disorders; renal disease; and chronic lung disease.

Symptoms of dehydration at any age may include some or all of the following: cracked lips, dry or sticky mucous membranes, sunken eyes, lethargy, and/or confusion. Urine output is minimal and the skin loses its elasticity (turgor) and is slow to return to its normal position after being raised off the back of the hand (tenting). The **heart** rate and respiratory rate may be elevated. A dehydrated infant may not shed tears when crying and may have a depressed fontanel (soft spot on their head), although recent studies have shown that a depressed fontanel is not an accurate indicator of dehydration.

Diagnosis

The general diagnosis of dehydration can be made based on the patient's symptoms and medical history. **Physical examination** may reveal any of the symptoms mentioned above, along with **shock**, rapid heart rate, and low **blood pressure**. Blood tests are required to determine what deficiency exists (or what is elevated) so that therapy for electrolyte replacement can be planned. Blood tests to check electrolyte levels and urine tests such as urine specific gravity are used to evaluate the severity of the fluid loss. Other laboratory tests may be ordered to determine if an underlying condition (e.g., diabetes or an adrenal gland disorder) is the cause.

Treatment

Increased fluid intake and replacement of lost electrolytes are usually sufficient to restore **fluid balance** in patients who are mildly or moderately dehydrated. For

individuals who are mildly dehydrated, just drinking plain water may be all the treatment that is needed. Adults may replace lost electrolytes by drinking sports beverages, such as Gatorade or Recharge. Parents should follow label instructions when giving children Pedialyte or other commercial products recommended for the treatment of dehydration in children. Children who are dehydrated should be given only clear fluids for the first 24 hours.

A child who is vomiting should sip one or two teaspoons of liquid every 10 minutes. A child who is less than a year old and who is not vomiting should be given one tablespoon of liquid every 20 minutes. A child who is more than one year old and who is not vomiting should take two tablespoons of liquid every 30 minutes. A baby who is being breast-fed should be given clear liquids for two consecutive feedings before breastfeeding is resumed. A bottle-fed baby should be given formula diluted with water to half the formula strength for the first 24 hours after symptoms of dehydration are identified.

To calculate fluid loss accurately, weight changes should be charted every day and a record kept of how many times a patient vomits or has diarrhea. A record of fluid output (including sputum or vomit) and of fluid intake or replacement should be kept for at least 24 to 48 hours to see if balance is being accomplished. Parents should note how many times a baby's diaper must be changed. If dehydration continues, emergency department treatment or hospitalization to receive intravenous fluids and electrolytes may be necessary.

Children and adults can gradually return to their normal diet after they have stopped vomiting and no longer have diarrhea. Gelatin is often a welcomed substitute for additional water and does count as fluid replacement. Bland foods should be reintroduced first, with other foods added as the **digestive system** is able to tolerate them. Milk, ice cream, cheese, and butter should not be eaten until 72 hours after symptoms have disappeared.

When treating dehydration, the underlying cause must be addressed. For example, if dehydration is caused by vomiting or diarrhea, medications should be prescribed to resolve these symptoms. Patients who are dehydrated due to diabetes, kidney disease, or adrenal gland disorders must receive treatment for these conditions as well as for the resulting dehydration. If dehydration is being caused by diuretics, a dose adjustment made by the physician or a change to a different diuretic may be necessary.

Prognosis

Mild dehydration rarely results in complications. If the cause is eliminated and lost fluid is replaced, mild dehydration can usually be resolved in 24 to 48 hours. Vomiting and diarrhea that continue for several days without adequate fluid replacement can be fatal since more is lost than water and sodium. Severe potassium loss may lead to cardiac arrhythmias, respiratory distress or arrest, or convulsions (seizures). The risk of life-threatening complications is greater for young children and the elderly. However, dehydration that is rapidly recognized and treated has a good outcome.

Health care team roles

The nurse and the physician have the greatest responsibility in recognizing and treating dehydration. For hospitalized patients, the physician should order appropriate fluid and electrolyte replacement and the nurse should ensure that the correct fluids are given to the patient. The nurse should monitor the patient for signs that the dehydration (e.g., decrease in fever, increase in blood pressure, reduced heart rate) is resolving and should notify the physician if it is not.

Blood tests used to diagnose dehydration are collected by specially trained nursing assistants or by laboratory technicians. Outpatient samples in a physician's office may be taken by the nurse or a technician. In some institutions, the nurse collects the blood sample. Usually, urine samples are collected by the nurse, and results calculated by the laboratory technician.

Prevention

Patients who are vomiting or who have diarrhea can prevent dehydration by drinking enough fluid to keep their urine the color of pale straw. Infants and young children with diarrhea and vomiting can be given electrolyte solutions such as Pedialyte to help prevent dehydration, as well as suppository medication to stop the vomiting. People who are not ill can maintain proper fluid balance by drinking several glasses of water before going outside on a hot day. It is also a good idea to avoid coffee and tea, which increase body temperature and water loss.

Patients should ask a pharmacist whether or not any medications they are taking may cause dehydration and what to do to prevent it other than adequate fluid intake. Prompt medical attention should be sought to correct any underlying condition that increases the risk of dehydration.

KEY TERMS

Extracellular—Outside the cells.

Hypertonic—One solution having a greater amount of solute (dissolved substance in a solution) than another solution, thus it exerts more osmotic pressure than the second solution and the body will attempt to equalize pressure by passing fluid through the cell membranes.

Hypotonic—One solution having a lesser amount of solute than another solution, thus it exerts less osmotic pressure than the second solution.

Intracellular—Inside the cells.

Isotonic—Two solutions exerting the same amount of osmotic pressure on a cell membrane.

Osmotic pressure—The pressure exerted on a semipermeable membrane that separates two solutions and the particles they contain.

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Dementia

Definition

Dementia is a condition characterized by a progressive, irreversible decline in mental ability, accompanied by changes in behavior and personality. There is commonly a loss of **memory** and skills that are required to carry out activities of daily living.

Description

Dementia is a group of symptoms caused by the gradual death of **brain** cells. The loss of cognitive abilities that occurs with dementia leads to impairments in memory, reasoning, planning, and personality. Dementia can occur at any age and may affect younger people as the result of disease such as **AIDS**, hypoxia (a deficiency of oxygen reaching the tissues of the body), or injury. However, it is primarily a disease of the elderly, affecting more than 15% of those over 65 years of age, and as many as 40% of those over the age of 80. The condition is somewhat more common among women than men. Some studies suggest that the risk for dementia is higher for African Americans and Hispanic Americans than it is for Caucasians. More than half of all nursing home admissions occur because of dementia.

While the overwhelming majority of people with dementia are elderly, it is not an inevitable part of aging. One of the challenges for health care professionals is to differentiate the early-stage cognitive deficits of dementia from normal age-related memory impairment. Persons with age-related memory impairment may tend to learn new information more slowly; but, if they are given additional time, their cognitive performance is usually adequate. Other problems that may be mistakenly labeled dementia include delirium, psychosis, depression, and the side effects of various medications.

Dementia presents a major health problem for the United States because of its huge impact on individuals and their families, the health care system, and society overall. The costs of dementia are considerable. While most people with the disease are retired and do not suffer income losses, the cost of care is often enormous. Financial burdens include lost wages for family caregivers, medical supplies and drugs, and home modifications to ensure safety. Nursing **home care** may cost several thousand dollars a month or more. As of 1998, the cost of caring for Alzheimer's dementia patients alone was estimated to be slightly over \$50 billion. The psychological costs are not as easily quantifiable, but can be even more profound. The person with dementia loses control of many of the essential features of life and personality, and loved ones lose a family member even as they continue to cope with the burdens of increasing dependence and unpredictability.

Causes and symptoms

Causes

Dementia is usually caused by degeneration in the cerebral cortex, the part of the brain responsible for thoughts, memories, actions, and personality. Death of

brain cells in this region leads to the cognitive impairment that characterizes dementia. Dementia may be caused by a variety of illnesses.

The most common cause of dementia is Alzheimer's disease (AD), accounting for half to three-quarters of all cases.

Vascular dementia accounts for 5–30% of all dementias in the United States. It occurs from a decrease in **blood** flow to the brain, most commonly due to a series of small strokes (multi-infarct dementia). Other cerebrovascular causes include vasculitis from syphilis, Lyme disease, or systemic lupus erythematosus; subdural hematoma; and subarachnoid hemorrhage. Because of the usually sudden nature of its cause, the symptoms of vascular dementia tend to appear more abruptly than those of Alzheimer's dementia. Symptoms may progress with the occurrence of new strokes. Unlike AD, the incidence of vascular dementia decreases after the age of 75.

Other conditions that may cause dementia include:

- AIDS
- Parkinson's disease
- Lewy body disease
- Pick's disease
- Huntington's disease
- Creutzfeldt-Jakob disease
- brain tumors
- hydrocephalus
- head trauma
- prolonged abuse of alcohol or other drugs
- **vitamin B₁₂** deficiency
- hypothyroidism
- hypercalcemia

Symptoms

Dementia is marked by a gradual decline of thought and other mental activities. The onset may be slow, occurring over months or years. The slow progression of dementia is in contrast with delirium, which involves some of the same symptoms, but has a very rapid onset and fluctuating course with alteration in the level of consciousness. However, delirium may occur along with dementia, especially since the person with dementia is more susceptible to the delirium-inducing effects of many types of drugs.

Symptoms of dementia may include:

- Memory losses: Memory loss is usually the first symptom noticed. It may begin with misplacing valuables

such as a wallet or car keys, then progress to situations such as forgetting appointments, where the car was left, or the route home. More profound losses follow, such as forgetting the names and faces of family members.

- **Impaired abstraction and planning:** The person with dementia may lose the ability to perform familiar tasks, to plan activities, and to draw simple conclusions from facts.
- **Language and comprehension disturbances:** The person may be unable to understand instructions, or follow the logic of moderately complex sentences. Later, the individual may not be able to understand his or her own sentences, and have difficulty forming thoughts into words.
- **Poor judgment:** The person may not recognize the consequences of his or her actions or be able to evaluate the appropriateness of behavior. Behavior may become ribald, overly friendly, or aggressive. Personal hygiene may be ignored.
- **Impaired orientation:** The person may not be able to identify the time of day, even from obvious visual clues; or may not recognize a location, even if familiar. This disability may stem partly from losses of memory and partly from impaired abstraction.
- **Decreased attention and increased restlessness:** These symptoms may cause the person with dementia to begin an activity and quickly lose interest, and to wander frequently. Wandering may cause significant safety problems, when combined with disorientation and memory losses. The person may begin to cook something on the stove, then become distracted and wander away while it is cooking.
- **Personality changes and psychosis:** The person may lose interest in once pleasurable activities, and become more passive, depressed, or anxious. Delusions, suspicion, paranoia, and hallucinations may occur later in the disease. Sleep disturbances may occur, including insomnia and sleep interruptions.

Diagnosis

Since dementia usually progresses slowly, diagnosing it in the early stages can prove difficult. However, as the elderly population grows and the prevalence of dementia increases, the importance of recognizing the early symptoms has become imperative.

Dementia may be suspected by the health care professional if memory deficits are exhibited during an examination or assessment. Information from the family members, friends, and caregivers may point to dementia as well. Diagnosis begins with a thorough physical exam

and complete medical history. A family history of either **Alzheimer's disease** or cerebrovascular disease may provide clues to the cause of symptoms. Simple tests of mental function, including word recall, object naming, and number-symbol matching, are used to track changes in the person's cognitive ability. If dementia is suspected, a complete review of medications and an assessment for chronic disease processes are indicated. If the patient shows no improvement after eliminating unnecessary medications and treating the chronic disease, then other tests are warranted. **Physical examination** and a variety of laboratory tests may rule out potentially treatable causes of dementia. These may include **hearing** or visual deficits, hypothyroidism, vitamin B₁₂ deficiency, and depression. Some of the laboratory tests that might be performed include a complete blood cell count and **urinalysis** (to rule out **infection**), serum electrolytes, glucose and **calcium** levels, and kidney and **liver function tests**.

The use of computed tomography (CT) or **magnetic resonance imaging** (MRI) to rule out vascular disease is somewhat controversial, since even if a cause is discovered, less than 11% of patients with cognitive decline have partially or fully reversible disease.

Treatment

Treatment of dementia starts with treatment of the underlying disease, where possible. The underlying causes of nutritional, hormonal, tumor-caused, and drug-related dementias may be reversible to some extent. Treatment for stroke-related dementia begins by minimizing the risk of further strokes, including smoking cessation, aspirin therapy, and treatment of **hypertension**. There are no known therapies that can reverse the progression of Alzheimer's disease.

Early intervention may allow the patient to compensate for the alterations in functioning, help to minimize complications, and have an improved quality of life. It may also allow the patient and family to plan for the future and to identify resources.

Periodically, new drugs are studied for the treatment of dementia. The only drugs currently approved for the symptomatic treatment of AD are tacrine (Cognex) and donepezil (Aricept). These drugs act by slowing down the degradation of neurotransmitters. They may provide temporary improvement in cognitive functioning for about 40% of patients with mild-to-moderate AD. However, drug therapy can be complicated by forgetfulness, especially if the drug must be taken several times a day.

Psychotic symptoms, including paranoia, delusions, and hallucinations, may be treated with **antipsychotic**

KEY TERMS

Amyloid plaques—Abnormal structures composed of parts of nerve cells surrounding protein deposits, found in the brains of persons with Alzheimer’s disease.

Neurofibrillary tangles—Abnormal structures composed of twisted masses of protein fibers within nerve cells, found in the brains of persons with Alzheimer’s disease.

drugs such as haloperidol, chlorpromazine, risperidone, and clozapine. Side effects of these drugs can be significant. Anti-anxiety drugs such as Valium may improve behavioral symptoms, especially agitation and **anxiety**, although BuSpar has fewer side effects. The anticonvulsant carbamazepine is also sometimes prescribed for agitation. Depression is treated with antidepressants, usually beginning with selective serotonin reuptake inhibitors (SSRIs) such as Prozac or Paxil.

In general, medications should be administered very cautiously to demented patients, in the lowest possible effective doses, to minimize side effects. Supervision of taking medications is generally required.

The primary goals of treatment for progressive dementia are to preserve as much functioning and independence as possible, and to maintain quality of life as long as possible. It is important that the patient and caregivers are aware that caring for a person with dementia can be difficult and complex. The patient must learn to cope with functional and cognitive limitations, while family members or other caregivers may need to assume increasing responsibility for the person’s physical needs. The patient and family should be educated early on in the disease progression to help them anticipate and plan for inevitable changes.

Behavioral approaches may be used to reduce the frequency or severity of problem behaviors such as aggression or socially inappropriate conduct. Problem behavior may be a reaction to frustration or over-stimulation. Understanding and modifying the situations that trigger it can be effective; strategies may include breaking down complex tasks such as dressing or feeding into simpler steps, or reducing the amount of activity in the environment to avoid confusion and agitation. Pleasurable activities such as crafts, games, and music can provide therapeutic stimulation and improve mood.

Modifying the environment can increase safety and comfort while decreasing agitation. Home modifications

for safety include removal or lock-up of hazards such as sharp knives, dangerous chemicals, and tools. Childproof latches may be used to limit access as well. Bed rails and bathroom safety rails can be important safety measures. Confusion may be reduced with the use of simpler decorative schemes and the presence of familiar objects. Covering or disguising doors may reduce the tendency to wander. Positioning the bed in view of the bathroom can decrease incontinence.

Long-term institutional care may be required for the person with dementia, as profound cognitive losses often precede death by a number of years. Early planning for the financial burden of nursing home care is critical. Useful information about financial planning for long-term care is available through the Alzheimer’s Association.

Family members or others caring for a person with dementia are often subject to extreme **stress**, and may develop feelings of anger, resentment, guilt, and hopelessness, in addition to the sorrow they feel for their loved one and for themselves. Depression is an extremely common consequence of being a full-time caregiver for a person with dementia. Support groups can be an important way to deal with the stress of caregiving. Contact numbers are available from the Alzheimer’s Association; they may also be available through a local social service agency.

Prognosis

The prognosis for dementia depends on the underlying disease. On average, people with Alzheimer’s disease live eight years past their diagnosis, with a range from one to 20 years. Vascular dementia is usually progressive, with death resulting from stroke, infection, or **heart** disease.

Health care team roles

Any member of the health care team may work with patients with dementia. The physician normally makes the diagnosis. Laboratory technicians may obtain laboratory tests, and radiology technicians may perform imaging studies, if ordered. Nurses assess patients and how dementia affects their functioning. **Patient education** is very important in managing dementia and is a nursing responsibility.

Prevention

There is no known way to prevent AD, although several drugs under investigation may reduce its risk or slow its progression. The risk of developing multi-infarct

dementia may be avoided by reducing the overall risk for strokes.

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Alzheimer’s Disease Education and Referral Center (ADEAR). P.O. Box 8250, Silver Spring, MD 20907-8250. (800) 438-4380. <<http://www.alzheimers.org>>.

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Demyelinating disease see **Multiple sclerosis**

Dental abscess

Definition

A dental **abscess** is a localized collection of pus in a cavity formed by the disintegration of tissues from a bacterial **infection**.

Description

Dental abscesses occur when a small area of tissue becomes infected and the body is able to “wall off” the infection and keep it from spreading. White **blood** cells, the body’s defense against some types of infection, migrate through the walls of the **blood vessels** in the area of the infection and collect within the damaged tissue. During this process pus forms, which is an accumulation of fluid, living and dead white blood cells, dead (necrotic) tissue and **bacteria**, or any other foreign invaders or materials; popcorn hulls, calculus, etc. This pus pocket is the abscess, characterized by swelling, redness, and **pain**.

The swollen area can rupture, allowing the pus to drain, but it will return if the cause of infection is not removed. As an abscess develops, the bacteria and host cells cause rapid destruction of connective tissues around the tooth and into the jawbone. Abscesses can be acute or chronic, with the acute abscess being the most painful. A chronic abscess may produce a dull pain with intermittent swelling, but can develop into an acute abscess at any time.

The most common types of dental abscesses are:

- Periapical abscess: located at the apex of an infected tooth surrounding the roots.
- Periodontal abscess: located in the periodontal ligament (PDL) surrounding the tooth.

Studies by the American Academy of Periodontology (AAP) find that periapical abscesses can occur on any tooth that has severe decay or is broken or chipped, but periodontal abscesses commonly involve the mandibular and maxillary first molars, maxillary incisors, and cuspids, followed by maxillary second molars.

Causes and symptoms

Periapical abscesses usually result from **dental caries** that allow bacteria to infect the center area of the tooth (pulp). But they can also occur after a traumatic injury to the tooth resulting in necrosis (death) of the pulp. This infection may spread out from the root of the tooth to the bones supporting the tooth, causing an abscess. This type of abscess is extremely painful and very sensitive to cold and hot, and to the touch. Acute inflammation of the apex commonly occurs with the tooth seeming to be slightly extruded from its socket. The patient may also have a **fever** and redness of the cheeks and gum tissue. The abscess itself may feel hot and hard to the touch. The bigger the abscess gets, the more painful it becomes.

A periodontal abscess occurs where pre-existing **periodontitis** is present. This infection occurs in the walls of the periodontal pocket as a result of bacterial invasion into the periodontal tissue. While abscesses usually spontaneously occur in patients with untreated periodontitis, they are more common in periodontitis patients with a systemic disease, in which there is a reduced ability to combat infections, such as individuals with diabetes or HIV, or patients on **chemotherapy**.

Periodontal abscesses are generally not sensitive to heat, and the pain is not as severe as with a periapical abscess, but the discomfort level is constant. They appear red, edematous (swollen), shiny, and very sensitive to the touch.

Other symptoms of a dental abscess include:

- earache
- general ill feeling
- bad breath or foul taste in mouth
- fever
- continuous or throbbing pain

Diagnosis

When a patient has swelling and pain it is necessary to locate the exact region causing the pain. X rays greatly aid in locating the tooth or teeth in question. Hot and cold tests may be performed by touching the teeth with ice or heated instruments. This helps to pinpoint the exact location of the pain and to determine the type of abscess. Percussion tests may also be done by tapping the teeth in question lightly with the small end of an explorer. After diagnosis, the general dentist may choose to treat the abscess, but may also refer the patient to an endodontist or periodontist. The entire treatment may take a number of visits to complete depending on the severity of the abscess.

The cost for treatment of a periapical abscess is normally covered under dental insurance at 80%. The cost is usually a few hundred dollars or more if the patient is referred to an endodontist because of the specialty field. The insurance then only covers a certain amount of the usual and customary charge (UCR), commonly about 50%. A patient has to consider whether to have a general dentist treat the abscess, or whether to pay the extra cost to have a specialist perform the treatment. Usually having a specialist treatment the abscess is worth the extra cost in the long run.

For a periodontal abscess, a dental hygienist may perform the necessary scaling and root planing required to treat this condition. The cost for periodontal abscess treatment is commonly covered by dental insurance at 80%. Even when treated by a periodontist, insurance normally covers the treatment at 80% because a periodontal abscess is considered part of the periodontal disease for which the patient is already being seen by the specialist.

Treatment

The goal of treating a dental abscess is to eliminate the infection while preserving the teeth and to prevent any complications. Releasing the direct pressure of the infection build up is the first step in the treatment.

With a periapical abscess, the pus is drained through an incision in the gum tissue, or by enlarging the hole in the tooth. This alleviates the pain and the tissue swelling.

During this process the patient is given a local anesthetic to minimize the pain. Often with a periapical abscess, the infection is severe and pain is so intense that the anesthetic is injected into the tooth or infected area for immediate relief. Extraction of the tooth is sometimes required, especially if an injury to the tooth has fractured through the bifurcation area and saving the tooth is not possible.

The principle treatment for a periodontal abscess is to establish drainage of the inflammation and to eliminate the infective agent. Anesthetics are required because of the pain involved and the discomfort caused by scaling and root planing. Careful insertion of a dull probe into the pus pocket along the tooth will usually produce the drainage needed and the symptoms normally dissipate. Scaling and root planing through the periodontal pocket to rid the area of the cause of the infection is necessary.

If necessary, surgical procedures may be undertaken. Surgery aims at pocket reduction if not elimination. An incision into the gum tissue and the laying open of a flap of tissue may be necessary in order to reach the infection more easily. Surgery must be gentle and efforts are made to avoid damage to the remaining periodontal attachment. As soon as the etiologic factors have been eliminated the swelling is reduced.

The healing process is usually uneventful and regeneration frequently occurs. The abscess will recur unless the cause of the infection is removed and the depth of the pocket is reduced. Extraction of the tooth is indicated after the acute symptoms have subsided, but in some cases, normal tissue contours cannot be developed and maintained.

In cases where the periodontal destruction approaches the periapical region of the tooth (the apex) the patient may develop pulpitis. Treatment may cause the patient to experience pain and discomfort following the root planing treatment and treatment for pulpitis will need to be completed, usually with **root canal therapy**.

Antibiotics are vital in ridding the system of any infection for both periapical and periodontal abscesses. If the infection is not eliminated the abscesses will recur with a stronger infection and more severe symptoms.

The types of antibiotics prescribed for acute abscesses include:

- Penicillin VK: an initial dose of 1000 mg followed by 500 mg four times daily for seven days.
- Amoxicillin (Augmentin): 250 mg three times daily for ten days.
- Erythromycin: 1000 mg first followed by 500 mg four times daily for seven days (for patients allergic to penicillin).

For chronic infections or infections with an inadequate response to penicillin, clindamycin is often prescribed (300 mg daily for seven days).

Warm salt-water rinses can soothe the gum tissue and help with the healing process. Over-the-counter medication can be taken for pain along with the antibiotics. Medications such as acetaminophen (Tylenol) reduce fever (if any) and pain. Anti-inflammatory medicines such as ibuprofen (Motrin and Advil) aid in reducing fever and also help reduce swelling and inflammation in the tissue.

Prognosis

While the loss of periodontal attachment is commonly rapid during an acute periodontal abscess, the potential for repair and healing is very high if the abscess is treated quickly and appropriately. The prognosis for a periapical abscess is similar, if it is treated quickly and appropriately with the elimination of the infection that is causing the abscess.

Health care team roles

The role of the dentist is vital in combating the infection of a dental abscess. The patient needs to be educated that abscesses and infections of the mouth do not subside on their own without recurrence. An endodontist should be consulted if a periapical abscess needs to be treated. A periodontist should be consulted if an existing condition of periodontitis is being treated. Each type of dentist needs to have a good working relationship with the patient.

The dental hygienist can complete the scaling and root planing of the abscessed area in the dental office or the periodontist's office. Dental assistants can aid in taking x rays of the area needing treatment and in sterilization of the instruments. The front desk is the first to greet a patient and the last to see a patient leave. Having a warm and courteous front office is vital to any dental office where treating disease, emergencies, and healing of patients is accomplished. All roles are important to the successful functioning of the health care team and good patient care.

Prevention

Dental abscesses can be prevented with regular dental care, including daily brushing and flossing, and regular dental check ups and cleaning. Wearing mouth guards during sports is one of the best ways to prevent an injury and trauma to the mouth.

KEY TERMS

Acute—Extremely sharp or severe, reaching a crisis rapidly.

Apex—The point at the end of the root of a tooth in the gum tissue.

Bifurcation—The area where the roots of the teeth separate into individual roots.

Calculus—Calcium deposits on teeth from the build up of plaque.

Chronic—Of long duration or frequent recurrence.

Cuspids—The teeth that are considered the cornerstone teeth of the mouth on the upper and lower jaws. More commonly known as the “eye” teeth.

Dental caries—Dental decay.

Edematous (edema)—An abnormal accumulation of serous fluid in the tissue.

Endodontist—A dentist who specializes in the diagnosis and treatment of disorders affecting the inside structures of the tooth.

Extraction—Surgical removal of a tooth.

Incisors—The teeth on the upper jaw right and left sides that sit next to the central front teeth.

Mandibular—Relating to the lower jaw region.

Maxillary—Relating to the upper jaw region.

Necrotic, necrosis—Pathologic death of tissue.

Periodontal—Tissue and structures that surround and support the teeth.

Periodontist—A dentist with specialized training for periodontal treatment and care.

Pulpitis—Inflammation of the pulp of a tooth involving the blood vessels and nerves.

Root canal—The space within a tooth that runs from the pulp chamber to the tip of the root.

Root canal therapy—The process of removing diseased or damaged pulp from a tooth, then filling and sealing the pulp chamber and root canals.

Root planing—Making the tooth smooth by removing built up calculus and tartar from below the gum tissue.

Scaling—The removal of food and debris from the portion of the tooth above the gum line.

Prosthodontist—A dentist with specialized training in crown and bridge treatment.

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American Dental Association (ADA), 211 East Chicago Avenue, Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org>>.

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Cindy F. Ovard, RDA

Dental anatomy

Definition

Dental anatomy is the study of the classification and morphology of teeth, as well as the study of the principles of occlusion.

Description

Dental anatomy may be considered the study of teeth at three different levels. First, teeth may be studied in terms of the elements of each individual tooth (for example, dentin and enamel). Second, teeth may be studied in terms of classification and numbering systems. Third, teeth may be studied in the larger context of the oral cavity, along with the principles of occlusion and structures that may display pathology such as the gingiva and the temporomandibular joint.

Teeth

The teeth are derived from the ectoderm and the mesoderm in the embryonic stages of development. Each tooth arises from either the maxilla (the bone that makes up the upper jaw) or the mandible (the bone that makes up the lower jaw). Teeth originating from the maxilla are considered to be in the superior dental arch, or the maxillary dental arch. Teeth arising from the mandible are considered to be in the inferior dental arch, also known as the mandibular dental arch.

Each tooth consists of:

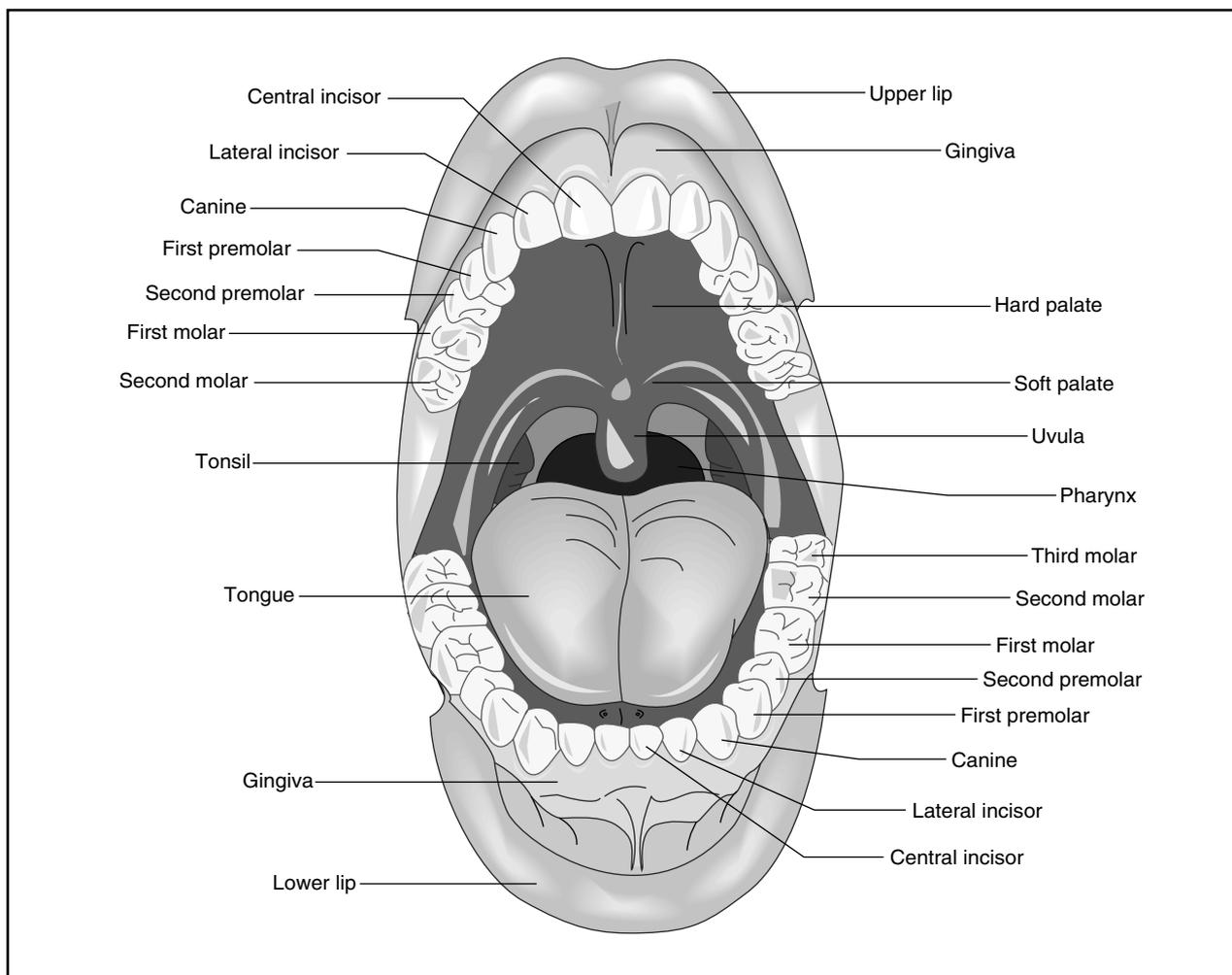
- **Crown:** The visible portion of a tooth.
- **Root:** The portion of the tooth embedded in the gum.
- **Pulp:** Located in the center of the tooth, it contains the arteries, veins, nerves and lymphatic tissue.
- **Blood vessels:** They carry nutrients to the pulp.
- **Root canal:** The canal in the root of the tooth is where the nerve and **blood** vessels travel with nutrients to the tooth from the mandible or the maxilla.
- **Ligament:** The connective tissue that surrounds the root of a tooth and connects it to the maxilla or mandible.
- **Bone:** Alveolar bone forms tooth socket and part of the teeth.
- **Cementum:** The layer of tissue covering the dentin on the root of the tooth. Serves the same role as enamel.
- **Dentin:** The calcified tissue underlying the enamel (on the crown) and cementum (on the root), making up the main bulk of the tooth.
- **Enamel:** The calcified outer layer of the crown of the tooth.

Although each tooth has the same basic structure, some variation exists. Different types of teeth have variation in their roots. Incisors and cuspids have only one root. Maxillary (upper) premolar teeth commonly have two roots, whereas the mandibular premolars commonly have one. The premolars may also have two roots fused to look as one. The molars on the maxillary arch have three roots, while, on the other hand, the molars on the mandibular arch have two roots.

Tooth types

Permanent teeth are divided into four groups based on their function and placement in the jaw. Teeth are given the same name whether they are in the upper or lower jaw. From medial (middle of the mouth) to lateral, the four types of teeth are listed below:

- **Incisors** cut the food. They are divided into central and lateral. They are the two most medial teeth on either



Major structures of the oral cavity. The maxillary third molars are missing in this adult dentition. (Delmar Publishers, Inc. Reproduced by permission.)

side (left and right) in the upper and lower jaw, for a total of eight.

- Cuspids also known as canines, cut and tear the food. They are the third teeth from the center, and there are a total of four (two upper, two lower).
- Pre-molars seize and shear the food. They are also known as bicuspid because they have two cusps, or projections on the surface of the teeth. There are eight total (four upper, four lower) between the cuspids and the molars.
- Molars grind the food. They are the most lateral teeth. There are a total of twelve, including the four “third molars” also known as wisdom teeth.

Children who still have their temporary teeth (also known as primary, deciduous, or “baby” teeth) have incisors (four upper, four lower), cuspids (two upper, two

lower), and molars (four upper and four lower), but lack pre-molars. There are 20 total primary teeth.

Tooth classification and numbering systems

Universal tooth numbering and classification allows health care professionals to discuss and identify teeth with a measure of certainty. Permanent dentition has a universal numbering system that begins by splitting the mouth into four quadrants; the upper right quadrant, the upper left quadrant, the lower right quadrant, and the lower left quadrant. Each quadrant contains eight teeth. The upper right quadrant consists of the eight teeth on the upper right side of the mouth from the third molar (wisdom tooth) to the right central incisor. The upper left quadrant is the same except on the left portion of the mouth from the third molar (wisdom tooth) to the left central incisor. The lower right quadrant consists of the

KEY TERMS

Gingiva—The gum tissue surrounding the teeth.

Mandible—The bone that helps make up the lower jaw of the mouth.

Mastication—Chewing and biting of the food in the mouth.

Maxilla—The bone that helps make up the upper jaw of the mouth.

Occlusal—Biting surface of the teeth.

teeth from the third molar on the lower left to the lower right central incisor. The same with the lower left quadrant from the third molar on the lower left to the lower left central incisor. Each quadrant can be named using acronyms; upper right (UR), upper left (UL), lower right (LR), lower left (LL).

General dentists generally number the teeth, beginning with the third molar in the upper right quadrant (number one), crossing to the upper left quadrant (the third molar is number 16), proceeding to the lower left quadrant (the third molar is number 17), and ending in the lower right quadrant with the third molar number 32 (third molars are known more commonly as the wisdom teeth). In contrast, orthodontists and oral surgeons use the acronyms of quadrants to help identify teeth, and number the teeth from medial to lateral (one to eight). Thus the upper right first (or central) incisor is also known as UR1, whereas the upper left third molar is known as UL8. LL5 would be the lower left second premolar and LR6 is the lower right first molar.

Primary, or temporary, teeth are systematically lettered in an alphabetical order beginning with A on the upper right quadrant, ending with J for the second molar in the upper right quadrant, proceeding with K for the second molar in the lower left quadrant, and ending with T for the second molar in the lower right quadrant. Primary teeth consist of twenty teeth total; ten on the maxilla and ten on the mandible

Occlusion

When discussing occlusion, one is essentially discussing the operation and conjunction of the teeth at rest and in the process of mastication (chewing). Two important elements in mastication are the muscles involved, and the temporomandibular joint.

MUSCLES. The four main mandibular muscles for dental anatomy are the:

- **Masseter:** The main muscle for the movement of the mandible for chewing.
- **Temporalis:** Maintains the position of the mandible at rest when a person is upright. During chewing it pulls the mandible back into the rest position.
- **Lateral pterygoid:** This muscle has a horizontal position and is the prime mover of the mandible into a protrusive position.
- **Medial pterygoid:** Works with the masseter muscle to aid in the elevation of the mandible. It is almost a mirror image of the masseter muscle—it gives extra aid in chewing.

TEMPOROMANDIBULAR JOINT. Also known as the TMJ, this is the connecting hinge between the lower jaw (the mandible) and the bone at the (lateral) base of the **skull** (the temporal bone). This joint is very fragile. A meniscus (piece of cartilage) separates the lower jawbone from the socket where it rests. Tendons, ligaments and muscles hold the TMJ in position. TMJ disorders can arise from **pain** because of muscle dysfunction (myofascial pain), pain because of degenerative bone disease (like arthritis), pain because of a broken bone, pain arising from dislocation of the meniscus, or pain arising from the dislocated joint. These dysfunctions can result in headaches, jaw soreness, neckaches and pain when chewing (often accompanied with a noise). Bite splints may be used to treat TMJ disorders caused by dislocation. Other therapies, ranging from isometric muscle exercises to oral surgery, may be required, based on the nature and severity of the TMJ disorder.

Gingiva

Normal, healthy gingiva may appear smooth or stippled. Known also as the gum tissue of the mouth, the gingiva shows the first signs of periodontal disease. Daily brushing and flossing help keep the gingiva healthy.

Function

Dental anatomy serves the important function of mechanical disruption and processing of food.

Role in human health

Properly functioning dental anatomy is essential for one of the first stages of food digestion—chewing. Chewing is essential for human health because (most) food is not prepared in a readily digestible form. Chewing increases the total surface area of the food by breaking it into smaller pieces, which allows more food to be digested. Chewing also breaks down any less-digestible barriers which may hinder absorption of food

in the gastrointestinal tract. For example, even after an orange is peeled, thin membranous tissue still surrounds the juicy, fruity portion of the orange. Chewing breaks down that barrier, making the nutrients inside much more accessible.

Common diseases and disorders

The most common childhood disease of the dentition is tooth decay. The **bacteria** demineralizes the enamel and dentin of the teeth, causing pain and swelling of the surrounding tissue if left untreated. Periodontal disease is a common disease among older adults associated with infectious bacteria affecting the tissues that support the teeth. Temporomandibular joint (TMJ) disorders cause pain to patients upon talking or chewing. TMJ disorders are commonly found in patients with physical, emotional, and social problems, as well as in individuals who experience work-related **stress**. Many types of TMJ have an excellent prognosis if treated.

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Dental and periodontal charting

Definition

Dental and periodontal charting provide a graphic description of the conditions in a patient's mouth, including caries (i.e., decay), restorations, missing or malposed teeth, clinical attachment levels, furcation (root) involvement, mobility, pocket depths, bleeding sites, and other deviations from normal. Other conditions that may be charted include erosion, abrasion, developmental anomalies and use of prostheses.

Purpose

Thorough charting of both visual and radiographic findings allows dental practitioners to collate information needed to assess the patient's level of dental and periodontal health or disease. Charting should be updated with each visit to follow the patient's progress with **home care**, monitor disease progression, and to track completed dental procedures.

Description

Dental charting is part of both initial and periodic dental examinations, and is included in the cost of care. Exams are normally covered by dental insurance.

Charting begins with tooth naming and numbering. The maxillary, or upper arch, and the mandibular, or lower arch, each contain 16 teeth in a full adult dentition. Teeth are paired right and left by size, shape, and function. Beginning at the midline, each arch includes two central incisors side by side. Continuing outward to right and left are pairs of lateral incisors, canines (cuspids), first premolars (first bicuspid), second premolars (sec-

ond cuspids), first molars, second molars, and third molars (wisdom teeth).

In a primary, or deciduous, dentition there are no premolars or third molars. From the midline, pairs are central incisors, lateral incisors, canines, first molars, and second molars. As the adult dentition erupts, first and second primary molars are replaced by adult premolars. Adult molars erupt behind the primary molars in space created by the lengthening maxilla and mandible.

The widely used universal system, adopted in 1974, assigns the permanent teeth numbers from 1 to 32. Primary teeth are assigned letters from *a* to *t*, regardless of their position in the mouth. In the permanent dentition, 1 is the third molar of the maxillary (upper jaw) right quadrant. Numbering continues sequentially around the upper arch to 16, the third molar of the maxillary left quadrant. Number 17 is the third molar of the mandibular (lower jaw) left quadrant, and numbering again continues sequentially around the lower arch to 32, the third molar of the mandibular right quadrant. Teeth may drift due to factors including other missing teeth, **malocclusion**, malpositioning, or congenital abnormalities.

Lettering of primary teeth is similar. An *a* is assigned to the second molar of the maxillary right quadrant, and lettering continues sequentially around the upper arch to *j*, the second molar of the maxillary left quadrant. The letter *k* is the second molar of the mandibular left quadrant, and lettering continues sequentially around the lower arch to *t*, the second molar of the mandibular right quadrant.

An older system, sometimes used by orthodontists, is Palmer's Notation. In that system, teeth are numbered 1 through 8 or lettered *a* through *e* by quadrant, beginning at the midline. Permanent maxillary canines, for instance, would be referred to as "upper right 3" and "upper left 3" instead of 6 and 11. Primary mandibular first molars would be referred to as "lower right *d*" and "lower left *d*" instead of *s* and *l*. When written down, the numbers or letters are enclosed in half boxes to denote upper or lower, left or right.

A dental chart can be anatomically correct, showing several views of each tooth, or it can be stylized, showing two rows of 16 circles each. Small boxes are usually placed above and below the rows to allow coded notations for each tooth. Each circle represents a tooth, and is divided to show a smaller round center and four outside surfaces. The round center represents the occlusal (i.e., biting surface) of posterior teeth, or the incisal (i.e., biting edge) of anterior teeth. The four surfaces surrounding the center, noted clockwise from the top, are buccal (i.e., outside surfaces of posterior teeth) or facial (i.e., outside surfaces of anterior teeth; mesial (i.e., proximal surface of a tooth closest to the midline); lingual (i.e., inside sur-

face of a tooth); and distal (i.e., proximal surface of a tooth farthest from the midline).

For the purposes of communication, tooth surfaces are referred to by their first initial. For instance, a restoration on the mandibular left first molar that covers the mesial and occlusal surfaces would be called an MO on 19. A carious lesion that extends from mesial to facial to incisal surface of the maxillary right lateral incisor would be an MFI on 7.

Both restorations and lesions can also be classified according to location. The G.V. Black system of classification is as follows:

- Class I: Pits and fissures of the occlusal surfaces of posterior teeth, and lingual surfaces of anterior teeth.
- Class II: Proximal surfaces of posterior teeth.
- Class III: Proximal surfaces of anterior teeth.
- Class IV: Proximal surfaces of anterior teeth that involve an incisal edge.
- Class V: Gingival third (i.e., closest to the gumline) of the facial, buccal, or lingual surfaces of anterior and posterior teeth.
- Class VI: Cusp tips.

A carious lesion on the proximal surface of the maxillary left canine could therefore be referred to as a Class III lesion on 11.

Missing teeth are normally charted first, marked out with an X or a single vertical line. Unerupted teeth may be completely circled, with the circle altered if necessary to show partial eruption. Both carious lesions and restorations are marked by coloring the portion of the tooth affected, usually in different colors. For more precise charting, shadings, colors or coded letters may be used to differentiate between types of restorations. Amalgam (i.e., silver) restorations might be colored blue, for instance, while composite (i.e., white) restorations might be outlined in blue. Gold crowns might be marked with a "G" (or designated with a blue outline and oblique lines), and porcelain crowns with a "P." Additionally, full-coverage crowns are usually marked by circling just the crown of the tooth on the chart in blue. Areas of decay or defective restorations are marked in red.

Endodontic (i.e., root canal) restorations can be marked with a black line extending up the length of the tooth root. A periapical **abscess** (i.e., **infection** of the tooth nerve) is marked with a small circle at the apex of the root. Conditions such as erosion, abrasion, and congenital abnormalities can be identified with boxed notes. The directions of malpositioned, drifted, and super-erupted teeth can be indicated with arrows.

Implants can be drawn on the chart in their relative positions, with fixed bridgework noted by connected lines. Partial and complete dentures can be marked with brackets.

When a single clinician writes and draws findings on a dental chart, there are concerns about time, accuracy, and cross-contamination. Charting by hand is most efficient with two people, one performing the exam and the other recording the findings on the chart. If a computer is available in the treatment area, a clinician can use a headset microphone and voice-activated charting software for ease and convenience.

Once the teeth themselves have been charted, periodontal charting is indicated. The periodontium, or support structure for teeth, includes gingiva (i.e., gums), periodontal ligaments and membranes, and bone.

Baseline data, recorded as part of the initial examination, is a resource for treatment planning. During treatment, the chart offers direction for instrumentation, alerting the clinician to complex pocketing, mobility, and root furcation involvement. Later, periodically updated charts evaluate the success of home care and professional treatment. Further uses for periodontal charting are as legal evidence, to support a diagnosis and justify treatment, and as forensic evidence. The best defense in a **malpractice** suit is complete and accurate documentation.

For a periodontal chart, the clinician measures and records pocket depths surrounding the teeth. In a healthy mouth, each tooth is surrounded by a free collar of marginal gingiva. At a depth of 0–3 millimeters, the gingiva is attached to the cementum, the surface of the tooth root. The surrounding 0–3 mm. space within the free collar is referred to as the sulcus. In an unhealthy condition, sulcus depths can be much greater because of loss of attachment and are referred to as periodontal pockets.

Measurement is accomplished with a calibrated periodontal probe, inserted into the sulcus parallel to the long axis of the tooth. Depending on design, the probe may be marked at each millimeter up to 10. A more common design has the markings at four and six deleted for easier reading. Color-coded probes may be marked in blocks, with a green block up to 3 mm (i.e., indicating a healthy condition), and a red block up to 6 mm (i.e., indicating an unhealthy condition and the presence of periodontal disease). Probes are designed with blunt or ball-tipped ends to avoid puncturing the junctional epithelium at the base of the sulcus during probing. Electronic probes are also available that record pocket depths automatically on a computerized chart.

For a full periodontal chart, six readings are taken on each tooth and recorded in six boxes above and below teeth on the chart. Beginning with tooth number 1, a

measurement is taken at the mesio-buccal line angle, the midbuccal, the distobuccal line angle, the distolingual line angle, the mid-lingual, and the mesio-lingual line angle. The probe can be “walked” around the circumference of the tooth for complete exploration.

As the sulcus is probed, other conditions can be noted. Inflamed gingiva can bleed spontaneously from finger pressure or from probing, even though the probe does not puncture tissue. A bleeding index can be determined by dividing the number of sites bleeding by the number of sites examined. If 24 sites are probed, for example, resulting in 12 of those sites exhibiting bleeding, the patient has a bleeding index of 50%. Bleeding sites can be noted on the chart by a red dot or by the letter B.

A plaque index can be determined by the same method. A clinician counts the number of teeth where plaque, a biofilm, is present, and divides that by the number of teeth examined. A plaque index is a useful motivational tool for patients when measured at periodic intervals.

Other conditions that might be noted on a periodontal chart include the presence of exudate, tooth mobility, color and contour of the gingiva, recession, and the amount of plaque and calculus. All these conditions, when added together, provide the clinician a comprehensive picture of the patient’s periodontal status. Planning and treatment can only begin when these conditions have been fully documented.

Some clinicians prefer to assign standardized classifications to the patient’s degree of periodontal health. The five recognized classifications are:

- Case Type I: **Gingivitis** is present when inflammation is apparent and the gingiva is characterized by changes in color, form, position and appearance. Bleeding and/or exudate may be present.
- Case Type II: Slight **periodontitis** is present when inflammation has progressed from the gingiva to deeper periodontal structures and bone, with slight bone loss. Probing depths are 3–4 mm, and there is some loss of connective tissue attachment.
- Case Type III: Moderate periodontitis is a more advanced stage of Slight Periodontitis, with increased destruction and tooth mobility. There may be furcation involvement in multirrooted teeth.
- Case Type IV: Advanced periodontitis involves major loss of bone support and increased tooth mobility and furcation involvement.
- Case Type V: Refractory progressive periodontitis is diagnosed when there is rapid bone and attachment loss

KEY TERMS

Calculus—Calcified mass of bacteria, fungi, dequimated epithelial cells and food debris that forms on the surface of a tooth.

Caries—Tooth decay.

Cusp—Pointed projection on the crown of the tooth.

Deciduous teeth—Primary, or “baby” teeth.

Distal—Proximal surface of tooth farthest from the midline.

Facial—Outside surface of anterior tooth, adjacent to the face. The term includes buccal (cheek) and labial (lips) areas.

Gingiva—Gum tissue.

Incisal—Biting edge of anterior tooth.

Lingual—Inside surface of tooth, adjacent to the tongue.

Mesial—Proximal surface of tooth closest to the midline.

Occlusal—Biting surface of posterior tooth.

Periodontics—Study of the support structures of teeth, including gingiva, ligaments and alveolar bone.

Plaque—Collection of bacteria growing in a soft mass on surface of tooth or gingiva. Also called biofilm.

Sulcus—Normal 0–3mm space between the tooth and the junctional epithelium and the gingival margin.

or slow, but continuous, loss. Normal therapy is resisted, and there is gingival inflammation and continued pocket formation.

A simplified method of charting periodontal conditions was adapted in 1992 from a system in use in Europe called the Community Periodontal Index of Treatment Needs (CPITN). The CPITN is endorsed by both the World Health Organization and the Federation Dentaire Internationale for periodontal screening. The 1992 adaptation, called Periodontal Screening and Recording (PSR) TM, is endorsed by the American Dental Association (ADA) and the American Academy of Periodontology (AAP). It is best described as an early detection system for periodontal disease. PSR TM is not intended to replace full periodontal charting, but to serve as a simple and con-

venient screening tool. PSR TM can indicate to the clinician when a more comprehensive examination is needed. The ADA and AAP recommend using PSR TM at regular intervals as an integral part of oral examinations.

Pocket depths are scored in sections by codes, rather than individually by millimeters. For this system, the mouth is divided into sextants: maxillary right, anterior and left; and mandibular right, anterior and left. The PSR TM probe is ball-tipped and coded with a single colored marking from 3.5 mm to 5.5 mm. The clinician records a single sextant code according to the deepest probing depth found in that sextant. Where there are no teeth present in a sextant, an X is recorded.

Code 0 is used when the colored area of the probe remains visible in all the pockets of the sextant. The clinician detects no calculus and no defective margins on restorations. No bleeding is evident on probing.

Code 1 indicates nearly the same conditions as Code 0, but bleeding is detected on probing.

Code 2 is used when calculus, either above or below the gumline, is detected. It may also be used to indicate defective restorative margins. The colored area of the probe is still completely visible.

Code 3 is necessary when the colored area of the probe is only partly visible in at least one pocket of the sextant.

Code 4 is used when the colored area of the probe is not visible in at least one pocket of the sextant, indicating a program depth more than 5.5 mm.

An asterisk is added to a sextant score to indicate problems such as mobility, root furcation involvement, mucogingival abnormalities, or gingival recession greater than 3.5 mm. The sextant scores are recorded in a set of six attached boxes that can be drawn on the chart. Printed stickers are also available and can be added to the chart on the appropriate date.

Results

After dental and periodontal charting, a patient is found to be in good dental health if there is no decay, no restorations or replacements are needed, and the patient’s periodontal pockets are between 0–3 mm with no bleeding or abnormal conditions. A prophylaxis (i.e., cleaning) is usually the only treatment prescribed. The patient is placed on recall at 3- to 12-month continued care intervals for routine, preventive, and oral health maintenance care.

Any decay found, however, calls for treatment by elimination of active disease, restoration, or extraction. Endodontics may be necessary to preserve a tooth. Crowns, bridgework, implants or dentures may also be

indicated. If periodontal pockets deeper than 3 mm are found, they indicate the presence of periodontal disease, which must then be evaluated and treated appropriately.

Health care team roles

Any member of the dental team is equipped to perform dental charting, including the dentist, hygienist, expanded function dental auxiliary, or assistant. If no computer is available, charting is easier with two people. One performs the examination and calls out the findings while the other enters them in the chart.

Dental hygienists normally handle periodontal charting as part of the initial or periodic exam. Again, if no computer is available, charting is easier with two people. Periodontal screenings provide an excellent opportunity for **patient education**. While working, the dental hygienist can explain the meaning of any findings to the patient, and discuss their implications. During periodic exams, the patient can be told if scores have improved since the last visit.

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Dental anomalies

Definition

Dental anomalies are craniofacial abnormalities of form, function, or position of the teeth, bones, and tissues of the jaw and mouth.

Description

Dental anomalies can range from missing or stained teeth to cleft palates. Many are expressions of other, more complex disorders. The National Institute of Dental and Craniofacial Research (NIDCR) estimates that in the United States a baby is born every hour with a craniofacial defect.

Causes and symptoms

Many dental anomalies are caused by inherited genetic defects or result from spontaneous genetic mutations. The Center for Biotechnology Information recognizes 1,250 gene loci for craniofacial diseases and disorders. Dental deformities may also have environmental, traumatic, or nutritional causes; these may develop or become clinically apparent at any time during an individual's life.

Genetic defects

The most common genetic craniofacial deformity is clefting of the lip and/or palate, a defect estimated by the NIDCR to occur once in every 500 births. A family history of clefting increases the chances of inheriting the disorder. Seen more often in boys than in girls, cleft lip is usually unilateral, appearing three times more frequently on the left side than on the right. Less common is a bilateral cleft, a condition formerly known as "harelip." An incomplete cleft stops short of the nostril; a complete cleft extends into the nostril. Both types frequently involve the palate as well. The typical patient with cleft palate and cleft ridge exhibits large defects in the roof of the palate with a direct opening into the nasal cavity.

Dentinogenesis imperfecta type II (DGI-II), another genetic defect, causes severely discolored teeth that break easily. Amelogenesis imperfecta produces only a soft, thin layer of tooth enamel. This lets the dentin show through, making teeth look yellow, and leaves them weak, easily damaged, and susceptible to decay.

Other genetic anomalies are less debilitating. **Malocclusion**, meaning bad or misaligned bite, is caused by crowding teeth, extra teeth, missing teeth, or jaws that are out of alignment. Most malocclusions are inherited genetically, although some can be caused by accidents, early or late loss of baby teeth, or prolonged thumb sucking. Orthodontia usually corrects this problem.

Relative microdontia is an inherited condition that produces smaller-than-normal teeth, usually in the upper jaw. To correct this condition crowns or veneers are applied to make the teeth the same size as the others. Microdontia is neither painful nor harmful; treatment is intended to improve the patient's bite and appearance.

Partial anodontia, or congenitally missing teeth, is a condition in which one or more permanent teeth fail to appear, although primary (baby) teeth usually erupt. Third molars are absent in as many as 35 percent of all subjects examined. Maxillary lateral incisors and maxillary and mandibular second premolars (bicuspid) also frequently fail to appear. When this happens, many dentists choose to leave the primary tooth in place to prevent the malocclusion that might otherwise occur. If this is not feasible, a dentist may extract the tooth and close the space with braces or cover it with a bridge.

Idiopathic anomalies

Stafne's bone cavity, also called static bone cyst or lingual mandibular bone concavity, is an anomaly of unknown etiology. A painless condition, it is an indentation of the jawbone that may contain muscle or salivary tissue. The skin covering this area is soft to the touch and feels concave. No treatment is required, although biopsies are often performed to rule out the presence of a malignant tumor.

Condylar hyperplasia, another idiopathic anomaly, affects the temporomandibular joint and surrounding tissues. The condition is characterized by unrestrained growth of the condyle, which deforms the face, jaw, and bite. Surgery is usually required to restore order, although once growth has stopped orthodontics are often helpful. Condylar hypoplasia occurs when one condyle is markedly shorter than the other, a condition that also causes facial and dental deformities. Surgery can restore balance, and orthodontics are indicated as well.

Environmental causes

Environmental anomalies are caused by external agents, including diet, that affect the teeth and gums. Extended use of the antibiotic tetracycline in young children, for example, can cause dark brown discoloration of the teeth. **Fluorosis**, an overabundance of fluorine in the diet, can create white or mottled spots on the teeth. This is most commonly seen in children who ingest greater-than-recommended amounts of fluoride by swallowing large quantities of fluoridated toothpaste. Teeth naturally darken with age, as the enamel thins and the dentin shows through. Coffee, tea, and red wine can also stain the teeth. Even children who swim an average of six hours or more a week in a pool may develop brown stains on their teeth.

Bulimia can cause severe decalcification of the teeth. Acid from constant regurgitation eats away at the enamel, especially in the molar region. This weakens the teeth, making them both susceptible to decay and highly sensitive. Unless the bulimia is arrested, sensitivity

increases until the nerve is exposed and **root canal therapy** is needed or extraction is required.

Poor **nutrition** can also cause dental anomalies. Scurvy, a disease caused by a lack of **vitamin C**, affects periodontal and other connective tissue, causing purple, swollen, bleeding gums and, if untreated, tooth loss. Anemia, caused by a lack of **iron** in the diet, causes fiery red gum tissues. Both of these anomalies can be corrected with proper nutrition and routine care.

Other anomalies

Concrescence is the fusion of teeth above and below the gum line, although each tooth has separate roots. The teeth are united by cementum only. It may be caused by crowding or injury. Most commonly it occurs with the second premolars (bicuspid). This is a painless anomaly and treatment is required only for cosmetic reasons.

Supernumerary teeth are extra permanent teeth that may or may not erupt and can be found anywhere in the mouth. The most common is the mesiodens, a small tooth with a cone-shaped crown and a short root situated between the maxillary central incisors. Heredity may play a role in the development of supernumerary teeth, but other factors are thought to contribute as well. Supernumerary teeth can be extracted with no harm to the patient.

Diagnosis

Dental anomalies can be evidence of systemic disease and may have more than one cause. After weighing the patient's symptoms, **pain** (if any), health risks, family history, aesthetic considerations, treatment costs, and insurance coverage, the dentist will decide whether to treat or simply monitor the condition.

Treatment

Treatment is intended to eliminate or diminish the defect, manage pain, and alleviate the patient's concerns. Treatment may progress in multiple phases, including a program of continuing care that allows the dentist or doctor to evaluate the treatment's effectiveness.

In most cases, surgery can correct the deformity. Cleft lips are usually repaired before the infant is a month or two old, with excellent cosmetic and functional results. Surgical repair of a cleft palate, however, is not usually performed until the patient is approximately eighteen months old, to minimize the risk of damaging important growth centers. Psychological services are often included as part of the treatment along with speech and **hearing** services.

Depending on the severity of the anomaly, treatment can be expensive, but medical and dental insurance can help limit out-of-pocket expenses for the patient. Sometimes treatment will be covered by medical insurance if procedures are performed by an oral surgeon or medical doctor instead of a dentist.

Prognosis

Although many orofacial anomalies are currently managed, rather than treated, the rapid advance of science—such as the ability to identify mutated genes—promise future cures and treatments that will eliminate or reduce the number of defects currently seen. **Gene therapy** may also someday be applied to the treatment of many craniofacial anomalies, both to repair congenital defects and to accelerate healing after trauma. Gene mapping may also help doctors know which patients are susceptible to what type of anomalies.

The NIDCR is the primary sponsor of craniofacial research and training in the United States. The institute supports a variety of projects, including basic studies of cell migration and differentiation, cell signaling, patterns of gene expression, growth factor effects, tooth formation and eruption, and bone formation. These studies explore the genetic and molecular mechanisms behind craniofacial abnormalities and are intended to prevent or correct the anomaly or improve the patient's ability to function with it.

Health care team roles

No one specialist can provide the range of treatment that is frequently needed for many dental anomalies. The most effective management is accomplished with a team of professionals who can render a comprehensive diagnosis, determine treatment needs and priorities, and supervise long-term planning. A list of physicians and specialists required to treat a craniofacial deformity might include: plastic surgeon, otolaryngologist (ear, nose, and throat specialist), audiologist, speech-language pathologist, oral/maxillofacial surgeon, orthodontist, pediatric/family dentist, dental hygienist, prosthodontist, geneticist/genetic counselor.

Prevention

The ADA advises dentists to discourage patients from using tobacco and illicit drugs, and to emphasize sound nutrition to maintain oral health and prevent nutritional anomalies. The NIDCR encourages clinical studies to diagnose genetic anomalies, decrease environmental risks, and improve treatment. **Genetic counseling**, map-

KEY TERMS

Anomaly—A deformity or abnormality.

Bridge—A dental prosthesis covering an open space in the mouth.

Cementum—A bony substance that covers the root of the tooth.

Condyle—The uppermost end of the mandible that sits in the zygomatic arch and allows the jaw to move.

Congenital—Present at birth; a nonhereditary condition acquired in utero.

Crown—1. The natural part of the tooth covered by enamel. 2. A restorative, protective shell that fits over a diseased or malformed tooth.

Decalcification—The wearing away of the enamel on the teeth.

Etiology—Cause or origin.

Extraction—Removal of the tooth.

Genetic—Inherited from the parents.

Mandible—Jaw, especially the lower jawbone.

Maxillary—Relating to the upper jaw region.

Maxillary central incisors—The front teeth on the upper jaw.

Maxillary lateral incisors—The teeth on the right and left quadrants of the upper jaw next to the front centrals.

Root canal therapy—Removal of the pulp of a tooth.

Veneer—A thin porcelain overlay that covers only the anterior surface of a tooth.

ping, and testing can help prevent dental anomalies in the next generation of children.

Resources

PERIODICALS

Tai, Chi-Chia E., I. Scott Sutherland, and Leland McFadden. "Prospective Analysis of Secondary Alveolar Bone Grafting Using Computed Tomography." *Journal of Oral and Maxillofacial Surgery* (November 2000): vol. 58, no. 11, 1241–1249.

ORGANIZATIONS

American Dental Association. 211 East Chicago Avenue, Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org>>.

National Institute of Dental & Craniofacial Research. Building 45, Room 4AN-24 45 Center Drive, MSC 6402 Bethesda, MD 20892-6402. (301) 594-9898 <<http://www.nidcr.nih.gov/research/extramural/cranio2.htm>>.

University of Minnesota School of Dentistry. Professor Karlind Moller, Preventive Sciences, 15-209 Moos Tower, 515 Delaware St. SE, Minneapolis, MN 55455. (612) 625-5945. <<http://www.umn.edu/dental/services/index.html>>.

OTHER

Howell, Dr. Maria Lopez. "Dental Discoloration: Causes and Cures." ADA Dental Minutes video. <<http://www.ada.org/public/media/minute/DMVol7/dm-discolor.html>>.

Howell, Dr. Maria Lopez. "Genetics and Dentistry." ADA Dental Minutes video. <<http://www.ada.org/public/media/minute/DMVol7/dm-genetic.html>>.

Howell, Dr. Maria Lopez. "Swimming Stains Teeth." ADA Dental Minutes video. <<http://www.ada.org/public/media/minute/DMVol-4/dm-swim.html>>.

Cindy F. Ovard, RDA

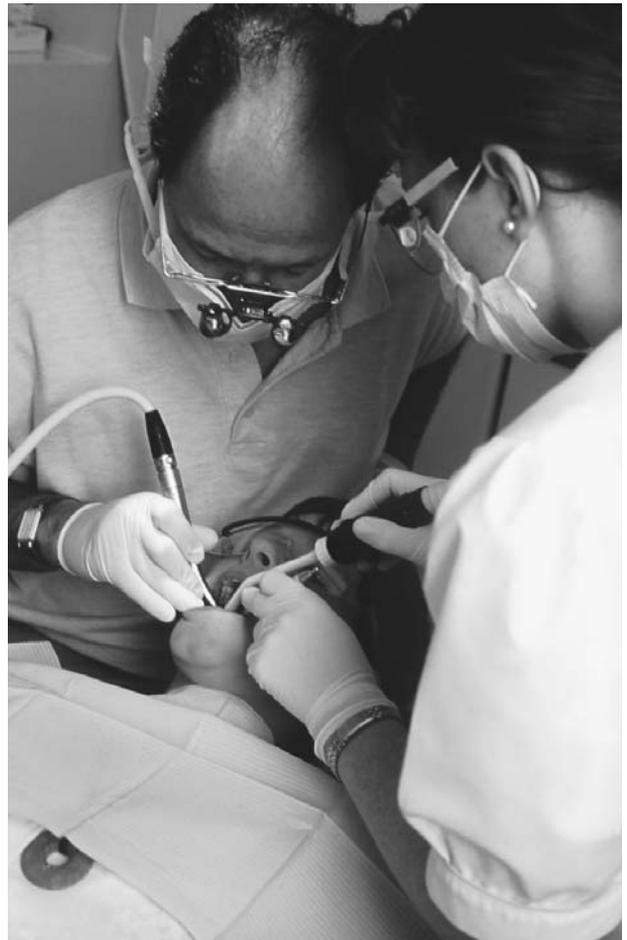
Dental assisting

Definition

Dental assistants are part of the dental health care team. They assist dentists in delivering oral health care to patients.

Description

The dental assistant uses interpersonal, administrative, and technical skills to perform a variety of tasks in the dental office. Dental assistants work with dentists when they perform dental treatments. Some of the tasks they perform before and during dental treatment include preparing patients for the treatment, passing dentists instruments and other materials, and keeping patients' mouths dry and clear using suction and other devices. They expose and develop x rays, or radiographs, as well as take impressions of teeth. Sometimes, dental assistants take patients' **blood pressure**, pulse, and medical histories. Dental assistants help comfort patients before, during, and after treatment. They also teach patients how to prevent oral disease and maintain their overall dental health. Administratively, a dental assistant may oversee an office's **infection control** practices, schedule patient appointments, answer phones, coordinate billing, and order supplies.



A dental assistant uses a suction tube while a dentist drills a patient's tooth. (Photograph by Francoise Sauze. Science Source/Photo Researchers. Reproduced by permission.)

The career offers variety of work, flexibility in scheduling, and direct contact with people. As of 1998, more than three in 10 dental assistants worked part-time. The median hourly wages in the profession was \$10.88 in 1998.

Work settings

Dental assistants work in general dental offices and all dental specialty settings, including orthodontics, pediatric dentistry, periodontics, endodontics, and oral surgery. They also work in solo practices or in **public health** dentistry, assisting in settings such as schools and community clinics. Dental assistants also work in hospitals to help treat bedridden patients and in dental school clinics, assisting dental students. Other opportunities for dental assistants exist in the insurance industry, as dental insurance claims processors; in vocational and other schools as instructors; and in dental product sales.

KEY TERMS

Oral and maxillofacial surgery—The dental specialty that focuses on the correction of orofacial deformities and removal of teeth.

Orthodontics—The dental specialty concerned with treating malocclusions, or bad bites.

Pediatric dentistry—The dental specialty concerned with the dental treatment of children and adolescents.

Periodontics—The dental specialty focused on treating diseases of the soft and hard tissues that surround and support the teeth.

Radiographs—X rays.

Education and training

While, in some states, dental assistants can work in the field without a college degree, dental assistants are usually trained at community colleges, vocational schools, technical institutes, universities, or dental schools. The Commission on Dental Accreditation of the American Dental Association is the agency that accredits dental assisting programs, of which there are over 200 in the United States. After completing a program that takes about nine to 11 months, plus an exam, dental assistants receive a certificate in dental assisting. To become a Certified Dental Assistant, or CDA, dental assistants must take the CDA examination after they have completed an accredited dental assisting program, or have at least two years of full-time on-the-job training as a dental assistant.

Advanced education and training

Associate or baccalaureate degrees are often required for dental assistants who want to go into teaching at colleges, technical institutes, vocational schools, or universities.

Future outlook

Job prospects in the field of dental assisting are expected to grow much faster than average, compared to other occupations. The job turnover is expected to be high, creating even more opportunity. Also, as the population ages and people keep their teeth, dental assistants will continue to be in demand.

Resources

BOOKS

Occupational Outlook Handbook, Dental Assistants section. U.S. Department of Labor. Bureau of Labor Statistics. Division of Information Services. 2 Massachusetts Ave., NE, Room 2860. Washington, D.C. 20212. (202) 691-5200. <<http://stats.bls.gov>>.

ORGANIZATIONS

American Dental Assistants' Association. 203 North LaSalle Street, Suite 1320, Chicago, IL 60601-1225. (312) 541-1550. <<http://www.dentalassistant.org>>.

American Dental Association. 211 E. Chicago Ave., Chicago, IL 60611. (312) 440-2806. <<http://www.ada.org>>.

Lisette Hilton

Dental caries

Definition

Dental caries, also known as tooth decay, is the destruction of the outer surface (enamel) of a tooth. Decay results from the action of **bacteria** that live in plaque, which is a sticky, whitish film formed by a protein in saliva (mucin) and sugary substances in the mouth. The plaque bacteria sticking to tooth enamel use the sugar and starch from food particles in the mouth to produce acid. Tooth decay can result in tooth loss.

Description

Thanks to the benefits of fluoride and fluoridated water, dental caries, also called dental cavities, are not as prevalent as in the years before and including the 1980s. While the majority of senior citizens a generation ago lost all their teeth, the vast majority of the elderly today have some or all of their natural teeth.

Although anyone can have a problem with tooth decay, children and senior citizens are the two high-risk groups. While both groups experience a diminishing caries rate, senior citizens are getting more cavities than children. Since older adults are keeping their teeth longer, they have become more prone to root caries, or root decay. Other high-risk groups include people who eat a lot of starchy and sugary foods, people living in areas without a fluoridated water supply, and people who already have numerous dental restorations (fillings and crowns).

Dental caries charting: classification of cavities

Classification and location	Method of examination
Class I	
Cavities in pits or fissures	Direct or indirect visual
Occlusal surfaces of premolars and molars	Exploration Radiographs are not useful
Facial and lingual surfaces of molars	
Lingual surfaces of maxillary incisors	
Class II	
Cavities in proximal surfaces of premolars and molars	Early caries: by radiographs only Moderate caries not broken through from proximal to occlusal: Visual by color changes in tooth and loss of translucency Exploration from proximal Extensive caries involving occlusal: direct visual
Class III	
Cavities in proximal surfaces of incisors and canines that do not involve the incisal angle	Early caries: by radiographs or transillumination Moderate caries not broken through to lingual or facial: Visual by tooth color change Exploration Radiograph Extensive caries: direct visual
Class IV	
Cavities in proximal surfaces of incisors or canines that involve the incisal angle	Visual Transillumination
Class V	
Cavities in the cervical 1/3 of facial or lingual surfaces (not pit or fissure)	Direct visual: dry surface for vision Exploration to distinguish demineralization: whether rough or hard and unbroken Areas may be sensitive to touch
Class VI	
Cavities on incisal edges of anterior teeth and cusp tips of posterior teeth	Direct visual May be discolored

SOURCE: Alvarez, K.H. *Williams & Wilkins' Dental Hygiene Handbook*. Baltimore: Williams & Wilkins, 1998.

Baby bottle tooth decay

Baby bottle tooth decay is a dental problem that frequently develops in infants who are put to bed with a bottle containing a sweet liquid. Baby bottle tooth decay is also called nursing-bottle caries and bottle-mouth syndrome. Bottles containing liquids such as milk, formula, fruit juices, sweetened drink mixes, and sugar water continuously bathe an infant's mouth with sugar during naps or at night. The bacteria in the mouth use this sugar to produce acid that destroys the child's teeth. The upper front teeth are typically the ones most severely damaged, the lower front teeth receiving some protection from the tongue. Pacifiers dipped in sugar, honey, corn syrup, or

other sweetened liquids also contribute to bottle-mouth syndrome. The first signs of damage are chalky white spots or lines across the teeth. As decay progresses, the damage to the child's teeth becomes obvious.

Causes and symptoms

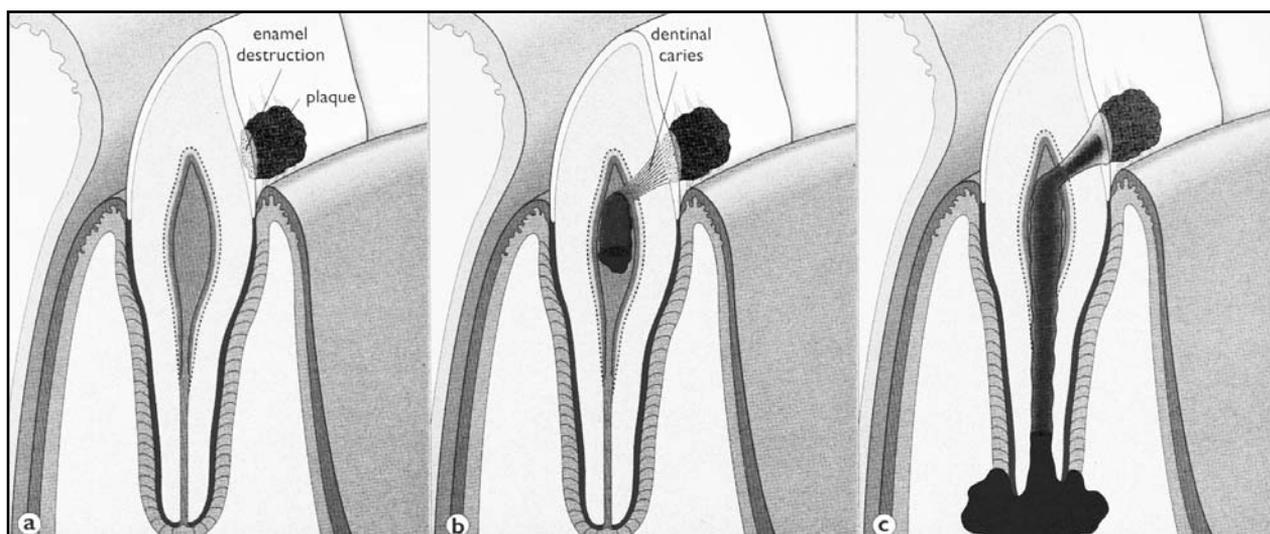
Tooth decay requires the simultaneous presence of three factors: plaque bacteria, sugar, and a vulnerable tooth surface. Although several microorganisms found in the mouth can cause tooth decay, the primary disease agent appears to be *Streptococcus mutans*. The sugars used by the bacteria are simple sugars such as glucose, sucrose, and lactose. They are converted primarily into lactic acid. When this acid builds up on an unprotected tooth surface, it dissolves the **minerals** in the enamel, creating holes and weak spots (cavities). As the decay spreads inward into the middle layer (the dentin), the tooth becomes more sensitive to temperature and touch. When the decay reaches the center of the tooth (the pulp), the resulting inflammation (pulpitis) produces a toothache.

The elderly are more prone to dental caries because more than 95% of senior citizens have lost some of the gum tissue that protects the tooth roots, exposing the roots to plaque and decay. It also is common to see decay around filling margins. Over time, fillings tend to weaken, fracture, and leak around the edges, which fosters the accumulation of bacteria. Another reason that the elderly get more cavities is that many take medications that reduce saliva, which naturally protects the teeth from caries.

Chewing tobacco is another culprit that increases the risk of tooth decay. A study showed that men who use chewing tobacco are four times more likely to have one or more decayed or filled root surfaces, compared to those who had never chewed tobacco.

Diagnosis

Tooth decay develops at varying rates. It may be found during a routine six-month dental checkup before the patient is even aware of a problem. In other cases, the patient may experience common early symptoms, such as sensitivity to hot and cold liquids or localized discomfort after eating very sweet foods. The dentist or dental hygienist may suspect tooth decay if a dark spot or pit is seen during a visual examination. Front teeth may be inspected for decay by shining a light from behind the tooth. This method is called transillumination. Areas of decay, especially between the teeth, will appear as noticeable shadows when teeth are transilluminated. X rays may be taken to confirm the presence and extent of the



Development of dental caries. (Photograph by Biophoto Associates. ScienceSource/Photo Researchers, .Inc. Reproduced by permission.)

decay. The dentist then makes the final clinical diagnosis by probing the enamel with a sharp instrument.

Tooth decay in pits and fissures may be differentiated from dark shadows in the crevices of the chewing surfaces by a dye that selectively stains parts of the tooth that have lost mineral content. A dentist can also use this dye to tell whether all tooth decay has been removed from a cavity before placing a filling.

Diagnosis in children

Damage caused by baby bottle tooth decay is often not diagnosed until the child has a severe problem, because parents seldom take their infants and toddlers for dental check-ups. Dentists want to initially examine primary teeth between 12 and 24 months. Children still drinking from a bottle anytime after their first birthday are likely to have tooth decay.

Treatment

To treat most cases of tooth decay in adults, the dentist removes all decayed tooth structure, shapes the sides of the cavity, and fills the cavity with an appropriate material, such as silver amalgam or composite resin. The filling is put in to restore and protect the tooth. If decay has attacked the pulp, the dentist or a specialist called an endodontist may perform root canal treatment and cover the tooth with a crown.

In cases of baby bottle tooth decay, the dentist must assess the extent of the damage before deciding on the treatment method. If the problem is caught early, the teeth involved can be treated with fluoride, followed by

changes in the infant's feeding habits and better **oral hygiene**. Primary teeth with obvious decay in the enamel that has not yet progressed to the pulp need to be protected with stainless steel crowns. Fillings are not usually an option in small children because of the small size of their teeth and the concern of recurrent decay. When the decay has advanced to the pulp, pulling the tooth is often the treatment of choice. Unfortunately, loss of primary teeth at this age may hinder the young child's ability to eat and speak. It may also have a bad effect on the alignment and spacing of the permanent teeth when they arrive.

Prognosis

With timely diagnosis and treatment, the progression of tooth decay can be stopped without extended **pain**. If the pulp of the tooth is infected, the **infection** may be treated with **antibiotics** prior to root canal treatment or extraction. The longer decay goes untreated, however, the more destructive it becomes and the longer and more intensive the necessary treatment will be. In addition, a patient with two or more areas of tooth decay is at increased risk of developing additional cavities in the future.

Scientists are working on several advances in the reversal and prevention of tooth decay. The advances under development include: *Smart* fillings to prevent further tooth decay, toothpaste to strengthen and restore tooth minerals, and mouthwashes and chewing gums that reverse early decay. Scientists are studying the use of **calcium phosphate cements (CPC)**, used to repair cranial defects, for **fractures** and bone loss from gum

disease. CPC might provide a successful drug delivery system in Smart fillings to prevent tooth decay from recurring around existing fillings and surrounding teeth. Other calcium phosphate-based technologies used in chewing gum and mouth rinses are being tested to remineralize hard tooth tissues or slow demineralization produced by caries. Scientists are researching controlled-release fluoride systems, placed between the teeth or in tooth pits and fissures, that deliver high fluoride concentrations to localized areas. Research is also being done on the use of filling materials to repair exposures of the tooth pulp, which could eliminate the need for **root canal therapy**.

Health care team roles

Dental assistants can provide patients and their families with education in caries prevention. This often includes instructions for **home care** and fluoride information. Dental assistants often participate in the treatment of dental caries, performing such tasks as taking x rays, assisting with materials during treatment, and setting up and maintaining treatment rooms. In some dental practices, dental hygienists assist with patient charting and taking x rays. Dental hygienists interpret findings and are often the first to see the decay during routine cleanings.

Prevention

It is easier and less expensive to prevent tooth decay than to treat it. The four major prevention strategies include: proper oral hygiene, fluoride, sealants, and attention to diet.

Oral hygiene

GENERAL CARE OF THE MOUTH. The best way to prevent tooth decay is to brush the teeth at least twice a day, preferably after every meal and snack, and to floss daily. Cavities develop most easily in spaces that are hard to clean. These areas include surface grooves, spaces between teeth, and the area below the gum line. Effective brushing cleans each outer tooth surface, inner tooth surface, and the horizontal chewing surfaces of the back teeth, as well as the tongue. Flossing once a day also helps prevent gum disease by removing food particles and plaque at and below the gum line, as well as between teeth. Patients should visit their dentist every six months for an oral examination and professional cleaning.

MOUTH CARE IN OLDER ADULTS. Older adults who have lost teeth or had them removed still need to maintain a clean mouth. Bridges and dentures must be kept clean to prevent gum disease. Dentures should be relined

and adjusted by a dentist whenever necessary to maintain a proper fit. These adjustments help to keep the gums from becoming red, swollen, and tender.

MOUTH CARE IN CHILDREN. Parents can easily prevent baby bottle tooth decay by not allowing a child to fall asleep with a bottle containing sweetened liquid. Bottles should be filled with plain, unsweetened water. A child should be starting to drink from a cup at around six months of age, and weaned from bottles at 12 months. If an infant seems to need oral comfort between feedings, a pacifier specially designed for the mouth may be used. Pacifiers, however, should never be dipped in honey, corn syrup, or other sweet liquids. After the eruption of the first tooth, parents should begin routinely wiping an infant's teeth and gums with a moist piece of gauze or soft cloth, especially before bedtime. Parents may begin brushing a child's teeth with a small, soft toothbrush at about two years of age, when most of the primary teeth have come in. They should apply only a very small amount (the size of a pea) of toothpaste containing fluoride. Too much fluoride may cause spotting (**fluorosis**) of the tooth enamel. As the child grows, he or she will learn to handle the toothbrush, but parents should control the application of toothpaste and do the follow-up brushing until the child is about seven years old.

Fluoride application

Fluoride is a natural substance that slows the destruction of enamel and helps to repair minor tooth decay damage by remineralizing tooth structure. Toothpaste, mouthwash, fluoridated public drinking water, and vitamin supplements are all possible sources of fluoride. It is important to note that bottled water and water from home purifiers often does not contain fluoride, so people who drink from these sources may have to supplement their fluoride use. Children living in areas without fluoridated water should receive 0.5 mg/day of fluoride (0.25 mg/day if using a toothpaste containing fluoride), from three to five years of age, and 1 mg/day from 6-12 years.

While fluoride is important for protecting children's developing teeth, it is also of benefit to older adults with receding gums. It helps to protect the newly exposed tooth surfaces from decay. Older adults can be treated by a dentist with a fluoride solution that is painted onto selected portions of the teeth or poured into a fitted tray and held against all the teeth.

Sealants

Because fluoride is most beneficial on the smooth surfaces of teeth, sealants were developed to protect the

irregular surfaces of teeth. A sealant is a thin plastic coating that is painted over the grooves of chewing surfaces to prevent food and plaque from being trapped there. Sealant treatment is painless because none of the tooth is removed, although the tooth surface is etched with acid so that the plastic will adhere to the rough surface. Sealants are usually clear or tooth-colored, making them less noticeable than silver fillings. They cost less than fillings and can last up to 10 years, although they should be checked for wear at every dental visit. Children should get sealants on their first permanent “6-year” molars, which come in between the ages of 5 and 7, and on the second permanent “12-year” molars, which come in between the ages of 11 and 14. Sealants should be applied to the teeth shortly after they erupt, before decay can set in. Although sealants have been used in the United States for about 25 years, one survey by the National Institute of Dental Research reported that fewer than 8% of American children have them.

Diet

Choosing foods wisely and eating less often can lower the risk of tooth decay. Foods high in sugar and starch, especially when eaten between meals, increase the risk of cavities. The bacteria in the mouth use sugar and starch to produce the acid that destroys the enamel. The damage increases with more frequent and longer periods of eating. For better dental health, people should eat a variety of foods, limit the number of snacks, avoid sticky and overly sweetened foods, and brush often after eating.

Drinking water is also beneficial by rinsing food particles from the mouth. Children can be taught to “swish and swallow” if they are unable to brush after lunch at school. Similarly, saliva stimulated during eating makes it more difficult for food and bacteria to stick to tooth surfaces. Saliva also appears to have a buffering effect on the acid produced by the plaque bacteria and to act as a remineralizing agent. Older people should be made aware that some prescription medications may decrease salivary flow. Less saliva tends to increase the activity of plaque bacteria and encourage further tooth decay. Chewing sugarless gum increases salivation and thus helps to lower the risk of tooth decay.

Resources

BOOKS

“Dental Caries and Its Complications—Tooth Decay.” In *The Merck Manual of Diagnosis and Therapy*, edited by Mark H. Beers, Robert Berkow, and Mark Burs. 17th ed. Rahway, NJ: Merck Research Laboratories, 1999.

KEY TERMS

Amalgam—A mixture (alloy) of silver and several other metals, used by dentists to make fillings for cavities.

Caries—The medical term for tooth decay.

Cavity—A hole or weak spot in the tooth surface caused by decay.

Dentin—The middle layer of a tooth, which makes up most of the tooth’s mass.

Enamel—The hard, outermost surface of a tooth.

Fluoride—A chemical compound containing fluorine that is used to treat water or applied directly to teeth to prevent decay.

Mucin—A protein in saliva that combines with sugars in the mouth to form plaque.

Plaque—A thin, sticky, colorless film that forms on teeth. Plaque is composed of mucin, sugars from food, and bacteria that live in the plaque.

Pulp—The soft, innermost layer of a tooth containing blood vessels and nerves.

Sealant—A thin plastic substance that is painted over teeth as an anti-cavity measure to seal out food particles and acids produced by bacteria.

Transillumination—A technique of checking for tooth decay by shining a light behind the patient’s teeth. Decayed areas show up as spots or shadows.

ORGANIZATIONS

American Dental Association. 211 East Chicago Avenue, Chicago, IL 60611. (312)440-2500. <<http://www.ada.org>>.

American Dental Hygienists’ Association. 444 North Michigan Avenue, Chicago, IL 60611. (800)847-6718.

Anna Nelson, Certified Dental Assistant, and president of the American Dental Assistants’ Association. 203 N. LaSalle St., Suite 1320, Chicago, IL 60601-1225. (312) 541-1550 or for Anna Nelson direct (415) 239-3479. <www.dental-assistant.org>.

National Institute of Dental Research. 31 Center Drive, MSC 2190, Building 31, Room 5B49, Bethesda, MD 20892-2190.

OTHER

Healthtouch Online. <<http://www.healthtouch.com>>.

Lisette Hilton

Dental casts

Definition

A dental cast is any dental prosthetic or device formed in a mold or used as a mold.

Purpose

Dental casts copy a patient's teeth and mouth structures for diagnostic purposes and are used as models for further casting of dental **prosthetics** such as bridges, crowns, implants, dentures, and partial dentures. Casts may also be used as education tools for dentists as they explain characteristics of a patient's bite or particular dental needs. Diagnostic casts can also show how a restoration will look when the work is complete.

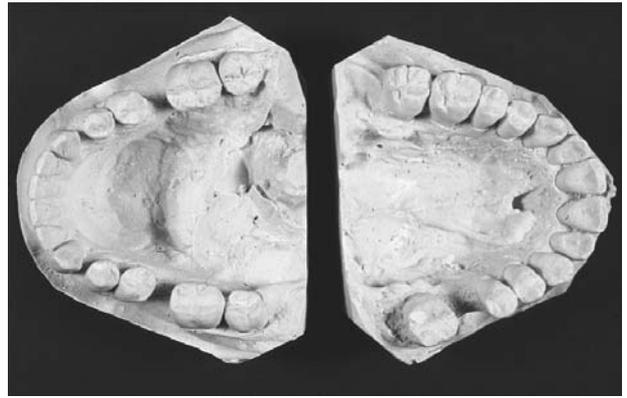
Description

Dentists are challenged to create solutions for problems that patients present from chipped or missing teeth, a collapsed bite, or teeth that are irregular or misshapen. A clear diagnosis of the condition often is made through the use of plaster-like dental casts of the patient's teeth and gums. These diagnostic casts allow the dentist to examine how the teeth fit together and what may be hampering the patient from chewing or speaking well. Often, the dentist will recommend replacement prosthetic devices for missing teeth. In the case of severely crooked teeth, the dentist may urge the patient to have the teeth realigned through braces or other **orthodontic appliances**.

From these initial casts, dental prosthetics are made that will fit into a patient's jaw structure and resemble the other teeth there. A variety of prosthetic devices can be cast from these initial casts: individual teeth for implants, crowns, bridges, dentures, and partial dentures.

The dentist first makes an impression of the patient's teeth and gums. A variety of impression materials are available, some are firm when used (waxes, plasters, putties, **zinc** oxide pastes) and some are more pliable (alginate and elastic silicones and polyvinyls). The elastic mediums are more stable and can stand longer before the casts are poured. Some impressions materials require that the cast be poured immediately or within a few hours. Some can wait several days or up to two weeks.

The impression produces a negative replica of the patient's teeth, which can then be cast in a variety of materials. Usually, plaster is used because it is inexpensive and sets up quickly. Other materials used include dental stone or special die stone. Both are very strong, but die stone is more abrasion resistant.



Dental casts are made from the impression of a patient's teeth, and may be used to help diagnose problems with bite, chewing, etc. (O.J. Staats, MD/Custom Medical Stock Photo. Reproduced by permission.)

From these casts, the dental technician can create wax diagnostic models of the proposed restoration. These wax models are finely-detailed sculptures of the mouth, showing how the restoration will look. From these, the prosthetics are cast.

Operation

The dental assistant prepares the impression medium and fills an impression tray that fits over the patient's mouth. The patient's teeth are dried either with gauze or a chemical product before the impression tray is fitted over the patient's teeth. The tray is held in place by the dental assistant for a brief time. The tray is removed in one motion, not rocked, in order to have a clean impression.

The impression is rinsed and disinfected and left to set. The dental assistant pours in the casting material. Sometimes this is only a few minutes after the impression is made; sometimes it can be several hours or days later.

Plaster-type casts are usually made first. These are used in diagnosis, **patient education**, and the creation of dental restorations.

The dental technician makes a single wax model of the prosthetic device to fit the patient's mouth, using the plaster cast as a guide. An investment mold is poured around the wax model and fired. The wax melts and drains out of the investment mold, leaving behind a durable mold into which the technician can pour a casting material. Restorative casting materials can be metals (gold, silver, amalgam), resins, or ceramics. These are poured into the investment mold to craft individual teeth, crowns, and other dental prosthetics. The mold is broken or opened, depending on whether the mold is reusable.

This technique is called lost wax casting and has been used for centuries to cast bronze sculptures or craft fine jewelry.

Maintenance

Alginate impressions are affected by water and can shrink or swell. This material often comes in powder form and should not be inhaled.

Casts made directly from impressions from plaster can be damaged through rough handling. Dental stone and dental die stone are more durable.

Dental prosthetics made from molds are long lasting and only require regular dental maintenance like tooth brushing and flossing. Dentures and partial dentures need to be rinsed and soaked to remove stains and odor. The dentist and dental assistant should inspect dental prosthetics often for any damage or wear, especially around the wires of partial dentures.

It should be noted that the impressions used to make plaster-like casts of the patient's mouth should be disinfected and dried before the casts are made. This protects dental personnel from any infectious agent attached to the impression when the cast was made and could be transferred to the cast.

Health care team roles

Dentists, dental assistants, and dental technicians work as a team to create and maintain dental casts. Dentists diagnose a particular problem in a patient's mouth and present solutions, depending on the specific nature of the case and the patient's comfort and budget. Sometimes, the exact solution is not fully determined until impressions of the patient's mouth are made and the dentist consults with the dental technician. Impressions are crucial to the problem-solving that the dentist and dental technician do. The dental assistant makes an impression of the patient's teeth and mouth structures and pours a hardened cast. The dentist examines this cast and sends it to the dental technician with recommendations for the creation of dental restorations. Dental technicians make wax diagnostic models from the mouth cast for various restorations (crowns, bridges, partial dentures, implants). These models are used by technicians to create metal frameworks and tooth structures in investment molds.

Training

Dental assistants and hygienists usually require some specialized training. Dental hygienists are often licensed. Dental technicians are trained at dental laboratories, though some dental schools offer coursework in dental restorations.

KEY TERMS

Bite—How the upper teeth and lower teeth fit together so that a person can chew and speak.

Bridge—A device that has at least one prosthetic tooth and two crowns. It is used to replace a missing tooth or teeth. The bridge is held in place when the adjacent crowns on the bridge are cemented over the two teeth on each side of the space left by the missing tooth or teeth.

Crown—A dental prosthetic that copies an existing tooth's shape (or ideal shape) and covers the tooth. It is cemented into place and feels like and is used as a normal tooth.

Denture—A dental prosthetic device consisting of a full set of teeth to fill the upper or lower jaw, or both. Also called false teeth.

Implant—A prosthetic tooth anchored permanently into the jaw bone by a post. It has the same strength and appearance as natural teeth.

Impression—An exact copy of the teeth and mouth using materials that will set sufficiently so that a more durable cast of the mouth can be made from plaster, dental stone, or other casting materials.

Investment mold—A plaster-like substance that is created around a wax model of an object that is to be cast in metal.

Lost wax casting—A process of casting metal that involves making a mold around a wax object that has been shaped exactly in the likeness of the intended finished object. The mold is then fired and the wax melts. The resultant mold is durable and capable of receiving molten metals which will be cast in the mold in the shape of the desired object.

Mold—A form or physical outline of an object used to hold a pliable material in order to copy the same shape or design.

Orthodontic appliances—Devices that help straighten the teeth; e.g. invisible braces, retainers, etc.

Partial dentures—A dental prosthetic of two or more teeth used to replace missing teeth.

Prosthetic device—A re-creation of a tooth or series of teeth to replace or improve the structure or appearance of a tooth or teeth.

Restoration—Any prosthetic device or process used to replace or improve the structure or appearance of a tooth or teeth.

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Dental cleaning see **Nonsurgical periodontal therapy**

Dental crowns, inlays, and bridges

Definition

Dental crowns, inlays, and bridges are prosthetic devices that replace missing teeth or part of a tooth. They are made of metal, porcelain, and resin, or a combination of these materials.

Purpose

Bridges, crowns, and inlays are created to restore a tooth's appearance, structure, or function. Inlays and crowns are intended to repair damage to individual teeth. They replace tooth structure lost by decay or injury, protect the part of the tooth that remains, and restore the tooth's shape and function. Bridges fill in a space in the jaw left by a missing tooth or teeth. They protect the shape of the mouth and restore function of the teeth and jaw.

Precautions

Some patients are allergic to the medications used for **local anesthesia** in dental restorations. In addition, many people are afraid of dental work. Most dentists in practice today can help patients with this specific fear.

Description

Crowns

The crown of a tooth is the portion that is covered by enamel. A restorative crown replaces this outer part to

protect and strengthen the tooth. This protection becomes necessary when a tooth cracks, has its entire structure weakened by decay, or becomes brittle after a root canal. Crowns can also cover dental implants or abutment (adjacent) teeth when fitting a bridge.

Crowns are also used to cover discolored or otherwise aesthetically displeasing teeth. **Cosmetic dentistry** does not use crowns as much as it once did, since crowns, though aesthetically pleasing, require more radical dental techniques. Dentists are opting for more conservative methods such as bleaching, bonding, or veneers to improve the aesthetic appearance of teeth.

The dentist first removes the decayed portion of the tooth. The tooth is then prepared for a crown. It may be tapered on the outside edges to a peg, reinforced with a cast metal core, or rebuilt with both a cast metal core and a post. An impression of the prepared tooth and the teeth next to it is made. A retraction cord is placed around the tooth in order to get the impression medium under the gum where the crown will be fitted.

The dental technician will create a new crown, using a cast made from this impression. The technique the technician uses is called lost wax casting. A wax model is made of the crown. Another mold is made around the wax model and both are fired in a kiln. The wax melts, leaving an opening into which a restorative material can be poured. The crown may be made of gold or stainless steel alone, metal with a veneer of tooth-colored porcelain or resin, or of porcelain or resin alone. The finished crown is then placed over the prepared tooth, adjusted, and cemented into place.

When a tooth has had a root canal and the root has been filled, the tooth may not be strong. Post crowns are used in these cases. The tooth is leveled at the gum line and a stainless steel or gold post is fitted into the root canal. This post can then receive the new crown and hold it in place.

For other patients, it may be necessary to implant the crown. In this case, a steel post is embedded in the patient's jawbone. It is left in place until the bone adheres to the post. The post is exposed and the crown is made and fitted.

New computerized techniques are making the restoration process faster and more comfortable. Chairside Economical Restoration of Esthetic Ceramics (CEREC) uses a computer system to allow the dentist to create ceramic crowns, inlays, and onlays, in one sitting. The tooth is prepared as usual but impressions are made digitally, using a hand-held camera. These photographs are converted to three-dimensional images on the computer screen, thus eliminating the need to take a physical impression of the patient's teeth. The dentist uses special 3D CAD/CAM software to design the crown. A milling

system attached to the CEREC machine is able to make a ceramic crown in 10-15 minutes.

Crowns can last 5-15 years or more, if they are well taken care of.

Bridges

Bridges are restorations that fill in a gap caused by missing teeth. They prevent the remaining teeth from shifting and provide a more stable surface for chewing. If the gap is not filled, the other teeth shift, affecting the patient's bite (occlusion), which sometimes produces **pain** in the jaw joint. As the teeth move and become crooked, they also become more difficult to keep clean. The risk of tooth decay and gum disease increases, also increasing the likelihood that additional teeth will be lost. A bridge is inserted to prevent this risk.

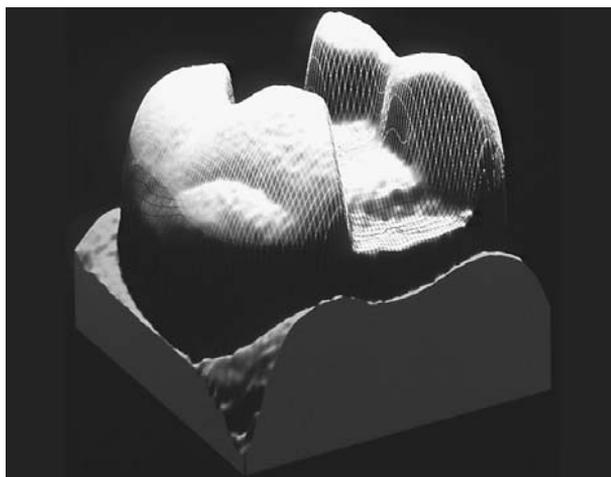
Bridges are appliances consisting of a metal framework and one or more artificial teeth (pontics) anchored to adjacent teeth. The abutment teeth carry the pressure when the patient chews food. Bridges can be removable or fixed (permanent). Removable bridges are attached to the abutment teeth by wires or precision attachments. Fixed bridges are attached to permanent crowns placed on abutment teeth. There are two types of fixed bridges—the crown-and-bridge design and the Maryland Bridge. A Maryland Bridge does not have crowns on it. The backs of the abutment teeth are reduced slightly and small wing-like appendages on the bridge are cemented to the back of the abutment teeth.

When the adjacent teeth are not strong enough to support a bridge, a two-implant bridge is required. This type of bridge takes longer for the permanent bridge to be fitted because of the necessity for the gums to heal. Posts are surgically implanted into the patient's bone and the gum closed. It takes several weeks for the bone to attach to the posts. The posts are re-exposed and the bridge is made to fit. It is then cemented in place.

Inlays

An inlay resembles a filling in that it fills the space remaining after the decayed portion of a tooth has been removed. The difference is that an inlay is shaped outside the patient's mouth and then cemented into place. After the decay is removed and the cavity walls are shaped, the dentist makes a wax pattern of the space. A mold is cast from the wax pattern. An inlay is made from this mold and sealed into the tooth with dental cement.

Inlays and their counterparts, onlays, are conservative alternatives to crowns. They don't require as much



A cavity is cut into a tooth in preparation for a dental inlay. An oral camera determines the exact dimensions of the cavity and the data are used to cut a perfectly fitting inlay from a ceramic block. (Photograph by Volker Steger. Science Source/Photo Researchers. Reproduced by permission.)

tooth preparation and often are more durable than amalgam fillings. Inlays cover the grooves on the surface of the molar. Onlays wrap over the tooth, covering more of its surface.

Inlays used to be made entirely of gold for its durability. New inlay alloys of palladium, nickel, or chromium are frequently used. Metals have been the dentist's choice for inlays in molars. When inlays are required for teeth that will be seen when a patient smiles, tooth-colored composites and porcelains are used. Reinforced porcelain and Lucite porcelain are durable but still may not be suitable for patients who grind their teeth. Composites are also used in fillings.

Preparation

Before a restoration is placed in the mouth, the dentist removes all traces of decay or damage and shapes the remaining tooth structure for the restoration. When bridges or crowns are necessary, the tooth or teeth that are to receive the crowns are shaped into posts or pegs. Temporary crowns and bridges are installed until the permanent restoration is delivered by the laboratory.

Aftercare

Temporary crowns or bridges must stay in place until the permanent restorations have been fitted to the patient's mouth. Dentists and dental assistants should educate the patient about ways to keep the temporary in place; e.g. avoid hard foods, gum and other sticky or chewy foods. If possible, the dental assistant and dentist

KEY TERMS

Abutment tooth—A crowned tooth that stabilizes a bridge or partial denture.

Bridge—An appliance of one or more artificial teeth anchored by crowns on the adjacent teeth.

CAD/CAM—A computer-aided design and manufacturing package.

Complete denture—A full set of upper or lower teeth, mounted in a plastic base. Dentures are also called false teeth.

Crown—A protective shell that fits over the tooth.

Dental caries—A disease of the teeth in which microorganisms convert sugar in the mouth to acid that erodes the tooth.

Enamel—The hard outermost surface of a tooth.

Inlay—A filling that is made outside of the tooth and then cemented into place.

Occlusion—The way upper and lower teeth fit together during biting and chewing.

Pontic—An artificial tooth.

Pulp—The soft innermost layer of a tooth that contains its blood vessels and nerves.

should encourage the patient to avoid eating foods on the side of the mouth where the temporary is. Also, the patient should be reminded to call immediately if the temporary is loosened so that it can be re-cemented.

There can be some gum swelling or discomfort when a crown or bridge is fitted. If a bridge implant was completed, there is naturally some discomfort from the surgery. The dentist can recommend medications or oral rinses to mitigate the discomfort.

Patients may also experience sensitivity to cold foods or drinks for a few weeks after a crown, bridge, or inlay is in place.

Patients should be urged to maintain normal **oral hygiene** while they wear a temporary and after the crown or bridge is in place. Specialty brushes and floss threaders may be used to remove plaque and food from around crowns and bridges.

The patient should see the dentist for an adjustment if there is any discomfort or irritation resulting from a restoration. Otherwise, the patient should see the dentist at least twice a year for an oral examination.

Complications

Restoration procedures typically require local anesthesia. Some people may have allergic reactions to the medication. A very small number of people are allergic to one or more of the metals used in a dental restoration. In most cases, the dentist can use another material.

Results

A well-made restoration should feel comfortable and last a relatively long time with proper care. Artificial dental restorations only approximate the original tooth, however. It is better, therefore, to prevent the need for restorative dental work than to replace teeth. Restorations are expensive, may require many appointments, and still need careful cleaning and attention.

Health care team roles

The dentist is crucial in diagnosing a patient's particular dental needs and determining the correct remedy. The dentist will prepare a patient's teeth for restorative work. Often, this requires a great deal of skill and structural knowledge in order to remove enough tooth material for the restoration to fit and yet leave enough architecture within the tooth in order to stabilize the restoration.

The dental technician prepares the restoration so that it will fit the prepared tooth and fit in with the rest of the patient's mouth structure. The technician is part scientist and part artist in order to craft natural looking teeth that match the others in a patient's mouth.

The dental assistant prepares the patient and the patient's teeth for the dentist to do what is necessary to determine what restoration is best suited for this particular patient. The dental assistant takes impressions of the patient's teeth and gums and makes plaster-type casts to aid the dentist in diagnosis and the dental technician in creating life-like restorations that fit comfortably in the patient's mouth.

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Janie Franz

Dental emergency see **Dental trauma**

Dental examination

Definition

A dental examination is part of an oral examination: the close inspection of the teeth and tissues of the mouth using physical assessment, radiographs, and other diagnostic aids. Dental care begins with this assessment, and is followed by diagnosis, planning, implementation, and evaluation.

Purpose

The examination identifies tooth decay and evaluates the health of the gums and other oral tissues. The fit of dentures and bridges (if any) are evaluated. The patient’s bite and **oral hygiene** are also assessed. The dentist then recommends the best treatment options to the patient.

Precautions

Before a dental examination patients with heart-valve disease must take **antibiotics** to prevent **bacteria** that may spread into the bloodstream from causing **endocarditis**. Hypertensive patients may need to have their **blood pressure** measured. Many dentists prefer not to examine patients who have active herpes sores on or near the mouth. To maintain a sterile environment, dentists and their assistants don gloves and masks.

Description

A dental examination is part of a comprehensive oral examination to evaluate the mouth, jaw, and teeth. The American Dental Association (ADA) recommends that

patients seeing a dentist for the first time receive a comprehensive examination, and that established patients be thoroughly evaluated every three years, with professional oral care and periodontal maintenance between examinations. Comprehensive evaluations are usually combined with a dental cleaning, x rays, and other diagnostic tests. If a new patient presents with an emergency, the situation will be evaluated and treated first. Once the emergency is over, an appointment for a complete oral examination will be scheduled.

The examination begins with a review of the patient’s complete medical and dental history, which is usually a form or questionnaire completed by the patient. Once the dentist is familiar with any special conditions that may affect the patient during the exam—heart disease, relevant **allergies**, or the use of medications such as **blood** thinners—the examination and cleaning can proceed.

Teeth

The dentist or dental hygienist uses instruments such as a mouth mirror, periodontal probe, and explorer to examine the teeth. Every tooth is checked for cavities; the conditions and positions of the teeth, both erupted and impacted, are noted; previous treatments, such as crowns and other restorations, are evaluated. The dentist’s observations are recorded on a tooth chart. The jaw joint and bite are evaluated, since an irregular bite can lead not only to excessive wear on the teeth but other dental problems as well. The fit of dentures and bridges, if worn, are inspected. Dentists frequently order other diagnostic tests such as x rays, blood tests, and **dental casts** as well.

Gums

The dentist or hygienist evaluates the gingiva, or gum tissue, for periodontal disease by checking for loose teeth, bone loss, and bleeding, swollen, or receding gums. A periodontal probe measures the depth of the pocket around each tooth. If the gums are healthy the pocket will be less than three millimeters deep. Pockets of four millimeters or more indicate periodontal disease. The deeper the pocket, the greater the chance for tooth loss unless treatment is begun.

Tissues of the mouth

An **oral cancer** screening is part of the dental examination. The dentist feels the lymph nodes on the face and neck, and checks the entire oral cavity—including the hard and soft palates, tongue, cheeks, lips, and floor of the mouth—for irregularities. If caught early, many types of oral **cancer** can be treated successfully.



A dentist and assistant check a woman's teeth during a dental exam. (Photograph by Carolyn A. McKeone. Science Source/Photo Researchers. Reproduced by permission.)

Patient education

Oral exams often include instructing the patient in flossing and brushing techniques, the use of fluoride toothpastes, and the prevention of tooth damage from contact sports and other activities. Patient concerns can also be discussed during a counseling session.

Insurance

Oral examinations are covered by most dental insurance at 100%. Annual x rays are also covered. Panorax and full-mouth x rays are usually covered every three to five years, except for emergencies or third molar (wisdom tooth) surgery.

Preparation

The dental office prepares for an examination by sterilizing all the equipment that will be used during the examination. The patient prepares by having a complete medical and dental history available or alerting the dentist or hygienist to any health changes, and taking pre-treatment medication, if necessary.

Aftercare

The patient will be advised that the teeth may be tender after a thorough cleaning and examination, and ibuprofen (Advil, Motrin) or acetaminophen (Tylenol) may be recommended to alleviate the discomfort. This tenderness usually subsides within a day or two.

Complications

Complications from an oral examination are rare, although the tissues and teeth may be sore for a few days.

Results

An oral examination should give the dentist a good idea of the patient's oral health. Once this is established, a complete treatment program can be scheduled and maintained.

Health care team roles

The dental staff work as a team during the examination. The front office confirms the appointment with the patient a day ahead of time, and reminds the patient of

information that will be needed for medical and dental histories. The registered dental hygienist (RDH) assesses the patient's **health history**, takes x rays, and cleans the teeth. Next the registered dental assistant (RDA) and dentist chart the existing conditions of the mouth and teeth, and counsel or educate the patient. This helps the patient feel comfortable and knowledgeable about the treatment required for optimum health.

Resources

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American Academy of Periodontology. 4157 Mountain Road, PBN 249, Pasadena, MD 21122. (410) 437-3749. <<http://www.perio.org>>.

American Dental Association. 211 East Chicago Avenue, Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org>>.

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Cindy F. Ovard, RDA

Dental filling materials see **Restorative dental materials**

KEY TERMS

Full-mouth x rays—A set of x-ray films that show all the teeth, consisting of 14 periapicals and two or four bitewings.

Panorex—Trade name for a single panoramic x ray taken by a camera that travels around the head, it shows all the teeth and both jaws in one film. It can reveal impacted teeth, cysts or tumors of the jaw, along with possible sinus infections and temporomandibular joint dysfunction.

RDA—Registered dental assistant, a licensed professional trained to assist the dentist at chairside, including preparation and maintenance of dental instruments, preparation of dental materials, taking impressions, etc.

RDH—Registered dental hygienist, a licensed professional. RDHs evaluate patient histories, clean teeth by removing deposits such as plaque and tartar, process dental x rays, and educate patients about oral hygiene.

Dental fillings

Definition

Dental fillings are metal amalgams or composite resins used to fill a cavity.

Purpose

Dentists use dental fillings to restore teeth damaged by **dental caries** (tooth decay). Dental caries are caused by microorganisms that convert sugars in food to acids which erode the enamel of a tooth, creating a hole or cavity. The dentist cleans out the decayed part of the tooth and fills the opening with an artificial material (a filling) to protect the tooth's structure and restore the appearance and utility of the tooth.

Precautions

As in any dental procedure, the dentist and dental assistant will need to use sterile techniques. Gloves and masks are essential as well as the sterilization of equipment and tools. This not only helps prevent the spread of infectious diseases like **AIDS** and hepatitis, but also the **common cold**.

The patient's reaction to anesthesia is the other main concern of the dentist and dental assistant when perform-

ing dental fillings. **Nitrous oxide** should be avoided with pregnant patients, and local anesthetics should be used with caution, though they are considered safe. Local anesthetics like Novocain and lidocaine have been in practical use for decades with few side effects reported. Some patients, however, are allergic to these drugs.

Description

Though dentists are encountering fewer and smaller cavities in their patients, there is still a need for dentists to fill cavities. Old fillings suffer wear and need to be replaced. Patients are demanding more restorative work on their teeth, sometimes opting for full mouth restorations that involve installing crowns, bleaching teeth or applying veneers, and replacing dark metal fillings with tooth-colored ones that create a monochromatic view in a patient's mouth.

Once the decay is removed and the tooth is prepared (see Preparation), the dentist has a wide choice of dental filling materials to choose from.

Amalgam fillings

The most common and strongest filling material is amalgam. It is a silver filling that is usually placed on the rear molars, which endure more stress during chewing. Amalgam fillings—used for large, deep cavities—are strong and very resistant to wear. Amalgam has been in use since 1833.

Amalgam is a mixture (an amalgam) of several metals, including liquid mercury (35% silver, 15% tin or tin and **copper**, a trace of **zinc**, and 50% mercury). When it is prepared, it has a malleable consistency which can easily be shaped to fit the prepared tooth. It hardens to a durable metal.

Despite its durability, many dentists and patients avoid amalgam fillings. Dentists have found that amalgam has a tendency to expand with time. As a result, teeth become fractured from the inside, often splitting the tooth. Patients often avoid amalgam for strictly aesthetic reasons. Amalgam fillings darken over time and make teeth look as if they are decayed.

The biggest reason amalgam has lost favor is a health concern due to its 50% mercury content. Although the American Dental Association (ADA) has pronounced amalgam safe in the quantity and composition of amalgam, some patients and dentists are disturbed by various reports of illness in relation to the mercury in amalgam fillings. Mercury is a toxic material. Some states are required to dispose of mercury waste as if it were a hazardous product. There is also an added risk of inhaling mercury particles when old fillings are removed.

Gold fillings

Gold fillings or inlays are created outside of the mouth by a dental technician and then cemented into place. They are also used to fill the back molars. Gold fillings are very durable. Like amalgam, however, they are not as aesthetically pleasing as tooth-colored fillings.

Composite fillings

Composite fillings, often called white fillings, are made of a plastic resin and finely ground glass. They must be applied to the tooth surface in thin layers. Dentists try to match the color of composites with neighboring teeth for a more natural look, making the filling appear invisible. Composite resin fillings often are made smaller than amalgam fillings and require less tooth preparation, thereby saving more natural tooth surface.

Composite fillings are bonded to the tooth so that the tooth becomes stronger than it was before. They are also less sensitive to temperature changes in the mouth that can damage the tooth; therefore there is less chance that the tooth will shatter because of the filling.

These fillings may not be suitable for large cavities in molars. Though composite durability increased in the 1990s, a porcelain inlay or crown may be the best choice for a durable, natural-looking restoration of a molar.

The major drawback of composite resin fillings is cost. They average one-and-a-half to two times more than the price of amalgam fillings. They also can be stained from drinking coffee and tea. Large composite fillings tend to wear out sooner than amalgam fillings.

Composite fillings can last seven to ten years, which is similar to the lifespan of amalgam fillings.

Resin ionomer

Resin ionomers are new, tooth-colored filling materials that contain a resin and fluoride. They are very suitable for children and for older adults who suffer from root decay that occurs as a person ages. These fillings seal the tooth and also protect it from future decay because of the fluoride that they release.

Preparation

During a routine checkup, the dentist may find a cavity in a tooth with a metal tooth probe. A new diagnostic tool, the DIAGNOdent, can detect evidence of cavities and pre-cavity conditions on the tooth's surface. A low-powered laser, the DIAGNOdent is able to detect decay so early that a dental cavity can be avoided. These pre-cavity areas can be protected with a sealant, thereby preventing further decay.

Cavities found since the 1990s are relatively small and not very deep, so there may be no need to anesthetize the area where the dental work will be done. High-speed drills often are able to clean out the decay quickly and with little discomfort. If the cavity is not very deep, the drill may not reach the sensitive nerves in the teeth which usually cause **pain**. Children and some adults may need anesthesia in any case. The dentist and the dental assistant need to be aware of the patient's history and if the patient reacts adversely to **local anesthesia**. (See Precautions and Complications.)

There are some dentists who use electronic dental anesthesia (EDA), a device that sends electrical charges to the gum through electrodes. Sometimes this is enough anesthesia for the procedure. At other times, EDA numbs the area where the anesthesia is administered, so that the patient doesn't feel the needle as it goes into the gum. Some dentists also provide soothing music to calm patients during the procedure. Other dentists will use local anesthesia in combination with nitrous oxide-oxygen analgesia to minimize discomfort through the drilling phase of a filling.

Dental lasers that generate a low-powered beam of light are being used to cut away decay, but without the whine of the drill and without using anesthesia. Though a bit slower than the conventional drill, lasers are very efficient at preparing a tooth to receive a filling. Unfortunately, lasers cannot yet remove old fillings or prepare a tooth surface to receive a crown.

Air abrasion is another way to remove decay without using anesthesia. Air abrasion machines produce a spray of air and powder. There is no vibration or heat. Because it has no vibration, it avoids microfractures in the tooth that sometimes occur with drills. Air abrasion removes only a small amount of the tooth's structure. Therefore, it is suitable for small cavities and the repair and replacement of old fillings. It also can repair chipped teeth and clean discolored or stained teeth.

After the cavity is cleaned of decay, the walls of the tooth are shaped and are ready to receive a filling material. If a composite resin filling is used, the tooth next needs to be etched so that the resin will adhere to the tooth. The tooth then is filled, shaped, and polished. The composite filling then must be hardened by shining a special light on it.

Aftercare

The dentist and dental assistant should advise the patient that the teeth, lips, and tongue may be numb for several hours after the procedure, if a local anesthetic was used. Some patients experience sore gums or a sensitivity to hot and cold in the tooth that has just been

filled. Normally, patients are advised to avoid chewing hard foods directly on new amalgam fillings for 24 hours. Composite fillings require no special caution since they set immediately. If patients experience continued pain or an uncomfortable bite, they should call their dentist.

Complications

Some patient's have allergic reactions to local anesthesia.

Results

Fillings restore a tooth's function and appearance. They permit the patient to continue to eat and chew properly and last for several years. Normal fillings will need to be replaced over a patient's lifetime. Since fewer dental caries have been observed since the last decade of the twentieth century, dentists are initially filling fewer teeth, but are replacing fillings as they fail and sometimes systematically, especially if the patient decides to cosmetically enhance his or her teeth. Since many of the initial cavities are quite small, patients are opting for more aesthetically pleasing filling materials even if they are not as durable.

Health care team roles

When the dentist discovers a cavity, filling options are discussed with the patient. The dental assistant prepares the dentist's workstation and lays out the specific instruments that are needed. The dental assistant prepares the filling material according to the manufacturer's directions and assists the dentist in preparing the tooth for filling and in the filling procedure itself. The dental assistant cleans the patient's mouth and returns the procedure room to order. All of the instruments that have been used are sterilized by the dental assistant.

Resources

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ORGANIZATIONS

American Dental Association. 211 East Chicago Ave., Chicago, IL 60611. (800)947-4746. (312)440-2500. <<http://www.ada.org>>.

KEY TERMS

Amalgam—A mixture of metals, primarily mercury used to make large, durable fillings. Also called silver fillings.

Anesthesia—A condition created by drugs that produces a numb feeling. General anesthesia produces unconsciousness whereas a local anesthesia produces numbness around the site where the drug was introduced.

Composite filling—A resin material that is tooth colored and is used to fill a tooth once decay has been removed. It is used most often in front teeth but may be used in any tooth for aesthetic reasons.

Crown—An artificial covering prepared by a lab technician to fit over a damaged tooth or one weakened by decay.

Dental caries—Tooth decay caused by microorganisms that convert sugars in food to acids which erode the enamel of a tooth.

Dental laser—A device that generates a low-powered beam of light that is used in place of a dentist's drill to cut away decay from a tooth or remove gum tissue.

Enamel—The hard outer surface of a tooth.

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Janie F. Franz

Dental floss see **Oral hygiene aids**

Dental hygiene

Definition

Dental hygiene is the profession of cleaning teeth and helping patients maintain oral health. Dental hygienists are licensed professionals—key members of the dental health care team who provide educational, clinical,

and therapeutic dental services, such as preventive care, dental examinations, and instruction about how patients can better care for their teeth and gums.

Description

Dental hygienists are trained to provide dental hygiene care for patients, they work with dentists to deliver oral care to patients, and they use their interpersonal skills to educate and motivate patients about how to prevent dental disease and maintain oral health. In the clinical setting, dental hygienists:

- Assess patients' teeth and gums and review oral histories.
- Educate patients about **nutrition** and self-care to prevent dental disease, teaching them how to clean the mouth using aids such as toothbrushes, interdental devices, and other efficacious products.
- Examine head, neck and dental areas for disease.
- Perform x rays and other diagnostic tests.
- Perform preventive dental services, such as removing calculus, stains and plaque from teeth, to keep the teeth and gums healthy.
- Screen for **oral cancer** and high **blood** pressure.
- Educate patients about oral health and its link to general health.
- Place and remove periodontal dressings or temporary fillings.
- Make impressions of teeth to use as models for dentists to evaluate treatment needs.
- Apply preventive agents such as sealants and fluorides to keep teeth healthy.
- Remove sutures.

In administrative roles, dental hygienists consult with dental health or insurance companies, market dental products, and initiate community dental health programs. Dental hygienists also hold positions at colleges and universities, where they teach dental hygiene or conduct clinical research. Another area of opportunity is in **public health**, where dental hygienists provide health policy, program administration and management; research community-based care methods; focus on oral health promotion and disease prevention; and help assess, develop, evaluate, and initiate oral health care delivery systems. In these capacities they often have little or no direct individual patient contact.

Dental hygiene is a profession that requires its practitioners to work closely with patients, earning their trust, maintaining a high level of oral care, and teaching them

Examples of services provided by dental hygienists

Types of services	Purpose	Individual	Family	Community
Preventive: Primary	To prevent disease occurrence	Sealants	Counsel parents on prevention of baby-bottle tooth decay	Promote water fluoridation
Preventive: Secondary	Early treatment to prevent disease progression	Plaque/calculus removal	Counsel on harmful oral habits	Oral screening and referrals
Educational	Guide to good health behaviors	Home care instruction	Nutritional counseling	Oral health units in schools
Therapeutic	Stop or control disease and maintain healthy oral tissues	Scaling/root planing Postoperative care	Smoking cessation, counseling	Sealant programs Fluoridation of water supply

SOURCE: Alvarez, K.H. *Williams & Wilkins' Dental Hygiene Handbook*. Baltimore: Williams & Wilkins, 1998.

the skills they need to stay healthy. Providing these valuable services usually fosters a tremendous sense of personal fulfillment. Dental hygiene is a highly skilled, prestigious discipline with room for advancement. Flexible hours and work environments make the work attractive. Dental hygienists have little problem finding full- or part-time work during daytime, evening and weekend hours in almost every area of the world. Many also enjoy the job security that dental hygiene offers. Rapid advances in **preventive dentistry** combined with an aging and growing population ensures that dental hygienists will be busy for the foreseeable future.

Work settings

Dental hygienists usually work in private dental practices. However, other employment settings include health maintenance organizations, long-term care facilities, schools, military bases, universities, research facilities, governmental agencies, dental supply companies, or in veterinary dental medicine.

Education and training

Dental hygienists are licensed oral health care professionals who have either a two-year diploma, certificate, or associate degree in dental hygiene or a four-year baccalaureate degree. They are educated through community college academic programs, technical colleges, dental schools, or universities. Dental hygienists should work well with others and have good manual dexterity and hand-eye coordination to use **dental instruments** in the small area of a person's mouth.

Students in dental hygiene programs receive laboratory, clinical, and classroom instruction in subjects such as anatomy, physiology, chemistry, microbiology, **pharmacology**, nutrition, radiography, histology, periodontology, pathology, dental materials, dental hygiene theory and practice, and social and behavioral sciences.

Dental hygienists must be licensed in the jurisdiction in which they practice. To become licensed, dental hygienists must have graduated from an accredited dental hygiene school and passed written and clinical examinations. Accredited dental hygiene programs require an average of 2,000 curriculum hours, including 585 hours of supervised clinical dental hygiene instruction. Two-year associate's degrees allow dental hygienists to take national, state, or regional license examinations.

Usually, an associate's degree is qualification enough for those who want to practice in a private dental office. High school students considering a career in dental hygiene should consider taking such courses as health, biology, psychology, chemistry, mathematics, and speech. Some baccalaureate degree programs require that applicants first complete two years of college before being accepted into dental hygiene programs. About half of the dental hygiene programs prefer applicants who have completed at least one year of college. Students or school counselors should contact individual programs for their requirements.

Advanced education and training

Dental hygienists who go into research, education, or administration usually need a master's degree in dental hygiene. Those oral hygienists who choose to go into public health dental hygiene usually must pursue graduate public health education at both schools of public health and dentistry.

Future outlook

Dental hygiene is projected to be among the 30 fastest growing occupations due to the increasing population and people's longer retention of their natural teeth.

Proper dental hygiene clinical attire

Outer garments (gowns, lab coats, scrub suits, uniforms) should adequately cover arms and street clothing. They should be disposable or laundered commercially (not taken home or worn outside the clinic).

The face mask should block out particles as small as microns and have a lining impenetrable to moisture. The mask should cover the nose and mouth and fit comfortably under glasses, if worn. Change the face mask before each patient and wear for no longer than 1 hour.

Protective eyewear should be worn by both the patient and client. The eyewear should be shatterproof, lightweight, easily disinfected, and provide wide coverage with side shields.

Gloves should be strong and durable, and impermeable to saliva, blood, and bacteria. The gloves should be nonirritating or harmful to skin and fit properly.

Jewelry should not be worn on hands and wrists to minimize areas for microorganisms.

SOURCE: Alvarez, K.H. *Williams & Wilkins' Dental Hygiene Handbook*. Baltimore: Williams & Wilkins, 1998.

In fact, the career path is expected to grow much faster than average through 2008. Salaries of dental hygienists are based on their responsibilities and specific positions, the geographic location of employment, and their type of work environment. They are similar to those of other health care personnel with similar education and experience. In 1998 dental hygienists earned median hourly wages of \$22.06. The middle 50% earned between \$17.28 and \$29.28 an hour. The lowest 10% earned less than \$12.37; the highest 10% earned more than \$38.81 an hour.

Resources**ORGANIZATIONS**

American Dental Association. 211 E. Chicago Ave. Chicago, IL 60611. (312) 440-2806. <<http://www.ada.org>>.

American Dental Education Association (ADEA). 1625 Massachusetts Avenue, NW, Washington, DC 20036-2212. 202-667-9433. <<http://www.adea.org>>.

American Dental Hygienists' Association. 444 North Michigan Avenue, Suite 3400, Chicago, IL 60611. (312) 440-8900. <<http://www.adha.org>>.

OTHER

Commission on Dental Accreditation. 211 E. Chicago Avenue, Chicago, IL 60611. 312-440-2718. education@ada.org.

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Lisette Hilton

Dental implants see **Dental prostheses**

KEY TERMS

Calculus—A hard mineral deposit formed on teeth; tartar.

Histology—Study of tissue structure.

Periodontology—Study of gum disease.

Plaque—Colorless, sticky film composed of acid and bacteria, which causes tooth decay.

Dental indices**Definition**

Dental indices provide a quantitative method for measuring, scoring, and analyzing dental conditions in individuals and groups. An index describes the status of individuals or groups with respect to the condition being measured.

Description

Oral health surveys depend on dental indices, as do researchers and clinicians, to help in understanding trends and patients' needs. In epidemiological oral health surveys, an index is used to show the prevalence and incidence of a particular condition, to provide baseline data, to assess the needs of a population, and to evaluate the effects and results of a community program. Researchers use indices to determine baseline data and to measure the effectiveness of specific agents, interventions, and mechanical devices. In private practice, index scores are used to educate, motivate, and evaluate the patient. By comparing scores from the initial exam during a follow-up exam, the patient can measure the effects of personal daily care.

The first dental index, developed by Schour and Massler, was known as a Papilla, Marginal gingiva and Attached gingiva (PMA) Index. Each of those areas was examined and scored from 0 to 5, depending on the severity of inflammation. The PMA Index, largely of historic interest now, was primarily used in surveys of acute **gingivitis**.

Today, dental indices are used to assess both individual and group oral health and disease status. They can be simple, measuring only the presence or absence of a condition, or they can be cumulative, measuring all evidence of a condition, past and present. Irreversible indices measure conditions that will not change, such as **dental caries**.

A reversible index measures conditions that can be changed, such as the amount of bacterial plaque present.

The status of a patient's periodontal health or disease is commonly measured by an index in private practices. One of the most widely used is the Periodontal Screening and Recording (PSR)TM Index, adapted in 1992 from a system in use in Europe called the Community Periodontal Index of Treatment Needs. The PSRTM is an early detection system for periodontal disease. It is not intended to replace full periodontal charting, but to serve as a simple and convenient screening tool. (The PSRTM is more fully discussed in the entry on dental and periodontal charting.)

In addition to measuring a patient's periodontal status, dental indices can measure the amount of plaque and calculus present or not present in a patient's mouth, the amount of bleeding present in the gingiva, the amount of tooth mobility present at a given time, the amount of **fluorosis** present, and the number of decayed, missing, or filled teeth present. Some of the more widely known indices are:

Plaque index (PI)

The PI as developed by Silness and Loe assesses the thickness of plaque at the cervical margin of the tooth (closest to the gum). Four areas, distal, facial or buccal, mesial, and lingual, are examined.

Each tooth is dried and examined visually using a mirror, an explorer, and adequate light. The explorer is passed over the cervical third to test for the presence of plaque. A disclosing agent may be used to assist evaluation. Four different scores are possible. A zero indicates no plaque present; 1 indicates a film of plaque present on the tooth; 2 represents moderate accumulation of soft deposits in the gingival pocket or on the tooth that can be seen by the naked eye; 3 represents an abundance of soft matter within the pocket or on the tooth.

Each area of each tooth is assigned a score from 0 to 3. Scores for each tooth are totaled and divided by the four surfaces scored. To determine a total PI for an individual, the scores for each tooth are totaled and divided by the number of teeth examined. Four ratings may then be assigned: 0 = excellent, 0.1-0.9 = good, 1.0-1.9 = fair, 2.0-3.0 = poor.

Plaque control record

A similar system for measuring plaque is credited to O'Leary, Drake, and Naylor. This system measures plaque present, rather than plaque not present, but no attempt is made to differentiate in the quantity of plaque seen on each surface. The number of surfaces examined may be increased from four to six. When using six sur-

faces, they are facial (or buccal), mesio-facial, mesio-lingual, lingual, disto-lingual, and disto-facial.

To determine an individual's score, the clinician multiplies the number of surfaces with plaque by 100, and divides that by the number of tooth surfaces examined. For example, if an individual has 26 teeth, that equals 104 surfaces. If eight surfaces are found to have plaque, then 800 is divided by 104, leaving a plaque control index of 7.6%. A score under 10% is considered good.

Oral hygiene index (OHI)

The OHI, developed by Greene, Vermillion, and Waggener, has two components, the debris index and the calculus index, and is an indication of oral cleanliness. The scores may be used singly or in combination. For scoring, the clinician divides the dentition into sextants and selects the facial (or buccal) and lingual tooth surface in each sextant that is covered with the greatest amount of debris and calculus. Twelve surfaces, therefore, will be evaluated. For this index, a surface includes half the circumference of the tooth.

Greene and Vermillion have also developed a simplified OHI in which the clinician measures only one tooth surface in each sextant, equaling only six surfaces.

DEBRIS INDEX (DI). For this index, debris is defined as soft, foreign matter consisting of bacterial plaque and food debris. The criteria include 0, no debris or stain present; 1, debris covering not more than one-third of the tooth surface or extrinsic stain without debris; 2, debris covering between one- and two-thirds of the tooth surface; and 3, debris covering more than two-thirds of the tooth surface.

CALCULUS INDEX (CI). Calculus, a hard calcified deposit of inorganic salts, is scored for this index with four criteria. They are 0, no calculus present; 1, supragingival calculus present covering not more than one third of the tooth surface; 2, supragingival calculus covering between one- and two-thirds of the tooth surface, or scattered subgingival calculus; and 3, supragingival calculus covering more than two-thirds of the tooth surface, or a continuous heavy band of subgingival calculus around the tooth.

To arrive at an OHI score, one first calculates the DI and CI scores by dividing the total scores for each tooth by the number of sextants. The DI and CI scores are then added to determine an OHI score. A perfect score would be 0, and the worst score possible is 12. In the simplified OHI, the worst score possible is 6.

Gingival index (GI)

Also attributed to Loe and Silness, the GI assesses the severity of gingivitis based on color, consistency, and

Types of dental indices

Type	Purpose
Individual assessment	Evaluation and monitoring the progress and maintenance of oral health Measures effects of personalized disease control programs over time Monitors progress of disease healing Patient education, motivation
Clinical trial	Determines the effect of an agent or procedure on the prevention, progression, or control of a disease Comparison of an experimental group with a control group
Epidemiologic survey	Survey for the study of disease characteristics of populations Not designed for evaluation of an individual patient

SOURCE: Alvarez, K.H. *Williams & Wilkins' Dental Hygiene Handbook*. Baltimore: Williams & Wilkins, 1998.

bleeding on probing. Each tooth is examined at the mesial, lingual, distal, and facial (or buccal) surface. A probe is used to press on the gingiva to determine its degree of firmness, and to run along the soft tissue wall adjacent to the entrance to the gingival sulcus. Four criteria are possible: 0, normal gingiva; 1, mild inflammation but no bleeding on probing; 2, moderate inflammation and bleeding on probing; 3, severe inflammation and ulceration, with a tendency for spontaneous bleeding.

Each surface is given a score, then the scores are totaled and divided by four. That number is divided by the number of teeth examined to determine the GI. Ratings are 0, = excellent; 0.1-1.0 = good; 1.1-2.0 = fair; 2.1-3.0 = poor.

Periodontal index (PI)

Developed by Russell, the PI determines the periodontal disease status of populations in epidemiologic studies. Each tooth is scored according to the condition of the surrounding tissues. On examination, each tooth is assigned a score using the following criteria:

- 0: Negative. Neither overt inflammation nor loss of function caused by the destruction of supporting tissue is noted.
- 1: Mild Gingivitis. Overt inflammation in the free gingiva is present, but does not circumscribe the tooth.
- 2: Gingivitis. Inflammation surrounds the tooth, but there is no apparent break in the epithelial attachment.
- 6: Gingivitis with pocket formation. The epithelial attachment of gum to tooth is broken. There is no inter-

ference with normal function. The tooth is not loose or drifting.

- 8: Advanced destruction with loss of function. The tooth may be loose or drifting. It may sound dull on percussion and may be depressible in the socket.

Scores for each tooth are added, and the total divided by the number of teeth examined. Scores can be interpreted as follows:

- 0-0.2: Clinically normal supportive tissues.
- 0.3-0.9: Simple gingivitis.
- 0.7-1.9: Beginning destructive periodontal disease.
- 1.6-5.0: Established destructive periodontal disease.
- 3.8-8.0: Terminal periodontal disease.

Gingival bleeding index (GBI)

Unwaxed dental floss is used to measure a GBI, developed by Carter and Barnes. A full complement of teeth has 28 proximal areas to be examined. Floss is passed interproximally, first on one side of the dental papilla, then on the other. The clinician curves the floss around each tooth and passes it below the gingival margin, taking care not to lacerate the gingiva. Any bleeding noted indicates the presence of disease. The numbers of bleeding areas versus proximal areas scored is recorded and used for patient motivation.

Mobility index

The mobility index, developed by Grace and Smales, can be useful to track the amount of mobility in teeth over a period of time. Grade 0 indicates no apparent mobility. Grade 1 is assigned to a tooth in which mobility is perceptible, but less than 1mm buccolingually. Grade 2 mobility is between 1-2 mm, and Grade 3 mobility exceeds 2mm buccolingually or vertically.

Dean's Dental Fluorosis Index

Dean's is used to score the amount of dental fluorosis (discoloration) present on teeth. Fluorosis generally appears as a horizontal striated pattern across a tooth. Molars and bicuspids are most frequently affected, followed by upper incisors. The mandibular incisors are usually least affected. Fluorosis tends to be bilaterally symmetrical. Defects may appear as fine white or frosted lines or patches near the incisal edges or cusp tips.

A score is given based on the two teeth most affected. If the teeth are not equal in appearance, the less affected tooth is the one scored.

Scores used in Dean's Index are as follows:

- Normal (0): The enamel is smooth, glossy and translucent, usually a pale creamy-white color.
- Questionable (1): There are slight aberrations from the translucency of normal enamel. Lesions may range from a few white flecks to occasional spots.
- Very mild (2): Opaque paper-white areas are visible, involving less than 25% of the facial or buccal tooth surface.
- Mild (3): White opacity of the enamel is more apparent than for code 2, but still covers less than 50% of the surface.
- Moderate (4): Marked wear and brown stain, frequently disfiguring, is visible.
- Severe (5): Hypoplasia is so marked that the general form of the tooth may be altered. Pitted or worn areas and brown stain are widespread. Teeth often have a corroded appearance.
- Excluded (8): Used for crowned teeth.
- Not recorded (9): Used for missing teeth or teeth that cannot be scored.

Decayed, missing and filled teeth (DMFT) index

To assess dental caries in a population, a DMFT index is used. During a systematic examination with a mirror and explorer that includes the crown and exposed root of every primary and permanent tooth, each crown and root are assigned a number based on the result of that exam. The numbers are recorded in boxes corresponding to each tooth to provide a DMFT chart. It is recommended that care be taken to record all tooth-colored fillings, which may be difficult to detect.

Number are assigned as follows:

- 0: A zero indicates a sound crown or root, showing no evidence of either treated or untreated caries. A crown may have defects and still be recorded as 0. Defects that can be disregarded include white or chalky spots; discolored or rough spots that are not soft; stained enamel pits or fissures; dark, shiny, hard, pitted areas of moderate to severe fluorosis; or abraded areas.
- 1: One indicates a tooth with caries. A tooth or root with a definite cavity, undermined enamel, or detectably softened or leathery area of enamel or cementum can be designated a 1. A tooth with a temporary filling, and teeth that are sealed but decayed, are also termed 1. A 1 is not assigned to any tooth in which caries is only suspected. In cases where the crown of a tooth is entirely decayed, leaving only the root, a 1 is assigned to both crown and root. Where only the root is decayed, only the root is termed a 1. In cases where both the crown and root are involved with decay, whichever site is

judged the site of origin is recorded as a 1. These criteria apply to all numbers.

- 2: Filled teeth, with additional decay, are termed 2. No distinction is made between primary caries which is not associated with a previous filling, and secondary caries, adjacent to an existing restoration.
- 3: A 3 indicates a filled tooth with no decay. If a tooth has been crowned because of previous decay, that tooth is judged a 3. When a tooth has been crowned for another reason such as aesthetics or for use as a bridge abutment, a 7 is used.
- 4: A 4 indicates a tooth that is missing as a result of caries. Only crowns are given 4 status. Roots of teeth that have been scored as 4 are recorded as 7 or 9. When primary teeth are missing, the score should be used only if the tooth is missing prematurely. Primary teeth missing because of normal exfoliation need no recording.
- 5: A permanent tooth missing for any other reason than decay is given a 5. Examples are teeth extracted for orthodontia or because of periodontal disease, teeth that are congenitally missing, or teeth missing because of trauma. The 5 is assigned to the crown, the root is given a 7 or 9. Knowledge of tooth eruption patterns is helpful to determine whether teeth are missing or not yet erupted. Clues to help in the determination include appearance of the alveolar ridge in the area in question, and caries status of other teeth in the mouth.
- 6: A 6 is assigned to teeth on which sealants have been placed. Teeth on which the occlusal fissure has been enlarged and a composite material placed should also be termed 6.
- 7: A 7 is used to indicate that the tooth is part of a fixed bridge. When a tooth has been crowned for a reason other than decay, this code is also used. Teeth that have veneers or laminates covering the facial surface are also termed 7 when there is no evidence of caries or restoration. A 7 is also used to indicate a root replaced by an implant. Teeth that have been replaced by bridge pontics are scored 4 or 5; their roots are scored 9.
- 8: This code is used for a space with an unerupted permanent tooth where no primary tooth is present. The category does not include missing teeth. Code 8 teeth are excluded from calculations of caries. When applied to a root, an 8 indicates the root surface is not visible in the mouth.
- 9: Erupted teeth that cannot be examined—because of orthodontic bands, for example—are scored a 9. When applied to a root, a 9 indicates the tooth has been extracted. The crown of that tooth would be scored a 4 or 5.

KEY TERMS

Buccal—Surface of a posterior tooth closest to the cheek.

Caries—Tooth decay.

Cementum—Outer surface of the tooth root.

Disclosing agent—Tablet or liquid containing a red dye that is used to color and reveal plaque in a patient's mouth.

Distal—Surface of a tooth farthest from the midline.

Edentulous—Without teeth.

Facial—Surface of an anterior tooth closest to the lips.

Fixed bridge—Two or more prosthetic crowns covering teeth on either side of a missing tooth. A pontic, or artificial tooth, is suspended between the crowns to fill the space.

Fluorosis—Mottled discoloration of tooth enamel due to excessive systemic ingestion of fluoride during tooth development.

Hypoplasia—Incomplete or defective development of the enamel of a tooth.

Lingual—Surface of a tooth closest to the tongue.

Mandibular—Pertaining to the lower jaw.

Maxillary—Pertaining to the upper jaw.

Mesial—Surface of a tooth closest to the midline.

Papilla—Triangular pad of gum tissue filling the space between the proximal surfaces of two adjacent teeth.

Pontic—Artificial tooth suspended between two prosthetic crowns to fill a space left by a missing tooth.

Sealant—Composite resin applied to pits and fissures of teeth to prevent decay.

Sulcus—Groove between the surface of a tooth and the epithelium lining the free gingiva.

- T: Indicating trauma, a T is used when a crown is fractured, with some of its surface missing but with no evidence of decay.

The “D” of DMFT refers to all teeth with codes 1 and 2. The “M” applies to teeth scored 4 in subjects under age 30, and teeth scored 4 or 5 in subjects over age 30. The “F” refers to teeth with code 3. Those teeth coded 6, 7, 8, 9, or T are not included in DMFT calculations.

To arrive at a DMFT score for an individual patient's mouth, three values must be determined: the number of teeth with carious lesions, the number of extracted teeth, and the number of teeth with fillings or crowns. A patient who has two areas of decay, six missing teeth and 11 filled or crowned teeth for example, has a DMFT score of 19. Teeth that include both decay and fillings or crowns, are only given one point, a D. Thirteen teeth (based on a full dentition of 32) remain intact.

It is also possible to determine more detailed DMFS (decayed, missing, or filled surface) scores. As anterior teeth have four surfaces and posterior teeth have five, a full dentition of 32 teeth includes 128 surfaces. A patient with seven decayed surfaces, 20 surfaces from which teeth are missing, and 42 surfaces either filled or included in a crown, the DMFS score is 69. Fifty-nine surfaces are intact.

For primary dentition, scoring is referred to as “deft” or “defs” (decayed, extracted, or filled).

Significant caries index

In 2000, the World Health Organization developed the significant caries index (SiC) to be used when studying DMFT scores on a global basis. A single population may include a number of individuals with low DMFT scores, as well as those with high scores. A mean DMFT value would not accurately reflect the status of the population. The SiC Index isolates and highlights those individuals with the highest caries values in a particular population.

To calculate a SiC Index, individuals are sorted according to DMFT values. The third of the population with highest caries scores is isolated, and a mean DMFT for this subgroup is calculated. The resulting value is the SiC Index.

Viewpoints

Researchers all over the world develop dental indices to suit their particular needs, resulting in some duplication. There are at least six indices that measure the presence or absence of plaque. Indices have become flexible, able to be adapted, modernized, or simplified to fit different needs. They will continue to develop as those needs change again.

Professional implications

Dental professionals from the private practice clinician to the researcher use indices to benefit their patients. A dentist or hygienist might use a PI to impress upon a patient the need for better **oral hygiene**. A World Health Organization researcher might use the same index to assess the **home care** practices of a population. Indices

will continue to be important and necessary tools for dental professionals.

Resources

BOOKS

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OTHER

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Cathy Hester Seckman, R.D.H.

Dental injuries see **Dental trauma**

Dental instruments

Definition

Dental instruments are tools used in the assessment, diagnosis, and treatment of oral diseases.

Purpose

Dental instruments are designed to be used by the dentist and staff during dental care. Instruments aid in the assessment and treatment of dental disease. Each is designed for a specific purpose.

Description

There are many different dental instruments used by oral health care professionals in their different roles and specialties. Certain types of instruments are unique to various therapeutic procedures.

Assessment

During an examination by a general dentist the following diagnostic instruments may be used:

- Cotton pliers: used for placing cotton rolls or pluggets to dry up saliva.
- Mouth mirror: used to view hard-to-see areas such as the roof of the mouth, behind the molars, and behind the anterior teeth.



Dental drill. (Photograph by Randy Duchaine. *The Stock Market*. Reproduced by permission.)

- Probes: used to measure the depth of periodontal pockets or sulci.
- Explorers: used to detect **dental caries** in tooth grooves and pits.

Restorative procedures

During restorative treatment the following types of instruments may be used:

- Amalgam carriers: for transferring amalgam from the tray to the patient's mouth.
- Burnishers: for smoothing the amalgam filling.
- Composite: for use as an alternate filling material when silver fillings are not appealing.
- Excavators: for removal of small amounts of decay close to the nerve.
- High speed hand piece: for removal of tooth decay. It is commonly known as the drill.
- Slow speed hand piece: for removal of deep decay from the teeth. It is commonly known as the slow drill, and is also used in extrinsic stain removal.
- Spatulas: for mixing compounds, such as alginate, plaster, dycal, and cements.

- Brush holders: for holding tiny brushes and reaching far in to the mouth.
- Carvers: for carving the amalgam filling to the shape of the tooth.
- Pluggers: for placing amalgam filling deep in the excavated tooth.
- Syringes: for washing out excavated teeth with sterile water.

Periodontal procedures

During periodontal treatment (concerning tissues surrounding the teeth), the following types of instruments may be used:

- Gingival knives: small knives used to cut gum tissue in the area of treatment.
- Chisels: **surgical instruments** that aid in the removal of infected bone.
- Surgical burs: used in high speed hand drills to aid in the sectioning of the infected bone or roots.
- Bone files: surgical instruments that aid in the filing of infected bone in order to remove that portion of infected bone.
- Scalers/curets: used for the removal of bacterial toxins and calculus below the gum line.

Endodontic procedures

During endodontic treatment (concerning diseases of the pulp), the following instruments may be used:

- Explorers: used to assess the root canals of the tooth.
- Spreaders: used to spread the hot gutta percha into the individual root canals.
- Files: used to clean out the nerve of the infected tooth. Files come in different lengths and sizes.
- Reamers: used to ream out the nerve. Reamers are bigger than a file.
- Broach: used to remove hardened nerve tissue (dead nerve tissue) and enlarge the canal.
- Syringes: used to flush the canals with sterile water for cleaning.

Orthodontic procedures

During orthodontic treatment (concerning alignment of teeth), the following instruments may be used:

- Cutting instruments: used to cut the wires already placed in the mouth.
- Wire forming: used to curve the wire to the correct spere for the individual patient.

- Utility plier: used to cut thick wires before placement in the mouth.
- Debonding instruments: used to remove molar bands from the molars.
- Debanding instruments: used to remove brackets from the teeth.
- Ligature forceps: used to place ligature ties around the brackets.
- Mosquito forceps: used to place ligature ties around odd angled teeth.
- Explorers: used to the remove ligature ties around the brackets.

Surgical procedures

During surgical procedures heavy-duty steel instruments are needed for leverage and lifting. The instruments are used to remove diseased bone or the roots of teeth. The following instruments may be used:

- Elevators: used to raise gum tissue or bone.
- Hemostats: used to grasp tissue for removal or retraction.
- Root tip picks: used to remove sectioned-off root tips.
- Tissue forceps: used to remove or retract tissue.
- Bone files: used to file down and remove diseased bone.
- Retractors: used to hold the cheeks and tongue out of the way.
- Wire cutters and twistors: used to cut wire during wire surgery for better healing of the bone and tissue.
- Extraction forceps: used to remove teeth.
- Periosteal elevators: used to elevate the periosteal (external to bone) tissue for better viewing of the surgical site.
- Scissors: used to cut soft tissue and surgical sutures.
- Scalpel: used to incise gum tissue.
- Needle holders: used to hold the needle during suturing.
- Surgical sutures: made from silk or thread, used to suture tissue together.

Operation

Dental instruments have a variety of applications. Many of the instruments can be used repeatedly after the sterilization process. The life span of the instruments depends on their usage, care, and the method of sterilization. Sterilization prevents the spread of diseases like hepatitis B. Following guidelines set by the ADA and the

manufacturer for proper sterilization of non-critical, semi-critical and critical instruments is advised.

Non-critical instruments can be treated with disinfectants classified as high, intermediate, or low relative to their effectiveness against bacterial spores and **viruses**. Non-critical instruments, such as articulators and spatulas, have no contact with mucous membranes. They do not require sterilization.

Semi-critical instruments touch mucus membranes but do not break the barrier of the mucosal surface or skin. They require sterilization or high-level disinfection, depending on whether they are affected by heat. Sterilization is usually achieved through methods that use extreme heat. Semi-critical instruments include amalgam condensers, hand pieces, and plastic vacuum tips.

Critical instruments require sterilization. These instruments penetrate or touch broken skin or mucus membranes. Critical instruments include needles, scalpels, surgical instruments, dental explorers, dental burs, and endodontic instruments. They must be sterilized.

Endodontic instruments need to be checked daily to determine usability. Files, reamers and broaches become brittle after months of sterilization. The CDCP and ADA recommend critical instruments be cleaned, bagged and then fully sterilized after each procedure. Heavy-duty gloves worn by the dental assistants during cleaning, disinfecting and sterilizing of most dental instruments is advised.

Maintenance

The ADA recommends that the working parts of all instruments be checked monthly. It is also recommended that a sufficient supply of instruments be maintained in order to allow for proper sterilization.

Health care team roles

Ultimately, the dentist is responsible for the ordering of dental instruments, but many offices delegate that task to a supervising dental assistant. The entire office staff is responsible for instrument sterilization. Instrument sterilization prevents **disease transmission** and maximizes the longevity of the instrument.

Training

Following the guidelines set forth by the instrument manufacturer is the best procedure for instrument maintenance and recirculation. The ADA recommends purchasing instruments from reputable companies that have the ADA seal of approval.

KEY TERMS

Amalgam—The material used in silver fillings.

Endodontic—Referring to the nerve and pulp of a tooth.

Endodontist—Dentist specializing in the removal of the nerve and pulp of the teeth.

Gutta percha—Material used during root canal therapy to fill the canals after the nerve has been removed.

Orthodontic—Referring to the movement of the teeth.

Orthodontist—Dentist specializing in the field of tooth movement.

Periodontal—Gum tissue surrounding the teeth.

Periodontist—A dentist who specializes in treating the gum tissue and bones of the mouth.

Sulcus—An indentation in an anatomic structure.

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Cindy F. Ovard, RDA

Dental laboratory technology

Definition

Dental laboratory technology is the science and craft of creating **dental prostheses**. It involves artistic talent, aptitude for precision work, good eyesight, and a high degree of manual dexterity. Knowledge of CAD/CAM computer programs, digital cameras, and digital imaging systems is also required.

Description

Preventive education has decreased the incidence of **dental caries**. Better dental health means that the demand for dentures has declined, while the need for dental prostheses and cosmetic procedures has increased.

Dental laboratory technicians are sought by dental laboratories, private dental practices, and medical institutions. These skilled craftspeople are part scientist, part artist, and part engineer. They must have manual dexterity, good eyesight, and a penchant for detailed, precision work.

Dental laboratory technicians create a variety of dental prostheses including crowns, bridges, artificial teeth, partial dentures, and complete dentures. They also prepare inlays—ceramic or resin structures that are cemented into a prepared tooth. Technicians also create onlays from those same materials which fit over the tooth but do not cover the tooth completely like a crown. In large laboratories, dental technicians may specialize in a single type of restoration, such as crowns or partial dentures. Some laboratories have ceramists who specialize in creating ceramic restorations of every type.

In order to design and craft these prostheses, a dental technician prepares wax diagnostic models from patients' mouth impressions. These wax models are finely detailed sculptures of the mouth, showing how the restoration will look and how it will work. From these, the prostheses are cast in investment molds through an ancient bronze casting and jewelry method, called the lost wax technique.

The investment mold is poured around the wax model of the prosthesis and is fired. The wax melts and drains out of the investment mold, leaving behind a durable mold into which the technician can pour a casting material. Restorative casting materials can be metals (gold, silver, amalgam), resins, or ceramics. These are poured into the investment mold to craft individual teeth, crowns, and other dental prostheses.

New computer applications are making the restoration process faster, more accurate, and more comfortable.

Implant and crown design is often time consuming, requiring several appointments to ensure a proper fit. Duplication technology (e.g. Geomagic Studio from Raindrop Geomagic of Morrisville, NC) uses 3-D scanners to scan a patient's mouth. This duplicates the shape, thickness, and color of the natural teeth. This information is processed through CAD software and used to generate a digital prosthesis that is virtually inserted into the digital image of the patient's mouth to check for an accurate fit. The dental prosthesis is then crafted in real materials and fitted into the patient's mouth.

Work settings

Dental laboratory technicians work mainly in dental laboratories. These are usually independent businesses, with one technician out of five owning his or her own laboratory. Some laboratories may also be connected with a dentist or a team of dentists, to create a one-stop service for patients. Some technicians work in hospitals or institutions which provide dental services to in-house patients, e.g. VA hospitals.

Laboratory facilities are clean, well lit, and carefully ventilated. Workstations may be equipped with computers, grinding equipment, polishing machines, and a variety of tools for fine detailed work. Most dental laboratory owners keep their facilities equipped with state-of-the-art tools, equipment (including a dental kiln), and materials. They also provide continuing training for their technicians in current procedures, techniques, and material use.

Education and training

Though most dental laboratory technicians learn while working on the job in the laboratory, many are now seeking professional training at junior colleges, dental schools, and vocational/technical institutions before seeking employment. Some dental schools offer course work in dental laboratory technology. In any event, technicians will still need to train on the job in order to learn the techniques and styles of a particular dental laboratory.

Early tasks on the job may be relatively menial in contrast to the skills the technicians will display later for the laboratory. They may prepare dental impressions or fire already prepared crowns or dentures. After three or four years of training, technicians are then able to design and craft dental prostheses for patients.

The ADA Commission on Dental Accreditation has accredited 34 programs in dental laboratory technology. Classroom instruction includes oral anatomy, dental materials science, fabrication procedures, computer software applications, digital imaging, and ethics. Students

complete course work in two years and receive an associate's degree.

Certification is available in some states through the National Board. This is voluntary and not necessary to work in the profession. Five areas of certification are available; crowns and bridges, ceramics, partial dentures, complete dentures, and **orthodontic appliances**.

Advanced education and training

Most dental schools offer specialization in prosthodontics. A prosthodontist is a dentist who does only dental restorations. Usually, prosthodontists have three or more years of education beyond their DDS (doctor of dental surgery) degree. They may supervise full mouth restorations or single crowns. They are often able to oversee the manufacture and fitting of fixed bridges, dentures, implants, or a combination of these prostheses. Periodontists, specialists in gums and bones, and oral and maxillofacial surgeons may also fit implants into the jaw. They also are required to have three or more years of education beyond their DDS degree.

Future outlook

More people in their retirement years have full, (or almost full) sets of teeth and no longer require complete dentures in old age. They are, however, requesting more enhancements to their appearance and more prostheses to improve their ability to chew and enjoy their food. Employment for dental laboratory technicians is favorable and may increase as the demand for prosthetic and cosmetic services increases with the aging of baby boomers.

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American Dental Association, 211 East Chicago Avenue, Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org>>.

KEY TERMS

Bridge—An appliance of one or more artificial teeth anchored by crowns on the adjacent teeth.

CAD/CAM—A computer-aided design and manufacturing package for the fabrication of dental prostheses.

Complete denture—A full set of upper or lower teeth, mounted in a plastic base. Dentures are also called false teeth.

Crown—A protective shell that fits over the tooth.

Dental caries—An infectious disease of the teeth in which microorganisms convert sugar in the mouth to acid that erodes the tooth structure.

Inlay—A filling that is made outside of the tooth and then cemented into place.

Onlay—A restoration that covers the upper surface of a tooth. It is bigger than a filling but smaller than a crown.

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Janie F. Franz

Dental patient preparation

Definition

Dental patient preparation is the process of preparing a patient mentally and physically to receive dental care.

Purpose

Good preparation helps patients form a positive attitude about dental health care. Ideally, this attitude will continue throughout life, enhancing optimal oral health. An important aspect of patient preparation is education about the risks and benefits of dental procedures. The patient should understand beforehand the reasons for any procedure and what to expect during and afterwards. The patient should have the opportunity to weigh the pros and cons of any procedure and make a knowledgeable decision based on accurate, honest, and timely information.

Precautions

Patients must be prepared in a manner that is understandable and appropriate. Groups that might need special preparation include the poor, the elderly, and people from different cultures. In addition, health care providers must give special attention in preparing children and mentally handicapped adults for dental care, and include a parent or caregiver in all decisions as well as information regarding aftercare.

Description

Undergoing dental care can be frightening to children and even to many adults. **Stress** and **anxiety** are reduced when a patient understands the reasons for procedures and what to expect. Risks of procedures must also be carefully explained, so that **informed consent** can be made.

Patient education is needed in cases of:

- dental benefits, insurance, and financial options
- initial examinations
- x rays
- crown preparation
- crown delivery
- implants treatment
- inlay preparation
- restorative therapy
- root canal therapy
- periodontal therapy
- oral and maxillofacial surgery

Time spent by the dental office staff for patient preparation is not billed separately to the patient or to insurance companies. Extra staff time in preparation and follow-up phone calls, as well as the cost of informational brochures, are usually well worth the relatively small

additional expense to achieve increased patient satisfaction and compliance.

Preparation

Using brochures and other written materials is one way to prepare patients. They have the advantages of giving patients time away from the office to consider new information and can answer common concerns without taking up staff time. It is also helpful to take a moment to explain procedures and answer questions when calling patients to confirm appointments.

Aftercare

A phone call from the dentist is common aftercare, especially following a surgical procedure. The dentist assesses patient comfort, answers questions, and reminds patients of what to expect during recovery. Good aftercare protocol builds the patient/doctor confidence and trust and can help detect medical complications before they become serious.

Complications

Poor patient preparation can lead to misunderstandings, including unwarranted fear about procedures or confusion about financial obligations. Rushing through explanations or using too much professional jargon, for example, might lead a patient to back out of treatment and neglect oral health care.

Results

Many people avoid visiting the dentist because of fear of discomfort or embarrassment about poor **dental hygiene**. Care in patient preparation can go a long way in making patients feel more at ease, making them more likely to maintain better oral health and visit their dentist regularly.

Health care team roles

The dentist or specialist prepares the patient and answers questions. The dental assistant plays a supportive role in patient education and preparation.

The front office staff can provide brochures as recommended by the dentist or dental assistant, and help the patient work out financial arrangements.

KEY TERMS

Crown delivery—Placement of a porcelain crown. Normally, the tooth is prepared two weeks prior to this procedure.

Crown prep—Preparing a tooth to receive a crown or cap.

Implant—A surgical procedure involving permanently placing a false tooth into the gum tissue.

Inlay—Preparing a tooth for a partial crown made out of porcelain or gold. This is similar to a crown, but only part of the tooth is involved.

Restorative treatment—Any type of dental procedure that restores a tooth's function. This is usually accomplished with silver (amalgam) fillings.

Root canal—Removal of the nerves and pulp of the tooth.

Tooth extraction—Surgical removal of a tooth.

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Cindy F. Ovard, RDA

Dental prostheses

Definition

Dental prostheses, artificially made devices resembling natural teeth, are used to replace missing or damaged teeth. These devices include inlays/onlays, crowns, bridges, dentures, partial dentures, and dental implants.

Purpose

Crowns and inlays/onlays are intended to repair damage to individual teeth. They replace tooth structure lost by decay or injury, protect the part of the tooth that remains, and restore the tooth's shape and function. Bridges, dentures, and partial dentures fill in a space in the jaw left by a missing tooth or teeth. They protect the shape of the mouth and restore function of the teeth and jaw.

Precautions

Some patients are allergic to the constituents in local or general anesthetic agents. In addition, many people are afraid of dental work and therefore may experience stress-related symptoms, even fainting, while in the dental office. Most dentists can help patients with this specific fear. Also, the dentist and dental assistant will need to be aware of any pre-existing conditions in the patient's history, e.g. diabetes, high **blood pressure**, **heart disease**, **hemophilia**, or HIV/AIDS.

Description

Inlays/onlays

An inlay resembles a filling in that it fills the space remaining after the decayed portion of a tooth has been removed. The difference is that an inlay is shaped outside the patient's mouth and then cemented into place. After the decay is removed and the cavity walls are shaped, the dentist makes a wax pattern of the space. A mold is cast from the wax pattern. An inlay is made from this mold and sealed into the tooth with dental cement.

Inlays and their counterparts, onlays, are conservative alternatives to crowns. They don't require as much tooth preparation and often are more durable than amalgam fillings. Inlays cover the grooves on the surface of the molar. Onlays wrap over the tooth, covering more of its surface.

Inlays used to be made entirely of gold for durability. New inlay alloys of palladium, nickel, or chromium are now frequently used. Metals are the dentists' choice for inlays in molars. When inlays are required for visible anterior teeth, tooth-colored composites and porcelains

are used. Reinforced porcelain and Lucite porcelain are durable but may not be suitable for patients who grind their teeth. Composites are also used in fillings.

Crowns

A prosthetic crown replaces the outer portion of the tooth to protect and strengthen it. This protection becomes necessary when a tooth cracks, has its entire structure weakened by decay, or becomes brittle after a root canal. Crowns can also cover dental implants or abutment (adjacent) teeth when fitting a bridge.

Crowns can also cover discolored or otherwise aesthetically displeasing teeth. **Cosmetic dentistry** does not use crowns as much as it once did. Crowns, though aesthetically pleasing, require more radical dental techniques. Dentists are opting for more conservative methods such as bleaching, bonding, or veneers.

The dentist first removes the decay, and the tooth is then prepared for a crown. It may be tapered on the outside edges to a peg, reinforced with a cast metal core, or rebuilt with both a cast metal core and a post. An impression of the prepared tooth and the teeth next to it is made. A retraction cord is placed around the tooth in order to get the impression medium under the gum where the crown will be fitted.

The dental technician will create a new crown, using a cast made from this impression. The technique the technician uses is called lost wax casting. A wax model is made of the crown. Another mold is made around the wax model and both are fired in a kiln. The wax melts, leaving an opening into which a restorative material can be poured. The crown may be made of gold or stainless steel alone, metal with a veneer of tooth-colored porcelain or resin, or of porcelain or resin alone. The finished crown is then placed over the prepared tooth, adjusted, and cemented into place.

When a tooth has had a root canal and the root has been filled, the tooth may not be strong. Post crowns are used in these cases. The tooth is leveled at the gum line and a stainless steel or gold post is fitted into the root canal. This post can then receive the new crown and hold it in place.

For other patients, it may be desirable to implant the crown. In this case, a steel post is embedded in the patient's jawbone. It is left in place until the bone adheres to the post. The post is exposed and the crown is made and fitted.

New computerized techniques are making the restoration process faster and more accurate. Chairside Economical Restoration of Esthetic Ceramics (CEREC) uses a computer system that allows the dentist to create

ceramic crowns, inlays, and onlays, in one sitting. The tooth is prepared as usual but impressions are made digitally, using a hand-held camera. These photographs are converted to 3-D images on the computer screen, thus eliminating the need to take a physical impression of the patient's teeth. The dentist uses special 3-D CAD/CAM software to design the crown. A milling system attached to the CEREC machine is able to make a ceramic crown in 10 to 15 minutes.

Provided they are well taken care of, crowns can last 5–15 years or more.

Bridges

Bridges fill in the spaces caused by missing teeth. They prevent the remaining teeth from shifting and provide a more stable surface for chewing. If the gap is not filled, the other teeth shift, affecting the patient's bite (occlusion), which sometimes produces **pain** in the jaw joint. As the teeth move and become crooked, they also become more difficult to keep clean. The risk of tooth decay and gum disease rises, increasing the likelihood that additional teeth will be lost. A bridge is inserted to prevent this from happening.

Bridges are made of a metal framework and one or more artificial teeth (pontics), which are anchored to adjacent teeth. The abutment teeth carry the pressure when the patient chews food. Bridges can be removable or fixed (permanent). Removable bridges are attached to the abutment teeth by wires or precision attachments. Fixed bridges are attached to permanent crowns placed on abutment teeth. There are two types of fixed bridges, the crown-and-bridge design and the Maryland Bridge. A Maryland Bridge does not have crowns. The backs of the abutment teeth are reduced slightly and small wing-like appendages on the bridge are cemented to the back of the abutment teeth.

When the adjacent teeth are not strong enough to support a bridge, a two-implant bridge is required. This type of bridge takes longer for the permanent bridge to be fitted because of the necessity for the gums to heal. Posts are surgically implanted into the patient's bone and the gum closed. It takes several weeks for the bone to attach to the posts. The posts are re-exposed and the bridge is made to fit. It is then cemented in place.

Implants

Dental implants are hard plastic or metal fixtures surgically embedded through the soft tissue into the jawbone that will act as artificial roots or anchors for a prosthetic tooth. Over time, bone will grow around these fixtures, firmly anchoring them. The implant posts are then surgically exposed and an artificial tooth is crafted and

fitted over these anchors. Implants may also serve as stable abutments for bridges, partial dentures, or over-dentures. Dental implants may be the best choice for patients who have denture intolerance or who cannot chew food properly with other prostheses.

Partial dentures

A partial denture is similar to a bridge in that it fills a gap left by missing teeth. It is a removable dental appliance consisting of artificial teeth fitted onto a metal frame, which attaches to an abutment tooth or teeth, with a metal clasp or precision attachment. A partial denture is often used at the end of a row of natural teeth, where there is only one abutment tooth. The pressure exerted by chewing is shared by the abutment tooth and the soft tissues of the gum ridge beneath the appliance.

Complete dentures

Complete dentures may be worn when all of the top or bottom teeth have been lost. A complete denture consists of artificial teeth mounted in a plastic base molded to fit the remaining oral anatomy. It may or may not be held in place with a denture adhesive.

Removable implant supported over-denture

Some people cannot wear dentures because they cannot tolerate having a foreign substance in their mouths. Others simply can no longer wear dentures because of serious bone loss. In response to this denture intolerance, a removal implant supported over-denture may be the best solution. Implant anchors may be installed in either the upper or lower dental arch or both. Five or six implants are anchored into the bone of the upper arch and four or five are placed in the lower arch. Each group of jaw implants is connected by a stabilizing bar. A custom-made over-denture is placed over the bar by means of a silicone gasket, which holds the denture in place and provides a cushion between the denture and the implants. For patients with **Parkinson's disease**, telescopic attachments are added to the over-denture that have the ability to adjust to varying pressures within the mouth, allowing these patients to chew better.

Preparation

Before a restoration is placed in the mouth, the dentist removes all traces of decay or damage and shapes the remaining tooth structure to receive the restoration. Impressions are taken of the mouth and models are created from which the dental prostheses are made. When bridges or crowns are necessary, the tooth or teeth that are to receive the crowns are shaped into posts or pegs.



False teeth. (AP/Wide World Photos. Reproduced by permission.)

Prostheses are made up in a laboratory using a model of the tooth structure. Temporary crowns and bridges are installed until the permanent restoration is delivered by the laboratory.

Aftercare

Temporary crowns or bridges must stay in place until the permanent restorations have been fitted to the patient's mouth. Dentists and dental assistants educate the patient about ways to keep the temporary in place, e.g. avoiding hard foods, gum, and other sticky or chewy foods. If possible, the dental assistant and dentist encourage the patient to avoid eating food on the side of the mouth where the temporary has been placed. Also, the patient is reminded to call immediately if the temporary is loosened so that it can be re-cemented.

There may be some gum swelling or discomfort when prostheses are fitted, or if surgery is performed. The dentist can recommend medications or oral rinses to reduce the discomfort.

Patients may also experience sensitivity to cold foods or drinks for a few weeks after a crown, bridge, or inlay is placed.

Patients are urged to maintain normal **oral hygiene** while they wear a temporary, and after the actual the crown or bridge is in place.

Dental prostheses, especially partial and full dentures, may take several weeks to adjust to. Inserting and removing dentures and other removable appliances takes practice. Speaking clearly may be difficult at first, but this usually passes with continued usage. Eating may also feel awkward. The patient should begin by eating small pieces of soft foods. Very hard or sticky foods should be avoided. Care should also be taken when eating hot food

or food with bones, since artificial prostheses may make the mouth less sensitive to hard objects and hot food.

Also, patients may experience a reduced sense of **taste**, since teeth act as taste sensors. Many patients will eat a lot of very spicy, salty, or sweet foods because they can taste them better. Since it is important to include a variety of foods in the diet so that proper nutritional needs are met, it may be necessary to adjust seasonings to counter the blandness patients may be experiencing.

Permanent prostheses should be cleaned as regularly as real teeth. Specialty brushes and floss threaders may be used to remove plaque and food from around crowns and bridges. Full or partial dentures should be removed and brushed daily with a specially designed brush and a denture cleaner or other mild soap. Optimally, full and partial dentures should be removed at night and soaked in a cleaning solution. This allows the soft tissues in the mouth to recover from the pressures of the prostheses. The solution will preserve the denture material, since it may shrink or warp if it dries out. At this time, patients should also clean their gums to increase **blood** circulation and maintain healthy bones and gums.

The patient should see the dentist for an adjustment if there is any discomfort or irritation resulting from a prosthesis. Otherwise, the patient should see the dentist at least twice a year for an oral examination. If the patient has had several teeth extracted before dentures were installed, these prostheses should be adjusted within the first six months after the dentures have been fitted. Patients should also expect to have their full dentures adjusted if they lose or gain ten pounds or more. Also, dentures may need to be relined or replaced every five to ten years.

Complications

Restoration procedures typically require **local anesthesia**. In some cases, the patient may require **general anesthesia** because the procedures involve gum surgery or the extraction of several teeth. Some people may have allergic reactions to either kind of anesthesia. A very small number of people are allergic to one or more of the metals or acrylics used in dental restorations. In most cases, the dentist can use another material.

Surgery is an invasive procedure. The risk of trauma or **infection** is always present, though it is often a minor risk. The patient may commonly experience swelling, nausea, pain, or bleeding. When these symptoms are prolonged or **fever** is present, there may be infection. Rarely, nerve disturbances or bone **fractures** may occur.

Some patients experience speech difficulties when they have dental prostheses, especially with full dentures

or several implants. Usually, this occurs during the first weeks after they have been fitted with prostheses for the maxillary or upper jaw bone. Once patients adapt to the prostheses, this problem disappears.

Results

A well-made dental prosthesis should feel comfortable and last a relatively long time with proper care. Artificial dental restorations only approximate the original tooth, however. They will never feel as comfortable or function as well as natural teeth. It is better, therefore, to prevent the need for dental prostheses to replace teeth. They are expensive, may require many appointments, and still need careful cleaning and attention.

Health care team roles

The dentist is crucial in diagnosing a patient's particular dental needs and determining the correct remedy. The dentist will prepare a patient's teeth for dental prostheses. Often, this requires a great deal of skill and structural knowledge in order to remove enough tooth material for the prosthesis to fit, yet leave enough architecture within the tooth in order to stabilize the restoration.

The dental technician prepares the dental prosthesis so that it will fit the prepared tooth and be compatible with the rest of the patient's mouth structure. The technician is part scientist and part artist and is able to craft natural-looking teeth that match the patient's mouth and facial features.

The dental assistant prepares the patient and the patient's teeth for the dentist. The dental assistant takes impressions of the patient's teeth and gums and prepares study models to aid the dentist in diagnosis and the dental technician in creating life-like prostheses that function comfortably in the patient's mouth.

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KEY TERMS

Abutment tooth—A healthy tooth or a crowned one that stabilizes a bridge or partial denture.

Anesthesia—A condition created by drugs that produces a loss of sensation, particularly pain. General anesthesia produces unconsciousness, a local anesthetic only results in localized numbness.

Bridge—An appliance of one or more artificial teeth anchored by crowns onto the adjacent teeth.

Complete denture—A full set of upper or lower teeth, mounted in a plastic base. Dentures are also called false teeth.

Crown—A protective shell that fits over a prepared tooth in order to restore its function.

Inlay—A filling that is made outside the tooth and then cemented into place.

Occlusion—The way upper and lower teeth fit together during biting and chewing.

Onlay—A restoration that covers the upper surface of a tooth. It is bigger than a filling but smaller than a crown.

Pontic—An artificial tooth suspended between two prosthetic crowns to fill a space left by a missing tooth.

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Academy of General Dentistry, Suite 1200, 211 East Chicago Avenue, Chicago, IL 60611. (312) 440-4300.
<<http://www.agd.org>>.

American Dental Association, 211 East Chicago Avenue, Chicago, IL 60611. (312) 440-2500.
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Janie F. Franz

Dental radiographs see **Dental x rays**

Dental specialties

Definition

There are nine dental specialties approved by the Council on Dental Education and Licensure of the American Dental Association (ADA). These are:

- **Dental public health:** Dental public health is the dental specialty devoted to promoting public dental health and preventing and controlling dental diseases through community and public education.
- **Endodontics:** Endodontics is the dental specialty focused on the morphology, physiology, and pathology of the periradicular (tooth root) tissues and human dental pulp.
- **Oral and maxillofacial pathology:** Oral and maxillofacial pathology deals with the nature, identification, and management of diseases affecting the regions of the mouth, jaw and adjacent parts of the face.
- **Oral and maxillofacial surgery:** Oral and maxillofacial surgery is the dental specialty that focuses on the diagnosis, surgical, and related treatment of diseases, injuries and deficiencies of the hard and soft tissues of the oral and maxillofacial regions. These specialists address functional and esthetic aspects of the areas treated.
- **Orthodontics and dentofacial orthopedics:** Orthodontics and dentofacial orthopedics is the specialty concerned with guiding and correcting children’s and adults dentofacial structures.
- **Pediatric dentistry:** Pediatric dentistry is the dental specialty that is devoted to providing primary and comprehensive preventive and therapeutic dental health care from infancy through adolescence. Pediatric dentists also provide dental care to children with special health care needs.
- **Periodontics:** Periodontics involves the prevention, diagnosis, and treatment of diseases affecting the tissues supporting and surrounding the teeth. The specialty also focuses on the maintenance of healthy gums and supporting dental tissues.
- **Prosthodontics:** Prosthodontics is the specialty concerned with the restoration of natural and replacement teeth, as well as contiguous oral and maxillofacial tissues.
- **Oral and maxillofacial radiology:** No definition has yet been approved by the ADA House of Delegates for this newly granted dental specialty. However, these specialists use imaging techniques to assist general dentists and other oral health specialists in the diagnostic assessment of diseases of the head and neck.

While there are overlapping responsibilities among the specialties, each focuses on an aspect of the oral cavity, maxillofacial area, or adjacent associated structures.

Description

According to the ADA, about 20% of all dentists practice a dental specialty, while the rest remain general dentists. Orthodontics and dentofacial orthopedics and oral and maxillofacial surgery make up nearly half of all specialties.

Dental public health specialists view the community, rather than the individual, as their patient. Their roles are to educate the public, using applied dental research, and initiate community-wide dental care and preventive programs.

Endodontics encompasses basic and clinical sciences of normal pulp biology and the causes, diagnosis, prevention, and treatment of diseases and injuries to the pulp and associated periradicular conditions. Endodontists specialize in root canal treatments to remove damaged tissue from inside tooth root canals. Root canal treatment, a nonsurgical endodontic treatment, treats the soft inner tissue of the tooth, called the pulp, when it becomes inflamed or infected. During a root canal, endodontists remove the damaged pulp, clean the area and fill and seal it to preserve the tooth. Surgical procedures performed by endodontists include apicoectomy, which removes **infection** or inflammation of the bony area surrounding the tooth's end.

Oral and maxillofacial pathologists research the causes, processes, and effects of diseases that affect the oral and maxillofacial regions, which include the head, face, mouth, teeth, gums, jaws, and neck. These specialists use clinical, radiographic, microscopic, biochemical, and other examinations to research and diagnose disease. The practice of oral and maxillofacial pathology includes research; clinical, radiographic, microscopic, biochemical or other disease diagnosis; and patient management.

Oral and maxillofacial surgeons treat patients who have problems with wisdom teeth, facial **pain** and misaligned jaws. They treat accident victims with facial injuries, perform reconstructive and dental implant surgery, offer treatments for tumors and cysts of the jaws, and specialize in functional and cosmetic conditions of the head, face, mouth, teeth, gums, jaws, and neck. Oral and maxillofacial surgeons also offer preventive care of the teeth, mouth, jaws, and facial structures.

These specialists offer a wide variety of surgical procedures performed in the office and hospital, including dentoalveolar surgery to treat impacted teeth and reconstructive surgery to address inadequate bone structure of

the upper or lower jaws, which can result from injury, some types of surgery, and dentures. They place dental implants, which are an option for replacing missing teeth, and treat facial infections, which can develop into life-threatening conditions if not addressed. Oral and maxillofacial surgeons are often called in to treat trauma of the face, jaws, mouth, and teeth, often from injuries such as **falls**, as well as facial pain from such things as temporomandibular joint (TMJ) disorders. Other conditions treated by oral and maxillofacial surgeons include deformities in skeletal growth between the upper and lower jaws, which can affect chewing and swallowing, and snoring or obstructive sleep apnea, a condition that can lead to excessive daytime sleepiness. Not all procedures performed by oral and maxillofacial surgeons are covered by dental or health insurance because they also offer some cosmetic procedures of the face, mouth, and neck.

Orthodontists and dentofacial orthopedic specialists specialize in diagnosing, preventing, and treating dental and facial irregularities, known as malocclusions. Orthodontists represent about 6% of all dentists. Orthodontists treat children and adults. The American Association of Orthodontists recommend that all children have an orthodontic screening no later than age seven.

Malocclusions are often inherited but can be caused by trauma, pacifier sucking, airway obstruction, dental disease, or premature loss of primary or permanent teeth. Orthodontists most commonly treat crowding of the teeth, overbites, open bites (when upper and lower incisor teeth do not touch when biting down), spacing problems, crossbite and underbites, or lower jaw protrusion. Orthodontic treatment, often involving the placement of braces, helps not only cosmetically, but also functionally.

Pediatric dentists provide primary and specialty oral care for healthy, normal children, as well as those with special needs. Much of what the pediatric dentist does involves educating parents and children. The pediatric dentist will advise parents about thumb sucking and pacifier habits, dental decay in the early years, proper brushing habits, bottle and breast-feeding, and more. In a child's later years, they'll advise children and their parents about protecting teeth during sports and other preventive dental issues. Pediatric dentists offer techniques that can protect children's teeth, such as dental sealants, which fill the crevices on the surfaces of the teeth to protect teeth from decay.

Periodontists specialize in preventing, diagnosing, and treating periodontal disease. Periodontal diseases are bacterial infections of the tissues around the tooth, which, if untreated, can result in tooth loss. Periodontists place dental implants, which replace missing teeth and look

and feel like natural teeth, and they perform periodontal surgery used to treat severe cases of periodontal disease. While simple procedures might suffice to remove the plaque and calculus below the gum line and remove **bacteria**, surgical procedures are often necessary if periodontal disease has caused deep pockets in the gums and loss of supporting bone structure. Cosmetic periodontal procedures include treatments to improve a gummy smile, as well as treatment to correct long teeth, or receding gums.

Prosthodontists understand dental laboratory procedures and work closely with dental technicians to create comfortable and attractive custom-made prostheses for patients. Prosthodontists offer patients options for replacing missing teeth. Sometimes this involves the placement of dentures or fixed bridges, while other patients prefer dental implants. Prosthodontists receive training in diverse dental conditions, including complex care management involving many specialties, post-oral **cancer** reconstruction, some children's dental problems, jaw joint conditions, traumatic injuries, and snoring and **sleep disorders**. Prosthodontists are also trained in some types of **cosmetic dentistry**, including bleaching techniques, tooth bonding, and veneers.

Oral and maxillofacial radiologists are dentists who specialize in the use of imaging and other technologies to diagnose and manage dental and associated diseases. They also advise state agencies and dental professionals about regulatory compliance in the use of and advances in **radiologic technology**.

Work settings

Dentists work in private practice offices, public hospitals and clinics, for the Federal Government, and in dental research.

Education and training

Most dentists go through three years or more of undergraduate school with an additional four years of dental school to become a general dentist. All dentists graduate from dental school with a degree in general dentistry, receiving either the DMD (Doctor of Dental Medicine) or DDS (Doctor of Dental Surgery) designation. While most schools today award DDSs, there is no difference in these degrees for general dentistry. Dental specialists must then undergo additional postgraduate training to become a dental specialist. About 17 states require dentists to achieve specialty licenses before practicing as specialists.

Dental public health specialists must successfully complete two years of academic study in a program

accredited by the Commission on Dental Accreditation leading to a graduate degree in public health, or complete two or more years of dental public health advanced education by a non-U.S. institution followed by completion of an accredited U.S. residency dental public health program.

Endodontists possess advanced surgical and nonsurgical skills that allow them to treat routine and complex cases. Endodontists attend two- or three-year advanced dental school endodontic programs.

Orthodontists and dentofacial orthopedic specialists must successfully complete a two- to three-year residency program of advanced education in orthodontics after graduating from a general dentistry program accredited by the Commission on Dental Accreditation of the ADA. Through their advanced training, orthodontists acquire the skills necessary to manage tooth movements and guide facial development.

Oral and maxillofacial surgeons undergo four years or more of postdoctoral, hospital-based surgical residency training after graduating from a four-year dental school program. Their education intensity is similar to that of internal medicine physicians and general surgeons.

Pediatric dentists need two to three years of specialty training following dental school to learn about children's dental problems and how to educate parents and children about avoiding these problems. They also learn about the care of special needs children, including hospitalized, handicapped, and chronically ill children.

Periodontists receive three years of periodontal training after graduating from dental school.

Prosthodontists receive three years of specialized training in an American Dental Association (ADA) accredited graduate education program after completing dental school.

Oral and maxillofacial radiology programs are between two and three years long.

Advanced education and training

All dental specialists can attend continuing education courses to keep up with research, clinical procedures, and technology. They can also apply to become board certified in their dental specialties.

Future outlook

While, the dental profession is expected to experience slower than average growth through 2008 because more people are avoiding problems associated with tooth decay, the demand for specialists could rise. Baby-boomers coming into middle age will require complicated work, including bridges. The elderly will be more

KEY TERMS

Calculus—Calcified deposits that have formed around teeth.

Dentition—The natural teeth.

Dentofacial—Relating to the dentition, or natural teeth.

Etiology—The science of disease origins and cycles.

Human dental pulp—The soft, moist, coherent solid tissue within the pulp cavity of the tooth.

Malocclusion—Bad bite.

Maxillofacial—The area of the jaws and face.

Morphology—The study of the configuration or structure.

Pathology—The study of the nature and cause of diseases and the changes produced by them.

Periradicular tissues—The tissue around the top of a tooth root.

Physiology—The science that looks at normal life processes (functions and activities) of organisms.

Temporomandibular joint (TMJ)—The joint of the lower jaw.

American Association of Endodontists. 211 E. Chicago Ave., Suite 1100. Chicago, IL 60611-2691. (800) 872-3636. <www.aae.org>.

American Association of Oral and Maxillofacial Surgeons. 9700 W. Bryn Mawr Avenue, Rosemont, Illinois 60018-5701. (847) 673-6200. <www.aaoms.org>.

American Association of Orthodontists. 401 N. Lindbergh Blvd., St. Louis, MO 63141-7816. 314-993-1700. <www.aaortho.org>.

American Association of Public Health Dentistry. 1321 N.W. 47th Terrace, Gainesville, FL 32605. <<http://pitt.edu/~aaphd/abdph.html>>.

American College of Prosthodontists. 211 East Chicago Ave., Suite 1000, Chicago, IL 60611. (312) 573-1260. <www.prosthodontics.org>.

American Dental Association. 211 E. Chicago Ave., Chicago, IL 60611. (312) 440-2500. <www.ada.org>.

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Lisette Hilton

likely to keep their teeth into old age and also will need complex procedures. Future general dental care will focus more on prevention and education.

Resources

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ORGANIZATIONS

American Academy of Oral and Maxillofacial Pathology. 710 E. Ogden Ave., Suite 600, Naperville, IL 60563-8614. (888) 552-2667. <www.aaomp.org>.

American Academy of Oral and Maxillofacial Radiology. PO Box 55722, Jackson, MS 39296. (601) 934-6060. <www.aaomr.org>.

American Academy of Pediatric Dentistry. 211 East Chicago Ave., Suite 700, Chicago, IL 60611-2663. (312) 337-2169. <www.aapd.org>.

American Academy of Periodontology. 737 N. Michigan Ave., Suite 800, Chicago, IL 60611. (312) 573-3256. <www.perio.org>.

Dental trauma

Definition

Dental trauma is an injury to the mouth and teeth, including oral structures such as the lips, tongue and cheeks.

Description

Dental trauma can occur during contact sports, motor vehicle accidents, falling and hitting the face, fighting and/or from untreated tooth decay. It can be caused by physical abuse or domestic violence.

Causes and symptoms

Injuries to a broken or knocked out (evulsed) tooth can cause severe **pain**. If the lower jawbone is cracked or broken, the patient will be unable to move the jawbone without pain and discomfort. Broken fillings or old crowns are susceptible to decay. They can weaken and undermine the tooth structure, causing the tooth to break. This could result in sharp edges and corners that may damage the tongue tissue.

Diagnosis

X rays (taken to reveal the extent of dental trauma to hard tissue) together with a thorough examination, aid in finding the source of the trauma.

Treatment

Tooth movement

If the entire tooth is knocked out of the socket (evulsion), the tooth must be found and repositioned back in the socket. If this is done in the first 20 minutes, there is a 90% chance of tooth survival. Thirty to 60 minutes cuts the tooth survival rate to 75%.

- The tooth should be picked up gently and held by the crown, not the root.
- The tooth should be carefully rinsed with water; it should not be scrubbed.
- The tooth should be kept moist; it should not be dried.
- If possible, the tooth should be placed in the socket; if this is not possible, it should be placed in a cup of milk.

If a tooth is bumped and still in the socket, but in the wrong position (luxation), dental help should be sought immediately. The following steps should be followed, depending on the position of the tooth.

- An upper tooth hanging down or lower tooth raised up (extrusion) should be repositioned in the socket using firm pressure. The tooth should then be stabilized by having the patient bite down firmly, or bite on a piece of cloth or a handkerchief.
- A tooth pushed back toward the tongue or pulled forward toward the face (lateral displacement) requires repositioning by using firm pressure. This may cause severe pain and biting down on a piece of cloth or handkerchief will help alleviate some of this pain and help to stabilize the tooth.
- Teeth pushed into the gum tissue or teeth that look short (intrusion) require no intervention. Repositioning may damage both tooth nerve and tissue.

Broken and fractured teeth

The fractured area should be cleaned, and a cold compress outside the cheek area should be applied. Dental help should be sought promptly. If a piece of the outer tooth has chipped off, but the inner soft tissue core (pulp) is undisturbed, the rough edges may be smoothed by the dentist and a simple filling placed. If most of the tooth is missing, but the pulp is not damaged, the tooth will require a protective covering with a crown. If the pulp has been damaged, the tooth will require root canal

treatment and a crown. A tooth fractured below the gum-line will require root canal treatment and protective restoration. A tooth with little remaining structure to retain a crown may have to be removed (extraction).

Cuts, abscesses, and pain

Cut lips, gums, or tongue require mild rinsing with cold water to remove debris. A cold compress should be applied to the injured area. Most cuts and abrasions are minor; a dental visit is not required. Dental care, however, should be sought if bleeding does not stop and the cut is deep. Pain and swelling can be controlled by ibuprofen (e.g., Advil, Motrin), which is an anti-inflammatory and a painkiller.

Abscesses and swollen gums are due to **infection** in the gum tissue or bone; ice should be placed on the swollen cheek to alleviate discomfort. **Antibiotics** and painkillers are generally needed to fight infection. If left untreated, the local infection can enter the bloodstream, causing serious illness. It could become life threatening in some cases. Treatment for the cause of an abscess should also be addressed. A periodontal abscess requires therapeutic sealing and root planing. An endodontic abscess requires a root canal and sometimes an apicoectomy (surgical removal of the tooth root).

Severe pain is caused mainly by trauma, but can be caused also by gum abscesses, tooth infection, bone infection, and some dental procedures. Prompt dental care can alleviate worries and aid in pain control.

With jawbone injuries, the jaw should not be moved. A handkerchief or towel should be tied around the jaw and over the head to secure the jaw in place. Immediate dental care should be sought. Severe pain may stem from temporomandibular joint (TMJ) disorders or trigeminal neuralgia.

Prognosis

The key to a good prognosis for a dental trauma is taking quick steps, remaining calm and getting dental attention within the first 20 minutes. Prevention is the best method.

Health care team roles

The dentist may delegate treatment to other staff members (e.g., registered dental assistants), who can take x rays and comfort the patient, while the office manager takes care of all financial matters and billing questions. The registered dental hygienist may administer an anesthetic agent where needed. All team members can alleviate patient fears during a trauma.

KEY TERMS

Crown—1. The natural part of the tooth covered by enamel. 2. A restorative crown is a protective shell that fits over a prepared tooth.

Eruption—The process of a tooth breaking through the gum tissue to grow into place in the mouth.

Eulsion—The forceful, and usually accidental, removal of a tooth from its socket in the bone.

Extraction—The surgical removal of a tooth from its socket in the bone.

Intrusion—A condition in which a tooth is forced upward into the bone tissue by a force outside the mouth.

Lateral displacement—A condition in which a tooth is forced out of alignment forward or backward, but remains in its socket.

Luxation—The movement of a tooth still in its bony socket.

Pulp—The innermost soft tissue of a tooth containing blood vessels, lymphatics, and nerves.

Root canal treatment—The process of removing diseased or damaged pulp from a tooth, then filling and sealing the pulp chamber and root canals. Also known as endodontic therapy.

Prevention

According to the study by the American Academy of Sports Dentistry, most dental traumas can be avoided if mouthguards are worn. They recommend that athletes, regardless of their age or gender, use mouth guards where facial impact is possible.

The American Dental Association's February 2000 news press release recommended preventive measures for avoiding a dental trauma:

- Yearly dental exams (including x rays).
- Teeth should be brushed and flossed thoroughly at least once a day.
- A mouthguard and helmet should be worn while playing all contact sports (football, soccer, hockey, baseball, boxing, basketball).
- A seatbelt should always be worn when in a moving vehicle.
- Foreign objects (pencils, fingernails, pens) should be kept out of the mouth.

Resources

ORGANIZATIONS

American Academy of Sports Dentistry. 211 East Chicago Avenue, Ste. 700, Chicago, IL 60611-2616. (312) 337-2169. <<http://www.acadsportsdent.org/>>.

American Dental Association 211 East Chicago Avenue, Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org/>>.

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Dental x rays

Definition

Dental x rays are pictures taken of the mouth area using high energy photons with very short wavelengths. They show the teeth and surrounding bone.

Purpose

Dental x rays are effective in discovering tooth decay, broken fillings, fractured teeth, tumors, occlusal trauma, or impacted or ectopic teeth that would otherwise be unseen by the eye, in between the teeth and below the gum tissue.

Description

Dental x rays are part of the **dental examination** for aiding in the diagnostic process. X rays are vital in the diagnosis of root canal treatment on checking the apical of the tooth and the surrounding structures for abscesses or bone loss. Without the aid of dental x rays, 60% of dental decay would be missed. Diagnostic x rays are essential in providing accurate information. The most common x rays taken are:

- bitewing x rays (vertical and horizontal bitewings)
- panoramic x rays

- periapical x rays
- occlusal x rays

Each is used in its own respective degree of diagnosis, with the bitewing x ray being the most common. Bitewings are the most effective in discovering tooth decay in between the teeth and on adjacent teeth. A bitewing shows only the top crown portion of the tooth structure. It is called a bitewing due to the way the patient can bite down and hold the film securely in place. The bitewing is good in diagnosing and evaluating periodontal conditions and bone levels between the teeth. They are also good in detecting tartar buildup.

The panoramic (a type of film used), or panorex (brand name) is also commonly taken on the initial visit to the dental office. This type of x ray makes a complete circle of the head from one ear to the other, to produce a complete two-dimensional representation of all the teeth. This x ray will also show bone structure beneath the teeth and the temporomandibular joint (TMJ). The panoramic is the most commonly used x ray in the aid of diagnostic decisions regarding third molar extractions (wisdom teeth) for people who are edentulous (the tooth is not there/has not erupted). This special x ray, however, has its advantages and disadvantages.

One advantage of the panoramic is that a broad area is imaged, showing many structures. Furthermore, the exposure level emits low radiation. The panoramic is excellent for evaluation of trauma, tooth development, and certain anomalies. A 1999 study at the University of Buffalo School of Dental Medicine demonstrated that calcifications in the carotid arteries, which were exposed on standard panoramic x rays, served as predictors of death from cardiovascular disease.

The main disadvantage of panoramic x rays is that the image shown does not provide the fine detail of a bitewing x ray. The procedure for taking a panoramic x ray is also somewhat confining to the patient, as the x ray machine takes a minute or more to fully encircle the head for the complete picture. These films are not good in aiding the diagnosis of decay, bone level, and certain types of periapical pathosis.

A periapical x ray is similar to a bitewing. This type of x ray shows the entire tooth area, from crown to root, and the bone surrounding the root from a side view. This type of film will reveal any root anomalies, changes in the bone and surrounding tissue, cysts, bone tumors, and abscesses. The fine detail in the periapical film is necessary in diagnosis and treatment planning, and is commonly taken during root canal treatment and crown restoration procedures.

Dental x rays

Type	Purpose
Bitewing (interproximal)	Show tooth crowns, alveolar crest, and interproximal area Check for cavities, look at previous dental work, and determine any bone loss
Edentulous (toothless)	Check for residual pathologic conditions, or foreign bodies Detect retained teeth or root tips prior to denture construction
Full mouth series	Includes a number of periapical and bitewing x rays to identify conditions in the bones around the teeth and nerve tissue in the teeth Can be used as comparison for future problems
Occlusal	Shows large areas of the maxilla, mandible, or floor of the mouth Shows entire upper or lower bite and how primary or permanent teeth are developing
Periapical	View the entire tooth from root to crown and its periodontal supporting structures Evaluate bone loss, determine causes of toothaches, and assess existing dental work
Panoramic	Supplement to periapical survey but not a substitute View general tooth development, check for specific problems such as trauma or temporomandibular joint (TMJ) pain

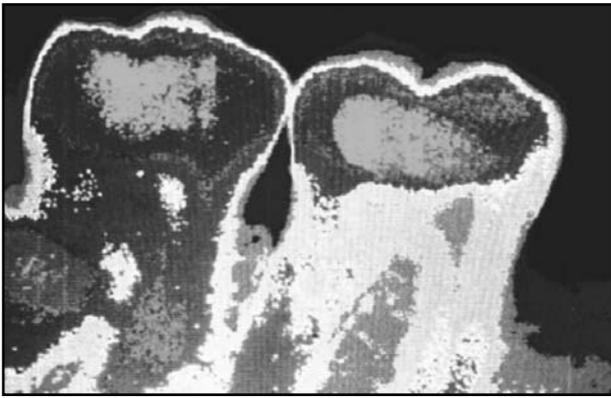
SOURCE: Alvarez, K.H. *Williams & Wilkins' Dental Hygiene Handbook*. Baltimore: Williams & Wilkins, 1998.

Occlusal films are least common. These films show the whole bite of the lower or upper jaw. Occlusal x rays, when taken, are mainly taken on children to show the eruption order of the permanent teeth.

X rays pass through hard and soft tissue in the mouth. The x ray beam is blocked by denser structures, such as teeth, fillings, jaws, and bones. Teeth appear lighter because fewer x rays go through the teeth to reach the film. Cavities and gum disease appear darker (shown by a dark spot in the tooth or loss of bone structure around the tooth) because of more x-ray penetration. On the film, the white images are the dense structures.

Operation

William Roentgen, a German scientist, discovered the x ray in 1895. He found that x rays are energy in the form of waves, similar to visible light. The only difference between light and x rays is that light does not have the ability to penetrate the body as x ray energy does. Light makes pictures of the outside of objects, while x rays have the ability to make pictures of the inside of objects. The name roentgen represents the amount of



A digitized x ray shows two molar teeth cavities. (Custom Medical Stock Photo. Reproduced by permission.)

exposure given off by one single energy photon. The amount of absorbed x ray in the body is a unit called a rad. A unit called “rem” accounts for the difference in biological effectiveness of different types of radiation, such as secondary radiation, or cosmic radiation. One rem equals one rad. One rad equals one R and one thousand milliroentgens, more commonly known as mrad; it is equal to one roentgen (R).

Research conducted in 2000 by the Idaho Radiation Network sets a maximum permissible x ray dose for one year at 5R (roentgens). A full mouth set of dental x rays consists of 18 to 20 films (bitewings, periapicals, occlusal and panoramic x rays). The amount of radiation for receiving the full-mouth set of x rays is 10 to 20 mrad (milliroentgens). The benefits derived from x rays greatly outweigh the radiation concerns. In 1999, the National Council on Radiation Protection reported that the amount of radiation an average person receives each year from background sources (e.g., outer space, materials in the earth, foods consumed, and naturally radioactive materials in the body) is 360 mrad.

Secondary radiation consists of the radiation waves left over after the source of radiation is stopped. Most secondary waves can penetrate tissue and are the most dangerous and damaging waves from radiation. Measures taken to prevent damaging rays are:

- setting radiation exposure to lower settings depending on the patient’s age, height, build and structure
- use of high-speed films to minimize exposure time
- use of lead-filled aprons to shield sensitive body parts, such as thyroid glands and gonads
- x ray badges worn by dental staff to monitor the amount of radiation exposure in the workplace

Maintenance

Dental x rays are essential in diagnosing and treating oral disease, abnormal tooth development, or trauma. At the initial dental examination, a full-mouth set of x rays may be taken (bitewings and panoramic). Thereafter, it is the dentist who should determine when and how often x rays will be required. Children are usually more cavity prone than adults; x rays may be taken with regard to degree of risk, or at the check-up examination every six months.

An adult presenting a **dental trauma** will need x rays to diagnose what the treatment should be. More x rays may be needed depending on the treatment plan and the extent of the injury.

The American Dental Association (ADA) recommends basic guidelines on taking dental x rays. On average, bitewing x rays should be taken approximately once a year. This is mainly to detect and treat any conditions early in their development. If the overall general health of the mouth is good, x rays can be taken every 18 to 24 months. The ADA also recommends that the type and frequency of dental x rays taken at an examination be based upon clinical judgment after the examination and consideration of the dental health and the general health of the patient.

Health care team roles

A registered dental assistant (RDA) or registered dental hygienist (RDH) commonly takes the x rays during a dental examination. They review the health and dental history, chart, and age of the patient to be x rayed. Adjustments are made to the x-ray unit depending on the size and age of the patient. The RDA then develops and mounts the x rays and presents them to the dentist. The dentist will interpret the x rays and complete the oral examination. A treatment plan will follow.

Training

An RDA and an RDH must have an x-ray certification in order to take and develop x rays. To become certified, full-mouth sets of x rays need to be taken. Knowledge of the x-ray machine unit is needed, as is the number of roentgens emitted from a variety of different x-ray machines. Furthermore, a working knowledge of angles and height of the x-ray unit is needed; this is necessary for taking fine-detailed images. Certification also requires knowledge of the principles of radiation safety.

Classes leading to certification as an RDA or RDH are available outside the work setting. Each state has dif-

KEY TERMS

Apical—Rounded end of the root of a tooth that is embedded in hard tissue (bone); toward the apex of the root.

Crown—1. The upper part of the tooth, covered by enamel. 2. A dental restoration that is a protective shell fitting over a tooth.

Eruption—The process of a tooth breaking through the gum tissue to grow into place in the mouth.

Pulp—The soft, innermost part of a tooth containing blood and lymph vessels, and nerves.

Root canal treatment—The process of removing diseased or damaged pulp tissue from a tooth, then filling and sealing the pulp chamber and root canals.

ferent bylaws regarding x-ray licensing for technicians. The rules of the state in which one is interested in working should be consulted.

Resources

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ORGANIZATIONS

American Dental Association. 211 East Chicago Avenue, Chicago, IL 60611. (312) 440-2500.
<<http://www.ada.org>>.

University of California Davis Radiology. 178 Mark Hall, University of California, Davis, CA 95616 (530) 752-3710 <<http://www.ehs.usdavis.edu>>.

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Cindy F. Ovard, RDA

Denture care

Definition

Denture care is the maintenance of removable artificial teeth. Full or complete dentures replace all teeth in the upper jaw (maxilla), lower jaw (mandible), or both jaws. Partial dentures replace some teeth.

Purpose

Dentures replace natural teeth lost because of a health condition or injury. The artificial teeth fit in the mouth, allowing a person to eat normally. Daily denture care by the patient helps prevent conditions such as plaque. Periodic dental appointments assure that dentures fit properly and that the patient's mouth is healthy.

Precautions

Dentures are fragile and can break if dropped. The American Dental Association (ADA) advises people to hold dentures over a towel or basin of water. The patient should not try to repair dentures.

Dentures should fit, so dental adhesive should be used only in an emergency. Extended adhesive use can conceal infections.

Sores

Dentures and partial dentures can cause sores in areas such as the jaw, below the tongue, and on the roof of the mouth (palate). Sores can swell slightly and are generally red. Poor **oral hygiene** and wearing dentures too long can lead to denture stomatitis (denture sore mouth). Symptoms often include an inflamed palate. The dentist may prescribe **antibiotics** or an antiseptic rinse.

Other causes of sores include poorly fitted dentures, an uneven bite, illness, and infections. Moreover, smoking, **alcoholism**, or **oral cancer** may cause sores. Furthermore, neglected sores could stimulate the growth of excess soft tissue. Tissue should be removed and a biopsy performed to detect malignant cells.

Description

People have worn dentures for thousands of years. Early material for artificial teeth included whale ivory. Today, most restorative teeth are made of plastic material such as acrylic resin.

Types of dentures

There are two types of complete dentures. Immediate dentures are placed in a patient's mouth after teeth are removed. These temporary dentures allow patients to have

Dental prostheses

Appliance type	Maintenance required for oral health
Orthodontic: fixed, removable, space maintainers	Specific plaque control instructions Orthodontic brushes Interdental aids: rubber tip, toothpick/holders, flossthreaders, proximal brushes, single tuft brushes Fluoride application: dentrifice, brush-on gel, gel trays Oral irrigation Store in water when not in use
Fixed partial dentures: natural teeth supported; implant supported	Toothbrushing instructions Oral irrigation Floss or yarn with threader Nonabrasive dentrifice with fluoride (do not use acidulated fluoride with composite and porcelain restorations)
Removable partial dentures, complete dentures, and overdentures	Power-assisted brush should not be used Use a separate toothbrush for dentures and natural teeth Immerse dentures in liquid cleanser after brushing Store in water when not in use

SOURCE: Alvarez, K.H. *Williams & Wilkins' Dental Hygiene Handbook*. Baltimore: Williams & Wilkins, 1998.

teeth while gums heal. Healing can take up to eight weeks. Conventional dentures are worn after gums heal.

Complete dentures rest on the dental ridge, the arch in the mouth that supports teeth roots.

For a partial denture, artificial teeth are attached to a base that fits on the gums. Clasps and attachments link the framework to the patient's other teeth.

An overdenture fits on the roots of natural teeth. Those teeth provide stability and support.

Costs for care

At-home denture care involves traditional oral hygiene and denture cleaning. In the spring of 2001, at-home denture products such as cleansers and toothpaste cost \$7 or less.

Denture care also includes dental appointments. In the United States in 2000, the average complete denture cost about \$874 for the upper arch and \$900 for lower arch, according to information compiled by <<http://www.bracesinfo.com>>. That information was based on statistics from sources including the ADA and the U.S. Bureau of Labor Statistics.

An acrylic partial denture cost averaged \$632, while a metal partial costs \$983.

Denture repairs averaged \$51 for an adjustment, \$91 for a broken denture with no teeth involved, \$90 for tooth replacement, and \$139 to reline dentures.

Dental plans may cover some costs. For example, the 2000 Delta Dental Plan of California assessed a patient co-pay of \$395 for the upper or lower complete denture, and \$495 for an immediate denture for one jaw. The co-pay for one partial was \$300 or \$395, with the higher cost for a metal framework.

Repair co-pays included \$20 for adjustments, \$50 for repairing the denture base, and \$25 for a tooth replacement. The plan allows one relining per denture in a year. The chairside reline cost was \$50 per denture and \$150 for laboratory relining.

Preparation

The process for making dentures generally starts with the dentist taking a wax impression of the patient's mouth. A material similar to plaster is poured into the impression to make a model of the teeth. The plaster model is sent to a lab, where a wax denture is made. The dentist fits this denture on the patient and then sends it to the lab where the permanent denture is created.

Aftercare

The dental team educates new denture wearers about how to adjust to restorative teeth and clean them.

Dentures should be rinsed to remove food particles. Then the patient brushes natural teeth and dentures to remove plaque and food. The ADA recommends using a toothbrush recommended for dentures or a soft bristle brush. Dentures can be cleaned with denture cleansers bearing the ADA Seal of Acceptance, mild liquid dish soap, or hand soap.

The new denture wearer is usually advised to wear the full denture most or all of the time. After an adjustment period, the dentist generally tells the patient to take the dentures out before bedtime. This gives the gums a chance to rest and promotes oral health, according to the ADA. When removed, dentures are soaked in water or a cleanser solution.

Complications

Bones and gums may shrink, especially during the first six months after teeth are removed. When shrinkage occurs, the dentist may need to rebase or reline the immediate dentures.

The new denture wearer may experience soreness. This is caused by the pressure of hard dentures on soft tis-

sue and is usually temporary. However, soreness is frequently a sign that dentures need adjusting.

The patient may also experience a temporary increase in saliva flow. If any symptoms persist, patients should contact their dentists.

Results

After a patient adjusts to new dentures, the person should have no trouble eating or speaking. Subsequently, modifications to dentures may be required because the shape of the mouth changes over time as gums recede or sink.

Dental adjustments include:

- Relining, adding material to reshape the denture.
- Rebasing, building a new base and placing the artificial teeth on it.
- Replacement of teeth.

A set of dentures may need to be replaced within five to 10 years.

Health care team roles

The dental team monitors the patient's mouth health during periodic check-ups.

In addition, the dental staff educates the new denture wearer about oral hygiene and how to adjust to wearing artificial teeth. Advice to new denture wearers includes:

- Eat soft foods and cut them into small pieces. After adapting to dentures, add other foods to the diet.
- Read aloud to adjust to speaking with dentures.
- Smiling, laughing, or coughing could cause dentures to slip. Gently biting down and swallowing will reposition the dentures.

Resources

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Instruction for patients with dentures

Item	Important instruction
Dental hygiene	Thoroughly clean dentures twice each day by immersing dentures in chemical solution and brushing for plaque removal; rinse thoroughly. It is preferable to leave the dentures out while sleeping, or for 6–8 hours during the day. Brush and massage the gums to clean away plaque and debris and stimulate circulation.
Denture storage	After cleaning, store the dentures in water in a covered container when they are not being worn. Keep the container in a safe place inaccessible to children or house pets.
Eating	New denture wearers should cut food into small pieces, avoid foods that need incising, and avoid raw vegetables, fibrous meats, and sticky foods until experience has been gained. Practiced denture wearers may select a variety of foods, but should not expect the same efficiency as with the natural teeth. Use the canine and premolar area to bite food, and push back as the food is incised; do not pull or tear the food in a forward direction. Take small portions and try to chew with some food on each side at the same time to stabilize the denture.
Over-the-counter products	Consult the dentist for advice about all denture problems, and before buying self-reline materials, adhesives, or other additives. Never attempt to alter the denture for relief of discomfort.
Speaking	Speak slowly and quietly. Practice by reading aloud at home, preferably in front of a mirror, and repeat and practice words that seem the most difficult.

SOURCE: Alvarez, K.H. *Williams & Wilkins' Dental Hygiene Handbook*. Baltimore: Williams & Wilkins, 1998.

ORGANIZATIONS

Academy of General Dentistry. 211 E. Chicago Ave., Chicago, IL 60611. (312) 440-4300. <<http://www.agd.org>>.

American College of Prosthodontists. 211 E. Chicago Ave., Suite 1000, Chicago, IL 60611. (312) 573-1260. <<http://www.prosthodontics.org>>.

American Dental Association. 211 E. Chicago Ave., Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org>>.

Centers for Disease Control and Prevention. National Center for Chronic Disease Prevention and Health Prevention. Division of Oral Health, MS F-10. 4770 Buford Highway, NE, Atlanta, GA 30341. (888) CDC-2306. <<http://www.cdc.gov>>.

National Institute of Dental & Craniofacial Research. National Institutes of Health. Building 45, Room 4AS-18, 45

KEY TERMS

Plaque—A transparent material in the mouth that contains bacteria and causes tooth decay.

Prosthodontics—The area of dentistry concerned with the replacement of missing teeth.

Center Drive MSC 6400, Bethesda, MD 20892-6400.
<<http://www.nidcr.nih.gov/>>.

Liz Swain

Dentures see **Dental prostheses**

Depression see **Depressive disorders**

Depressive disorders

Definition

A depressive disorder is defined by the National Institute of Mental Health (NIMH) as an illness that involves the body, mood and thoughts. It encompasses feelings of overwhelming sadness and despair that persist or intensify over time.

Description

Occasional feelings of unhappiness or sadness are normal, but when such feelings dominate everyday life causing physical and mental deterioration, they are termed depressive disorders. In *Caring For The Mind, The Comprehensive Guide to Mental Health*, Dianne and Robert Hales state that comparing everyday blues to clinical depression is like comparing a cold to **pneumonia**. Nearly 19 million American adults, approximately 10% of the population, suffer from depression in any given year. Less than one of three of these will ever pursue, or receive, medical care. In a survey conducted by the National Mental Health Association, it was found that nearly half of those surveyed believed that depression was not an illness, but rather a personal emotional weakness. However depressive disorders are valid illnesses that require treatment and can literally be life-threatening: Fifteen percent of all people diagnosed as being depressed actually do commit suicide. Thirty percent may make unsuccessful attempts.

Categories of depression include:

- major depression
- seasonal affective disorder
- **bipolar disorder**
- dysthymia
- depression due to a general medical condition
- **postpartum depression**
- substance-induced depression

Major depression

Major depression can be mild, moderate or severe, and the rating of its severity is based upon the number of symptoms the person has, and how seriously these symptoms affect their lives. Typical symptoms are:

- lack of interest in once-enjoyable activities
- loss or gain of weight
- difficulty concentrating or making decisions
- feelings of worthlessness and hopelessness
- changes in sleep patterns, either insomnia or hypersomnia

People with major depression may be preoccupied with death or suicide. In children, it may manifest itself as irritability or *acting out*. According to the National Comorbidity Survey, major depression is the single most common mental illness in the United States, affecting one in ten Americans, and women twice as often as men. Ten to 15% of people over 65 and 25% of those in **nursing homes** show symptoms, and NIMH estimates that better than half of elderly Americans who suffer from major depression do not receive appropriate treatment.

Seasonal affective disorder (SAD)

The unique characteristic of SAD is *when* the depression occurs. Incidences usually occur at a specific time each year. SAD can be either unipolar, showing depressive symptoms only, or bipolar, having cycles of depression and elevated mood. SAD typically begins in the autumn, when the days grow shorter, and continues through the winter, ending in the spring. A less common form begins in the spring and ends in early fall. The NIMH estimates that ten million Americans have SAD.

Bipolar disorder

Close to two million Americans are diagnosed as having bipolar disorder, or manic depression, a mental illness that is characterized by cycles of giddy elation and despondency. Approximately one-fifth of all depressive disorders are termed bipolar. People suffering from bipolar illnesses often first exhibit hypomania, a mild state of

mania, in which they are often able to accomplish a great deal, go without sleep, and exhibit extreme self-confidence. As the disease progresses, they may cycle into full-blown mania, and engage in much more dangerous behavior, such as wild spending sprees, promiscuous sexual activity, substance abuse, and other self-destructive behaviors. This euphoric phase is followed by the depths of classic depression.

Dysthymia

Dysthymia, or chronic mild depression, has been described as sadness that will not end. There has been debate among mental health professionals for several years as to whether dysthymia is a truly separate entity from major depression, and the answer remains unclear. NIMH studies have shown that three-quarters of those diagnosed with dysthymia also had other disorders, including major depression, panic or **anxiety** disorders, and substance abuse. The National Comorbidity Survey suggested that approximately 6% of Americans will develop this disorder in their lifetimes.

Depression due to a general medical condition

Many people are not aware that physical disease can cause depression. One of the significant differences in this type of depression is that patients continue to feel good about themselves, and complain that the depression is interfering with their normal life activities.

Postpartum depression

It is not unusual for a new mother to have what is termed baby blues shortly after giving birth. This involves feeling sadder than usual, crying easily, and typically occurs in the first seven to 10 days after birth. However, about 1% of all new mothers develop a true mental illness, postpartum depression, between a month and a year after giving birth. The symptoms are similar to major depression, but some women may develop more serious complications, including hallucinations and delusions.

Substance-induced depression

Many different medications, both legal and illegal, can cause depression. **Alcoholism** has long been linked closely with depression, but it is now known that one in four alcoholics suffered from depression before they ever drank, and will remain depressed whether they drink again or not, unless the depression is treated.

Causes and symptoms

As study of the **brain** and nervous system has advanced, it has become known that depression is a complicated biological process that interrupts the normal balance of neurotransmitters, or messenger chemicals such as norepinephrine or serotonin.

Major depression

Heredity appears to be strongly linked to major depression. As a rule, the rate of depression between family members of a person suffering from major depression is one to three times higher than in families where there is none. An identical twin is 66% more likely to become depressed if the other develops the illness. However therapists can often see predictable patterns of behavior that lead to depression. Life traumas such as grief also seem to lead to major depression.

Seasonal affective disorder

SAD is common in northern climates. It is nearly nine times more prevalent in New Hampshire as in Florida, indicating that the altered brain chemistry that produces the depression is related to the decrease in light in northern climates during the winter. However, the cause of SAD is still under investigation.

Bipolar disorder

Bipolar disorders are believed to be caused by abnormal functioning of the brain. Heredity is considered a major factor.

Dysthymia

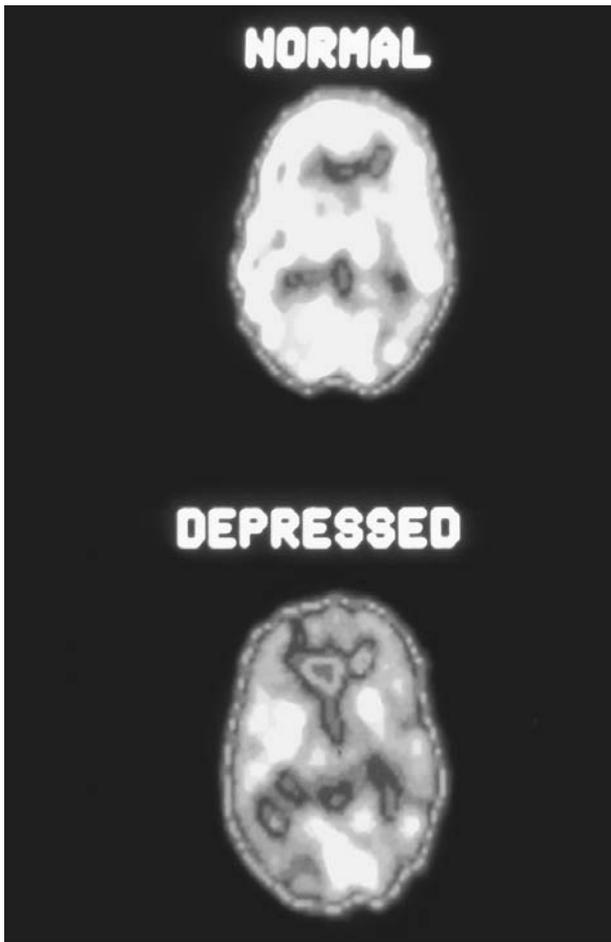
Like other depressions, dysthymia has been related both to hereditary chemical imbalances within the brain and to traumatic events in life, often going back to childhood. Some research has linked dysthymia to attention deficit hyperactivity disorder (ADHD) and conduct and **personality disorders**.

Depression due to a general medical condition

Among the physical illnesses capable of causing depression are **cancer**, **heart** disease, hormonal problems (such as thyroid disorders), Alzheimer's and **Parkinson's Disease**, brain tumors, head injuries, infectious illnesses, and malnutrition/vitamin deficiency.

Postpartum depression

This type of depression appears related to changes in hormonal chemistry that affects a woman's brain chemistry.



Positron emission tomography (PET) scans comparing a normal brain with that of someone with a depressive disorder. (Photo Researchers, Inc. Reproduced by permission.)

Substance-induced depression

Among the substances that are capable of causing depression are:

- alcohol
- minor tranquilizers such as valium
- heroin and other narcotics
- antihistamines
- anticancer drugs
- steroids and corticosteroids
- anti-seizure medications such as dilantin or depakot
- anti-inflammatory drugs
- cocaine, when its initial elevation in mood has passed
- estrogen
- L-dopa, a drug used to treat Parkinson's disease

Diagnosis

Many people go to their primary care practitioner with complaints of insomnia, lack of appetite, or other physical complaints only to discover that what they actually have is depression. A thorough **physical examination** is needed, including a family history of depression, the person's use of alcohol or other drugs, and medications being taken. Psychological testing and a mental status examination may be conducted. Several clinical inventories or scales may be used to assess a patient's mental status and determine the presence of depressive symptoms. Among these tests are: the Hamilton Depression Scale (HAM-D), Child Depression Inventory (CDI), Geriatric Depression Scale (GDS), Beck Depression Inventory (BDI), and the Zung Self-Rating Scale for Depression. These tests may be administered in an outpatient or hospital setting by a general practitioner, nurse, social worker, psychiatrist, or psychologist. The guidelines for diagnosing depression are found in the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)*.

Treatment

Major depression, dysthymia, and seasonal affective disorder are all treated effectively with psychosocial therapy of various kinds and antidepressant medications.

Antidepressants

Antidepressant medications, without any other type of treatment, are estimated to relieve the symptoms of 60–70% of clinically depressed people. Selective serotonin reuptake inhibitors (SSRIs) such as fluoxetine (Prozac) and sertraline (Zoloft) reduce depression by increasing levels of serotonin, a neurotransmitter. Some clinicians prefer SSRIs for treatment of dysthymic disorder. Anxiety, **diarrhea**, drowsiness, headache, sweating, nausea, poor sexual functioning, and insomnia are all possible side effects of SSRIs.

Tricyclic antidepressants (TCAs) are older and less expensive medications than SSRIs, but they have more severe side effects, including persistent dry mouth, sedation, dizziness, and irregular heartbeat. Because of these, caution is taken when prescribing TCAs to elderly patients. TCAs include amitriptyline (Elavil), imipramine (Tofranil), and nortriptyline (Aventyl, Pamelor). A 10-day supply of TCAs is potentially lethal, so these drugs are questionable treatment options for patients at risk for suicide.

Monoamine oxidase inhibitors (MAOIs) such as tranylcypromine (Parnate) and phenelzine sulfate (Nardil) block the action of monoamine oxidase, a **cen-**

tral nervous system enzyme. Patients taking MAOIs must restrict foods high in tyramine (found in red wine, aged cheeses, and meats) from their diet to avoid potentially serious **hypertension**.

Heterocyclics include bupropion (Wellbutrin) and trazodone (Desyrel). Bupropion should not be prescribed for patients with **seizure disorder**. Side effects of the drug may include agitation, anxiety, confusion, tremor, dry mouth, fast or irregular heartbeat, headache, low **blood pressure**, and insomnia. Because trazodone has a sedative effect, it is useful in treating depressed patients with insomnia.

Psychosocial therapy

Psychotherapy explores an individual's life to bring to light possible contributing causes of the present depression. During treatment, the therapist facilitates an awareness of thought patterns and how they developed. There are several different subtypes of psychotherapy, but all have the common goal of helping the patient develop healthy problem solving and coping skills.

Electroconvulsant therapy

ECT, or electroconvulsive therapy, is normally employed after other treatment options have been explored. But it may be used sooner if severe depression, suicide risk, or psychosis is present, or if the person is unable or unwilling to take medication. About half of those who do not improve from other therapies recover after having ECT.

The treatment consists of a series of electrical pulses that move into the brain through electrodes on the patient's head. ECT is given under **general anesthesia** and patients are administered a muscle relaxant to prevent convulsions. Although the exact mechanisms behind the success of ECT therapy are not known, it is believed that the electrical current modifies the electrochemical processes of the brain, consequently relieving depression. Headaches, muscle soreness, nausea, and confusion are possible side effects immediately following ECT. **Memory** loss, typically transient, is reported by ECT patients.

Phototherapy

Phototherapy, or exposure to fluorescent light bulbs installed in a metal box with a plastic screen ten to twenty times brighter than indoor lighting, has proven effective in treating SAD. Phototherapy is often combined with other treatments such as medication or psychosocial therapy. The person sits in front of this light box for anywhere from one-half hour to two hours.

Alternative treatment

St. John's wort (*Hypericum perforatum*) is used throughout the world to treat depression. In Germany, St. John's Wort is the most widely used antidepressant. This herbal antidepressant has few reported side effects, but some users have experienced high **blood** pressure, headaches, stiff neck, nausea, and vomiting. NIMH is currently involved in a three-year study of its efficacy. However, in February 2000, a **public health** advisory was issued by the Food and Drug Administration (FDA) stating that St. John's wort may interact with other medications commonly prescribed for heart disease, depression, seizures, and certain cancers, as well as anti-rejection drugs used for transplant patients. Healthcare providers were advised to alert their patients to the risk of this interaction.

Holistic treatment can also be very therapeutic in treating depression. Good **nutrition**, proper sleep, **exercise**, and full engagement in life are very important to a healthy mental state.

Prognosis

Untreated or improperly diagnosed depression is the number one cause of suicide in the United States. Yet treatment can result in dramatic improvement for between 75–80% of patients, and should be clearly evident within three to four months. Five to 10% of patients still report depression two years after initially being treated, but there are varying reasons for this, including medication noncompliance and alcohol abuse. The risk of recurrence climbs significantly with each episode.

Prevention

Education is crucial for patients with depressive disorders. They must learn to recognize symptoms and to take an active part in their treatment. Extended maintenance treatment with antidepressants may be required in some patients to prevent relapse. Physical exercise and staying connected to self-help support groups have both been shown to be effective in preventing depression. Early intervention with children with depression is effective in arresting development of more severe problems.

Health care team roles

Psychiatrist

Psychiatrists are licensed medical doctors who have undergone a three-year psychiatric residency. They diagnose depression, determine appropriate treatment, and provide psychotherapy and support for patients.

KEY TERMS

Clinical depression—Depression that is serious enough to require psychiatric intervention and treatment.

Hypersomnia—The need to sleep excessively; a symptom of dysthymic and major depressive disorder.

Neurotransmitter—A chemical in the brain that transmits messages between neurons, or nerve cells. Changes in the levels of certain neurotransmitters, such as serotonin, norepinephrine, and dopamine, are thought to be related to depressive disorders.

Psychomotor agitation—Disturbed physical and mental processes (fidgeting, wringing of hands, racing thoughts); a symptom of major depressive disorder.

Psychomotor retardation—Slowed physical and mental processes (slowed thinking, walking, and talking); a symptom of major depressive disorder.

Education on the nature of depression, and the various treatment options available, are important adjuncts to the therapy they provide.

Primary care practitioner (PCP)

Though depression is a mental illness, depression may be diagnosed by primary care practitioners because depressed patients often exhibit distinct physical symptoms. Psychiatrists frequently become involved only after a consultation is requested. The importance of a psychiatric referral for further evaluation cannot be overstated. It can literally save a severely depressed person's life.

Registered nurse (RN), psychiatric nurse, or licensed practical nurse (LPN)

Both RNs and LPNs must complete a prescribed nursing course and pass a state examination. RNs typically have a degree in nursing, and psychiatric nurses have additional training specific to their field. Both RNs and LPNs are the health care team members who are most involved with depressed patients in outpatient clinics and in psychiatric units, where patients at risk for suicide must be monitored. Observational skills, empathy, and the ability to listen are necessary assets for nurses. Education about depression typically comes from both physicians and nurses.

Social workers

Social workers are usually either certified (CSW) or licensed clinical social workers (LCSW). A two-year graduate degree, specialized training that includes supervised clinical work with the mentally ill, and state licensure are typical requirements. Social workers often conduct supportive groups or programs that help people vent feelings or work on ways to better be able to cope.

Mental health assistants

These are staff members on inpatient psychiatric units who have been provided with special training in order to assist with the care of people with mental illness. They normally aid patients with day-to-day needs, accompany them to appointments or for walks if necessary, help deal with crises, and assist professional staff in providing care.

Resources

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- Whybrow, Peter C. *A Mood Apart*. New York: HarperCollins, 1997.

ORGANIZATIONS

- American Psychiatric Association (APA). Office of Public Affairs. 1400 K Street NW, Washington, DC 20005. (202) 682-6119. <<http://www.psych.org>>.
- American Psychological Association (APA). Office of Public Affairs. 750 First St. NE, Washington, DC 20002-4242. (202) 336-5700. <<http://www.apa.org>>.
- National Alliance for the Mentally Ill (NAMI). 200 North Glebe Road, Suite 1015, Arlington, VA 22203-3754. (800) 950-6264. <<http://www.nami.org>>.
- National Depressive and Manic-Depressive Association (NDMDA). 730 N. Franklin St., Suite 501, Chicago, IL 60610. (800) 826-3632. <<http://www.ndmda.org>>.
- National Institute of Mental Health (NIMH). 5600 Fishers Lane, Rm. 7C-02, Bethesda, MD 20857. (301) 443-4513. <<http://www.nimh.nih.gov/>>.

Joan M. Schonbeck

Development assessment

Definition

Developmental assessment involves the measure of a child's attainment of physical or cognitive skills that allow continued maturation, learning, and function in society.

Purpose

Developmental assessment is used to observe functional ability in children and to identify any deviations from the norm. It is used to recognize whether or not a disability may exist and if so, where the specific problem areas lie. Developmental tests provide information regarding the milestones a child has attained, and can help in determining the course of intervention to attain further milestones. Results of developmental tests may also be used to indicate the level of progress achieved after intervention, and are often used by both clinicians and researchers.

Description

In addition to the use of a test with established reliability and validity, a developmental assessment should include data collection in the form of an interview, history, and clinical observation. The interview should take place with the parents/caregivers and, if age-appropriate, the child, in an informal and friendly setting. The concerns and goals of the parents and child are important to note, and information regarding the child's developmental and medical history may be obtained at this time. In addition to the parent report, it is important to look at **medical records** if they are available. Information regarding the mother's **pregnancy**, labor, and delivery, and the child's medical/surgical history, health status, medications, precautions, and other items of relevance is helpful in providing a background for the assessment.

Clinical observation of the child is useful in determining factors that may contribute to developmental difficulties. In addition, it is helpful to watch a child moving under his or her own volition, instead of under a therapist's directions. Observation may include, but is not limited to: the manner in which the infant or child is held by the parent (e.g. posture, support required); preferred means of mobility (e.g. wheelchair, ambulation [walking], crawling, scooting, rolling); antigravity posture and movements; equilibrium and righting reactions; balance, including base of support; compensations; and assistance required for stability or mobility.

There are a number of assessment tools available that measure gross motor development. Some, but not all, of these tools will be summarized here.

Screening tests

Screening tests are the most basic form of developmental assessment tool, and are used to determine whether or not a concern exists. The Alberta Infant Motor Scale (AIMS) is used during the first year of life to identify motor delay and to evaluate maturation over time. Fifty-eight items related to posture, movement, and weight bearing in prone, supine, sitting, and standing positions take 10 to 20 minutes to observe. Researchers have found predictive validity, interrater (the consistency of the rating between different people performing the test), and test-retest reliability of the AIMS to be good. In addition, there is high concurrent validity with the Peabody Developmental Motor Scales' gross motor portion.

The Miller First Step Screening Test for Evaluating Preschoolers assesses cognitive and physical function in children 35 to 74 months of age. It uses 18 games that are age-appropriate and takes approximately 20 minutes. The Denver II is a comprehensive screening test encompassing 125 items in the personal-social, fine motor-adaptive, language, and gross motor domains. The test is norm-referenced from birth to six years; however, it has been criticized for poor specificity.

Motor assessments

The Test of Infant Motor Performance (TIMP) consists of observation of 28 items and elicitation of 31 items in infants up to four months of age. It is found to be highly sensitive to small changes in development and valid in measuring behaviors of functional relevance. Test-retest reliability has been found to be high; more research needs to be done on predictive validity. Administration takes 25 to 45 minutes.

The Movement Assessment of Infants (MAI) is a criterion-referenced test for infants in the first year of life. Sixty-five items related to muscle strength/tone, primitive **reflexes**, automatic reactions, and volitional movement, including quality of movement, are assessed. Researchers report that interrater and test-retest reliability is good; however, the MAI has been found to over-identify infants with motor delay (i.e. produce a high rate of false positives).

The Peabody Developmental Motor Scales (PDMS) is a norm- and criterion-referenced test that examines gross and fine motor function in children from birth to 83 months (the second edition includes up to 71 months). The gross motor scale includes reflexes, balance, nonlocomotor, locomotor, and receipt and propulsion of objects. The

fine motor scale includes grasp, hand functions, eye-hand coordination, and manual dexterity. High reliability and validity have been reported; however, criticisms of the test prompted the creation of a second edition, the PDMS-2. This edition is updated with new normative data representative of the current U.S. population. Reliability and validity were studied for gender, race, and other subgroups of the normative sample. In addition, more specific scoring criteria and illustrations were added.

The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) is a norm-referenced test that examines gross and fine motor function in children aged four-and-a-half to fourteen-and-a-half years. The gross motor subtests assess speed and agility, balance, bilateral coordination, and strength. The fine motor subtests assess upper-limb coordination, speed and dexterity, response speed, and visuomotor control. Administration takes 45 to 60 minutes, and reliability (interrater and test-retest) is high. Critics of the test have pointed out, however, that some of the items, e.g. “tapping feet alternately while making circles with fingers,” do not measure skills relevant to everyday function. In addition, it is important to note that failure of items may result as much from cognitive and perceptual difficulties as from motor difficulties.

The Gross Motor Function Measure (GMFM) is designed to evaluate change in motor performance over time in children with **cerebral palsy**. The test contains 88 items in five groups: lying and rolling; sitting; crawling and kneeling; standing; and walking, running, and jumping. Interrater and test-retest reliability have been demonstrated as high.

Comprehensive assessments

The Bayley II consists of a norm-referenced test of motor performance (manipulation, coordination of large muscle groups, dynamic movement, postural imitation, stereognosis [the ability to recognize solid objects by touch]), and mental ability (object permanence, **memory**, problem solving, complex language) in children from birth to 42 months. It also contains a criterion-referenced behavior scale that looks at affect, interests, activity, and fearfulness. Test-retest and interrater reliability have been found to be higher for older ages than for younger ages with this test. This test takes approximately 45 to 60 minutes to administer.

The Early Intervention Developmental Profile (EIDP) consists of six scales in the following areas: perceptual/fine motor; cognition, language, social/emotional; self-care; and gross motor development. It is designed to be administered wholly by any member of a multidisciplinary team to children from birth to 36 months.

Content validity, in addition to interrater and test-retest reliability, have been found to be good.

Assessments of functional capabilities are not necessarily developmental milestone-based; however, their use is important in determining whether or not specific disabilities exist. These disabilities may be related to mobility, transfer, self-care or social function. Examples of functional assessments include the Pediatric Evaluation of Disability Inventory (PEDI) and the Functional Independence Measure for Children (WeeFIM).

Results

In a norm-referenced test, the child's score is compared to the average of a group of children. This average is obtained by collecting scores from a large population. In a criterion-referenced test, the scores are interpreted based on absolute criteria such as the number of items performed correctly. Raw scores on tests often can be converted to age equivalent scores, standard scores, motor quotients and percentile rankings.

Once scores are obtained, they must be analyzed along with the information gathered during the interview, history, and observation. Although the normative populations used for the tests are representative of the U.S. population, cultural differences in motor development need to be considered as well. All of this information may be used to guide intervention and/or identify areas of progress or concern. Once specific areas of dysfunction are noted, goals and objectives may be formulated to treat these areas.

Health care team roles

Physical and occupational therapists usually perform developmental motor assessments; however, the more comprehensive scales are often designed for administration by any or all members of the health care team. This team may include any or all of the following: physician, nurse, physical therapist, occupational therapist, speech and language pathologist, special educator, psychologist, and social worker. It is important that whoever administers the test takes care to learn the test and procedure for administration.

Resources

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KEY TERMS

Concurrent validity—Relationship between performance on a given test and another well-established test which is purported to measure the same skills.

Content validity—The likelihood that the test measures what it says it is to measure.

Interrater reliability—Relationship of an individual's score on first administration of a test to the score on second administration.

Predictive validity—The likelihood that a child's performance on the test predicts an actual behavior.

Specificity—Ability of a test to identify those who do not have a disorder.

Test-retest reliability—Index of agreement between two different testers for the same test.

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Diabetes mellitus

Definition

Diabetes mellitus is a condition that occurs when either the **pancreas** does not produce enough insulin or the body's cells stop responding to the insulin that is produced. In either case, glucose in the **blood** cannot be absorbed or used by the cells of the body.

Description

Diabetes has been recognized as a disease since ancient times. Egyptian papyri described its symptoms in 1550 B.C., and Hindu physicians noted 500 years later that insects were drawn to the sugary urine of people afflicted with diabetes. The disease was first named in 230 B.C. by Apollonius of Memphis, who took it from the Greek *diabainein* (to pass through), a description of the unquenchable thirst and copious urine produced by diabetics. It was not until the latter part of the eighteenth century that the British physician John Rollo appended the Latin term *mellitus* (honey-sweet) to distinguish diabetes from other diseases that caused excessive urine production.

Diabetes mellitus is a chronic disease that causes serious health complications including renal failure, **heart** disease, stroke, blindness, and peripheral neuropathy with vascular insufficiency, putting patients at risk for **gangrene** and subsequent amputation of the extremities. Approximately 16 million Americans have diabetes; of these, it is estimated that around 5.4 million are undiagnosed. Diabetes afflicts 120 million people worldwide, with the World Health Organization predicting that the number will reach 300 million by 2025.

Physiology

Every cell in the human body requires fuel to function. The body's primary energy source is glucose, a simple sugar resulting from the digestion of foods containing **carbohydrates**. Glucose from the digested food circulates in the blood as a ready energy source for any cells that need it. Insulin is a protein hormone secreted into the blood by cells in the pancreas called islets of Langerhans. Insulin bonds to a receptor site on the outside of a cell, and acts like a key to open a doorway into the cell through which glucose can enter. The **liver** may convert excess glucose to concentrated energy sources like glycogen or fatty acids, which are stored for later use. If there is insufficient insulin production, or when the doorway no longer recognizes the insulin key, glucose stays in the blood rather than entering the cells.

As the level of glucose in the blood rises, a condition called hyperglycemia results. The body will try to dilute this high blood glucose level by drawing water out of the cells, pumping it into the bloodstream, and excreting it in urine. It is not unusual for those with undiagnosed diabetes to complain of constant thirst, to drink large quantities of fluids, and to urinate frequently as their bodies attempt to get rid of the extra glucose.

At the same time that the body is attempting to rid itself of glucose in the blood, its cells are starving for glucose and sends signals to eat more food, giving patients tremendous appetites. To provide energy for the starving cells, the body also tries to convert **fats** and **proteins** into glucose. Breaking down these substances causes acid compounds called ketones to form in the blood and to be excreted in the urine. As ketones build up in the blood, a condition called ketoacidosis can occur. If left untreated, this condition can be life threatening, eventually leading to **coma** and death.

Types of diabetes mellitus

Type 1 diabetes, sometimes called juvenile diabetes, commonly begins in childhood or adolescence. It occurs more frequently in populations descended from northern European countries than in those from southern Europe, the Middle East, or Asia. This form of diabetes is also called insulin-dependent diabetes because people who develop it need to have insulin injections at least once a day. In this form of diabetes, the body produces little or no insulin. Its onset is sudden, and it usually—but not always—occurs in people under 30.

Brittle diabetics are a subgroup of type 1 in which patients have frequent and rapid blood sugar level swings, alternating between hyper- and hypoglycemia. These patients may need several injections of different types of insulin taken at specific times during the day to maintain a blood glucose level within a fairly normal range.

The more common form of diabetes is type 2, sometimes called age-onset or adult-onset diabetes. It accounts for more than 90% of all diabetes in the United States. This form occurs most often in people who are over 50, as well as those who are overweight and sedentary; it is also more common in people of Native American, Hispanic, and African-American descent. People who have migrated to Western cultures from East India, Japan, and Australian Aboriginal cultures are also more likely to develop type 2 diabetes than those who remain in their native countries.

Type 2, also called noninsulin-dependent diabetes, is considered a milder form of diabetes because of its gradual onset (sometimes developing over the course of several years) and because it can often be controlled with

diet and oral medication. The consequences of uncontrolled and untreated type 2 diabetes, however, are as serious as those caused by type 1. Many people with type 2 diabetes are able to control their blood glucose with diet and oral medications, but for those who cannot, insulin injections may be necessary. In recent years, an alarming trend was being noted in Western culture, particularly in the United States: a tendency for children, teenagers, and young adults, particularly those who are obese, to develop this type of diabetes.

Another type of diabetes is **gestational diabetes**, which can develop during **pregnancy** and generally resolves after the delivery of the baby. This diabetic condition develops during the second or third trimester in approximately 2% of pregnancies. The condition is normally treated by diet, however, insulin injections may be required for periodic exacerbation control. Women who develop diabetes during pregnancy are at higher risk for developing type 2 diabetes within five to 10 years.

Diabetes may also develop as a result of or in concert with pancreatic disease, **alcoholism**, malnutrition, or other severe illnesses that tax the body's **immune system**.

Causes and symptoms

The causes of diabetes mellitus are unclear, however, there appear to be both hereditary and environmental factors involved. Research has shown that some people who develop diabetes have common genetic markers. In type 1 diabetes, the immune system is probably triggered by a virus or other microorganism that destroys the cells in the pancreas that produce insulin.

Type 2 diabetes is characterized by the insulin resistance syndrome, in which peripheral adipose and muscle cells fail to respond appropriately to circulating insulin, which the pancreas produces in response to food loads. Research has now shown that the insulin resistance syndrome is closely associated with dyslipidemia, an imbalance in the ratio of total cholesterol to the cholesterol fractions of either low-density lipoproteins (bad cholesterol) or to high-density lipoproteins (good cholesterol). Untreated or inadequately treated dyslipidemia leads to atherosclerosis and eventually to the microvascular complications mentioned above. Patients with type 2 diabetes and dyslipidemia are often treated with one of the drugs from the group known as statins, in addition to oral antidiabetic agents.

Age, **obesity**, and family history may all play a role in the development of type 2 diabetes. Symptoms may begin so gradually that a person may not be aware of them. Early signs are fatigue, extreme thirst, and frequent urination. Other symptoms may include sudden weight

loss, slow wound healing, urinary tract infections, or blurred **vision**. It is not unusual for type 2 diabetes to be detected while a patient is seeing a doctor for another health concern that is actually being caused by the as-yet-undiagnosed diabetes.

Individuals who are at high risk of developing type 2 diabetes mellitus include those who:

- Are obese (more than 20% above their ideal body weight).
- Have a primary relative (immediate family member) with diabetes mellitus.
- Belong to a high-risk ethnic population (African American, Native American, Hispanic, or Native Hawaiian).
- Have been diagnosed with gestational diabetes or have delivered a baby weighing more than 9 lbs (4 kg).
- Have been diagnosed with transient diabetes at the time of a moderate to severe systemic **infection** (like protracted pneumonia).
- Have high **blood pressure** (140/90 mmHg or above).
- Have a high-density lipoprotein cholesterol level less than or equal to 35 mg/dL and/or a triglyceride level greater than or equal to 250 mg/dL.
- Have had impaired glucose tolerance or impaired fasting glucose on previous testing.

Several common medications can impair the body's use of insulin, causing a condition known as secondary diabetes. These medications include treatments for high blood pressure (furosemide, clonidine, and thiazide diuretics), drugs with hormonal activity (oral contraceptives, thyroid hormone, progestins, and systemic glucocorticoids), and the anti-inflammation drug indomethacin. Several drugs used to treat mood disorders can also impair glucose absorption. These drugs include haloperidol, lithium carbonate, phenothiazines, tricyclic antidepressants, and adrenergic agonists. Other medications that can cause diabetes symptoms include isoniazid, nicotinic acid, cimetidine, and heparin.

Symptoms

Symptoms of diabetes can develop suddenly (over days or weeks) in previously healthy children or adolescents, or can develop gradually (over several years) in overweight adults past the age of 40. The classic symptoms include fatigue, frequent urination, excessive thirst, excessive hunger, tingling of hands and feet, pruritus, and weight loss. In sudden-onset diabetes, some patients may have a "fruity" odor to their breath.



Wrinkled, dehydrated skin of a person in a diabetic coma. Untreated diabetes mellitus results in elevated blood glucose levels, causing a variety of symptoms that can culminate in a diabetic coma. (Photo Researchers, Inc. Reproduced by permission.)

Ketoacidosis, a condition that results from starvation or uncontrolled diabetes, is common in patients with type 1 diabetes. Its symptoms include abdominal **pain**, vomiting, tachypnea, and extreme fatigue or lethargy. Patients with ketoacidosis will also have a characteristically sweet, fruity breath odor. Left untreated, this condition may lead to coma and death.

With type 2 diabetes, the condition may not become evident until the patient presents for medical treatment for some other condition. A patient may have heart disease, chronic infections of the gums and urinary tract, blurred vision, numbness in the feet and legs, and slowly healing **wounds**. Women may experience genital itching.

Diagnosis

Urine tests

Diabetes is suspected based on symptoms, but many of its symptoms may also suggest other diseases. Urine tests can begin the winnowing process that leads to a definitive diagnosis. Urine tests can detect ketones and protein in the urine; they can also show urine "spill," the renal threshold at which the **kidneys** will spill excess blood sugar into the urine. They can help assess how adequately the kidneys are functioning, and are used to monitor the disease once the patient is compliant with the recommended diet, oral medications, or insulin.

Blood tests

Although urine tests can confirm an initial suspicion of diabetes, specific blood tests are often required to make the differential diagnosis. One such diagnostic tool

is the fasting glucose test. Blood is drawn via a venipuncture after a period of at least eight hours of fasting, usually in the morning prior to breakfast. The red blood cells are separated from the sample and the amount of glucose is measured in the remaining plasma. A plasma level of 7.8 mmol/L (200 mg/L) or greater can indicate diabetes. The fasting glucose test is usually repeated on another day to confirm the results. A postprandial glucose test involves taking blood one to two hours after the patient has eaten a meal.

A glucose tolerance involves blood and urine sampling over a three- or five-hour period after a patient drinks a specially prepared syrup of glucose and other sugars. During the test the patient drinks no other fluids. When patients are healthy, the blood glucose level rises immediately after the drink and then decreases gradually as insulin is used by the body to metabolize the glucose. In patients with diabetes, the serum glucose rises and stays elevated after drinking the sweetened liquid. A plasma glucose level of 11.1mmol/L (200 mg/dL) or higher two hours after drinking the syrup and at one other point during the two-hour test period confirms the diagnosis of diabetes. During this time, the urine is tested for glucose spill.

A diagnosis of diabetes is confirmed if there are symptoms of diabetes and a blood glucose level of at least 11.1 mmol/L, a fasting plasma glucose level of at least 7 mmol/L, or a two-hour plasma glucose level of at least 11.1 mmol/L during an oral glucose tolerance test.

Monitoring glucose levels

The blood test that gives the best indication of average blood glucose levels over time is the hemoglobin A1C (HbA1C) test. It measures the percentage of hemoglobin A that has become glycosylated (coated with glucose) during the past three months. (Red blood cells have a life span of about 100 days; after that they are recycled by the bone marrow.) A normal reading for healthy individuals is about of 4–6% glycosylated HbA1C. Diabetics whose disease is well controlled will read 7% or lower. A reading of 8% or higher indicates the need for a change in treatment or better dietary compliance; these patients are also at increased risk for such complications as eye disease, kidney disease, and nerve damage. The HbA1C test should be performed at least twice a year to be sure that blood glucose levels stay within safe and healthy levels.

Home blood glucose monitoring kits are available so patients with diabetes can monitor their daily glucose readings. For decades, a small needle or lancet was used to prick the finger and a drop of blood was collected and analyzed by a monitoring device. Modern blood moni-

toring devices, however, are strapped on like a wrist watch; no finger sticks are required. This is especially helpful for patients who need to test their blood glucose levels several times during the day.

Treatment

There is no cure for diabetes; it can, however, be controlled so that patients can live a relatively normal life. Treatment focuses on two goals: keeping blood glucose readings within a normal range (140 mg/dL, the standard accepted by the American Diabetes Association) and preventing the development of long-term complications. Careful monitoring of diet, **exercise**, and blood glucose levels are important, affecting the need for insulin replacement as well as the dose of oral antidiabetic agents. Lack of consistent control leads to complications of the disease.

Dietary changes

Diet and moderate exercise are the first treatments implemented in diabetes. For many type 2 diabetics, weight loss may be an especially important part of treatment. A well balanced, nutritious diet provides approximately 50% to 60% of calories from carbohydrates, around 10% to 20% from protein, and less than 30% of calories from fat. The number of calories required by an individual depends on their age, weight, and activity level. Calorie intake also needs to be distributed over the course of the entire day so that surges of glucose entering the blood are kept to a minimum. The timing of snacks must also correspond to the timing and type of insulin being used.

Counting the calories in different foods can be complicated, so patients are usually advised to consult a nutritionist, who will set up an individualized, easily managed diet for each patient. Both the American Diabetes Association and the American Dietetic Association recommend diets based on the use of food-exchange lists. Each food-exchange unit contains a known amount of calories in the form of protein, fat, or carbohydrate. A patient's diet plan will allow a certain number of exchanges from each food category (meat or protein, fruits, breads and starches, vegetables, and fats) to be eaten at mealtimes and as snacks. Patients can choose which foods they eat as long as they stick with the number of exchanges prescribed and adhere to their schedule if they take a combination of insulin types. The food exchange system, along with an exercise program, can help patients lose excess weight and improve their overall health. This may be especially important for type 2 diabetics.

Oral medications

A variety of oral medications are available to help lower blood glucose in type 2 diabetics. They act in a variety of ways to control postprandial (after meal) glucose levels; the particular medication or combination of drugs chosen will be based largely on the individual patient profile. Some oral medications stimulate the pancreatic beta cells to produce additional insulin. Others change the way receptors on peripheral adipose (fat) and muscle cells receive the insulin and act on it, and still others block the intestinal absorption of food byproducts that would increase blood glucose levels.

All drugs have side effects that may make them inappropriate for particular patients. For example, some medications may stimulate weight gain or cause **stomach** irritation, so they may not be the best treatment for individuals who are already overweight or who have stomach ulcers. While these medications are an important aspect of treatment for type 2 diabetes, they are not a substitute for an appropriate diet and exercise. Oral medications are not effective for type 1 diabetes, in which the patient produces little or no insulin.

Insulin

Patients with type 1 diabetes need daily injections of insulin to help their bodies utilize glucose. The amount and type of insulin required depends on the individual patient's height, weight, age, food intake (quantity and timing), and activity level. Some patients with type 2 diabetes may need to use insulin injections if their diabetes cannot be controlled with diet, exercise, and oral medication. Injections are given subcutaneously, using a small needle and syringe. Injection sites can be anywhere on the body where there is adequate subcutaneous tissue, including the upper arm, abdomen, hips, or upper thigh.

Purified human insulin is most commonly used, however, insulin from beef and pork sources is also available. Insulin may be given as an injection of a single dose of one type of insulin once a day. Different types of insulin (short-acting rapid-onset, slow-onset long-acting) can be mixed and given in one dose or split into two or more doses during the day. Patients that require multiple injections over the course of a day may be able to use an insulin pump that administers small doses of insulin on demand. The small battery-operated pump is worn outside the body and is connected to a tube that is inserted into the abdomen. Pumps can be programmed to inject small doses of insulin at various times during the day, or the patient may be able to adjust the insulin doses to coincide with glucometer readings, meals, and exercise.

There are also multiple-dose insulin injection devices available that are commonly referred to as insulin pens. They are designed to hold a cartridge containing several days' worth of insulin dosages.

Regular human insulin is fast-acting and begins to work within 15–30 minutes; its peak glucose-lowering effect occurs about two hours later and its effects last approximately 4–6 hours. Neutral protamine Hagedorn (NPH) and Lente insulin are intermediate-acting insulins that start to work within 4–8 hours, and last 18–26 hours. Ultralente is a long-acting form of insulin that starts to work within four to eight hours and lasts 28 to 36 hours. Many diabetics combine a long- or intermediate acting insulin with a short-acting one to provide the proper insulin peak at mealtimes. Premixed insulins are available in standard doses. Newer forms of insulin are under investigation.

Although the goal of most diabetes treatment is to lower blood glucose levels, hypoglycemia, or low blood glucose, can be caused by too much insulin, too little food, alcohol consumption, or increased exercise. A patient with symptoms of hypoglycemia may be hungry, irritable, confused, and tired. The patient may be diaphoretic (sweating profusely), pale, and shaky. Left untreated, the patient can lose consciousness or have a seizure soon after these symptoms appear. This condition, called an insulin reaction or insulin shock, should be treated by giving the conscious patient something with readily available sugar to eat or drink like orange juice, hard candy, or sugar cubes. If the patient has declined into unconsciousness, do not try to feed them. This is a critical condition and always requires emergency intravenous therapy.

Surgery

Transplantation of healthy pancreatic tissue into a diabetic patient can be successful. However, it is not clear if the potential benefits outweigh the risks of the surgery and drug therapy required.

Alternative therapies

Since uncontrolled diabetes can be life-threatening if not properly managed, patients should be instructed to not attempt treatments without medical supervision. Patients interested in alternative and herbal remedies should be instructed about the possible benefits, but cautioned to consult with a health care professional before they try them. Some alternative therapies may interact negatively with some of the oral antidiabetic agents or other drugs, such as antihypertensives or anticoagulants.

KEY TERMS

Diabetic peripheral neuropathy—Condition in which the sensitivity of nerves to pain, temperature, and pressure is dulled, particularly in the legs and feet.

Diabetic retinopathy—A condition in which the tiny blood vessels to the retina are damaged, leading to blurred vision, sudden blindness, or black spots, lines, or flashing light in the field of vision.

Hemoglobin A—Normal hemoglobin found in the blood of an adult.

Hemoglobin A1C—One of three fractions of hemoglobin A; the other two are HbA1a and HbA1b. Because HbA1c can become glycosylated, it is an important measure of blood glucose over the past three months.

Hyperglycemia—Abnormally high levels of blood glucose.

Hypoglycemia—Abnormally low levels of blood glucose.

Ketoacidosis—Condition that results in untreated diabetes from the body's attempt to burn fat for fuel when carbohydrates cannot be utilized. Ketones, the byproduct of fat metabolism, enter the bloodstream and make the blood more acidic than the body's tissues.

Pruritus—Itching.

Tachypnea—Rapid breathing.

For patients who are willing to consult with their physician, alternative options may include:

- Fenugreek has been shown in some studies to reduce blood insulin and glucose levels while also lowering cholesterol.
- Bilberry may lower blood glucose levels, as well as help to maintain healthy **blood vessels**.
- Garlic may lower blood sugar and cholesterol levels.
- Cayenne pepper may help relieve the pain of diabetic neuropathy.

Any therapy that lowers **stress** levels may also be useful in treating diabetes by helping to reduce insulin requirements. Among the alternative treatments that aim to lower stress are hypnotherapy, biofeedback, and **meditation**.

Prognosis

Uncontrolled diabetes is a leading cause of blindness, end-stage renal disease, and peripheral vascular insufficiency, which leads to limb amputations. It also doubles the risks of heart disease and increases the risk of stroke. Eye problems including **cataracts**, **glaucoma**, and diabetic retinopathy are also more common in diabetics.

Diabetic peripheral neuropathy is a condition where nerve endings, particularly in the legs and feet, become less sensitive. Diabetic foot ulcers are a particular problem since the patient does not feel the pain of a blister, callous, or other minor injury. Poor blood circulation in the legs and feet contribute to delayed wound healing. The inability to sense pain along with the complications of delayed wound healing can cause minor injuries, blisters, or calluses to become infected and difficult to treat. In cases of severe infection, the infected tissue begins to break down and rot away. The severe infection may further exacerbate diabetes and increase blood glucose levels, perpetuating the problem. In the most serious infection cases, toes, feet, or legs may need to be amputated.

Diabetes can also affect the kidneys, a condition called diabetic nephropathy. This usually means that soft kidney tissue hardens and thickens, a process called sclerosis; this is especially true for the glomerulus (kidney membrane), which filters protein and other waste products from the blood. The ADA estimates that 35–45% of type 1 patients and 20–30% of type 2 patients have damaged kidneys. Because the symptoms of nephropathy may not appear until 80% of kidney function is gone, periodic tests of kidney function are especially important for patients with diabetes. Once renal function drops to 10–15%, **kidney dialysis** or a kidney transplant become necessary.

The risk of heart disease for patients with diabetes is two to four times higher than that of the general population. Death from heart disease is also two to four times higher in diabetics, as is the risk of stroke. These statistics hold for people with both type 1 and type 2 diabetes. The risk of cardiovascular disease increases with age, obesity, smoking, poor blood glucose control, and family history of heart disease.

Health care team roles

All members of the health care team may come into contact with diabetic patients. The nurse plays a particularly important role in teaching patients the skills necessary to manage this complex disease, and educating them about the effects of their medications.

Prevention

Research continues on ways to prevent diabetes and to detect those at risk for developing the disease. While the onset of type 1 diabetes is unpredictable, the risks for developing type 2 diabetes can be reduced by maintaining a healthy weight and exercising regularly. The physical and emotional stresses of surgery, illness (especially systemic infection), pregnancy, and alcoholism can all increase the risks for diabetes, so maintaining a healthy lifestyle is critical to preventing the onset of type 2 diabetes and further complications. Research is in progress to determine the usefulness of placing high-risk patients on metformin (Glucophage; an oral antidiabetic drug used to treat type 2 diabetes) prophylactically in an effort to delay or prevent the onset of type 2 diabetes.

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Diabetic diet see **Diet therapy**

Diabetic retinopathy see **Retinopathies**

Diagnostic medical sonography

Definition

Diagnostic medical sonography, or ultrasound, is a technique using high frequency sound to create images of specific areas of the body to diagnose various pathologies. The diagnostic medical sonographer performs examinations, records anatomic condition and provides diagnostic information.

Description

Under the supervision of a physician, the diagnostic medical sonographer provides patient services using medical ultrasound to gather data necessary to diagnose various conditions and diseases. The sonographer uses advanced computerized technology to produce images. The images are viewed on a video screen or converted by computer to produce photographs or printouts of ultrasonic patterns. The imaged patterns help the physician determine the diagnosis.

The sonographer's responsibilities include image production through patient positioning and operation of clinical instrumentation, patient care, quality control, technical assistance with interventional procedures, image manipulation and processing, and the preliminary interpretation of the ultrasound examination for the sonologist.

Supporting the physician, the sonographer obtains, reviews, and integrates pertinent patient history and supporting clinical data to facilitate optimum diagnostic results. This involves performing appropriate procedures and recording anatomical, pathological, and/or physiological data for interpretation by a physician, and recording and processing sonographic data and other pertinent observations made during the procedure for presentation to the interpreting physician.

Before the procedure, sonographers explain the ultrasonic procedure to patients and help patients assume the correct physical positions for required exposure to ultrasonic waves. At all times, the sonographer is required to exercise good judgment in the performance of sonographic services.



A pregnant woman undergoes an ultrasound. (Photograph by Larry Mulvehill. Science Source/Photo Researchers. Reproduced by permission.)

Work settings

Some sonographers can work in a variety of medical settings including hospitals, clinics, private offices, and other facilities performing examinations in their areas of specialization. More experienced sonographers may work on a contractual basis or for mobile services.

Education and training

A sonographer must have a thorough knowledge of cross-sectional anatomy and pathology, as well as the skills to manipulate a wide variety of sophisticated instruments. Individuals entering diagnostic medical sonography are required to have a strong academic background in the basic sciences and a strong comprehension of computer technology.

Diagnostic medical sonography programs vary in length from one to four years depending on the program design and the degree or certificate awarded. Program entry requirements range from a high school diploma to specific qualifications in a clinically related Allied Health profession such as nursing, radiotechnology, nuclear medicine, etc. Typical program curriculums can

include ultrasound physics and instrumentation, patient care procedures, professionalism and ethics, physiology and pathophysiology, and sonographic anatomy and scanning techniques.

Many programs involve an internship as part of the course of study. Interns work in medical facilities to apply classroom theory and gain practical skills. Following graduation, candidates take a national qualifying exam administered by the American Registry of Diagnostic Medical Sonographers (ARDMS). Continuing education is required of all sonographers to maintain registration. Candidates become Registered Diagnostic Medical Sonographer (RDMS) when they pass the ARDMS exam.

Advanced education and training

Diagnostic medical sonographers may wish to specialize through formal and/or continuing education after graduation and certification. Recent advancements in the technology have led to increased specialization. Specialties include spectral and color doppler, **vascular**

sonography, endocavity imaging, and intraoperative ultrasound.

Future outlook

Diagnostic medical sonography is a rapidly expanding field. The non-invasive, non-ionizing nature of the technology makes it an attractive modality. Continuing advancements in the technology provide a broader application of sonography. Therefore, an increasing need exists for well-trained and dedicated sonographers.

Important recent advances include the transvaginal scan that involves specially designed probes placed in the vagina that produce better images and more information in patients in the early stages of **pregnancy**. Transvaginal scans are becoming valuable in the early diagnosis of ectopic pregnancies and in detecting fetal abnormalities in the first trimester of pregnancy. Another recent advancement, doppler ultrasound, is useful in detecting fetal **heart** rates and fetal **blood** flow. Color doppler is useful in the diagnosis and assessment of congenital heart abnormalities. Also, three-dimensional ultrasound, which can create better scans by providing volumetric measurement, is moving from the research and development stages and into more widespread application.

Graduates of diagnostic medical sonography programs can find many employment opportunities in hospitals, medical centers, and mobile services. There are many opportunities for advancement, both within an institution and within the field. Advancement can depend on continuing education, specialization, and experience. Starting salaries for recent graduates range from \$28,000 to \$32,000.

Career opportunities also exist outside the healthcare field. Graduates can find employment in industry as education specialists, researchers and administrators and with equipment manufacturers as sales representatives.

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KEY TERMS

Color Doppler—An ultrasound technique used to locate areas of motion, such as blood flow in vessels.

Doppler—Technique for calculating the relative velocity between two points by measuring the shift in frequency of a sound wave transmitted from one point to another.

Transducer—Often called probes, transducers come in different shapes and sizes for use in different ultrasonic scanning situations.

Ultrasonic—A sound beyond the range of human hearing.

Ultrasound—The diagnostic or therapeutic use of ultrasound and esp. a noninvasive technique involving the formation of a two-dimensional image used for the examination and measurement of internal body structures and the detection of bodily abnormalities.

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Daniel J. Harvey

Dialysis, kidney

Definition

Dialysis treatment replaces the function of the **kidneys**, which normally serve as the body’s natural filtration system. Through the use of a **blood** filter and a chemical solution known as dialysate, dialysis removes waste products and excess fluids from the bloodstream, while maintaining the proper chemical balance of the blood. There are two types of dialysis treatment: hemodialysis and **peritoneal dialysis**.

Purpose

Dialysis also can be used to remove overdosed drugs or poisons from the bloodstream more quickly than normally functioning kidneys. Its most prevalent application, however, is for patients with temporary or permanent kidney failure. For patients with end-stage renal disease (ESRD), dialysis is the only renal replacement



A man undergoes hemodialysis on a dialysis machine. (Giovax Communication/Phototake NYC. Reproduced with permission.)

therapy available other than kidney transplantation. In the United States, nearly 250,000 patients receive regular dialysis treatments to manage ESRD.

Precautions

Blood pressure changes during hemodialysis may pose a risk for patients with **heart** disease. Peritoneal dialysis may be the preferred treatment option for these patients. Peritoneal dialysis is not recommended for patients with abdominal adhesions or other abdominal defects, such as a hernia, which might compromise the efficiency of the treatment. It is also not recommended for patients who suffer frequent bouts of diverticulitis (inflammation of diverticuli, small pouches in the colon).

Description

There are two types of dialysis treatment: hemodialysis and peritoneal dialysis.

Hemodialysis

Hemodialysis is the most frequently prescribed type of dialysis in the United States. The treatment involves

circulating the patient's blood outside of the body through an extracorporeal circuit (ECC), or dialysis circuit. Two needles are inserted into the patient's vein, or access site, and are attached to the ECC, which consists of plastic blood tubing, a filter known as a dialyzer (artificial kidney), and a dialysis machine that monitors and maintains blood flow and administers dialysate. Dialysate is a chemical bath that is used to draw waste products out of the blood.

Since the 1980s, the majority of hemodialysis treatments in the United States have been performed with hollow fiber dialyzers. A hollow fiber dialyzer is composed of thousands of tube-like hollow fiber strands encased in a clear plastic cylinder several inches in diameter. There are two compartments within the dialyzer (the blood compartment and the dialysate compartment). The membrane that separates these two compartments is semipermeable; it allows the passage of certain sized molecules across it, but prevents the passage of other, larger molecules. As blood is pushed through the blood compartment in one direction, suction or vacuum pressure pulls the dialysate through the dialysate compartment in a counter-current, or opposite direction. These opposing pressures

work to drain excess fluids out of the bloodstream and into the dialysate, a process called ultrafiltration.

A second process, called diffusion, moves waste products in the blood across the membrane into the dialysate compartment, where they are carried out of the body. At the same time, electrolytes and other chemicals in the dialysate solution cross the membrane into the blood compartment. The purified, chemically balanced blood is then returned to the body.

Most hemodialysis patients require treatment three times a week, for an average of three to four hours per dialysis “run.” Specific treatment schedules depend on the type of dialyzer used and the patient’s current physical condition. While the treatment prescription and regimen is usually overseen by a nephrologist (a doctor that specializes in the kidney), dialysis treatments are typically administered by a nurse or dialysis technician in outpatient clinics known as dialysis centers or in hospital-based dialysis units. In-home hemodialysis treatment is also an option for some patients, although access to this type of treatment may be limited by financial and lifestyle factors. An investment in equipment is required and another person in the household should be available for support and assistance with treatments.

Peritoneal dialysis

In peritoneal dialysis, the patient’s peritoneum (lining of the abdomen) acts as a blood filter. A catheter is surgically inserted into the patient’s abdomen. During treatment, the catheter is used to fill the abdominal cavity with dialysate. Waste products and excess fluids move from the patient’s bloodstream into the dialysate solution. After a waiting period of six to 24 hours, depending on the treatment method used, the waste-filled dialysate is drained from the abdomen and replaced with clean dialysate.

There are three types of peritoneal dialysis:

- Continuous ambulatory peritoneal dialysis (CAPD). This treatment is self-administered and requires no machine. The patient inserts fresh dialysate solution into the abdominal cavity, waits four to six hours, and removes the used solution. The solution is immediately replaced with fresh dialysate. A bag attached to the catheter is worn under clothing.
- Continuous cyclic peritoneal dialysis (CCPD). An overnight treatment that uses a machine to drain and refill the abdominal cavity, CCPD takes 10–12 hours per session.
- Intermittent peritoneal dialysis (IPD). This hospital-based treatment is performed several times a week. A

machine administers and drains the dialysate solution, and sessions can take up to 24 hours.

Peritoneal dialysis is often the treatment option of choice for infants and children, whose small size can make vascular access difficult to maintain. Peritoneal dialysis also may be performed outside of a clinical setting, which is more conducive to regular school attendance.

Preparation

A dialysis technologist, nurse, or nursing assistant weighs patients immediately before and after each hemodialysis treatment to assess their **fluid balance**. The dialysis technologist, nurse, or nursing assistant also measures and records blood pressure and temperature and assesses patients for any physical changes since their last dialysis run. Regular blood tests, performed by laboratory technologists, monitor chemical and waste levels in the blood. Prior to treatment, patients are typically administered a dose of heparin (an anticoagulant that prevents blood clotting) to ensure the free flow of blood through the dialyzer and an uninterrupted dialysis run.

Aftercare

Both hemodialysis and peritoneal dialysis patients must be vigilant about keeping their access sites and catheters clean and infection-free during and between dialysis runs.

Dialysis is just one facet of a comprehensive treatment approach for ESRD. Although dialysis treatment is very effective in removing toxins and fluids from the body, there are several functions of the kidney it cannot mimic, such as regulating high blood pressure and red blood cell production. Patients with ESRD need to watch their diet and fluid intake carefully and adhere to prescribed medications to effectively manage their disease.

Complications

Many of the risks and side effects associated with dialysis are a combined result of both the treatment and the poor physical condition of the ESRD patient. Dialysis patients should be instructed to report side effects to their healthcare provider.

Anemia

Hematocrit (Hct) levels, the percentage of whole blood comprised of red blood cells, are typically low in ESRD patients. This deficiency is caused by a lack of the hormone erythropoietin, which is normally produced by the kidneys. The problem is exacerbated in hemodialysis patients, who may incur blood loss during hemodialysis

KEY TERMS

Access site—The vein tapped for vascular access in hemodialysis treatments. For patients with temporary treatment needs, access to the bloodstream is gained by inserting a catheter into the subclavian vein. Patients in long-term dialysis require stronger, more durable access sites, called fistulas or grafts, that are surgically-created.

Dialysate—A chemical bath used in dialysis to draw fluids and toxins out of the bloodstream and supply electrolytes and other chemicals to the bloodstream.

Dialysis prescription—The general parameters of dialysis treatment that vary according to each patient's individual needs. Treatment length, type of dialyzer and dialysate used, and rate of ultrafiltration are all part of the dialysis prescription.

Dialyzer—An artificial kidney usually composed of hollow fiber that is used in hemodialysis to eliminate waste products from the blood and remove excess fluids from the bloodstream.

Erythropoietin—A hormone produced by the kidneys that stimulates the production of red blood cells by bone marrow.

ESRD—End-stage renal disease; chronic or permanent kidney failure.

Extracorporeal circuit (ECC)—The path the hemodialysis patient's blood takes outside of the body. It typically consists of plastic tubing, a hemodialysis machine, and a dialyzer.

Hematocrit (Hct) level—A measure of red blood cells.

Peritoneum—The abdominal cavity; the peritoneum acts as a blood filter in peritoneal dialysis.

treatments. Epoetin alfa, a hormone therapy also known as EPO (sold under the trade name Epogen), and intravenous or oral **iron** supplements are used to manage anemia in dialysis patients.

Cramps, nausea, vomiting, and headaches

Some hemodialysis patients experience cramps and flu-like symptoms during treatment. These may be caused by a number of factors, including the type of dialysate used, composition of the dialyzer membrane, water quality in the dialysis unit, and the ultrafiltration

rate of the treatment. Adjustment of the dialysis prescription often helps alleviate symptoms.

Hypotension

Because of the **stress** placed on the **cardiovascular system** with regular hemodialysis treatments, patients are at risk for hypotension, a sudden drop in blood pressure. This can often be controlled by medication and adjustment of the patients' dialysis prescription.

Infection

Both hemodialysis and peritoneal dialysis patients are at risk for **infection**. Hemodialysis patients should keep their access sites clean and watch for signs of redness and warmth that could indicate infection. Peritoneal dialysis patients must follow the same precautions with their catheters in order to prevent peritonitis. Peritonitis, an infection of the peritoneum, causes flu-like symptoms and can disrupt dialysis treatments if not detected promptly.

Infectious diseases

Because there is a great deal of blood exposure involved in dialysis treatment, a slight risk of contracting hepatitis B and hepatitis C exists. The hepatitis B **vaccination** is recommended for most hemodialysis patients. As of 1997, there has only been one documented case of HIV being transmitted in a United States dialysis unit to a staff member, and no documented cases of HIV ever being transmitted between dialysis patients in the United States. The strict standards of **infection control** practiced in modern hemodialysis units makes the chance of contracting one of these diseases very small.

Results

Fluid retention may be relieved after dialysis treatment. The patient's overall sense of physical well being may also be improved. Because dialysis is an ongoing treatment process for many patients, a baseline for normalcy can be difficult to gauge.

Health care team roles

Patients receiving dialysis treatments are cared for by a team that includes nephrologists, dialysis technicians, nurses, radiology technicians, and laboratory technicians. Registered dietitians, nutritionists, and nurses instruct patients about dietary changes to manage their disease.

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Barbara Wexler

Dialysis technology

Definition

Dialysis technology is a highly specialized field of nephrology (care of the **kidneys**). In clinical practice settings dialysis technologists provide dialysis treatment under the supervision of a physician or **registered nurse**. The dialysis technologist is responsible for all medical devices and equipment involved in renal replacement therapies, such as reprocessing and water treatment equipment. Along with patient care and equipment operation, maintenance, and repair, dialysis technologists act to ensure regulatory compliance.

Description

Dialysis is treatment for patients with temporary or permanent kidney failure. For patients with end-stage renal disease (ESRD) dialysis is the only renal replacement therapy available other than kidney transplantation. In the United States, nearly 250,000 patients receive regular dialysis treatments to manage ESRD.

Hemodialysis, performed by dialysis technologists, is the most frequently prescribed type of dialysis in the United States. The treatment involves circulating the patient's **blood** outside of the body through an extracorporeal circuit (ECC), or dialysis circuit. Two needles are inserted into the patient's vein, or access site, and are attached to the ECC, which consists of plastic blood tubing, a filter known as a dialyzer (artificial kidney), and a dialysis machine that monitors and maintains blood flow and administers dialysate. Dialysate is a chemical bath that is used to draw waste products out of the blood.

Dialysis technology involves health care workers with a variety of job titles—dialysis technologist, hemodialysis technician, renal dialysis technician, clinical nephrology technologist. All of these allied health professionals are trained to provide direct patient care to people who must undergo hemodialysis because their kidneys no longer adequately rid their bodies of waste products. Dialysis technologists assess patients' **vital signs** prior to dialysis, perform dialysis, monitor patients during and after treatment, and document clinical findings. They administer drugs, including local anesthetics, and are trained to provide emergency medical intervention such as administering oxygen or performing **cardiopulmonary resuscitation (CPR)**.

Dialysis technologists also are responsible for ensuring the proper functioning of dialysis machines; in some settings they perform routine equipment maintenance and repairs. Dialysis technologists are often involved in **patient education**, instructing patients and families about in-home dialysis treatment and reinforcing the importance of adherence to prescribed treatment.

Work settings

Dialysis technologists may work in hospitals, outpatient clinics, or freestanding dialysis centers. Work environments must be scrupulously clean and well maintained to prevent **infection** of patients and health care workers. In the work setting, there must be strict adherence to safety standards since dialysis technologists routinely handle dangerous chemicals during the course of performing their responsibilities.

Education and training

Dialysis technologist trainees generally require at least a high school diploma; in some states, prior patient care experience and/or college course work in health sciences may be required. The areas of study addressed during course work may include:

- hazard communications and safety; specific risks of peracetic acid solution

- prevention of occupational injuries
- power failure/manual dialysis
- managing chemical agents and chemical emergencies
- water safety, testing, treatment
- monitoring dialysis patients; dialysis process
- pathophysiology of kidney and **urinary system**; hypo/hyperkalemia
- machine preparation and operation
- medication, documentation, and quality assurance

Since 1996, the National Nephrology Technology Certification Organization (NNCO) has offered certification examinations for nephrology clinical technicians and nephrology biomedical technicians. To take the NNCO certification examination, candidates must have a high school diploma or its equivalent, and at least one year or 2,000 hours of experience in nephrology technology or they must have completed a year-long educational program in nephrology technology. The certification exam in biomedical nephrology technology measures candidates' knowledge in the following areas:

- principles of dialysis
- scientific concepts
- electronic applications
- water treatment
- equipment functions
- environmental/regulatory issues

Candidates who pass the national certification examination in clinical nephrology technology may use the designation CCNT after their names. Those who pass the certification examination in biomedical nephrology technology use the designation CBNT after their names. To retain certification, candidates must retake the examination every four years or meet alternative certification requirements. State licensure requirements vary, however, most states require from 15–35 hours of continuing medical education annually.

Advanced education and training

Dialysis technologists can advance from trainee positions to chief technologist posts at major medical centers. Some dialysis technologists participate in clinical research and teaching. Others work closely with biomedical engineers to improve hydraulic and electrical systems used in dialysis equipment. Some medical facilities encourage dialysis technologists to continue their education and advance to become licensed vocational nurses, registered nurses, or other specialized health care therapists or practitioners.

KEY TERMS

Dialysate—A chemical bath used in dialysis to draw fluids and toxins out of the bloodstream and supply electrolytes and other chemicals to the bloodstream.

Dialysis prescription—The general parameters of dialysis treatment that vary according to each patient's individual needs. Treatment length, type of dialyzer and dialysate used, and rate of ultrafiltration are all part of the dialysis prescription.

Dialyzer—An artificial kidney usually composed of hollow fiber that is used in hemodialysis to eliminate waste products from the blood and remove excess fluids from the bloodstream.

Erythropoietin—A hormone produced by the kidneys that stimulates the production of red blood cells by bone marrow.

ESRD—End-stage renal disease; chronic or permanent kidney failure.

Extracorporeal circuit (ECC)—The path the hemodialysis patient's blood takes outside of the body. It typically consists of plastic tubing, a hemodialysis machine, and a dialyzer.

Future outlook

Throughout the United States, the employment prospects for dialysis technologists are excellent. The number of patients on dialysis continues to increase, and the average duration (the length of time patients remain on dialysis) is also increasing. Advances in medical technology, the increasing prevalence of end stage renal disease (ESRD), and the aging population all point to an increasing need for renal care practitioners, especially dialysis workers. For example, according to the California Labor Market Information Division, in the state of California, projected growth in opportunities between 1990–2005 is 42%.

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Barbara Wexler

Diarrhea

Definition

Diarrhea is an increased frequency of stools or bowel movements (more than two or three per day) or liquidity of feces.

Description

In a normal adult, about 10 quarts (liters) of fluid waste leaves the **stomach** each day. All but a liter and a half is absorbed in the **small intestine**. The unabsorbed contents enter the large bowel or colon. Most of the fluid in the feces is reabsorbed by the **large intestine**. The fluid loss is about 100 milliliters each day. From a strictly medical perspective, diarrhea is defined as stool weight of more than 250 grams in 24 hours. In practice, the calculation of stool weights is restricted to persons with chronic diarrhea.

There are three broad classes that encompass most cases of diarrhea.

- Non-inflammatory diarrhea. This is described as a watery, non-bloody bowel movement that is associated with diffuse abdominal cramping, nausea, vomiting or bloating. The most common cause of non-inflammatory

diarrhea is a bacterium that produces a toxin. Common examples of non-inflammatory **bacteria** include *Escherichia coli*, *Staphylococcus aureus*, *Bacillus cereus* and *Clostridium perfringens*. Some **viruses** and amoeba such as *Giardia lamblia* also cause non-inflammatory diarrhea. This diarrhea is typically mild but may be voluminous, involving large amounts of fluid (10 to 200 mL/kg/day). Such fluid loss results in **dehydration** and loss of electrolytes. There is usually no **blood** loss.

- Inflammatory diarrhea. This is usually characterized by the presence of **fever** and blood in the stool and is associated with left lower quadrant cramps, urgency and tenesmus (anal spasms). Common causes of inflammatory diarrhea include **infection** with *Campylobacter* or *Yersinia* species or infection with some species of *Escherichia coli*. Diarrhea due to these pathogens tends to be less voluminous, less than 1 liter per day.
- Enteric fever. This is characterized by abdominal tenderness, confusion, prolonged high fever, prostration and occasionally a rash. Common causes of enteric fever-related diarrhea include *Salmonella typhi* or *Salmonella paratyphi*. Multi-organ disease is frequently encountered.

Inflammatory diarrhea must be distinguished from ulcerative colitis.

Non-professionals may use the term diarrhea in reference to increased incidence of bowel movements, a sense of fecal urgency, increased stool liquidity or **fecal incontinence**.

Causes and symptoms

Many cases of non-inflammatory diarrhea are caused by the organisms listed in the description section. The symptoms of diarrhea include nausea, weakness and dehydration. After more than three of four episodes of diarrhea, lethargy develops. Occasionally, diffuse abdominal cramping is experienced.

Inflammatory diarrhea is characterized by fever, nausea, sweating (diaphoresis) and lower abdominal tenderness and cramping. Tenesmus is common but not always present. Weakness and dehydration are often present. Lethargy develops after three or four episodes of diarrhea.

Diarrhea that is associated with enteric illness will be accompanied by prolonged high fever, confusion, prostration, respiratory distress and abdominal tenderness. Organisms that cause diarrhea have been described.

In babies and young children, dehydration is a significant problem that must be rapidly corrected to avoid

severe consequences. Lethargy may be the most prominent symptom in these children.

In cases of chronic diarrhea, anemia may be present due to blood loss. Fatigue and lethargy are the most common observable symptoms. Laboratory tests can be used to confirm anemia due to blood loss. The same persons should be tested for ova and parasites in the stool.

Diagnosis

The causative agent of diarrhea may be recovered from a stool sample. Once recovered, it is grown in a laboratory, using standard culture techniques and procedures. Among persons with dysentery, the rate of positive identification of agents using bacterial culture is 60 to 75%. Persons with a recent history of possible exposure to amoeba, whether through travel or from sexual preference, should have a wet mount examination of stool for amoeba.

Laboratories should be alerted to the possibility of exposure to *E. coli* if exposure to improperly prepared food is suspected.

Stool should be examined for ova and parasites in persons with diarrhea that persists for more than 10 days. Three such examinations for ova and parasites should be performed.

Rectal swabs should be considered for persons suspected of having *Neisseria gonorrhoeae*, *Chlamydia* or herpes simplex virus.

Sigmoidoscopy should be considered for persons with severe rectal **pain**, tenesmus or rectal discharge. Sigmoidoscopy is often useful for differentiating infective diarrhea from ischemic or ulcerative colitis.

Treatment

There are four main elements of treatment: rehydration, diet, antidiarrheal agents, and antibiotic therapy.

Rehydration

Drinking fluids such as tea, sport drinks, fruit juices and some mildly carbonated beverages, augmented with water, will rapidly replace fluid lost through diarrhea. Fluids should be consumed as rapidly as affected persons will tolerate them. Experts recommend fluid intake levels of 50-200 mL/kg/day. Severely dehydrated individuals may require hospitalization and intravenous fluid therapy with lactated Ringer's solution. Persons who do not require hospitalization can make a similar solution that can be taken orally at home. Combine the following:

- 0.5 teaspoon salt

- 1.0 teaspoon baking soda
- 8 teaspoons water
- 8 ounces orange juice
- water to equal 1 quart

Diet

If persons with diarrhea consume adequate **carbohydrates** and fluids, most will avoid dehydration. Fluids that contain electrolytes are especially useful. Broth-based soups with crackers, sport drinks and some soft drinks contain salt, potassium, sugar and bicarbonate. These substances are lost with diarrhea. The bowel should not be stressed during recovery from diarrhea. This can be accomplished by avoiding foods that are high in fiber, fatty foods, milk and dairy foods, alcohol and **caffeine**. Eating relatively small meals on a frequent basis is helpful. Tea and fruit juices provide nourishment without stressing the **digestive system**.

Antidiarrheal agents

Persons with mild to moderate diarrhea usually benefit from antidiarrheal preparations. If diarrhea does not subside or worsens with the use of such agents, they should be discontinued and competent medical assistance sought. Preparations containing opioids (such as loperamide) should not be used by persons with bloody diarrhea or high fevers. In others, they will decrease stool liquidity, quantity and tenesmus. The following preparations are generally useful:

- bismuth subsalicylate (Pepto-Bismol)
- loperamide (Imodium AD)

Antibiotic therapy

For the majority of persons with diarrhea, the condition is self-limiting. As such, antibiotic therapy is not indicated. For persons with moderate to severe diarrhea, antibiotic therapy may be helpful. Symptoms of bloody stools, fever and tenesmus are indications for the use of an antibiotic. The following are often used while awaiting the results of a **stool culture**. Because they are used without accurately identifying a causative agent for the diarrhea, their use is characterized as empirical.

- a fluoroquinolone such as ciprofloxacin
- erythromycin
- trimethoprim/sulfamethoxazole

Antibiotics are indicated for persons with so-called traveler's diarrhea or for diarrhea that is caused by cholera, shigellosis or salmonellosis.

Prognosis

Most cases of diarrhea are self limiting. Once the causative agent or toxin is discharged with the fecal flow, recovery can begin. Over 90% of persons with acute diarrhea will recover fully with adequate rehydration or the use of antidiarrheal agents. Laboratory determination of the cause in such instances is infrequently required. The cost is not justified. Laboratories identify approximately 3% of causative agents from stool cultures.

Laboratories will frequently examine stool samples for the presence of blood to differentiate inflammatory and non-inflammatory causes of diarrhea. After a diagnosis of inflammatory diarrhea has been made, stool cultures are needed to determine appropriate antimicrobial therapy.

Hospitalization for diarrhea is uncommon but warranted for severe diarrhea. Babies and older persons are at increased risk for adverse outcomes, including death, from diarrhea.

Each day, more than 1,700 babies around the world die from diarrheal diseases. Most of these are due to a lack of potable drinking water. With adequate hydration using non-contaminated water, most of these deaths could be prevented. Without clean drinking water, their prognosis is often poor.

Health care team roles

Diarrhea is usually diagnosed by someone other than a professional member of a health care team. Treatment is often provided by the same person. When professional advice is sought, a family physician, internist, pediatrician, physician's assistant or nurse practitioner is most likely to be consulted. A laboratory technician may process stool samples and identify a causative agent. In unusual circumstances, a pathologist may be called upon to identify a causative pathogen. A specialist in infectious diseases may provide assistance. Epidemiologists and sanitarians have an interest in diarrhea outbreaks or clusters of cases. Health officers may be called upon to take preventive measures if food sources, public restaurants or day care centers are shown to be the causes of a diarrhea outbreak.

Prevention

Handwashing and personal hygiene are critical methods for preventing diarrhea. Adequate handwashing alone will prevent a majority of diarrhea cases.

Adequate sanitation and attention to cleanliness are the best ways to prevent outbreaks of diarrhea disease. Persons handling food must always wash their hands

KEY TERMS

Diaphoresis—An alternative for sweating.

Incontinence—The inability to voluntarily control elimination of bodily wastes.

Inflammation—A physiological response to stress on the body that is characterized by redness, tenderness, increased temperature, swelling and decrease or loss of function.

Ova—Eggs.

Sigmoidoscopy—Procedure to visualize the interior of the colon. A flexible tube is inserted in the anus. An operator looks into the colon that is illuminated by a light at the end of the tube.

Stool—An alternative name for feces.

Tenesmus—A feeling that a bowel movement is imminent.

before touching any food. Food, especially poultry and shellfish, must be stored at appropriate temperatures and thoroughly washed before being prepared for consumption.

Food must be properly prepared and held or stored at proper temperatures. Prior to cooking, foods should be kept at temperatures below 40°F (4.4°C). During cooking, the internal temperature of foods should exceed 160°F (71°C) to ensure the destruction of pathogens. While being served, food should be held at temperatures between 40 and 140°F (4.4 and 60°C). The total time that food should be allowed to remain within these temperatures is four hours. After four hours total time, including original serving and subsequent reheating, the food should be discarded. Foods that contain eggs such as mayonnaise and salads should be kept cold and protected from heat and sunlight.

Day care facilities must be constantly cleaned and disinfected. Employees who change diapers must wash their hands before returning to work.

Persons should drink only potable water. Water that is used for washing dishes or personal uses such as tooth brushing should also be boiled before use if the source of the water is not assured to be potable and safe.

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- American College of Gastroenterology, 4900 B South 31st Street, Arlington VA 22206. (703) 820-7400. Fax: (703) 931-4520. <<http://www.acg.gi.org>>.
- American College of Osteopathic Emergency Physicians, 142 E. Ontario Street, Suite 550, Chicago, IL 60611. 312-587-3709 or 800-521-3709. Fax: 312-587-9951. <<http://www.acoep.org>>.
- Centers for Disease Control and Prevention, 1600 Clifton Road, Atlanta, GA 30333. (404) 639-3534 or (800) 311-3435. <<http://www.cdc.gov/ncidod/eid/vol7no1/brown.htm>>. <<http://www.cdc.gov/netinfo.htm>>.
- College of American Pathologists, 325 Waukegan Road, Northfield, IL 60093. (800) 323-4040. <<http://www.cap.org>>.

Pan American Health Organization, 525 Twenty-third Street, NW, Washington, D.C. 20037. (202)974-3000. Fax: (202)974-3663. <<http://www.paho.org>>. E-mail: web-master@paho.org.

World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland. +41 (22) 791 4140. Fax: +41 (22) 791 4268. <<http://www.who.int/gtb>>. information@who.org.

OTHER

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L. Fleming Fallon, Jr., MD, DrPH

Diathermy *see* **Heat treatments**

Diet and health

Definition

Diet has a tremendous effect on health. Diet plays a role in promoting health and reducing chronic disease for many conditions such as preventing **obesity**, **diabetes mellitus**, coronary **heart** disease, and **cancer**, as well as low birth weight in babies.

Description

The concept of diet quality in relation to health has changed over time. **Nutrition** scientists focused on preventing nutrient deficiencies early in this century, but now the shift has changed, exploring diets and chronic disease prevention and treatment. Adequate nutrition is essential to reduce morbidity and mortality from acute and chronic disease. Well-nourished people are more resistant to disease and are better able to tolerate other therapy and to recover from acute illnesses, surgery, and trauma. Nutrition also plays a key part in a patient's recovery from a disease or treatment.

Consumption of a wide variety of foods, with appropriate amounts of protein, carbohydrate, fat, **vitamins** and **minerals** is the basis of a healthy diet. However, today's major health care problems are increasingly the result of acute and chronic conditions related to dietary intake. In fact, eight of the 10 leading causes of death, including coronary heart disease, stroke, diabetes mellitus, and some cancers, can be attributed to diet and alcohol. Some chronic diseases continue to increase due to factors such as the rise in obesity in Western populations, Americans in particular.

There is no disputing that a healthy diet can help to prevent illness and promotes a feeling of well-being. A research study reported in the *Journal of the American Medical Association* suggested that by following the current dietary guidelines, women are able to live longer. Women whose diets included large amounts of fruits, vegetables, whole grains, low-fat dairy, and lean meats had a lower risk of death. Women who were considered to have the best diets (those eating the highest intake level of recommended foods from the current dietary guidelines) had a 30% lower risk of death from any cause compared with those eating the lowest level of recommended foods.

Viewpoints

The position of the American **Dietetics** Association on the role of nutrition and diet in health promotion and disease prevention programs includes steps for primary, secondary, and tertiary prevention. These steps include the following guidelines:

- **Primary prevention (health promotion):** Health promotion is a population-based approach that encourages behaviors for better health. For example, nutrition classes at a local adult education center could be considered a primary prevention measure.
- **Secondary prevention (risk appraisal and risk reduction):** For people at risk of illness who are beginning to encounter health-related problems, secondary prevention encompasses risk appraisal and screening to detect preclinical disease, and early intervention to promote health and well-being. For example, cholesterol screening for people with a family history of cardiovascular disease could be considered a secondary prevention measure.
- **Tertiary prevention (treatment and rehabilitation):** For people experiencing illness or injury, tertiary prevention includes treatment and rehabilitation to promote maximum health and prevent further disability and secondary conditions resulting from the initial health problem. Examples of tertiary prevention include **medical**

nutrition therapy or diabetes education for people diagnosed with type 2 diabetes mellitus.

Experts in nutrition recommend a variety of foods and the maintenance of an ideal weight. Large amounts of fat, saturated fat, and cholesterol should be avoided. Individuals should consume adequate starch and fiber and avoid excess sugar and sodium.

Dietary guidelines

The Dietary Guidelines for Americans, published by the U.S. Department of Agriculture and Health and Human Services, can provide a broad overall view of good nutrition. These dietary guidelines include these basic recommendations:

- Eat a variety of foods; let the food pyramid guide your food choices.
- Control your weight.
- Be physically active each day.
- Eat a diet low in saturated fat and cholesterol, and moderate in total fat.
- Eat a variety of vegetables, fruits, and grains.
- Eat sugar in moderation.
- Use salt in moderation.
- If you drink alcohol, do so in moderation; no more than two drinks per day of wine, beer, or spirits.
- Keep food safe to eat; follow the government safety precautions as outlined on the food package.

The Food Guide Pyramid was created by the U.S. Department of Agriculture to help Americans choose foods from each food grouping. It focuses on fat intake, which is too high in most Americans. The food pyramid, developed by nutritionists, provides a visual guide to healthy eating. At its base are those foods that should be eaten numerous times each day, while at its apex are those foods that should be used sparingly. The pyramid suggests a range of servings in each group so that the number of servings can be adjusted to suit each individual's caloric requirements. The daily recommendations (from bottom to top) of the food pyramid include:

- bread, cereal, rice, and pasta: 6–11 servings
- vegetables: 3–5 servings
- fruits: 2–4 servings
- milk, yogurt, and cheese: 2–3 servings
- meat, poultry, fish, dried beans, eggs, and nuts: 2–3 servings
- **fats**, oils, and sweets: use sparingly

Other programs use the *National Cholesterol Education Program Step 1 Diet* guidelines, which may be followed to assist in controlling weight. The guidelines provided by the National Cholesterol Education Program can be followed for maintaining optimal **blood** lipid levels [total cholesterol, low-density lipoproteins (LDL), high-density lipoproteins (HDL), and triglycerides]. Health promotion and disease prevention are central components of national recommendations to improve the health of Americans in an initiative called *Healthy People 2000*. This program is a series of national health promotion and disease prevention objectives that examine the association between nutrition and chronic disease. A program called Healthy People 2010 is planned.

National and international trends

Major diet and health targets in the United States include:

- **Obesity.** Obesity has become a major problem for Americans due to inactive lifestyles and poor diets. Estimates suggest that over 50% of Americans are overweight. Dietary modification can reduce obesity, in turn decreasing conditions and diseases such as coronary heart disease, atherosclerosis, **hypertension**, cancer, diabetes, and high blood cholesterol.
- **Diabetes.** Since 1990, type 2 diabetes has jumped by 33% nationwide in the United States. Being overweight and contracting diabetes are closely linked.
- **Fat and cholesterol intakes.** These are still too high. Since the 1960s, the average blood cholesterol level has decreased, mostly due to a shift from red meat to poultry, from whole to lower-fat milk, and from butter and lard to margarine and vegetable oils. Cholesterol has dropped to about an average of 205 mg/dl from the peak of the coronary epidemic in the 1960s of 220 to 230 mg/dl. Intake of saturated fat was about 16% in the 1960s; it has now been reduced to approximately 12%. Fat intake is still too high. It is estimated that the average American consumes about 40% of their calories from fat. Fat source (i.e. saturated, monounsaturated, or polyunsaturated) is an important issue to consider when reducing overall fat in the diet, as some fats reduce cholesterol while others raise cholesterol.
- **Stroke incidence.** Stroke incidence and related deaths have dropped in the last 30 to 40 years, likely due to better **blood pressure** control, less smoking and drinking, and possibly an increase in fruits and vegetable consumption.
- **Lack of exercise.** Energy expenditure has declined due to more sedentary lifestyles. Those who sit at a com-

puter all day expend fewer calories than in physical-labor jobs.

- *“Fad” and herbal diets.* Throughout the 1990s and into this century, the market for dietary supplements and herbal remedies has exploded. The nutritional implications of many of these compounds has not been established with scientific research, and therefore the health implications are unknown in many cases.
- *Health supplements.* There are a great many claims about particular vitamins, minerals, and/or antioxidants having beneficial health effects on the market today. Proper nutrition with an adequate diet is the best way to achieve vitamins, but a supplement may be required when intake is inadequate. It is important to check with a dietitian or doctor before taking nutritional supplements or alternative therapies if other medications are taken for chronic illness, because they may cause a drug interaction.

Dietary recommendations in Europe and Australasia are comparable with those in the United States. The European guidelines suggest, as do those in the United States, that total fat should provide 30% or less total energy, which implies that complex **carbohydrates**, fruits, cereals, and vegetables should be increased to replace the foods rich in total and saturated fat which have been eliminated. The European Atherosclerosis Society states that for those with total cholesterol levels of 200-250 mg/dl (5.2-6.5 mmol/L), dietary modification to reduce the risk of coronary heart disease (CHD) is required. While CHD incidence is declining in western Europe, Australia, and the United States, it is rapidly rising in central and eastern Europe and in some Asian countries. These regions are undergoing unprecedented economic growth and rapidly changing lifestyles in many aspects including dietary intake. These changes have led to an increase in CHD incidence and death. Singapore, the most economically developed country in Asia, also has the highest prevalence of CHD deaths, at rates similar to those of the United States and Australia. This region may serve as a warning that Asia may expect an escalation in CHD. Although cholesterol levels vary widely over Asia, CHD mortality is evidenced where cholesterol levels have increased from previously low levels and in regions where the highest cholesterol levels predominate. Australasian (National Heart Foundation of New Zealand Scientific Committee and the National Heart Foundation of Australia) and European (British Hyperlipidaemia Association, British Hypertension Society) guidelines for the prevention of CHD in clinical practice emphasize the need to determine the absolute CHD risk for any individual in order to decide the most appropriate therapy. This, of course, includes

dietary management to control fat intake and cholesterol. Clearer statements and guidelines on the prevention and control of diabetes and hypertension as well as diet, obesity, **exercise**, and smoking may be appropriate.

Professional implications

Qualified dietetics professionals assist in encouraging good nutrition and/or dietary change as a method of promoting health and preventing chronic disease. Nursing and allied health professionals can reinforce good dietary choices and provide nutrition guidance for patients in hospitals, long-term care facilities, or in community settings.

In general, only registered dietitians (R.D.) have sufficient training and knowledge to accurately assess the nutritional adequacy of a patient's diet, especially if chronic disease is present. A doctor may also have a nutrition background or specialization and may thus be able to conduct a **dietary assessment** or to provide general nutrition advice and/or **diet therapy**.

When an individual or patient is using dietary means to help recover or control a disease or condition, it is often called medical nutritional therapy. To maintain health in a patient with a nutrition-related illness, all health care team members and especially the patient must commit to achieving optimum health through medical nutritional therapy. Prioritized goals are critical when developing the nutrition treatment plan. Continuous assessment is made by the patient and health care team members to evaluate the importance of these and other goals. Physicians must understand the dietary approaches an individual is using and reinforce this diet therapy when interacting with the individual. The position of the American Dietetic Association is that medical nutritional therapy is effective in treating disease and preventing disease complications.

Resources

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KEY TERMS

Dietitian—A health professional who has a bachelor's degree, specializing in foods and nutrition, and in addition undergoes a period of practical training in a hospital or community setting. Many dietitians further their knowledge by pursuing master's or doctoral degrees. The title "dietitian" is protected by law so that only qualified practitioners who have met education qualifications can use that title.

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American Dietetic Association. 216 W. Jackson Blvd. Chicago, IL 60606-6995. (312) 899-0040. <<http://www.eatright.org>>.

American Heart Association National Center. 7272 Greenville Avenue, Dallas, Texas 75231. (800) AHA-USA1. <<http://www.americanheart.org>>.

Food and Nutrition Information Center Agricultural Research Service, USDA. National Agricultural Library, Room 304, 10301 Baltimore Avenue, Beltsville, MD 20705-2351. (301) 504-5719, Fax (301) 504-6409. <<http://www.nal.usda.gov/fnic/>>. fnic@nal.usda.gov.

OTHER

Food and Nutrition Professionals Network
<<http://nutrition.cos.com>>.

Crystal Heather Kaczkowski, MSc.

Diet pills see **Fad diets**

Diet therapy

Definition

Diet therapies are specially designed and prescribed for medical and/or general nutritional reasons.

Purpose

Diet therapy promotes a balanced selection of foods vital for good health. By combining foods appropriate for each individual and drinking the proper amount of water, one can help maintain the best possible health. Eating the proper diet is critical for the health of individuals, groups with special medical and dietary needs, and entire populations afflicted with malnutrition.

Precautions

A particular modified diet is prescribed specifically for each individual. Those individuals who have medical conditions or who are sensitive to certain foods need to be very compliant and cautious about what they eat.

Individuals should not follow a "fad" diet without first consulting a registered dietitian or physician. Popular (but sometimes dangerous) low-carbohydrate diets, for example, may deprive the body of the glucose it needs for **central nervous system** and **brain** functions.

Description

Nutrition is the science concerned with the human body's use of nutrients and food substances. Proper nutrition decisions are important for the optimal health of each individual. This is especially true for those individuals with specific dietary needs and acute or chronic diseases. The nutrients necessary to maintain normal growth and health include **proteins, carbohydrates, fats, vitamins, and minerals**. Included in these nutrients are eight amino acids the body cannot produce but that must be derived from proteins, four fat-soluble and ten water-soluble vitamins, ten minerals, and three electrolytes.

Nutrient classes

PROTEIN. Protein is important for building body tissue and synthesizing enzymes. Enzymes are specialized organic substances that act to regulate the speed of chemical reactions in human **metabolism**. Twenty amino acids of the 100 or more occurring in nature make up proteins. Animals and plants are quick and available sources of what are termed “essential” amino acids; they are called essential because the body cannot build them internally. Normal growth and health are dependent upon these essential amino acids. Dietitians recommend that a healthy diet includes 10–20% of daily calories from protein (poultry, fish, dairy, and vegetable sources).

CARBOHYDRATES. Carbohydrates provide most of the energy in the majority of human diets. Foods rich in carbohydrates are usually the most abundant and cheapest. The carbohydrates containing the most nutrients are the complex carbohydrates, such as unrefined grains, tubers, vegetables, and fruits. Simple carbohydrates or sugars should be eaten in moderation, since they are high in calories but low in nutrients.

Carbohydrates are needed in the form of glucose by the brain and central nervous system (CNS). A minimum of 1.6 oz (50 g) of glucose is required daily for proper functioning of the CNS. If the body is denied carbohydrates, it will use ketone bodies for energy, but this is not a good energy source for the body, and may have unfavorable health effects.

FATS. Fats supply energy and essential fatty acids and promote absorption of the fat-soluble vitamins A, D, E, and K. The accumulation of body fat has become a serious health concern; over 50% of Americans are considered overweight. Fats are compact fuels efficiently stored in the body for later use when carbohydrates are in short supply. Fats produce more than twice as much energy as carbohydrates, approximately 9 Kcals/gram versus about 4 Kcals/gram for carbohydrate and protein. Dietary fats are broken down into fatty acids that pass into the **blood**. These fatty acids are either saturated or unsaturated (mono-unsaturated, polyunsaturated, or trans-unsaturated). Saturated fats, derived mostly from animal sources, have been found to raise the level of total cholesterol in the bloodstream, and certain unsaturated fats tend to lower the level of total cholesterol in the blood stream. For example, mono-unsaturated fats like oleic acid in olive oil reduce low-density lipoprotein cholesterol (bad cholesterol) and increase high-density lipoprotein cholesterol (good cholesterol), thus reducing the risk of **heart** disease. Saturated and trans-unsaturated fatty acids both raise serum cholesterol; in contrast, neither mono-unsaturated nor polyunsaturated fats have this effect.

INORGANIC MINERAL NUTRIENTS. Inorganic mineral nutrients are required to build tissues. They are also important for muscle contractions, nerve reactions, and blood clotting. All of these mineral nutrients must be supplied in the diet. Minerals are categorized as major elements or trace elements. Major elements consist of **calcium**, **phosphorus**, magnesium, **iron**, iodine, and potassium. Trace elements include **copper**, cobalt, manganese, fluorine, and **zinc**.

VITAMINS. Vitamins increase the breakdown and absorption of proteins, carbohydrates, and fats. Certain vitamins help form blood cells, hormones, nervous system chemicals, and genetic materials. Vitamins are classified into two groups: fat-soluble vitamins, such as A, D, E, and K; and water-soluble vitamins, such as **vitamin C** and the B-vitamin complex. Fat-soluble vitamins are usually found in foods that contain fat. Because excess amounts are stored in the body’s fat and in the **liver** and **kidneys**, fat-soluble vitamins do not have to be consumed every day. The water-soluble vitamins, C and B complex, cannot be stored and must be consumed daily to replenish the body’s supply.

Food types

Foods can be widely grouped into breads and cereals; legumes, tubers or starchy roots; vegetables and fruits; meat, fish, and eggs; milk and milk products; fats and oils; and sugars. Breads and cereals are high in starches (carbohydrates), but whole cereals also often supply significant amounts of protein. However, these cereals should be eaten in conjunction with other protein foods to supply all the essential amino acids. Meat, fish, and eggs supply all the essential amino acids that the body needs to build its own proteins.

Milk and milk products also provide a plentiful amount of protein, phosphorus, calcium, and vitamins. Legumes are rich in starch but also furnish more protein than cereals or tubers. Tubers provide a variety of minerals and vitamins. Vegetables and fruits are a direct source of many minerals and vitamins. Fats and oils are high in calories but usually contain few nutrients. Sugars, which are heavily consumed in more affluent countries, contain few nutrients and can cause tooth decay.

Dietary guidelines

The Food and Nutrition Board of the National Research Council of the National Academy of Sciences has determined dietary standards called Recommended Dietary Allowances (RDA). These standards explain the daily amounts of energy, protein, minerals, and fat-soluble and water-soluble vitamins needed by healthy males and females, from infancy to old age. The RDA has been

under revision and is replaced by the Dietary Reference Intakes (DRI) as of 2001. The DRI will be applicable to Canadians and Americans. Like the RDA, the DRI recommends an average daily intake for a nutrient, but the DRI is more comprehensive than the RDA. It incorporates updated scientific research into providing expert guidance for issues such as risk reduction for chronic disease and upper limits of intake for nutrients with adverse health effects.

Experts in nutrition recommend a variety of foods and the maintenance of an ideal weight. Large amounts of fat, saturated fat, and cholesterol should be avoided. Individuals should consume adequate starch and fiber and avoid excess sugar and sodium.

The U.S. Department of Agriculture and the U.S. Department of Health and Human Services have developed official dietary guidelines that include these seven basic recommendations:

- Eat a variety of foods.
- Control your weight.
- Eat a low-fat, low-cholesterol diet.
- Eat plenty of vegetables, fruits, and grains.
- Eat sugar in moderation.
- Use salt in moderation.
- If you drink alcohol, do so in moderation; no more than 2 drinks per day of wine, beer, or spirits.

The food pyramid, developed by nutritionists, provides a visual guide to healthy eating. At its base are those foods that should be eaten numerous times each day, while at its apex are those foods that should be used sparingly. The pyramid suggests a range of servings in each group so that the number of servings can be adjusted to suit each individual's caloric requirements. The daily recommendations (from bottom to top) of the food pyramid include:

- bread, cereal, rice, and pasta: 6–11 servings
- vegetables: 3–5 servings
- fruits: 2–4 servings
- milk, yogurt, and cheese: 2–3 servings
- meat, poultry, fish, dried beans, eggs, and nuts: 2–3 servings
- fats, oils, and sweets: use sparingly

Energy requirements

Carbohydrates, proteins, and fats provide energy in the form of calories to fuel the body for metabolic processes, growth, and activity. When an individual consumes as many calories each day as the body uses, they

are in a state of energy balance and will neither gain nor lose weight. When more calories are eaten than the body uses, the excess calories are stored as fat and weight increases. On the other hand, when fewer calories are consumed than the body needs, stored fat is burned and weight decreases. Using the metric system nomenclature, a kilojoule (kJ) is used instead of a kilocalorie (kcal), where 1 kcal=4.184 kJ and 1 megajoule (MJ)=1000 kJ.

The amount of energy required depends on such factors as an individual's weight, gender, age, and activity level, so an estimation should be made based on these parameters. Some dietary guidelines do suggest an average energy intake for people in different age groups, but many of the guidelines do not base the estimations on measures such as activity level. The Food and Agriculture Organization/World Health Organization uses a more accurate method for estimating energy requirements for populations and individuals. They define energy requirement as "... the amount of energy needed to maintain health, growth, and an appropriate level of physical activity." The "appropriate level of physical activity" is not a standardized level, but is dependent on social, cultural, and lifestyle factors. Physical activity categories for light, moderate activity or heavy work are used to provide a better energy estimation. For example, a 143 lb (65 kg) woman between the ages of 30-60 years who participates in light activity would require about 2190 kcal/day (9.2 MJ/day). At a moderate activity level, this same woman would require approximately 2300 kcal/day (9.6 MJ/day) and 2550 kcal/day (10.7 MJ/day) for heavy activity.

Calorie-modified diet

Calorie-modified diets are prescribed to correct weight problems with a healthy diet. Low-calorie diets are designed for weight reduction and are prescribed for people who are overweight or obese. High-calorie diets are recommended for people with greatly increased energy needs such as athletes in training or individuals fighting diseases such as **cancer**, **AIDS**, or **cystic fibrosis**. High-calorie diets are also prescribed to treat anorexia nervosa.

Calorie-modified diets are planned by dietitians and should be prescribed following a complete **physical examination** and **dietary assessment** or dietary history. A low-calorie diet provides enough energy to meet the person's metabolic needs and activity level. It includes a balanced variety of foods, but limits carbohydrates and alcohol. A low-calorie diet should not aim to promote a weight loss of more than approximately 1–2 lb (500 grams to one kilogram) per week. In general, for a slightly overweight person, it is not wise to lose more than 1 lb (about 500 grams) per week. A high-calorie diet usually

provides an extra 500–1,000 calories, leading to a weight gain of about 1 lb (500 grams) per week for most people. It has a high protein content, normal fat content, and emphasizes foods that pack many calories into a small volume. Snacking between meals is encouraged as a way to increase the calories consumed.

When caloric limits allow, have no more than two drinks of wine, beer or liquor per day.

Fiber-modified diet

Fruits and vegetables are excellent sources of fiber. Fiber has important nutritional benefits such as facilitating the movement of food through the digestive tract, helping to prevent constipation. Research suggests low dietary fiber may be responsible for increasing the incidence of diverticulosis and may also be associated with cancer of the colon.

High-fiber diets, including whole grains (especially bran), raw vegetables, unpeeled fresh fruits, nuts, and seeds, are recommended to:

- increase fecal bulk
- increase intestinal movement
- prevent or treat constipation, diverticulosis, **Crohn's disease**, or irritable bowel syndrome
- help lower cholesterol
- assist with weight loss in people who are overweight and improve sugar tolerance in diabetics

Low-fiber diets exclude raw fruits and vegetables, whole grains, nuts, and seeds, while emphasizing soft, mild foods. They are recommended to:

- decrease fecal bulk
- slow intestinal movement
- decrease **stomach** acid secretion
- treat a variety of disorders including indigestion, **diarrhea**, bowel inflammation, and heart attack

Protein-modified diet

High-protein diets are designed to provide about 0.05 oz (1.5 g) of protein for each kilogram of a person's body weight. Complex proteins, such as milk and meats, should make up one-half to two-thirds of the daily protein requirement. High-protein diets are recommended for people who:

- have an increased need for protein due to protein-calorie malnutrition, severe **stress**, or conditions such as AIDS, cancer, or **burns** with high metabolic rates that lead to the loss of large amounts of protein

- have malabsorption syndromes, celiac disease, or other disorders characterized by poor food absorption

A low-protein diet excludes dairy products and meats, and requires that about three-fourths of the daily allowance of protein come from high-value protein sources. Supplements may be prescribed to prevent amino acid deficiencies. Low-protein diets are used in treatment of cirrhosis and kidney disease.

Low-cholesterol diet

Dietary modification is the first weapon in the fight against the high cholesterol levels that contribute to heart disease and atherosclerosis. Low-cholesterol diets are prescribed to reduce the risk of heart disease and to treat atherosclerosis, diabetes, high cholesterol (which may be hereditary and might also require cholesterol-reducing drugs), and high **blood pressure**. A low-cholesterol diet is not a cure for the conditions it is prescribed to treat, so most people must stay on the diet for the rest of their lives.

The American Heart Association eating plan recommends that total cholesterol intake should be less than 0.01 oz (300 mg) per day and total fat intake should be 30% or less of total calories. Saturated fatty acid intake should be less than 10% of calories or for anyone with elevated blood cholesterol levels or heart disease, saturated fat and cholesterol intake is limited even further to 7% of total calories per day.

The AHA eating plan also suggests:

- Polyunsaturated fatty acid intake should be 8–10% of calories.
- Mono-unsaturated fatty acids should make up the rest of the total fat intake, up to 15% of total calories.

These guidelines apply to all healthy individuals over two years of age.

Low-fat diet

Most American diets contain too much fat. Fat often makes up about 40% of total calories consumed each day. Registered dietitians recommend limiting fat to 30% or less of daily calories, since consumption of too much fat has been linked to **obesity**, heart disease, and several types of cancer. A low-fat diet usually limits daily fat intake to 1.76 oz (50 g), while an extremely low-fat diet limits fat consumed each day to 0.88–1.05 oz (25–30 g). The grams of fat in your diet will depend on the calories you need. Low-fat diets are recommended to:

- help prevent heart disease
- help prevent colon, prostate, and breast cancers

- help treat a variety of conditions including **gout**, AIDS, **gallbladder** disease, liver disease, celiac disease, inflammatory bowel disease, and heartburn
- lose or control weight

Some fat is required in the diet to prevent essential fatty acid deficiencies, but most people consume more than enough fat to meet these needs.

Cutting back on fat will likely help you eat fewer calories. Make sure to read the nutrition facts label on foods. The Dietary Guidelines recommend limiting fat intake to 30% of calories or less, which corresponds to 1.87 oz (53 g) of fat in a 1,600 kcal diet, 2.57 oz (73 g) of fat in a 2,200 kcal diet, and 3.28 oz (93 g) of fat in a 2,800 kcal diet.

Gluten-free diet

Gluten and gliadin are proteins found in certain grains and grain-containing products. These proteins are toxic to cells within the intestinal tract of an individual who is “intolerant” and cause difficulty in food absorption. Celiac disease is caused by intolerance to these proteins. This intolerance causes patients with celiac disease to suffer weight loss, diarrhea, malnutrition, and bloating. By eliminating foods containing gluten from the diet, further damage to the intestines can be prevented, symptoms are relieved, and malabsorption of nutrients is corrected. A gluten-free diet eliminates all foods containing wheat, rye, barley, and malt, and must be followed for life.

Low-purine diet

This diet restricts food, such as sardines, liver, and eggs, that cause the body to produce uric acid. It is usually prescribed as part of a treatment program for gout (a disease usually caused by having too much uric acid in the body) and **kidney stones**, which also includes **exercise** and medication. In addition to excluding organ meats (sweetbreads, liver, kidney) and certain types of fish (anchovies, sardines, mackerel) and limiting the amount of other purine-containing foods such as shrimp, meats, and dairy products, this diet emphasizes drinking about 2 qt (1.89 l) of water and fruit juice daily, to promote the excretion of uric acid, and eating fruits and vegetables that increase urine alkalinity and the solubility of uric acid.

Low-salt diet

On the average, Americans consume about 0.17 oz (5 g) of salt or sodium daily. Dietary guidelines suggest that 0.08 oz (2.4 g) of sodium should be the upper limit, even if there are no signs of heart disease. Most people

with heart disease should limit their sodium intake to less than 0.07 oz (2 g) a day, and some low-salt diets restrict sodium to as little as 0.008 oz (250 mg) per day. The amount of salt in the diet is important for people who have high blood pressure or congestive **heart failure**.

Some experts believe excessive intake of salt is a major reason for high blood pressure, especially in Western countries. Excess sodium encourages the body to retain fluid, thereby increasing fluid pumped by the heart and circulating in the bloodstream. Diets high in salt also can be harmful to people with congestive heart failure because the excess fluid backs up into the **lungs**, causing congestion.

Potassium chloride is a common ingredient in salt substitutes. But too much potassium can be harmful for people with kidney problems. One way to enhance the flavor of food while eliminating salt is to add lemon juice, herbs, spices, or flavored vinegar.

Low phenylalanine diet

A low phenylalanine diet is normal treatment for phenylketonuria (PKU). PKU is a rare genetic disorder in the degradation of dietary phenylalanine that if left untreated, can result in severe progressive mental retardation. The diet is extremely restrictive, and rigorous dietary compliance is necessary to reduce or prevent mental retardation. Close supervision by a registered dietitian or physician is necessary.

A normal diet cannot be tolerated by people with PKU. Dietary treatment necessitates avoiding foods containing high levels of protein. A diet contains only the amount of phenylalanine which is essential for the body. Basic principles of the PKU diet state that:

- Meat, fish, cheese, eggs, milk and nuts are not allowed because they are rich in protein and thus phenylalanine.
- Other foods which contain moderate amounts of protein (i.e. potato and cereals) are given in small measured quantities. These foods are spread out between the day's meals to keep the phenylalanine levels steady.
- Most fruits, some vegetables, and salads can be taken in normal quantities but excessive use should be avoided.
- Sugar, jam, syrups, and fats such as butter, lard, and cooking oil can be used fairly freely.
- There are many low protein manufactured foods available on prescription. These can all be taken freely to provide variety in the diet. Foods include pasta, low protein bread, biscuits, flour, and spaghetti, etc.
- Infants can be fed phenylalanine-free formulas.

There is a high incidence of tooth decay among individuals affected by PKU because of the increased amounts of CHOs consumed.

Diabetic diet

For the most part, dietary management is the key to keeping diabetes in check. There is controversy regarding dietary recommendations for diabetes control and at present, there is no single diet that meets the needs of all diabetics. The general rules for healthy eating as discussed previously apply to diabetics as well.

Several dietary methods are available for controlling blood sugar levels. The Food Guide Pyramid is recommended by the U.S. government for everyone including diabetics. Some experts believe these dietary guidelines may be sufficient for diabetics, although there are more detailed dietary methods available for controlling blood sugar. These methods may be complex, however, which deters many diabetics from using them. The American Diabetic Association and American Dietetic Association developed the Diabetic Exchange Lists, the most common system used for controlling blood sugar. Other nutrition experts recommend adopting a Mediterranean diet because they point out the food pyramid has some drawbacks; for example, there is little focus on meal planning. Carbohydrate counting plans may assist but may also be complicated and require a committed learner; the concepts of the Diabetic Exchange Lists may be difficult to understand for some people.

Type 1 and type 2 diabetics on insulin or oral medication must focus on controlling blood glucose levels by coordinating food intake with insulin administration or medication, or other variables such as exercise.

Nutrition habits that assist in glucose control:

- Stick to a meal plan.
- Appropriately treat hypoglycemia (low blood sugar).
- Quickly respond to hyperglycemia (high blood sugar).
- Maintain consistent snacking habits.

The recommendation given by the American Diabetes Association is to eat more starches. This is the opposite of what has been advised in past years. Current research studies now show it is healthiest for everyone to eat more grains, beans, and starchy vegetables to control fat and cholesterol. Total carbohydrate intake has greater impact on blood glucose control than the source of carbohydrate. However, consumption of complex carbohydrates (i.e. whole grain bread, beans, etc.) are better than eating foods that are sucrose (simple sugar) based.

Both weight loss and blood sugar control are particularly important for overweight type 2 diabetics who are not taking medication. Health effects are most beneficial after initial weight loss. A 10% decrease in body weight can control the progression of type 2 diabetes. Other important issues are controlling lipid (cholesterol and triglyceride) levels, and blood pressure. Controlling fat intake is important because diabetics are about twice as likely to get cardiovascular disease compared to other people.

Research shows that diabetics have the same protein requirements as other people, but with onset of nephropathy, protein should be limited to 0.8 grams/kg per day for adults, with 80% coming from high biological value protein.

Traditional diets may offer some health advantages

Certain populations have dietary habits that are much healthier than the typical Western diet, which is often too high in fat and cholesterol. Research has shown that the traditional Mediterranean diet, Japanese diet, or “hunter-gatherer” diets have health advantages. The dietary habits characteristic of Mediterranean countries with the consumption of olive oil (mono-unsaturated fatty acid) as the main fat source appear to provide optimal health benefits with a low incidence of coronary heart disease. The Mediterranean diet consists of large amounts fruit, vegetables, pulses, nuts, cereal products, and fish, while generally only small amounts of meat and dairy foods are consumed.

Preparation

Effective estimation of an individual’s diet is required in order to provide **dietary counseling** and guidance. If a dietary assessment is not conducted in preparation, using proper methodologies, it will be difficult for the dietitian to draw any conclusions regarding the need for diet therapy.

Despite the diet type, all foods should be prepared appropriately. This includes adequate cooking time and proper storage. Some diets must be phased-in gradually.

Aftercare

Regular physician follow-up is always important when the individual has been placed on a special diet because of a health condition.

One cannot live on “a diet” permanently, because strict guidelines are difficult and painstaking to follow. Therefore, dietary modifications have to be lifestyle

KEY TERMS

Calorie—Commonly referred to as a calorie, but is actually a kilocalorie (kcal). A kilocalorie is the energy required to raise the temperature of one kilogram of water one degree Celsius. It is how the energy content of food is measured.

Dietary assessment—An estimation of food and nutrients eaten over a particular time point. Some of the most common dietary assessment methods are food records, dietary recalls, food frequency questionnaires, and diet histories.

Dietitian—A dietitian is a health professional who has a bachelor's degree, specializing in foods and nutrition, and in addition undergoes a period of practical training in a hospital or community setting. Many dietitians further their knowledge by pursuing master's or doctoral degrees. The title "dietitian" is protected by law so that only qualified practitioners who have met education qualifications can use that title.

Electrolytes—Any of the various ions, such as sodium, potassium, or chloride, required by cells to regulate the electric charge and flow of water molecules across the cell membrane.

Kilojoule—In Europe and other countries, food energy values are frequently given in kilojoules (kJ), the metric unit of energy. Using the metric system nomenclature, a calorie is converted into a kilojoule (kJ), where 1 kcal=4.184 kJ and 1 megajoule (MJ)=1000 kJ. To convert kilojoules to kcals, divide by 4.184.

Legumes—A pod, such as a pea or bean, that splits into two valves with the seeds attached to one edge of the valves.

Nutritionist—Some dietitians call themselves "nutritionists" but in general, the term "nutritionist" is not protected by law, therefore anyone can call themselves a nutritionist.

Trans-unsaturated fatty acids (also called trans-fatty acids or trans-fat)—To make foods that will stay fresh on the shelf or to get a solid fat product, such as margarine, food manufacturers hydrogenate (i.e. add hydrogen) to polyunsaturated oils. This changes the double bond on the carbon atom from a cis configuration to a trans configuration, making the fatty acid saturated, and more of a health concern. For example, stick margarines are known to contain more trans fatty acids than liquid oils.

changes in food selection and more healthy attitudes about nutrition and wellness.

Risks

There is always the possible risk of non-compliance of any diet. However, when the individual is placed on the appropriate diet and the primary physician is aware of any known **allergies**, there are very few risks involved, if any.

Results

When special diets are followed as prescribed, better health is the expected outcome, with a decreased risk of acquiring many diseases. However, it is up to an individual to implement the necessary dietary modifications. If a patient does not follow the recommended dietary guidance, then they will not receive a benefit. Typically, modest effects are seen in weight loss or reduction in serum **lipids** (i.e. cholesterol) often due to failure to fully comply with the dietary recommendations provided by a dietitian or doctor.

The outcome of any diet therapy will be better when combined with exercise unless the patient is unable to exercise for medical reasons.

If the appropriate diet is prescribed by medical professionals, abnormal results are very rare.

Health care team roles

A certified nutrition professional such as a registered dietitian (R.D.) should be seen for a dietary assessment and professional dietary counseling prior to commencing diet therapy. Beware of individuals prescribing diets without an education in **dietetics** and nutrition. In general, only registered dietitians have sufficient training and knowledge to accurately assess the nutritional adequacy of a patient's diet, especially if chronic disease is present. Some dietitians call themselves nutritionists, but the term "nutritionist" is not regulated by law; therefore anyone can call themselves a nutritionist. A doctor may also have a nutrition background or specialization and may thus be able to conduct a dietary assessment or to provide general nutrition advice and/or diet therapy.

Resources

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Stampfer, M. J., et al. "Primary prevention of coronary heart disease in women through diet and lifestyle." *New England Journal of Medicine* 343 (2000): 16–22.

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American Dietetic Association. 216 W. Jackson Blvd. Chicago, IL 60606-6995. (312) 899-0040. <<http://www.eatright.org>>.

American Heart Association National Center. 7272 Greenville Avenue, Dallas, Texas 75231. (800) AHA-USA1. <<http://www.americanheart.org>>.

Food and Nutrition Information Center Agricultural Research Service, USDA. National Agricultural Library, Room 304, 10301 Baltimore Avenue, Beltsville, MD 20705-2351. (301) 504-5719. Fax (301) 504-6409. <<http://www.nal.usda.gov/fnic>>. fnic@nal.usda.gov.

National Society for Phenylketonuria. P.O. Box 26642, London, UK, N14 4ZF. <<http://web.ukonline.co.uk/nspku>>.

OTHER

Food and Nutrition Professionals Network. <<http://nutrition.cos.com>>.

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Dietary assessment

Definition

A dietary assessment is an estimation of food and nutrients eaten over a particular time point. There are a number of dietary assessment tools used by dietitians, nutritionists, and doctors that aid in **dietary counseling**. These include:

- food records or diaries (including weighed intakes)
- dietary recalls

- food frequency questionnaires (FFQs)
- dietary histories
- observed intakes
- chemical analyses of duplicate collections of foods consumed
- biological assessments (e.g. doubly-labelled water, plasma carotene, etc.)

Purpose

A dietary assessment is often conducted to determine the macronutrient (energy or caloric, protein, and fat) content and the micronutrient (vitamin and mineral) content of the diet to assist in providing dietary counseling. The validation of dietary assessment instruments is important to evaluate the diet in terms of a chronic disease risk factor. It is often used as a tool to help the patient lose weight, or to prevent or treat conditions or diseases that are influenced by food intake and nutritional status (i.e. cardiovascular disease, **cancer**, **obesity**, diabetes, hyperlipidemia).

A guide to the amount an average person needs each day to remain healthy has been determined for each vitamin and mineral as well as macronutrients. In the United States, this guide is called the recommended daily allowance (RDA). Consumption of too little or too much of certain **vitamins** and **minerals** may lead to a nutrient deficiency or a nutrient toxicity respectively. The RDA suggests a level of vitamin and minerals that is adequate for approximately 98% of healthy people in the population. The dietitian may use the dietary assessment to compare it to population requirements for nutrients (such as the RDA) to ensure the diet has proper intakes of energy, protein, fat, vitamins, and minerals. The RDA is under revision and will become the Dietary Reference Intakes, and will be applicable to Canadians and Americans.

Precautions

Dietary assessments are estimations based on an intake of a particular time point and cannot generalize that the diet is adequate or inadequate since intake varies day to day. For example, fruit and vegetables may be lacking on a day that was surveyed for the dietary assessment while overall the diet may be adequate in fruit and vegetable intake. Thus, care must be taken regarding generalizations about deficiencies or adequacy of nutrient intake. Intake of energy, **carbohydrates**, and protein varies less from day to day and may be estimated more closely than vitamin and mineral intakes.

Description

Some of the most common tools that assist in providing dietary advice include food records, 24 hour dietary recalls, food frequency questionnaires, diet histories, and several other methods including biochemical indices. These tools are explained in greater detail below. Furthermore, a scientific assessment of nutritional status may be made by using a combination of the information collected from clinical evaluations, biochemical tests, and dietary information. The clinical evaluation includes measurements of various anthropometric parameters such as height, weight, and percent body fat (determined by skinfolds or hydrostatic weighing). In addition, a clinical evaluation may also include observations for signs of nutrient deficiencies in the mouth, skin, eyes, and nails. The information collected from a clinical evaluation can be compared with that obtained from the dietary assessment and biochemical tests to provide a comprehensive picture of the patient's current nutritional status and relative risk factors for diet-related illnesses.

Food records

This method instructs subjects to record at the time of consumption all foods and beverages consumed for a specified duration, typically one to seven days, in order to quantify intake. Three or seven day food records are the most common. Food records can be estimated or weighed, the latter providing a more precise measure of intake. Portion sizes can be obtained through the use of household measures, cups, spoons, and scales. All days of the week should be proportionally included to avoid day of the week effects on nutrient and compositional intake. The weighed food record is the preferred method for assessing individual requirements because of its ability to determine intake quantitatively. Disadvantages of the method are that it is laborious and it may be a considerable burden to correctly measure and record intake.

24-hour recall

The 24-hour recall is a method for quantifying dietary intake for a group average and is not suited for individual dietary characterization although it is often used for this purpose. A person's previous 24-hour food intake is probed by an interviewer to provide detailed descriptions of portion sizes, condiments used, cooking method, and brand names. Quantities are often estimated in household measures or using food models for assistance to more accurately quantify intake. Recalls can be repeated on several occasions in the same person in order to increase accuracy and precision. Advantages of the 24-hour recall is that it is inexpensive, quick, and places little burden on the patient. Single 24-hour recalls do not

provide sufficient information on nutrient intakes and cannot account for day to day variation in intake, however, repeated 24 hour recalls can be used to more precisely estimate intake.

Food frequency questionnaire

A food frequency questionnaire (FFQ) is generally designed to provide qualitative data regarding food consumption patterns rather than nutrient composition and intake. The aim is to assess the frequency at which certain foods are consumed, for example, daily, weekly, monthly or yearly. Advantages of the FFQ are that it is quick, inexpensive, and can be administered by patients themselves. Disadvantages are that it cannot provide adequate quantitative data to use for individuals, although semi-quantitative FFQs provide some measure of quantity. As well, it does not address culture-specific foods since it primarily contains lists of somewhat standard North-American type foods. Accuracy and validation in specific cultures necessitates the use of another dietary assessment tool.

Diet history

The diet history attempts to measure usual intake in the past over a longer time period than other methods of dietary assessment. It consists of three parts, although it is often modified, including a 24 hour recall, a food frequency questionnaire, and a 3 day food record. Portion sizes are estimated by a variety of methods including household measures, food models, household utensils, photographs, or actual food. An advantage of the diet history is that it provides qualitative and quantitative data of food intake. It also considers seasonal and day to day variations. Disadvantages are that the method is labor-intensive.

Other methods

The use of a portable electronic set of tape recording scales (PETRA), photographs, voice-taped, and videotaped recordings have been used as dietary assessment tools.

Biochemical tests may also be used to further identify a patient's nutritional status. Serum albumin, hemoglobin or **hematocrit** are used to measure plasma protein. Lymphocytes and various skin tests are used to measure **immune system** integrity, and various urine tests such as a calculation of urinary nitrogen are used as an indication of protein **metabolism**. Other indices include urinary potassium, serum concentrations of carotenoids, and stable isotopes that measure water turnover which is an indicator of energy expenditure. These indices are often more reliable and representative of true intake than methods which rely on the subject's ability to record or recall intake.

Other sources that can be used for dietary reference and guidance for food choices are “The Dietary Guidelines for Americans” which is published by the U.S. Department of Agriculture and Health and Human Services. The “Food Guide Pyramid” was created by the U.S. Department of Agriculture to help Americans choose foods from each food grouping. It focuses on fat intake, which is too high in most Americans.

There are also a number of internet websites where food records or recalls can be self-administered by patients for dietary assessment. Some of these websites are listed in the resources sections below.

Preparation

Systematic problems exist in the quantification of food intake using dietary assessment tools that depend on self-reported measures (i.e. when the patient subjectively reports their own food intake). This is due to the fact that these methods rely on the patient’s ability to recall or record food intake accurately. Therefore, selection of the appropriate method for dietary assessment is important to meet the goals of dietary counseling.

Complications

Measurement of dietary intake typically relies on self-reported data. Most dietary collection tools using self-reported intake have not included a test for accuracy or bias to validate the data collected. These validations are difficult to conduct because in an individual who is eating at home, there are few methods to use as a reference to validate the dietary intake data.

There are subgroups of the population that are more likely to provide inaccurate intake data, creating error. In general, obese people are more apt to underestimate their food consumption because they may go on “a diet” or deliberately omit foods during the food-recording period. Individuals may alter their food intake temporarily as they are cognizant that their food intake is being monitored, possibly to conform to socially acceptable foods and food habits. For example, during a 24 hour recall, an obese person may not want to admit to a dietitian that they overate the previous day, therefore, they may underreport their food intake.

Another source of error comes from weighing and measuring foods. Errors involved in the estimation of food portions can reach 90% but are typically 20-50% when scales are not used to weigh foods.

KEY TERMS

Dietary assessment—An estimation of food and nutrients eaten over a particular time point. Some of the most common dietary assessment methods are food records, dietary recalls, food frequency questionnaire, and diet histories.

Dietitian—A dietitian is a health professional who has a bachelor’s degree, specializing in foods and nutrition, and undergoes a period of practical training in a hospital or community setting. Many dietitians further their knowledge by pursuing master’s or doctoral degrees. The title “dietitian” is protected by law so that only qualified practitioners who have met education qualifications can use that title.

Macronutrient—A nutrient such as protein, carbohydrate, or fat.

Micronutrient—An organic compound such as vitamins or minerals essential in small amounts and necessary to growth and health of humans and animals.

Nutritionist—Some dietitians call themselves “nutritionists,” but in general, the term “nutritionist” is not protected by law, therefore anyone can call themselves a nutritionist.

Results

A dietary assessment may indicate where a nutritional problem or inadequacy may lie, but it is up to an individual to implement the necessary dietary modifications. If a patient does not follow the recommended dietary guidance following dietary assessment, then they will not receive any benefit from dietary assessment. Typically, modest effects are seen in weight loss or reduction in serum **lipids** often due to failure to fully comply with the dietary recommendations provided.

Health care team roles

In general, only registered dietitians (R.D.s) have sufficient training and knowledge to accurately assess the clinical evaluation and nutritional adequacy of a patient’s diet. Although there are many websites and software programs that provide guidance for self-use for conducting a basic dietary assessment, these should be used with caution. The term “nutritionist” is not regulated by law; therefore anyone can call themselves a nutritionist. A doctor may also have a **nutrition** background or special-

ization and may thus be able to conduct a dietary assessment or to provide general nutrition advice. However, one research study demonstrated that even though most doctors admitted they had ready access to a publicly funded dietician, 50% of doctors refer less than a quarter of their patients to dietitians. Major barriers for doctors to improving dietary counseling for patients include short visit times, limited nutrition coursework in medical schools, and poor patient compliance with physicians' dietary prescriptions.

Resources

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- Food and Nutrition Professionals Network
<<http://nutrition.cos.com/>>.

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related illnesses such as cardiovascular disease, **cancer**, **obesity**, diabetes, and hyperlipidemia.

Purpose

Today's major health care problems are increasingly the result of acute and chronic conditions related to poor **nutrition** and/or overconsumption. A large proportion of coronary disease and cancer can be attributed to unhealthy eating habits and obesity. Chronic diseases continue to increase due to such factors as the rise in obesity in the American population.

Individualized nutritional counseling can provide the patient important insight into food-related illnesses and education regarding how various nutrients (protein, carbohydrate, fat, alcohol) affect illnesses or obesity. Alternatively, dietary counseling can provide prevention of nutrition-related conditions such as the need for weight management. Dietary counseling can be tailored to meet the treatment needs of patients at diagnosis of specific illnesses, can help reduce complications and/or side effects, and can improve general well-being. Prevention at all levels: primary (preventing disease), secondary (early diagnosis), and tertiary (preventing or slowing deterioration) requires active patient participation and guidance and support from the dietician or physician. Education, motivation, and counseling are needed for effective patient participation. In addition to **patient education**, dietary counseling often includes meal planning.

A guide to the amount an average person needs each day to remain healthy has been determined for each vitamin and mineral as well as macronutrients. In the United States, this guide is called the *recommended daily allowance (RDA)*. The RDA is under revision and will become the Dietary Reference Intakes, and will be applicable to Canadians and Americans. Dietary counselors may use the RDA as a guide when providing counseling. Consumption of too little or too much of certain **vitamins** and **minerals** may lead to a nutrient deficiency or a nutrient toxicity respectively. A dietitian can advise the patient about any vitamin or mineral inadequacy concerns during the dietary counseling session.

Precautions

When providing dietary counseling, registered dietitians and nutritionists should recognize the benefit of individualizing nutritional care and that a "one-size-fits-all" approach to modifying eating habits cannot be effective.

Dietary counseling

Definition

Dietary counseling provides individualizing nutritional care for encouraging modification of eating habits. It may also assist in prevention or treatment of nutrition-

Description

Effective dietary counseling includes a comprehensive evaluation that considers presence of disease, lipid profile, **blood pressure**, and weight history and goals. In addition, factors such as lifestyle, time available for food preparation, work schedule, and personal food preferences must be considered. Food choices are driven not only by the physiological necessity for nutrients, but also by the social aspects of food consumption, i.e. gathering with friends at a restaurant. This complex relationship concerning food choices often makes dietary counseling a challenge for managing specific nutrition-related disease or conditions. For example, a patient with cardiovascular disease may need to select low-fat foods when attending a social dinner or party.

There are many issues related to nutrition goal outcomes that need to be considered when planning appropriate dietary counseling. When considering the appropriate counseling approach for an individual with a specific illness, particular attention needs to be given to usual food choices, food likes and dislikes, learning style, cultural issues, and socioeconomic status.

Other factors that may be assessed during dietary counseling include:

- medical history, including assessment of any nutrition-related illnesses, and biochemical and anthropometric measures
- **dietary assessment** (dietary analyses)
- psychosocial evaluation, including food-related attitudes and behaviors
- sociological evaluation, including cultural practices, housing, cooking facilities, financial resources, and support of family and friends
- nutrition knowledge
- readiness to learn or change; as well as learning style analyses
- current **exercise** and activity level

Preparation

A dietary assessment is often conducted to determine the macronutrient (energy or caloric, protein, and fat) content and the micronutrient (vitamin and mineral) content of the diet to assist in providing dietary counseling. The validation of dietary assessment instruments is important to evaluate the diet in terms of chronic disease risk factors such as a high fat diet or a diet low in antioxidants and/or fruits and vegetables.

Some of the most common dietary assessment tools that assist in providing dietary counseling include food

records, dietary recalls, food frequency questionnaires, diet histories, and several other methods including biochemical indices. A scientific assessment of nutritional status may be made by using a combination of the information collected from clinical evaluations, biochemical tests, and dietary information. The clinical evaluation includes measurements of various anthropometric parameters such as height, weight, and percent body fat (determined by skinfolds or hydrostatic weighing). In addition, a clinical evaluation may also include observations for signs of nutrient deficiencies in the mouth, skin, eyes, and nails. The information collected from a clinical evaluation can be compared with that obtained from the dietary assessment and biochemical tests to provide a comprehensive picture of the patient's current nutritional status and relative risk factors for diet-related illnesses.

Aftercare

Dietary counseling is only effective if the individual is willing to implement the necessary dietary modifications. If patients do not follow the recommended dietary guidance, they will not receive a benefit from counseling. Typically, modest effects seen in weight loss or reduction in serum **lipids** are often due to failure to comply fully with the dietary recommendations provided.

Complications

Systematic problems exist in the quantification of food intake using dietary assessment tools and self-reported measures (i.e. when the patients subjectively report their own food intake). This is due to the fact that these methods rely on the patient's ability to recall or record food intake accurately. Therefore, selection of the appropriate method for dietary assessment is important to meet the goals of dietary counseling.

Results

Goals of dietary counseling for preventative nutrition or treatment of nutrition-related illness:

- Providing adequate calories for attaining reasonable weights for adults, ensuring normal growth and development rates for children and adolescents, and meeting increased metabolic needs during **pregnancy** and **lactation** or recovery from catabolic illness. Reasonable weight for adults is defined by considering weight history and is a weight that both the individual and health professional determine is attainable and can be maintained long term.
- Achieving optimal lipid levels. The guidelines provided by the *National Cholesterol Education Program* can be followed for maintaining optimal **blood** lipid levels

KEY TERMS

Dietary assessment—An estimation of food and nutrients eaten over a particular time point. Some of the most common dietary assessment methods are food records, dietary recalls, food frequency questionnaires, and diet histories.

Dietary counseling—Individual nutritional advice provided to a patient by a registered dietitian, nutritionist, or doctor for encouraging modification of eating habits.

Dietitian—A dietitian is a health professional who has a bachelor's degree, specializing in foods and nutrition, and undergoes a period of practical training in a hospital or community setting. Many dietitians further their knowledge by pursuing master's or doctoral degrees. The title "dietitian" is protected by law so that only qualified practitioners who have met education qualifications can use that title.

Macronutrient—A nutrient such as protein, carbohydrate, or fat.

Micronutrient—An organic compound such as vitamins or minerals essential in small amounts and necessary to growth and health of humans and animals.

Nutritionist—A general term for someone who works with the principles of nutrition. Some dietitians call themselves "nutritionists," but the term "nutritionist" is not protected by law, and therefore anyone can call themselves a nutritionist.

[total cholesterol, low-density lipoproteins (LDL), high-density lipoproteins (HDL), and triglycerides]. Nutrition intervention plays an important role in reaching recommended lipid levels through maintenance of a low-fat diet.

- Ensuring the diet contains appropriate or reasonable amounts of protein, **carbohydrates**, fat, vitamins, and minerals.
- Preventing, delaying, or treating nutrition-related risk factors and complications.
- Improving overall health through optimal nutrition.

What methods are most helpful for dietary modifications?

Clearly, dietary advice tailored to suit individual needs and tastes is more appropriate than general dietary

advice. The issue is how to elicit a beneficial change in dietary habits and how to encourage a patient to stick to the dietary recommendations provided. Typically, dietary modifications have demonstrated limited success especially regarding weight control. Several methods have been used to induce behavioral change in individuals such as the *Transtheoretical (Stages of Change) Model*. It is one of most popular models of health behavior change that classifies individuals into stages according to their degree of readiness to consider change, and identifies the factors that can induce transitions from one stage to the next. The model suggests change in health behavior involves progression through six stages including precontemplation, contemplation, preparation, action, maintenance, and termination. It utilizes different types of skills training and advice at different stages and has shown promising success in diet modification interventions.

It may be easier to introduce new behaviors than to eliminate established behaviors. Therefore, if weight loss is a concern, recommending the patient start exercising regularly may be more effective than changing current dietary patterns.

Positive feedback or implementation of a reward system may be advantageous in helping some patients follow dietary advice.

In general, changing behaviors such as making healthier food choices and increasing exercise will be much more successful and pleasurable in the long-term than dieting. Furthermore, an individual cannot live on a diet permanently; therefore, when food intake increases, weight gain will follow unless energy expenditure is increased through exercise or by other means. Dieting may encourage a "yo-yo" weight loss/gain where often even more weight is gained back than was lost and often in less favorable proportions of a fat to muscle ratio. When weight is lost, muscle and fat are both lost. Sometimes the weight that is regained after weight loss has a higher content of "fat" (adipose tissue) than the weight previously lost (which may have contained a significant percent of skeletal muscle). This is only one of the reasons why exercise is so important in maintaining body weight. In fact, because muscle is metabolically active tissue, the body actually needs more energy or calories to feed the muscles even when at rest (for example, sitting still or sleeping). Dietary counseling may help reinforce dietary modifications and assist in achieving permanent weight control.

Other sources that can be used for dietary reference and self-counseling for individuals are *The Dietary Guidelines for Americans* which is published by the U.S. Department of Agriculture and Health and Human Services. *The Food Guide Pyramid* was created by the

U.S. Department of Agriculture to help Americans choose foods from each food grouping. It focuses on fat intake, which is too high in most Americans. In addition, the *National Cholesterol Education Program* provides a Step 1 diet that may be followed to assist in controlling weight.

Health care team roles

In general, only registered dietitians (R.D.s) have sufficient training and knowledge to accurately assess the nutritional adequacy of a patient's diet. The term "nutritionist" is not regulated by law; therefore anyone can call themselves a nutritionist. A doctor may also have a nutrition background or specialization and may thus be able to provide general nutrition counseling. However, one research study demonstrated that even though most doctors admitted they had ready access to a publicly funded dietician, 50% of doctors refer less than a quarter of their patients to dietitians. Major barriers to improving dietary counseling for patients include short visit times, limited nutrition coursework in medical schools, and poor compliance with physicians' dietary prescriptions.

For effective therapy to occur, all health care team members and especially the patient with the nutrition-related illness must commit to the goals of counseling. The prioritized goals are critical when developing the nutrition treatment plan. Continuous assessment is made by the patient and health care team members to evaluate the importance of these and other goals. Physicians must understand the nutrition approaches an individual is using and reinforce this therapy when interacting with the individual.

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Food and Nutrition Information Center Agricultural Research Service, USDA. National Agricultural Library, Room 304, 10301 Baltimore Avenue, Beltsville, MD 20705-2351. (301) 504-5719. Fax: (301) 504-6409. <<http://www.nal.usda.gov/fnic/>>. <fnic@nal.usda.gov>.

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Food and Nutrition Professionals Network
<<http://nutrition.cos.com/>>.

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Dietary fats see **Fats, dietary**

Dietetics

Definition

Dietetics professionals are responsible for educating individual clients in developing healthy lifestyles, as well as for providing quality nutritional services to the public. Standards of professional practice have been developed by the American Dietetic Association to ensure that dietetics professionals are the most reliable sources of information regarding food and **nutrition**.

Description

Registered dietitians (RD) and dietetic technicians (DTR) receive their credentials from the Commission on Dietetic Registration, which ensures that these professionals have fulfilled all academic requirements and completed a registration examination. Dietetics professionals work in a variety of settings involving foodservice management, clinical nutrition, and community nutrition. They work to provide nutrition education classes on topics such as breastfeeding, food safety, and diet fads. They may counsel hospital patients on health-related conditions and facilitating weight loss. They are also qualified to educate the public on proper nutrition for people of all ages including infants and the elderly.

Work settings

Registered dietitians and dietetic technicians are qualified to work in a variety of settings including hospitals, **nursing homes**, schools, and health clinics. In hospitals and nursing homes, dietetics professionals usually perform more clinical duties such as assessing the nutritional status of patients to aid in their treatment and recovery. They must demonstrate an understanding of a variety of nutrition topics, including calculating nutrient and tube feeding needs, and various nutrition-related diseases, such as diabetes, **Crohn's disease**, and cardiovascular disease. In schools, dietitians can provide services to cafeterias in helping them develop healthy meals and snacks, as well as conduct nutrition education classes for

students and teachers. Dietitians also play a very prominent role in health clinics such as WIC (Supplemental Program for Women, Infants, and Children), in which they advocate the healthy development of children by educating women on the importance of breastfeeding and **infant nutrition**. Many dietetics professionals also become certified as dietary managers in which they are responsible for supervising in a foodservice setting.

Education and training

To become a registered dietitian, a bachelor's or master's degree in dietetics may be received from a school that is a Coordinated Program (CP) accredited by the Commission on Accreditation for Dietetics Education (CADE) in which academics and supervised practical experience are combined. A graduate of a Coordinated Program may then take the Registration Examination for Dietitians to become an RD. Individuals may also enroll in a Didactic Program in Dietetics (DPD) that is also approved by CADE. After graduating with a bachelor's degree, the supervised practical experience may be completed either at a CADE-accredited Dietetic Internship or a CADE-approved Preprofessional Practice Program (AP4). This also qualifies the individual to take the Registration Examination for Dietitians.

To become a registered dietetic technician, an associate's degree must be received from a CADE-accredited Dietetic Technician Program or a baccalaureate degree from a CADE-approved DPD. DTRs must also participate in a supervised practical experience at the Dietetic Technician Program, but it is not required that they take a registration examination.

The academics involved in the undergraduate study of dietetics includes generalized courses such as biology, chemistry, statistics, and management. More detailed courses are devoted to topics such as general nutrition, food science, nutritional assessment, advanced nutrition, experimental foods, and **diet therapy**. Undergraduate work also consists of clinical experience in work settings in which students gain a more hands-on experience in the field of dietetics. This allows students to get a new perspective on the field that goes beyond traditional teaching methods. By encouraging active participation, students will gain a better understanding of what is necessary to develop the counseling skills and research capabilities essential to dietetics.

Advanced education and training

Dietitians can further enhance their education and abilities by receiving a master's degree in dietetics or another field related to nutrition. Some CADE-accred-

ed/approved programs also offer graduate coursework that can be completed at the same time as the dietetic internship. Dietetics professionals are also responsible for keeping up to date with the latest information regarding nutrition and utilizing the available technology that can enhance learning.

Future outlook

Dietetics is a constantly changing field in which new information is being uncovered and advances in technology are being made. While technology has become an integral part of nutrition education, it is likely to become even more prominent in years to come. Many dietitians have even designed web sites in order to market their practice. Dietitians have begun utilizing services such as email and the Internet to communicate with clients. This also allows them to communicate with people who travel or are too busy to schedule an appointment. Using the Internet to communicate with clients has its advantages as well as its disadvantages though. While it offers more flexibility for both the client and the professional and allows dietitians to reach a wide geographical range of people, it also limits dietetics professionals in accurately assessing patients because they are not seen in person.

One of the major drawbacks to using the web for nutrition information is that much of the information tends to be inaccurate or exaggerated. This will give dietetics professionals an even bigger role in working to ensure that the public is getting the most accurate and up-to-date information from the web and has resulted in more career opportunities for dietetics professionals. Since most nutrition information comes from search engines like <www.yahoo.com> or <www.medscape.com>, these companies have begun hiring dietetics and nutrition professionals to edit content and develop appropriate health-related messages for consumers. Many dietitians also work as consultants for Web sites who may need expert advice on nutrition-related topics. With the advances in technology and development of new computer programs for nutrition education, the role of dietitians will continue to grow as the need for the most up-to-date information continues to grow.

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Lisa M. Gourley

Differential count see **White blood cell count and differential**

Digestive system

Definition

The digestive system is a group of organs and tissues responsible for the conversion of food into absorbable chemicals which are then used to provide energy for growth and repair.

Description

The digestive system is also known by a number of other names, including the gut, the digestive tube, the alimentary canal, the gastrointestinal (GI) tract, the intestinal tract, and the intestinal tube. The digestive system consists of the mouth, esophagus, **stomach**, and small and large intestines, along with several glands, such as the salivary glands, **liver**, gall bladder, and **pancreas**.

Function and role in human health

The glands in the digestive system secrete digestive juices containing enzymes that break down the food chemically into smaller, more absorbable molecules. In addition to providing the body with the nutrients and energy it needs to function, the digestive system also separates and disposes of waste products ingested with the food.

Food is moved through the alimentary canal by a wavelike muscular motion known as peristalsis, which consists of the alternate contraction and relaxation of the smooth muscles lining the tract. In this way, food is passed through the gut in much the same manner as toothpaste is squeezed from a tube. Churning is another

type of movement that takes place in the stomach and **small intestine**, which mixes the food so that the digestive enzymes can break down the food molecules.

Food in the human diet consists of **carbohydrates**, **proteins**, **fats**, **vitamins**, and **minerals**. The remainder of the food is fiber and water. The majority of minerals and vitamins pass through to the bloodstream without the need for further digestive changes, but other nutrient molecules must be broken down to simpler substances before they can be absorbed and used.

Ingestion

Food taken into the mouth is first prepared for digestion in a two-step process known as mastication. In the first stage, the teeth tear and break down food into smaller pieces. In the second stage, the tongue rolls these pieces into balls (boluses). Sensory receptors on the tongue (**taste buds**) detect taste sensations of sweet, salt, bitter, and sour, or cause the rejection of bad-testing food. The olfactory nerves contribute to the sensation of taste by picking up the aroma of the food and passing the sensation of **smell** on to the **brain**.

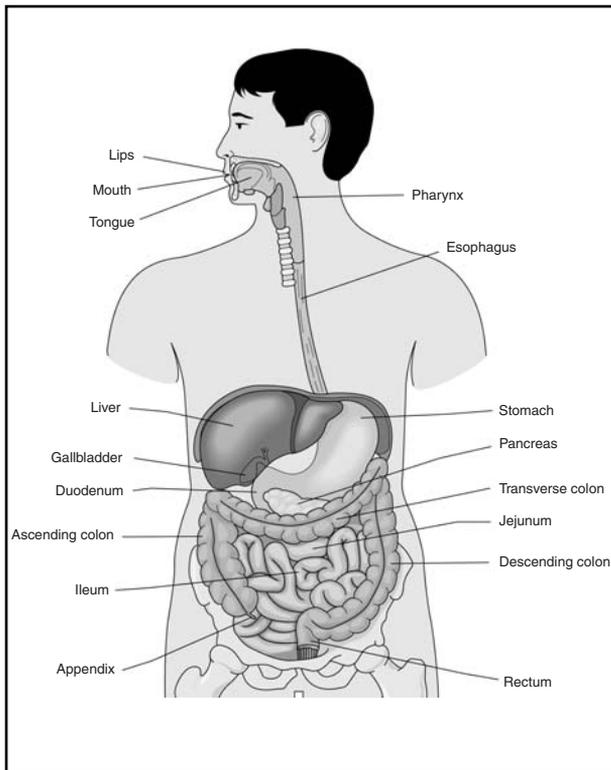
The sight of the food also stimulates the salivary glands. Altogether, the sensations of sight, taste, and smell cause the salivary glands, located in the mouth, to produce saliva, which then pours into the mouth to soften the food. An enzyme in the saliva called amylase begins the break down of carbohydrates (starch) into simple sugars, such as maltose. Ptyalin is one of the main amylase enzymes found in the mouth; ptyalin is also secreted by the pancreas.

The bolus of food, which is now a battered, moistened, and partially digested ball of food, is swallowed, moving to the throat at the back of the mouth (pharynx). In the throat, rings of muscles force the food into the esophagus, the first part of the upper digestive tube. The esophagus extends from the bottom part of the throat to the upper part of the stomach.

The esophagus does not take part in digestion. Its job is to get the bolus into the stomach. There is a powerful muscle (the esophageal sphincter), at the junction of the esophagus and stomach, which acts as a valve to keep food, stomach acids, and bile from flowing back into the esophagus and mouth.

Digestion in the stomach

Chemical digestion begins in the stomach. The stomach, a large, hollow, pouched-shaped muscular organ, is shaped like a lima bean. When empty, the stomach becomes elongated; when filled, it balloons out.



The parts of the human gastrointestinal tract. (Delmar Publishers, Inc. Reproduced by permission.)

Food in the stomach is broken down by the action of the gastric juice containing hydrochloric acid and a protein-digesting enzyme called pepsin. Gastric juice is secreted from the lining of the stomach walls, along with mucus, which helps to protect the stomach lining from the action of the acid. The three layers of powerful stomach muscles churn the food into a fine semiliquid paste called chyme. The chyme (pronounced “kime”) is periodically passed through an opening (the pyloric sphincter), which controls the passage of chyme between the stomach and the beginning of the small intestine.

Gastric juice

There are several mechanisms responsible for the secretion of gastric juice in the stomach. The stomach begins its production of gastric juice while the food is still in the mouth. Nerves from the cheeks and tongue are stimulated and send messages to the brain. The brain in turn sends messages to nerves in the stomach wall, stimulating the secretion of gastric juice before the arrival of the food. The second signal for gastric juice production occurs when the food arrives in the stomach and touches the lining. This mechanism provides for only a moderate addition to the amount of gastric juice that was secreted when the food was in the mouth.

Gastric juice is needed mainly for the digestion of protein by pepsin. If a hamburger and bun reach the stomach, there is no need for extra gastric juice for the bun (carbohydrate), but the hamburger (protein) will require a much greater supply of gastric juice. The gastric juice already present will begin the break down of the large protein molecules of the hamburger into smaller molecules: polypeptides and peptides. These smaller molecules in turn stimulate the cells of the stomach lining to release the hormone gastrin into the bloodstream.

Gastrin then circulates throughout the body, and eventually reaches the stomach, where it stimulates the cells of the stomach lining to produce more gastric juice. The more protein there is in the stomach, the more gastrin will be produced, and the greater the production of gastric juice. The secretion of more gastric juice by the increased amount of protein in the stomach represents the third mechanism of gastric juice secretion.

Digestion and absorption in the small intestine

While digestion continues in the small intestine, it also becomes a major site for the process of absorption, that is, the passage of digested food into the bloodstream, and its transport to the rest of the body.

The small intestine is a long, narrow tube, about 20 ft (6 m) long, running from the stomach to the **large intestine**. The small intestine occupies the area of the abdomen between the diaphragm and hips, and is greatly coiled and twisted. The small intestine is lined with muscles that move the chyme toward the large intestine. The mucosa, which lines the entire small intestine, contains millions of glands that aid in the digestive and absorptive processes of the digestive system.

The small intestine, or small bowel, is sub-divided into three sections, the duodenum, the jejunum, and the ileum. The duodenum is about 1 ft (0.3 m) long and connects with the lower portion of the stomach. When fluid food reaches the duodenum it undergoes further enzymatic digestion and is subjected to pancreatic juice, intestinal juice, and bile.

The pancreas is a large gland located below the stomach that secretes pancreatic juice into the duodenum via the pancreatic duct. There are three enzymes in pancreatic juice which digest carbohydrates, **lipids**, and proteins. Amylase, (the enzyme found in saliva) breaks down starch into simple sugars such as maltose. The enzyme maltase in intestinal juice completes the break down of maltose into glucose.

Lipases in pancreatic juice break down fats into fatty acids and glycerol, while proteinases continue the break-down of proteins into amino acids. The gallbladder,

located next to the liver, secretes bile into the duodenum. While bile does not contain enzymes, it contains bile salts and other substances that help to emulsify (dissolve) fats, which are otherwise insoluble in water. Breaking the fat down into small globules allows the lipase enzymes a greater surface area for their action.

Chyme passing from the duodenum next reaches the jejunum of the small intestine, which is about 3 ft (0.91 m) long. Here, in the jejunum, the digested breakdown products of carbohydrates, fats, proteins, and most of the vitamins, minerals, and **iron** are absorbed. The inner lining of the small intestine is composed of up to five million tiny, finger-like projections called *villi*. The villi increase the rate of absorption of the nutrients into the bloodstream by extending the surface of the small intestine to about five times that of the surface area of the skin.

There are two transport systems that pick up the nutrients from the small intestine. Simple sugars, amino acids, glycerol, and some vitamins and salts are conveyed to the liver in the bloodstream. Fatty acids and vitamins are absorbed and then transported through the **lymphatic system**, the network of vessels that carry lymph and white **blood** cells throughout the body. Lymph eventually drains back into the bloodstream and circulates throughout the body.

The last section of the small intestine is the ileum. It is smaller and thinner-walled than the jejunum, and it is the preferred site for **vitamin B₁₂** absorption and bile acids derived from the bile juice.

Absorption and elimination in the large intestine

The large intestine, or colon, is wider and heavier than the small intestine, but much shorter—only about 4 ft (1.2 m) long. It rises up on one side of the body (the ascending colon), crosses over to the other side (the transverse colon), descends (the descending colon), forms an s-shape (the sigmoid colon), reaches the rectum, and anus, from which the waste products of digestion (feces or stool), are passed out, along with gas. The muscular rectum, about 5 in (13 cm) long, expels the feces through the anus, which has a large muscular sphincter that controls the passage of waste matter.

The large intestine extracts water from the waste products of digestion and returns some of it to the bloodstream, along with some salts. Fecal matter contains undigested food, **bacteria**, and cells from the walls of the digestive tract. Certain types of bacteria of the large intestine help to synthesize the vitamins needed by the body. These vitamins find their way to the bloodstream along with the water absorbed from the colon, while excess fluids are passed out with the feces.

Liver

The liver is the largest organ in the body and plays a number of vital roles, including metabolizing the broken-down products of digestion, and detoxifying substances that are harmful to the body. The liver also provides a quick source of energy when the need arises and it produces new proteins. Along with the regulation of stored fats, the liver also stores vitamins, minerals, and sugars. The liver controls the excretion and production of cholesterol and metabolizes alcohol into a mild toxin. The liver also stores iron, maintains the hormone balance, produces immune factors to fight infections, regulates blood clotting, and produces bile.

Gallbladder

The **gallbladder** lies under the liver and is connected by various ducts to the liver and the duodenum. The gallbladder is a small hollow organ; its main function is to store bile until it is concentrated enough to be used by the small intestine. The gallbladder can store about 2 oz of bile. Bile consists of bile salts, bile acids, and bile pigments. In addition, bile contains cholesterol dissolved in the bile acids.

Appendix

The appendix is a hollow finger-like projection that hangs from the cecum at the junction between the small intestine and the large intestine. The appendix does not function in humans; however, in some animals, such as rabbits, the appendix is rather large and helps in the digestion of cellulose from bark and wood, which rabbits eat. The appendix in humans is therefore a vestigial organ, which may have had uses for earlier types of ancestral human digestive processes before the evolution of *Homo sapiens*.

Pancreas

When food reaches the small intestine, the pancreas secretes pancreatic juices. When there is no food in the small intestine, the pancreas does not secrete its juices.

Insulin is another important hormone secreted by a group of cells within the pancreas called the islets of Langerhans, which are part of the **endocrine system**, rather than the digestive system. Insulin released into the bloodstream targets liver and muscle cells, and allows them to take excess sugar from the blood and store it in the form of glycogen.

KEY TERMS

Amylase—A digestive enzyme found in saliva and the pancreas that breaks down carbohydrates to simple sugars.

Bile—Liquid produced in the liver and stored in the gallbladder that emulsifies fats.

Gastric juice—Digestive juice produced by the stomach wall that contains hydrochloric acid and the enzyme pepsin.

Gastrin—A hormone produced by the stomach lining in response to protein in the stomach that produces increased gastric juice.

Helicobacter pylori—Recently discovered bacteria that live in gastric acids and are believed to be a major cause of most stomach ulcers.

Lower esophageal sphincter—A strong muscle ring between the esophagus and the stomach that keeps gastric juice and even duodenal bile from flowing upwards out of the stomach.

Lymphatic system—The system that produces, transports, and filters lymph throughout the body. It also transports fats, proteins, and some vitamins to the blood system.

Mucosa—The digestive lining of the intestines.

Nutrients—Vitamins, minerals, proteins, lipids, and carbohydrates needed by the body.

Peristalsis—The wavelike motion of the digestive system that moves food through the digestive system.

Villi—Fingerlike projections found in the small intestine that add to the absorptive area for the passage of digested food to the bloodstream and lymphatic system.

Common diseases and disorders

Several disorders of the esophagus are esophagitis, esophageal spasm, and esophageal **cancer**. Esophagitis (heartburn) is an inflammation of the esophagus usually caused by the reflux of gastric acids into the esophagus and is treated with antacid (alkalis). Esophageal spasm is also caused by acid reflux. Esophageal cancer can be caused by smoking and is generally fatal.

Disorders of the stomach include hiatal hernia, ulcers, and gastric cancer. A hiatal hernia occurs when a portion of the stomach extends upwards into the thorax through a large opening in the diaphragm. It is a condi-

tion that commonly occurs in people over the age of 50. Stomach ulcers are sores that form in the lining of the stomach. They may vary in size from a small sore to a deep cavity, surrounded by an inflamed area, sometimes called ulcer craters. Stomach ulcers and ulcers that form in the esophagus and in the lining of the duodenum are called peptic ulcers because they need stomach acid and the enzyme pepsin to form. Duodenal ulcers are the most common type. They tend to be smaller than stomach ulcers and heal more quickly. Ulcers that form in the stomach lining are called gastric ulcers. About 4 million people have ulcers, and 20% of those have gastric ulcers. Those people who are at most risk for ulcers are those who smoke, are middle-age and older men, are chronic users of alcohol, and those who take anti-inflammatory drugs, such as aspirin and ibuprofen. It is believed that about 80% of stomach ulcers may be caused by the bacterial **infection**, while about 20% may be from other causes, such as the use of anti-inflammatory medicines.

The most common liver disorder in the United States and other developed countries is cirrhosis of the liver. The main cause for this disease is **alcoholism**. Cirrhosis is characterized by the replacement of healthy liver cells by fibrous tissue. The replacement process is gradual and takes a period of two to 10 years to complete. There is no cure for the disease. Symptoms may not be noticed in its early development, but in its advanced stages there are a number of symptoms and the condition can lead to **coma**. Close medical attention is required to treat the disease.

Another common liver disorder is hepatitis. It is an inflammation of the liver caused by **viruses**. The most noticeable symptom of this disease is **jaundice**, that is, the skin, eyes, and urine turn yellow. The nine viruses known to cause hepatitis include hepatitis A, B, C, D, and E; the recently discovered F and G viruses; and two herpes viruses (Epstein-Barr and cytomegalovirus).

Gallstones may form in the gallbladder. If the amount of cholesterol in the bile acids increases or the amount of acid decreases, then some of the cholesterol will settle out of the acid to form gallstones that accumulate and block the ducts to the gallbladder. Infection in the gallbladder may lead to gallstones. Gallstones may be in the gallbladder for years without giving any signs of the condition, but when they obstruct the bile duct they cause considerable **pain** and inflammation. Infection and blockage of the bile flow may follow. Surgical removal of the gallbladder may be necessary to treat this condition. Since the liver both produces and stores sufficient amounts of bile, the loss of the gallbladder does not interfere with the digestive process provided fat intake in the diet is regulated. If the gallstones contain mainly cholesterol, drug treatment for the stones may be possible. But if there is too much other material in the gallstones, sur-

gery may still be necessary. Even after being treated successfully by drugs and diet, the condition can return. The drug treatment takes years to dissolve gallstones.

If food gets trapped in the appendix, an irritation of its membranes may occur leading to swelling and inflammation, a condition known as **appendicitis**. If the condition becomes serious, removal of the appendix is necessary to avoid a life-threatening condition if it were to rupture.

When the pancreas does not produce sufficient insulin to store dietary sugar, the blood and urine levels of sugar reach dangerous levels. **Diabetes mellitus** is the resultant disease. Mild cases can be controlled by a properly regulated diet, but severe cases require the regular injection of insulin.

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Crystal Heather Kaczowski, MSc.

Diphenhydramine *see* **Antihistamines**

Diplegia *see* **Paralysis**

Disease transmission

Definition

Disease transmission is the means by which contagious, pathogenic microorganisms are spread from one person to another.

Description

There are four major pathways by which pathogenic organisms may be spread to an individual: contact transmission, airborne transmission, vehicle transmission, and vector transmission.

Contact transmission

Infectious particles may be spread through direct or indirect contact with an infected individual, animal, or inanimate object. Direct contact refers to instances in which there is direct person-to-person spread of a disease. This occurs in the case of sexually transmitted diseases (STDs), when the genitals of one individual come into direct contact with the genitals of a person suffering from an STD such as herpes simplex virus (HSV). Contact of an uninfected person with infected **wounds** or **blood** may result in direct transmission, such as in the case of human **immunodeficiency virus** (HIV), if he/she is not protected by **universal precautions**.

A very common form of direct contact transmission occurs when infectious particles in the form of airborne droplets are expelled by an infected individual by sneezing or coughing and inhaled by another individual. Expelled droplets may travel for several meters before falling and therefore are easily spread to surrounding individuals. Examples of diseases that are caused by inhalation of infectious droplets are **influenza** (caused by the influenza virus) and **tuberculosis** (caused by the bacterium *Mycobacterium tuberculosis*).

Indirect contact results in the transmission of infectious particles from person to person via an intermediary carrier. Inanimate objects such as eating utensils, medical instruments, or equipment used in food preparation may become contaminated with a pathogenic microorganism and in turn spread the disease to other individuals. Infected needles may be the source of indirect transmission of pathogens between intravenous drug users. The hands of a health care worker may also cause the transmission of infectious particles from patient to patient if adequate handwashing practices are not enforced.

Organ transplantation presents a unique mode by which disease may be transmitted. Microorganisms that have disseminated to the donor organ may be transplanted to the recipient and subsequently cause disease. For example, hepatitis C virus (HCV) may be transmitted by **liver** transplantation if the donor organ is infected. Similarly, transmission of cytomegalovirus (CMV) from infected donor **kidneys** may occur.

KEY TERMS

Cleaning—The physical removal of microorganisms from an object, usually with water with or without a detergent.

Disinfection—Treatment which destroys most microorganisms from an object.

Droplet nuclei—Tiny particles on which microorganisms may be carried in airborne transmission.

Sterilization—The complete removal of all living microorganisms from an object or fluid.

Universal precautions—An infection-control technique designed to prevent the transmission of blood-borne diseases. These guidelines were initially developed by the Centers for Disease Control in 1987.

Airborne transmission

Airborne transmission differs from droplet transmission in that infectious particles are carried on tiny particles called droplet nuclei and may remain suspended or carried in the air for hours or days. These aerosolized particles may be widely dispersed before settling, therefore increasing the chance that they will be inhaled. Organisms that survive well under dry conditions (e.g. *Staphylococcus aureus*) are often spread by the airborne route.

There are many ways in which infectious microorganisms remain airborne. Droplet nuclei may be dispersed by ventilation and respiratory equipment, such as nebulizers, humidifiers, and air conditioners. *S. aureus* may be shed on skin scales from contaminated skin. *Mycobacterium tuberculosis* may be transmitted by droplet or airborne transmission and may survive for years in dust particles. Other organisms may be transmitted by disrupted soil or dried fecal matter.

Vehicle transmission

The spread of infectious agents through a common reservoir such as food or water supply is referred to as vehicle or common supply transmission. Food products may become contaminated after being handled by unwashed hands or processed by unclean equipment. Cattle infected with bovine spongiform encephalopathy (BSE, also known as mad cow disease) may cause **Creutzfeldt-Jakob disease** in humans who consume the cow's nervous system tissue. Water may be contaminated by infected feces, urine, or other body fluids, and diseases can be spread by drinking or bathing in this contaminated

water. For example, the diarrheal disease cholera (caused by the bacterium *Vibrio cholerae*) is often spread by drinking water contaminated by infected fecal matter.

The blood supply is another means of vehicle transmission. Donated blood may be infected with any number of microorganisms (HIV, HCV, etc.) that could be transmitted upon transfusion. Contaminated drugs or intravenous fluid supplies at hospitals may also result in vehicle transmission of disease.

Vector transmission

Vector transmission occurs when an insect, arthropod, or rodent is the source of **infection**. Often the source of infection is an animal reservoir and the vector serves as an intermediate in the chain of infection. In the case of Lyme disease, the vector is a deer tick that transmits the spirochete *Borrelia burgdorferi* from deer to humans. **Malaria** is spread by the bite of female *Anopheles* mosquitoes infected with the protozoan *Plasmodium*. Rodents may also act as a vector—hantavirus infects many species of wild mice without causing disease but it causes disease in humans who inhale virus particles in aerosolized feces or urine.

Role in human health

There are numerous practices that can be adopted in a home, business, or health care setting in order to reduce the risk of disease transmission. These include:

- **Handwashing:** Good hand hygiene is the simplest and most effective method for preventing hospital-acquired (nosocomial) infections. Antiseptic agents that have both detergent and antimicrobial effects are recommended.
- **Food preparation:** Common causes of food contamination are *Salmonella*, *Staphylococcus aureus*, and *Clostridium perfringens*. To reduce the risk of food-borne illness, it is recommended that food be cooked to a temperature of 74°C (165°F) or greater and then stored at 4°C (40°F) or cooler.
- **Waste disposal:** Serious enteric (intestinal) diseases are common in less developed countries where adequate drainage and treatment of sewage is not available. For example, cholera is often spread in areas where there is no clean water supply or sanitary disposal of sewage.
- **Sterilization:** An object is sterile when it is free of living organisms. There are multiple techniques that can be used to sterilize an object or fluid, including heat (moist or dry), irradiation, chemical treatment, or filtration. It is almost always recommended that critical items (those that enter normally sterile areas of the body) be sterilized.

- **Cleaning and disinfecting:** Cleaning is the physical removal of microbes from an object, while disinfection is defined as treatment to destroy microorganisms (although this does not normally lead to sterile conditions). Semicritical or noncritical items (those that do not enter sterile areas of the body) may be cleaned or disinfected based on the degree of risk of infection.
- **Protective barriers:** The Centers for Disease Control and Prevention (CDC) recommend that universal precautions be used by all health care workers in contact with the body fluids of patients. These precautions include the following: wearing gloves when in contact with the blood, body fluids, mucous membranes, or non-intact skin of patients; wearing masks and/or protective eyewear during procedures that are likely to generate droplets of blood; and placing all disposable sharp items (needles, scalpel blades, etc.) in puncture-resistant containers for disposal.

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Stéphanie Islane Dionne

Dislocations and subluxations

Definition

Dislocation is the displacement of bones that form a joint. A joint is where two or more bones meet. In a dislocation, the surfaces of the bones that normally articulate with each other (i.e., join together to allow movement) no longer line up correctly, and none of the joint surfaces are touching. Subluxation is a partial dislocation, so some contact remains between the joint surfaces.

Description

Ligaments and joint capsules are tough bands of connective tissue that hold the bones together. Muscles and tendons also help strengthen joints. Any event that subjects a joint to unusual force may cause a dislocation by stretching and tearing these supporting structures. This trauma allows one or more of the bones to go out of alignment, so that the articular (joint) surfaces of the bones no longer have their correct relationship with each other. A dislocation may affect any size joint in the body. The most common dislocations of the major joints involve the shoulder, patella (i.e., kneecap), and elbow. The process of restoring the bones to their correct alignment is known as reduction.

Several important problems that may arise from a dislocation require urgent attention. First, the injury is almost always very painful until the dislocation is reduced. Second, the deformity produced by the dislocation may stretch, kink, or tear adjacent major **blood vessels** or nerves. This effect on the neurovascular structures may severely threaten the circulation or nerve function in the more distal part of the limb, and may cause irreversible damage if not corrected in time. Complete dislocation of the knee (i.e., not just the kneecap) is especially dangerous in this regard. A different problem, which particularly affects the hip, is that part of the bone may receive its normal **blood** supply through the joint itself; when the joint dislocates, that part of the bone may lose its blood supply and become ischemic. Finally, hemorrhage and swelling progressively develop in the joint and the surrounding structures, so relocating the bones may become more difficult as time elapses. For all these reasons, prompt reduction of a dislocation is important.

Physicians describe a dislocation by referring to the movement of the more distal of the bones involved. Thus, an anterior dislocation of the shoulder is one in which the humerus shifts anteriorly with respect to the shoulder socket. Additionally, a dislocation may be open or closed.



This x ray shows the dislocation between two bones in a finger. (Photo Researchers, Inc. Reproduced by permission.)

This refers to the skin overlying the joint, meaning that an open injury is one in which the joint surfaces are exposed to the environment outside the body. An open injury creates a serious risk of bacterial **infection** of the joint. In a closed dislocation the skin remains intact.

Causes and symptoms

Common causes of dislocations and subluxations include **falls**, motor vehicle accidents, sports, and horse-play. These activities may apply isolated or combined forces such as stretching, twisting, and compression to the affected joint. The force involved may be as minor as yawning, which may allow the mandible to slip out of the temporomandibular joint. Conditions that predispose to dislocation include:

- shallow or abnormally formed joints
- joints weakened by disease or previous dislocation

- previous joint replacement surgery
- medical diseases that contribute to falls

Diagnosis

History

A thorough history is important to determine:

- the circumstances that led to the injury
- the time at which the injury occurred
- the type of force applied to the joint
- the likelihood of other associated injuries
- other medical and orthopedic history
- medications and allergies
- use of alcohol and illicit drugs
- time of the last oral intake
- tetanus status, if there are any open wounds

Physical examination

The examination must always start with the ABCs of resuscitation: airway, breathing, and circulation. Doctors and nurses must not allow a painful, deformed joint to distract them from potentially life-threatening injuries to the head, neck, chest, or abdomen. The examination of a dislocated joint typically will show deformity, tenderness, and resistance to movement. There may not be visible swelling. The distal neurovascular examination is very important—a dislocation that causes loss of the pulse in a limb is a far greater emergency than one in which the circulation is intact. Also, later exams will determine whether efforts to reduce the dislocation have affected the neurovascular function. The nurse must frequently inspect the injured limb for color, pulse, and function of motor and sensory nerves.

X-ray studies

Standard x-ray pictures of a joint usually will show a dislocation, and may show the additional presence of a fracture or other injury. Occasionally, special views or even advanced techniques such as computerized tomography (CT) may be necessary to demonstrate the problem.

Shoulder dislocation

A shoulder dislocation is a condition in which the head of the upper arm bone (humerus) is dislocated from the socket (glenoid). It can dislocate forward, backward, or downward. The injury is extremely painful, and may happen when throwing an object forcefully. The affected arm will be put in a sling, and instructions for the care of

the injury will be given to the patient. The area should be iced three or four times every day, and the shoulder should be exercised to speed healing and prevent reinjury in the future.

Shoulder separation

A different condition that may be mistaken for a dislocation is acromioclavicular separation, often called AC separation or shoulder separation. This is technically a sprain, involving the stretching and tearing of ligaments that hold the tips of the acromion (i.e., part of the scapula) and the clavicle near each other. Shoulder separation typically results from a direct blow to the top of the shoulder, often in a young man, as may occur in contact sports or a motorcycle accident. The injury is painful, the patient will not want to move the shoulder, and the shoulder may lose its normal contour. The part of the shoulder just beyond the tip of the clavicle will be very tender. Regular x-ray pictures may not demonstrate a widening of the space between these two bony areas.

Knee dislocation

A patellar or patellofemoral dislocation (dislocation of the knee cap) is another common injury. In this condition, the knee cap moves laterally (to the outside of the leg) due to sideways motion of the lower leg while the upper leg is stationary. The injury will present with swelling and **pain** in the knee area. On palpation, the patella is discovered to be in the wrong position. Weakness of the joint makes it more susceptible to reinjury, and certain exercises may be prescribed to strengthen the area. Patellar injury also makes a person more likely to develop arthritis in the joint.

Nursemaid's elbow

Another injury, common only in children between the ages of one to four, is subluxation of the radial head, or Nursemaid's elbow. This condition may also cause damage to the annular ligament. The case of Nursemaid's elbow demonstrates some of the challenges and pitfalls of diagnosing dislocation or subluxation. The cause is a simple, direct pull on the outstretched hand or wrist of a small child; this may occur when dangling a toddler by the hands in play, or when lifting a child who has fallen. The pulling action causes the head of the radius to move slightly out of position at the elbow. Often the caregiver may not associate such an innocent act with the onset of the problem. The child keeps the arm still against the body and cries if someone moves it. Often, the caregiver and even the medical staff will mistakenly believe that the problem lies in the wrist or the shoulder. The nurse and doctor must question the caregiver in detail about the

events leading to the onset of pain. Then, a careful examination will show that even slight supination of the forearm, which rotates the radius, is the motion that causes pain and resistance. X-ray studies are of little use in this condition, because the head of the radius is not displaced enough to appear abnormal.

Treatment

Initial treatment

Immediate treatment of a dislocation involves splinting the affected area. Splinting diminishes pain, protects the joint and nearby structures from further injury, and assists in transporting the patient. The patient may effectively splint the joint by supporting it with the hand; otherwise, the initial care provider may use pillows, a sling, folded cardboard, or other handy material to fit around the area. Application of ice helps control swelling and pain. The patient must receive nothing by mouth, in case anesthesia is necessary. Care providers should remove any rings or other constricting items distal to the site of injury. The patient will appreciate prompt medication for pain.

Emergency department reduction

Successful reduction of many dislocations and subluxations is possible in the emergency department (ED). Often, the physician will order intravenous (IV) medications such as narcotics (i.e., fentanyl) or morphine sulfate (Morphine) and benzodiazepines (i.e., lorazepam [Ativan] or midazolam [Versed]) to relieve pain, sedate the patient, and relax the surrounding muscles. Then the physician will employ a suitable technique of manipulating the joint in order to bring the bones back into alignment.

Operative reduction

Reduction in the ED is not always successful, sometimes due to the patient's severe pain or **anxiety**. In other cases, swelling and entrapment of structures around the joint prevent the bones from returning to their proper position. In these instances, the patient will require **general anesthesia** in the operating room (OR). Also, in cases of open dislocation, the orthopedist usually will take the patient to the OR in order to thoroughly flush contamination from the joint.

Post-reduction care

The pain and limitation of joint movement will improve substantially after successful reduction. After any manipulation the nurse and physician must recheck and document the neurovascular function in the limb. In almost all cases the physician will request repeat x-ray studies in order to demonstrate that the reduction was

KEY TERMS

Anterior—Toward the front of the body.

Benzodiazepines—The class of drugs related to diazepam (Valium), used to relax muscles and cause sedation.

Clavicle—The collarbone.

Distal—Farther from the center of the body.

Humerus—The arm bone, connecting the shoulder and the elbow.

Ischemic—Suffering from lack of arterial blood supply.

Narcotics—The class of drugs related to morphine, used to relieve pain.

Neurovascular—Pertaining to the function of nerves and blood vessels.

Prosthetic—Referring to an artificial part of the body.

Radius—The bone of the forearm which joins the wrist on the same side as the thumb.

Reduction—The restoring of bones to their correct alignment.

Scapula—The shoulder blade.

Splinting—Preventing movement of a joint.

Supination—The twisting motion of the forearm, wrist, and hand that turns the palm upward.

Temporomandibular—Relating to the meeting point of the skull and the lower jaw.

successful. The physician will usually order pain medicine and a splint or support for the injured area. Most patients will be able to go home after reduction of a dislocation, although a patient who receives heavy sedation or anesthesia may require several hours of recovery before discharge. The nurse will need to instruct the patient and caregivers regarding:

- allowable movement of the injured area
- proper application of a splint or other support
- use of ice (**Heat treatments** are contraindicated in acute and subacute stages.)
- dosing and side effects of medications
- warning signs of impending problems with neurovascular function
- plans for follow-up appointments

Prognosis

Almost all patients who have a dislocation will need follow-up with an orthopedist. The injured ligaments and other joint structures may require many weeks to heal. Exercises and **physical therapy** will help improve function and decrease pain. Recurring dislocation or persistent loss of function may lead to surgical reconstruction, or even replacement of a joint.

Numerous factors influence the ultimate outcome of a dislocation. These include:

- extent of the original injury to the joint
- presence of associated injuries
- time delay to reduction of the dislocation
- the patient's prior overall fitness as well as previous function of the affected joint
- the patient's motivation to **exercise** and strengthen the injured area
- the patient's ability to modify behavior and avoid re-injury

For some patients, especially athletes, decrease in limb function and time lost from normal activities may jeopardize career prospects and future earning potential. The patient, family, or coaches may put pressure on the doctor and support staff for a rapid and complete recovery, although this may not always be possible.

Health care team roles

Emergency medical technicians perform initial rescue, begin to stabilize the patient, splint the injured area, and transport the patient to the hospital. The nurse receives the patient at the ED, performs further assessment, and orders x-ray tests directly or after consulting with the physician, depending on local policies. Later, the nurse carries out orders for medications and other treatments as directed by the physician, monitors the patient throughout the hospital stay, and prepares the patient for discharge. The aide assists the nurse.

A radiology technician performs the x-ray studies ordered by the doctor or nurse. Later, a social worker may help coordinate care after discharge. The physical therapist works to rehabilitate the patient through exercise, massage, and other treatments. A certified athletic trainer (ATC) is sometimes employed in an effort to reduce the possibility of repeated injury in susceptible persons.

Prevention

Prevention of dislocations and subluxations starts with awareness of inherently dangerous activities (e.g., riding motorcycles, climbing ladders, consuming alcohol) and avoidance of behavior that may cause specific injuries (e.g., crossing the legs for prosthetic hip dislocation, pulling toddler by hand for Nursemaid's elbow). Participants should use appropriate protective equipment for work or sports, maintain good overall fitness, and allow sufficient time for healing of a previously injured body part before resuming full activity.

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Diverticulitis see **Diverticulosis and diverticulitis**

Diverticulosis and diverticulitis

Definition

Diverticulosis is a condition in which the inner layer of the colon herniates (bulges out) through the outer, muscular layer, creating pouches called diverticula. Diverticulitis refers to inflammation and **infection** in one or more diverticula.

Description

Diverticula tend to occur most frequently in the last segment of the **large intestine**, the sigmoid colon. They occur with decreasing frequency toward the beginning of the colon. The chance of developing diverticula increases with age, so that by the age of 50, about 20–50% of all people will have some diverticula. By the age of 90, virtually everyone will have developed some diverticula. Most diverticula measure about 3 mm (0.19 inches) to just over 3 cm (1.18 inches) in diameter. Larger, or giant diverticula, are extremely rare, but may measure as large as 15 cm (5.9 inches) in diameter.

Causes and symptoms

Diverticula are believed to be caused by overly forceful contractions of the muscular wall of the large intestine, often caused by straining to produce a bowel movement. As areas of this wall spasm, they become progressively weaker, allowing the inner lining to bulge through. The anatomically weakest areas of the intestinal wall occur next to **blood vessels** which course through the wall, so diverticula commonly occur in this location.

Diverticula are most common in the developed countries of the West (North America, Great Britain, northern and western Europe). This is thought to be due to the diet of these countries, which tends to be low in fiber. This produces smaller volumes of stool. In order to move this smaller stool along the colon and out of the rectum, the colon must narrow itself significantly, and does so by contracting forcefully. This causes an increase in pressure, which, over time, weakens the muscular wall of the intestine and allows diverticular pockets to develop.

The origin of giant diverticula development is not completely understood; one theory involves gas repeatedly entering and becoming trapped in an already existing diverticulum, causing it to stretch and expand.

The great majority of people with diverticulosis will remain symptom-free. Many diverticula are incidentally discovered during examinations for other conditions of the intestinal tract.

Some patients with diverticulosis have symptoms such as constipation, cramping, and bloating. It is unclear whether these symptoms are actually caused by the diverticula themselves, or whether some other gastrointestinal condition, such as irritable bowel syndrome, might be responsible. Because many diverticula develop in areas near **blood vessels**, one serious, although infrequent, risk of diverticulosis is intestinal bleeding. Seventy-five percent of such bleeding episodes occur in diverticula located on the right side of the colon. About 50% of the time the bleeding will stop on its own.

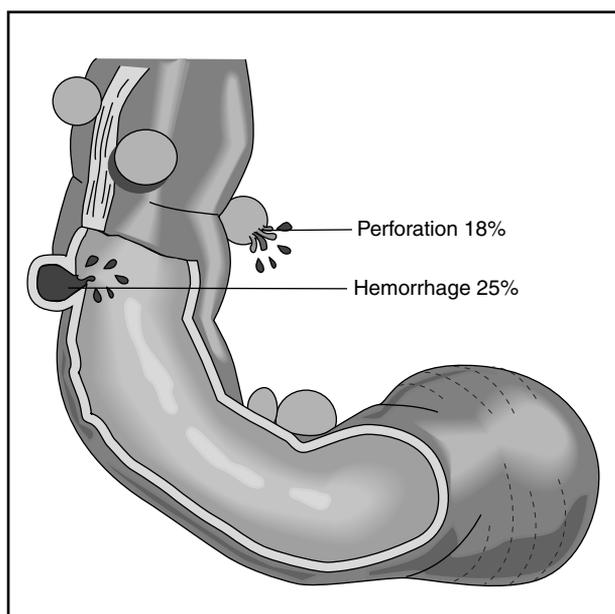


Illustration of diverticula in the sigmoid colon. Diverticulosis is almost always located in the descending or sigmoid colon. (Delmar Publishers, Inc. Reproduced by permission.)

One of the most common and potentially serious complications of diverticulosis is inflammation and infection of a particular diverticulum, a condition called diverticulitis. Diverticulitis is usually found in the sigmoid colon, the final segment of the large intestine that empties into the rectum where most diverticula are found. Older adults have the most serious complications from diverticulitis, although very severe infections also may occur in patients under the age of 50. Men are three times as likely as women to be stricken with diverticulitis.

Diverticulitis is believed to occur when a hardened piece of stool, undigested food, and **bacteria** (called a fecalith) becomes lodged in a diverticulum. This blockage interferes with the blood supply to the area, and infection sets in.

The patient with diverticulitis experiences **pain** (especially in the lower left side of the abdomen) and **fever**. In response to the infection and the irritation of nearby tissues within the abdomen, the abdominal wall muscles may begin to spasm. About 25% of all patients with diverticulitis have some rectal bleeding, although this rarely becomes severe. Abscesses (pockets of infection) may appear within the wall of the intestine, or even on the exterior surface of the intestine. When a diverticulum weakens sufficiently, and is filled to bulging with pus, a perforation in the intestinal wall may develop. When the infected contents of the intestine spill into the abdomen, peritonitis may occur. Other complications of

diverticulitis include the formation of fistulas and colonic strictures.

Diagnosis

The majority of diverticula do not cause any symptoms, and are often found during an examination being performed for some other medical condition. When diverticula are suspected because a patient begins to have sudden rectal bleeding, the location of the bleeding can be identified with **colonoscopy**. In this procedure a colonoscope, a small, flexible tube, is inserted through the rectum and into the colon. The tip of the scope has a fiber-optic camera, which allows the view through this colonoscope to be projected onto a television screen. The operator can introduce the colonoscope through the entire colon to find the source of the bleeding.

Angiography can also trace the source of intestinal bleeding, although it is used less often. It involves inserting a tiny tube through the femoral artery in the groin, and advancing it into one of the major arteries that supplies the colon. Contrast medium that will appear on x-ray films is injected, and the area of bleeding is located by looking for an area where the contrast is leaking into the lumen of the colon.

Diagnosis of diverticulitis is not difficult in patients with previously diagnosed diverticulosis. The presence of left-lower quadrant abdominal pain and fever in such patients should prompt suspicion of diverticulitis. Examination of the abdomen will usually reveal tenderness to touch, with the patient's abdominal muscles contracting strongly to protect the tender area.

During a rectal exam, the clinician may be able to feel an abnormal mass if there has been perforation and **abscess** formation at the site of the perforation. Palpating this mass may prove painful to the patient.

When diverticulitis is the suspected cause of the patient's symptoms, tests traditionally used to diagnose colonic disorders such as **barium enema** and endoscopy are contraindicated during the acute phase of the illness. The concern is that the increased pressure exerted on the colon during these exams may increase the likelihood of perforation of the diverticula. After several weeks, when the diverticulitis has resolved, these examinations may be performed in order to confirm the diagnosis and extent of the disease.

Treatment

Only about 20% of patients with diverticulosis experience symptoms that prompt them to seek medical care. Most people never know that they have diverticula. For those individuals with cramping pain and constipation

due to diverticulosis, the usual treatment involves increasing the fiber in the diet. This may be done with dietary supplements of bran or psyllium seed to increase stool volume, or by increasing the patient's intake of fruits, vegetables, legumes, and whole-grain foods. Bleeding diverticula are usually treated by bed rest, with blood transfusion if needed for hemorrhaging. In cases of very heavy hemorrhaging, medications to encourage clotting may be injected during the course of a diagnostic angiography.

While there are almost no situations when uncomplicated diverticulosis requires surgery, giant diverticula always require removal due to the high risk of infection and perforation. The usual treatment involves removing that portion of the intestine.

Treatment for uncomplicated diverticulitis usually requires hospitalization to rest the bowel. This involves keeping the patient from eating and drinking anything. The patient receives IV (intravenous) fluids and **antibiotics**. Some physicians treat mildly ill patients at home with a liquid-only diet and oral antibiotics.

The complications of diverticulitis need to be treated aggressively, because mortality (death rate) from perforation and peritonitis is quite high. Abscesses may be drained of their infected contents by inserting a needle through the skin of the abdomen and into the abscess. If this is unsuccessful, laparotomy (open abdominal surgery) is required to resect the segment of the colon that contains the abscess. Fistulas require surgical repair by removing a segment of the colon that contains the origin of the fistula, followed by immediate anastomosis (reconnection) of the two free ends of colon. Peritonitis requires open surgery. The entire abdominal cavity is irrigated (washed) with a warmed sterile saltwater solution, and the damaged piece of intestine is removed. Obstructions require immediate surgery to prevent perforation. Massive, uncontrollable bleeding is rare, and may require removal of part or all of the large intestine.

During any of these procedures, the surgeon must decide how much of the intestine must be removed. When the amount of intestine removed is great, it may be necessary to perform a **colostomy**, which involves pulling the end of the remaining intestine through the abdominal wall, to the outside. This bit of intestine is then fashioned so that a bag can be fitted over it. The patient's feces collect in the bag, because the intestine no longer connects with the rectum. The colostomy may be temporary, in which case another operation will be required to reconnect the intestine, after substantial healing has occurred. Otherwise the colostomy is permanent, and the patient must adjust to living permanently with the

colostomy bag. Most patients with colostomies are able to lead full, active lives.

Occasionally, a patient has such severe diverticular disease that the surgeon recommends removal of a portion of the colon as a preventive measure, to avoid the high risk of surgery performed after a complication has set in. It is recommended for patients identified as at very high risk of experiencing dangerous complications of diverticulosis. Such elective surgery may be recommended:

- for older patients who have had several attacks of diverticulitis
- for patients under age 50 who have had even one attack
- when treatment does not get rid of a painful mass
- when the intestine appears to be strictured on colonoscopic or barium enema (This could suggest the presence of cancer.)
- when certain patients begin to regularly experience painful urination or urinary infections (this suggests that there may be a connection between the intestine and the bladder)
- when there is any question of **cancer**
- when the diverticular disease appears to be progressing rapidly

Prognosis

The prognosis for people with diverticula is excellent, with only 20% of such patients ever seeking any medical care for their condition.

While diverticulitis can be a difficult and painful disease, it is usually quite treatable. Prognosis is worse for individuals who have coexisting medical problems, particularly those requiring the use of steroids, which increase the chances of developing a serious infection. Prognosis is also worse in the elderly.

Health care team roles

Diverticulitis and diverticulosis are often diagnosed by primary care practitioners and gastroenterologists during the course of examinations for other problems. In some instances, patients may require surgical intervention. Imaging studies to assist in diagnosis are performed by x-ray technologists; laboratory technologists may be involved in obtaining blood and stool samples for analysis.

Patient education

Nurses, dietitians, and nutritional counselors have important roles in teaching patients about dietary

KEY TERMS

Angiography—An x-ray study of the arteries in a particular part of the body. Angiography is often performed in order to localize internal bleeding.

Bowel obstruction—A blockage in the intestine which prevents the normal flow of waste down the length of the intestine.

Colonic stricture—Strictures that form after a bout of diverticulitis resolves, leaving scar tissue that narrows the colon lumen.

Colostomy—A procedure performed when a large quantity of intestine is removed. The end piece of the intestine leading to the rectum is closed.

Diverticula—Outpouchings in the large intestine caused when the inner, lining layer of the large intestine (colon) bulges out (herniates) through the outer, muscular layer.

Endoscopy—Examination of an area of the gastrointestinal tract by putting a lighted scope, usually bearing a fiber-optic camera, into the rectum, and passing it through the intestine.

Fistula—An abnormal connection formed between two organs which usually have no connection whatsoever (e.g. the colon and bladder).

Peritonitis—A potentially life-threatening infection and inflammation of the lining of the abdominal cavity, the peritoneum.

Sigmoid colon—The final portion of the large intestine which empties into the rectum.

changes to prevent these conditions. Nurses, social workers, and ostomy specialists also may be involved in educating patients pre- and postoperatively about **colostomy care**.

Prevention

While there is no absolutely certain way to prevent the development of diverticula, it is believed that high-fiber diets are beneficial. Foods recommended for their high-fiber content include whole-grain breads and cereals, and all types of fruits and vegetables. Most experts suggest that individuals consume about 20–35 grams of fiber daily. If this is not possible to achieve through diet, there are fiber products that can be mixed into 8 ounces of water or juice, and which provide about 4–6 grams of fiber per dose.

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Barbara Wexler

DNA see **Inheritance, principles of**

DNA test see **Genetic testing**

DNA typing

Definition

DNA typing is a laboratory procedure that detects normal variations in a sample of DNA (deoxyribonucleic acid). DNA typing is most often used to establish identity, parentage, family relationship and appropriate matches for transplantation of organs and tissues.

Description

DNA

DNA is a molecule that stores genetic information required for the development of the body and the control of cellular processes. Each strand of DNA is made of individual nucleotides that are joined together. Each nucleotide is made up of a phosphate group, a five-car-

bon sugar (deoxyribose), and an organic base. Adenine, thymine, guanine, and cytosine are the four bases found in DNA. The sequence of bases in DNA determines the genetic code of an individual. Every person excluding identical twins has a different sequence of bases.

The DNA sequence is made up of coding and non-coding regions. A coding region is a section of DNA, called an exon, that contains the instructions for the production of a particular protein. The primary structure of **proteins** is determined by the sequence of bases in the exons of a gene. Exons are located within the genes but are separated by non-coding regions called introns. Genes make up about 5% of human DNA and the other 95% consists of non-coding regions. The function of the non-coding regions is for the most part unknown.

Normal variations can occur in the DNA sequence of the coding and non-coding regions. Sequence polymorphism and length polymorphism are the two main forms of DNA variation. Sequence polymorphism results from differences in the sequence of bases at a particular locus. A locus is a specific location on a DNA molecule. Length polymorphism results from differences in the length of DNA at a particular locus. Differences in the length of the DNA are due to variations in the number of times that a certain sequence of bases is repeated. The number of times that a certain sequence is repeated at a specific locus will often vary between individuals. A locus that has a repeated unit of nine to ninety-eight bases is called a variable number tandem repeat locus (VNTR) or minisatellite. Loci that have a repeating unit of only two to seven bases are called short tandem repeats (STRs) or microsatellites. For example CAGACAGACAGA is an STR of four bases that is repeated three times.

Nuclear and mitochondrial DNA

Two strands of single stranded DNA wind together to form double stranded DNA in the form of a double helix. The DNA strands are held together by hydrogen bonds that form between the bases. Adenine joins with thymine and guanine joins with cytosine. Two sequences are said to be complementary if they have a sequence that allows them to join together to form double stranded DNA.

Most DNA is packaged with proteins to form microscopic structures called chromosomes. Chromosomes are found in the nucleus of each cell of the body and can be visualized under the **microscope**. Each cell of the body, except for the egg and the sperm cells, normally contains 22 pairs of chromosomes and two sex chromosomes (46 chromosomes in total). The egg and sperm cells each contain 23 chromosomes.

DNA is also found in the mitochondria. The mitochondria are energy producing organelles found in most cells. There are many mitochondria found in each cell. Each mitochondria contains one copy of circular DNA. Since there are many mitochondria in each cell, a lot of mitochondrial DNA may be present in only a small sample of cells. Mitochondrial DNA is found in the egg cells but not the sperm cells. Mitochondrial DNA is, therefore, only passed down from a mother to her offspring.

Methods of DNA typing for identity, parentage, and family relationships

RESTRICTION FRAGMENT LENGTH POLYMORPHISM (RFLP) ANALYSIS. RFLP analysis was the first technique used for forensic DNA typing. During RFLP analysis, DNA that has been isolated from a sample is cut into short sections by an enzyme called a restriction endonuclease. An enzyme is selected that will make a cut in the DNA at a specific sequence of bases on either side of a VNTR locus. This results in different sized fragments of DNA. Different people will have fragments of DNA of different lengths due to differences in the number of repeating units at a particular DNA locus. After the DNA is cut into pieces, the fragments are separated according to size by a process known as gel electrophoresis. DNA fragments are negatively charged at an alkaline pH owing to the phosphate groups. The smaller the fragment, the faster it will migrate to the positive electrode (anode). After separating the DNA fragments, the gel is soaked in a solution of sodium hydroxide and sodium chloride which separates the double stranded DNA into single stranded DNA, a process called denaturation. The single stranded DNA is transferred from the gel to a nylon membrane. A piece of DNA called a probe is added to the DNA that is affixed to the membrane. The probe will attach to a section of DNA on the membrane that has a complementary base sequence. The probe chosen corresponds to a specific locus that has a variable number of repeats containing the bases complementary to the probe. Either a fluorescent or radioactive material is bound to the probe so that it can be visualized. Either one or two bands will be visualized for each probe used. If the person has inherited the same length DNA fragment at a locus from both parents then only one band will be seen. If two different sized DNA fragments are inherited then two bands will be visualized. The DNA is analyzed using a panel of probes each specific for a different locus. A DNA type is made up of a pattern of different sized bands at different loci. The frequencies of the VNTRs that are inherited at each locus determines the probability of a DNA match.

POLYMERASE CHAIN REACTION (PCR). PCR based STR analysis is a more modern approach to DNA typing. The first step of the process is to isolate DNA from a

sample of tissue such as **blood** or semen. The isolated DNA, called the template, is mixed with a heat-stable form of DNA polymerase (e.g., Taq polymerase), deoxynucleotide triphosphates, and DNA primers. These reagents are suspended in a buffer and together are called the master mix. The template and master mix are added to a tube and the tube is placed into an incubator called a thermal cycler. The purpose of the thermal cycler is to control the temperature of each of the three phases of DNA amplification.

The first step in PCR is denaturation. This is accomplished by heating the mixture to 94°C, which separates the strands. After denaturation, the temperature of the thermal cycle is automatically lowered to 64°C. The primers are short sequences of DNA that can bind to one of the DNA strands on either side of the target sequence to be amplified. Four primers are required for each section of DNA that is being analyzed. The primers are selected so that they flank an STR region. The binding of the primers to complementary base sequences on the target DNA is called annealing, and requires a lower temperature. After the annealing step, the temperature is increased to 72°C, which is the optimal temperature for DNA polymerase. Once the primers have annealed, the DNA polymerase binds to single stranded DNA between the primers and fills in the sequence with the deoxynucleotide triphosphates. This results in synthesis of a new piece of double stranded DNA consisting of the STR locus and the primer regions. This process is called primer extension. After extension, the new double strands of target DNA are denatured by heating the mixture to 94°C again. After a suitable incubation, the temperature is lowered to 64°C to facilitate annealing of primers, and then is adjusted to 72°C for extension of new complementary strands. Each cycle increases the number of DNA pieces containing the STR locus. Each time this process is repeated the amount of target DNA doubles. After 20 cycles (about two hours) there will be over one million identical copies of the STR locus. DNA typing for identification, parentage and familial studies uses probes that encompass various STR loci. If a person has inherited the same number of repeats from his or her mother and father, then only one band will appear for that locus. If the person has inherited a different number of repeats from his or her mother and father, then two bands will be seen for that locus.

DNA typing to establish identity, parentage, and family relationship

DNA typing used for identification purposes and the establishment of parentage and family relationships looks for variation within the non-coding regions of the

DNA. It relies on the presence of length polymorphisms such as VNTRs and STRs.

DNA typing determines the number of times that a particular sequence is repeated at a particular locus. DNA typing usually analyzes the number of repeats at four or more separate loci. The loci chosen for DNA typing have a high degree of variability and are usually found on different chromosomes.

It is possible that two unrelated individuals will possess the same number of repeats at a particular locus. It is less likely, however, that two unrelated individuals will have the same number of repeats at a number of different loci. In order to determine the possibility that a match in DNA types occurred by chance, the frequency of the determined number of repeats in the individual's ethnic group is calculated. For example, if the frequency of the repeat number in the ethnic group is 1 in 10,000, then there is a 1 in 10,000 chance that the match occurred by chance. By using a number of different loci, one can decrease the chances that the match occurred by chance and increase the chances that the two DNA samples are from the same individual. While it is mathematically impossible to prove that two samples are identical using this procedure, it is possible to prove absolutely that two samples are not identical. This occurs when a different number of repeats is found at a locus.

Mitochondrial DNA typing may be performed if nuclear DNA typing is not successful or when there is insufficient nuclear DNA for typing. It is also sometimes used to help establish maternity. Variations in mitochondrial DNA are typically discovered by sequencing (determining the order of bases).

PARENTAGE AND FAMILY RELATIONSHIP. DNA typing used for establishment of parentage and family relationships uses either RFLP analysis or PCR based STR analysis. DNA typing is the method most often used to establish paternity. It may also be used to establish parentage in cases where neonates have been mistakenly switched in the nursery. DNA typing can be used to resolve immigration cases when family relationships are disputed.

The basis for DNA typing in parentage and family relationship cases is that each child inherits one of each chromosome from their mother and one of each chromosome from their father. The child should, therefore, inherit a set number of repeats at a particular locus from their mother and a set number of repeats at that locus from their father. At some loci they may inherit the same number of repeats from their mother and from their father. During parentage analysis the number of repeats found at different loci is compared between the child and the alleged parent. It is helpful, but not absolutely necessary,

to perform DNA typing on the known parent as a comparison. Sometimes the DNA of siblings and other family members will also be typed for comparison. If the alleged parent is the true biological parent, then at each locus analyzed, the child should have the same repeat number as the parent. Since a match can occur by chance it is necessary to calculate the frequency of the repeat number in the alleged parent's ethnic group. Usually when a match is found the chance of parentage is greater than 99%. For example a 1/1000 chance that the match occurred by chance corresponds to a 99.9% chance that the alleged parent is the true biological parent.

If the alleged parent's repeat numbers do not match with the child's repeat numbers then parentage can usually be ruled out. What can make this analysis tricky is that sometimes a small alteration can occur in the DNA of the child that is not present in the parent. This can cause the child to have a different repeat number than their true parent at a specific locus. It is therefore important that more than one loci be analyzed.

Forensic and non-forensic identification

Modern day DNA typing for identification purposes usually uses PCR and STRs rather than RFLP analysis. DNA typing can be used to help identify a victim of a homicide. The DNA type of the victim can be compared to the DNA types of alleged family members to see if there is a match. DNA typing has also been used to identify soldiers killed in battle. The U.S. Department of Defense has a collection of tissue samples from soldiers so that, if necessary, they can be identified through DNA typing.

DNA typing can also help to determine whether a suspect was at a particular crime scene. DNA can be isolated from tissue such as skin, blood, hair and semen left at the scene. The DNA type of the sample at the crime site can be compared to the DNA type of the suspect. If there is a difference in the DNA type at any locus then the DNA obtained is definitely not from the suspect. If the DNA type is identical at all loci then the probability that this occurred by chance must be determined.

Transplantation matches

DNA typing for transplantation matches looks at normal variation in the coding region of the DNA. DNA typing can be used to identify an appropriate match for a transplant such as a bone marrow transplant. A successful transplant requires a close match of human leukocyte (HLA) antigens between donor and recipient. The HLA antigens are proteins that are located on the surface of most cells. There are six subregions on chromosome number six that each contain at least one HLA locus. The

subregions are divided into two classes. HLA-A, HLA-B, and HLA-C comprise Class I and HLA-DR, HLA-DP, and HLA-DQ comprise class II. Each subregion has at least one gene that has a number of different genetic variants (allels). The HLA gene products mediate the recognition and the destruction of foreign cells such as **bacteria** and **viruses**. They also mediate the destruction (rejection) of transplanted cells that do not express the same HLA alleles as the recipient. Therefore, a transplant from a donor with very different HLA antigens is likely to be rejected by the body's **immune system**. Conversely, if the donor and recipient have a close HLA match then the transplant has a better chance of being successful.

DNA typing looks for characteristic sequence differences in the genes that produce the HLA antigens. For example, there are more than fifty HLA-A variants. Each HLA-A variant is produced by a different gene. The HLA variants inherited by an individual can be determined by extracting DNA from blood cells and using PCR to amplify the HLA loci. Specific primers or probes are used to identify the variants for each of the six subregions.

Viewpoints

Early use of DNA typing for forensic evidence was marred by technical difficulties. By the year 2001, however, DNA typing techniques had improved considerably and had become highly accurate tools for forensic evidence. DNA typing evidence is now widely used in most North American and European courts. The quality of the evidence is still dependent, however on the methodology used, the number of loci examined and the quality of the laboratory where the typing is performed. Contamination of the DNA sample collected from the crime site is also a concern if proper techniques are not followed.

The increasing use of DNA typing has led to the formation of databases that contain DNA typing information. DNA data banks of convicted criminals exist in each of the 50 states and in many other countries. The FBI has also created a national DNA data bank of convicted criminals called CODIS (combined DNA index system). These DNA data banks require convicted felons to donate blood samples for DNA typing prior to parole. The type of felonies for which DNA typing is required varies from state to state. It is anticipated that most laws will be amended to require DNA typing of all convicted felons. It is also possible that laws may be enacted to force all people arrested for a crime to donate a DNA sample to the database.

Many countries obtain DNA samples from ordinary citizens when trying to eliminate suspects of a particular

KEY TERMS

Amniocentesis—Prenatal testing performed at 16-20 weeks of pregnancy which involves inserting a needle through the abdomen of a pregnant mother and obtaining a small sample of fluid from the amniotic sack. Can be used to obtain a sample of the baby's cells for DNA typing.

Antibody—Protein produced by the body in response to the presence of a foreign antigen.

Antigen—A substance that induces an immune response.

Chorionic villus sampling (CVS)—Prenatal testing performed at 10-12 weeks of pregnancy which involves inserting a catheter through the vagina of a pregnant mother or inserting a needle through the abdomen of the mother and obtaining a sample of placenta. Can be used to obtain a sample of cells for DNA typing.

Chromosome—A microscopic structure, made of a complex of proteins and DNA, that is found within each cell of the body.

DNA (deoxyribonucleic acid)—The hereditary material that influences the development and functioning of the body.

Eugenics—A discredited movement which attempts to improve the human race by preventing the creation of offspring in individuals with undesirable traits and promoting the creation of offspring in those with desirable traits.

Forensic—Related to or used in the courts of law.

Gene—A functional segment of DNA that contains the instructions for the production of a particular protein. Each gene is found on a specific location on a chromosome.

HLA typing—The determination of the type of human leukocyte antigens possessed by an individual.

Locus—Specific physical location on a DNA molecule.

Nucleus—A membrane bound spherical structure that contains the chromosomes and is found in most cells.

Polymorphism—Genetic variation.

STR (short tandem repeats)—A locus of DNA that has a repeating unit of two to seven bases.

VNTR (variable number tandem repeats)—A locus of DNA that has a repeating unit of 9 to 98 bases.

crime. For example DNA samples may be collected on hundreds of men in a rural area where a sexual assault has occurred. Although citizens are not required by law to donate their DNA, it is likely that they experience a great deal of social coercion. The United States does not currently allow DNA typing of those who are not convicted of a crime. There are concerns, however, that the databases could be expanded to include all citizens and be used as a method of identification similar to a social security number.

Commercial databanks exist which store DNA samples or DNA typing results of children. If the child is later kidnapped then DNA samples obtained from such items as gum and licked stamps can be used to try and locate and identify the child. Some people would argue that these databanks are unnecessary since a child's DNA type can be deduced from that of other family members should it become necessary. This stored information could also be used later as evidence against the child. If the commercial data bank becomes bankrupt or changes ownership then there may be concerns about the control, availability and ownership of the DNA. In addition, issues of non-paternity can be discovered during this process.

The existence of DNA databanks raise concerns about privacy and discrimination. There is a concern that DNA typing may yield other unintended genetic information about the individual and his or her family. There has been some discussion about donating DNA samples that have been collected for forensic DNA typing to researchers. This research could yield very specific genetic information on the individual. There is a concern that the genetic information obtained could be used for discriminatory purposes. For example, the information could result in the discrimination of citizens by employers and health insurance companies.

Professional implications

DNA typing results often become evidence in a court of law. It is, therefore, important that health care professionals involved in collecting samples for DNA typing follow strict protocols that prevent contamination and insure that samples are obtained from the correct person. It is also important that a chain-of-evidence is established. A chain-of-evidence documents who has handled the evidence and when it was transferred to another person. A chain-of-evidence can help to demonstrate that evidence was not altered prior to its introduction in court. Often, laboratories that perform DNA typing for parentage have kits designed to insure that proper protocols are followed. They may also have designated blood collection centers that will obtain the samples required for DNA typing. Many hospitals have specific protocols,

kits, and chain-of-evidence procedures in place to insure that samples for DNA typing are collected and handled properly. In some cases special training programs are offered to health care professionals who are involved in collecting samples for DNA typing used as forensic evidence.

It is important that health care professionals try to help prepare their patients for paternity test results since the results can sometimes be unexpected and can often be quite devastating. It can be helpful to explore the motivation behind the testing and discuss the implications of possible test results. The limitations of the testing should also be adequately discussed. The quality of the laboratory chosen for paternity testing should also be evaluated.

Some health care professionals may be called upon to offer paternity testing prenatally. The patient needs to be informed about the risks of losing a normal **pregnancy** if prenatal testing methods such as **amniocentesis** and **chorionic villus sampling** are performed. It is also typically more expensive to perform paternity testing prenatally. Many patients when provided with complete information about prenatal paternity testing choose to have the tests performed after the child is born.

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Doctor-patient relationship see
Professional-patient relationship

Docusate see **Laxatives**

Doppler echocardiography see
Echocardiography

Doppler ultrasonography

Definition

Doppler ultrasonography, also called Doppler ultrasound, is a noninvasive diagnostic procedure that uses an ultrasound scanner to convert sound waves into images of **blood** flow in body tissue and organs. Doppler ultrasonography does not use ionizing radiation and is used for a variety of clinical applications.

Purpose

Doppler ultrasonography is used during an ultrasound examination to assess the direction, velocity, and turbulence of blood flow. It is frequently used in cardiac and vascular scanning to evaluate blood flow and diagnose abnormalities in flow. Cardiac applications include the detection of **heart** valve problems, the determination of arterial vessel narrowing (stenosis) or blockage, the diagnosis of congenital cardiac defects, and the evaluation of damage following **myocardial infarction** (heart attack). Vascular applications include the work-up of stroke patients, the assessment of blood flow in the major abdominal arteries, and the evaluation of vessels in the arms, legs, and neck. Vascular conditions that can be diagnosed using Doppler ultrasonography include deep vein thrombosis (DVT), a blocked carotid artery, blood clots, tumors with vascular involvement, and abdominal aortic aneurysm. Doppler ultrasonography can also be used to determine whether a patient is a candidate for a surgical or other interventional procedure, such as vascular grafting, or it can be used during and after cardiac and



A physician can monitor blood flowing through a patient's carotid artery using the Doppler technique. (*Science Source/Photo Researchers. Reproduced by permission.*)

vascular surgical procedures to assess blood flow and the success of the procedure. In obstetric ultrasound, Doppler ultrasonography is used to check fetal cardiac activity.

Doppler ultrasonography can be performed in a hospital radiology or cardiology department, a hospital vascular laboratory, at the patient's bedside, in the emergency department, in an operating room, or in an outpatient imaging center, depending on the patient's medical condition. Doppler ultrasonography is a noninvasive, safer, and faster alternative to x-ray **angiography**, which involves radiation exposure, the injection of a contrast dye, and catheterization of **blood vessels**, although ultrasound may not yield images that are as detailed as those from x rays during catheterization.

A new device introduced in 2000 combines Doppler ultrasonography with endoscopy. The Doppler ultrasound scanner is interfaced with an endoscopy system, and the Doppler ultrasound images can be simultaneously displayed with the endoscopic images on one monitor, like a picture-in-picture display. Clinical applications include the evaluation of ulcers and hemorrhaging, vascular abnormalities of the intestinal tract, and enlarged vessels in the digestive tract, as well as assessment during endoscopic surgical procedures.

Precautions

The test is widely used because it is noninvasive, uses no x rays, and gives excellent images. It is harmless, painless, and widely available.

Because smoking can cause constriction of blood vessels, patients should not smoke before an ultrasound examination of the blood vessels.

Description

Doppler ultrasonography is performed using an ultrasound scanner with Doppler imaging capabilities; most scanners used for general-purpose abdominal, cardiac, and vascular scanning are equipped with Doppler. Ultrasonography involves the use of sound waves above the level of human **hearing**, and works similarly to sonar or radar. Sound waves are transmitted through the body and echoed back to produce an image of the area of interest. Ultrasound waves used for diagnostic imaging are typically in the range of 2 to 10 megahertz (MHz).

Doppler ultrasonography uses the frequency shift caused by the Doppler effect to produce images of blood flow. The Doppler effect is a principle of physics involving light and sound; relative to an observer, the frequency of any light or sound wave will vary as the source of the wave approaches or moves away. With regard to medical ultrasound, the Doppler principle states that sound waves increase in frequency when they echo from objects (in this case, red blood cells) moving toward the transducer and decrease in frequency when they echo from objects moving away from it. This change in frequency, which is related to the velocity of the moving red blood cells, is then measured and used to determine blood flow velocity. Therefore, Doppler imaging allows the frequency of the speed of blood flow to be calculated relative to a computer marker placed by the sonographer.

There are several different modes of Doppler ultrasound. Most ultrasound scanners include both continuous- and pulsed-wave Doppler. Continuous-wave Doppler is the simplest mode, and is commonly used in cardiac studies for blood flow analysis. This mode receives flow information from all the moving reflectors in the path of the beam and can provide maximum velocity through the target area. Pulsed-wave Doppler allows the operator to select the area of interest for flow analysis using cursors superimposed on the 2-D image. Depth-selective information is obtained by acoustic pulses emitted from the transducer, allowing the precise location of the target area, as well as the flow, to be determined. Most ultrasound scanners also have color Doppler imaging capability, which superimposes color over moving structures on the gray-scale images. For example, red and

yellow in a blood vessel image indicate flow away from the probe, while blue and green indicate flow toward the probe. Color Doppler imaging can be used to identify areas of arterial narrowing. Another Doppler feature is power Doppler, which is more sensitive than color Doppler imaging and can produce images of structures not normally able to be depicted with ultrasound, for example, inflammation or signs of congenital heart disease in a fetus. Power Doppler mode may only be included on advanced ultrasound scanners.

During an ultrasound examination, the patient is positioned on a bed or table so the area to be imaged can be easily accessed. An acoustic coupling gel, a special gel that enhances the transmission of ultrasound waves, is spread on the skin over the area of interest. A handheld ultrasound probe with a transducer (a crystal that transmits and receives the sound waves) is placed on the skin and positioned appropriately to acquire images of the blood vessels. Usually gray-scale images, which use different shades of gray to indicate differences in the strength of echoes (echoes from blood are of lower strength and appear darker than surrounding tissue) are acquired first, and then the Doppler mode is selected to acquire Doppler images that are superimposed over the gray-scale images. The sonographer is able to use the scanner's computer to mark areas and calculate parameters of interest, such as blood flow velocity in vessels with narrowing or blockage. Ultrasound scanners are usually equipped with a videotape recorder or digital image acquisition system to record the Doppler examination, as well as a medical image printer for hard copies of still images.

Preparation

There is no special preparation needed for this test, other than removing clothing and jewelry covering the area to be imaged.

Aftercare

No special aftercare is necessary.

Results

A Doppler ultrasonography test that shows no restricted blood flow or other abnormalities is a normal finding.

Findings indicating restricted blood flow or other cardiovascular abnormalities are abnormal results. Disrupted or obstructed blood flow through the carotid artery or other neck arteries may indicate the person is at risk of having a stroke. Narrowed arterial flow or clots in

KEY TERMS

Angiography—During cardiac catheterization, the procedure of acquiring x rays of the heart and coronary arteries after injection of a radiopaque substance (often referred to as a dye or contrast agent).

Catheter—A flexible or preshaped curved tube, usually made of plastic, used to evacuate or inject fluids into the body. In cardiac catheterization, a long, fine catheter is inserted through a blood vessel into the chambers of the heart.

Doppler imaging—A mode of ultrasound imaging that uses the physics principle of the Doppler effect (sound frequency waves shift relative to the observer, allowing velocity measurement) to produce color or gray-scale images of blood flow velocity and heart motion.

Endoscopy—A minimally invasive procedure that uses a scope with a camera on the end to examine the inside of a body cavity or organ.

Grafting—Implantation of a biological or artificial portion of a blood vessel to repair the vessel and restore flow. Doppler ultrasound is used to evaluate the patency of the grafted area.

Noninvasive—Pertaining to a diagnostic procedure or treatment that does not require the skin to be broken or a body cavity to be entered.

Transducer—A device that converts electrical signals into ultrasound waves and ultrasound waves back into electrical impulses, also called a probe.

Ultrasound—Sound waves at high frequencies beyond the level of human hearing; frequencies of approximately 2 to 10 megahertz are often used for diagnostic imaging.

the legs may also be imaged. Abnormal findings are then used to plan further diagnostic tests and/or treatment.

Health care team roles

Doppler ultrasonography is performed by an ultrasonographer with special training in ultrasound techniques, particularly cardiac and vascular imaging. The sonographer should be a registered vascular technologist or a registered cardiac sonographer. A radiologist, cardiologist, or other physician experienced in ultrasound imaging techniques interprets the ultrasound examination results. During some examinations, the sonographer may

print out images and consult with the radiologist or cardiologist; alternatively the radiologist or cardiologist may perform some of the scanning.

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ORGANIZATIONS

American Institute of Ultrasound in Medicine. 14750 Sweitzer Lane, Suite 100, Laurel, MD 20707-5906. (301) 498-4100. <<http://www.aium.org>>.

American Registry of Diagnostic Medical Sonographers. 600 Jefferson Plaza, Suite 360, Rockville, MD 20852-1150. (800) 541-9754. <<http://www.ardms.org>>.

American Society of Radiologic Technologists (ASRT). 15000 Central Avenue SE, Albuquerque, NM 87123-2778. (800) 444-2778. <<http://www.asrt.org>>.

Society of Diagnostic Medical Sonography. 12770 Coit Road, Suite 708, Dallas, TX 75251-1319. (972) 239-7367. <<http://www.sdms.org>>.

Society of Vascular Technology. 4601 Presidents Drive, Suite 260, Lanham, MD 20706. (301) 459-7550. <<http://www.svt.net>>.

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Down syndrome

Definition

Down syndrome is the most common chromosome disorder and genetic cause of mental retardation. It occurs because of the presence of an extra copy of chromosome 21. For this reason, it is also called trisomy 21.

Description

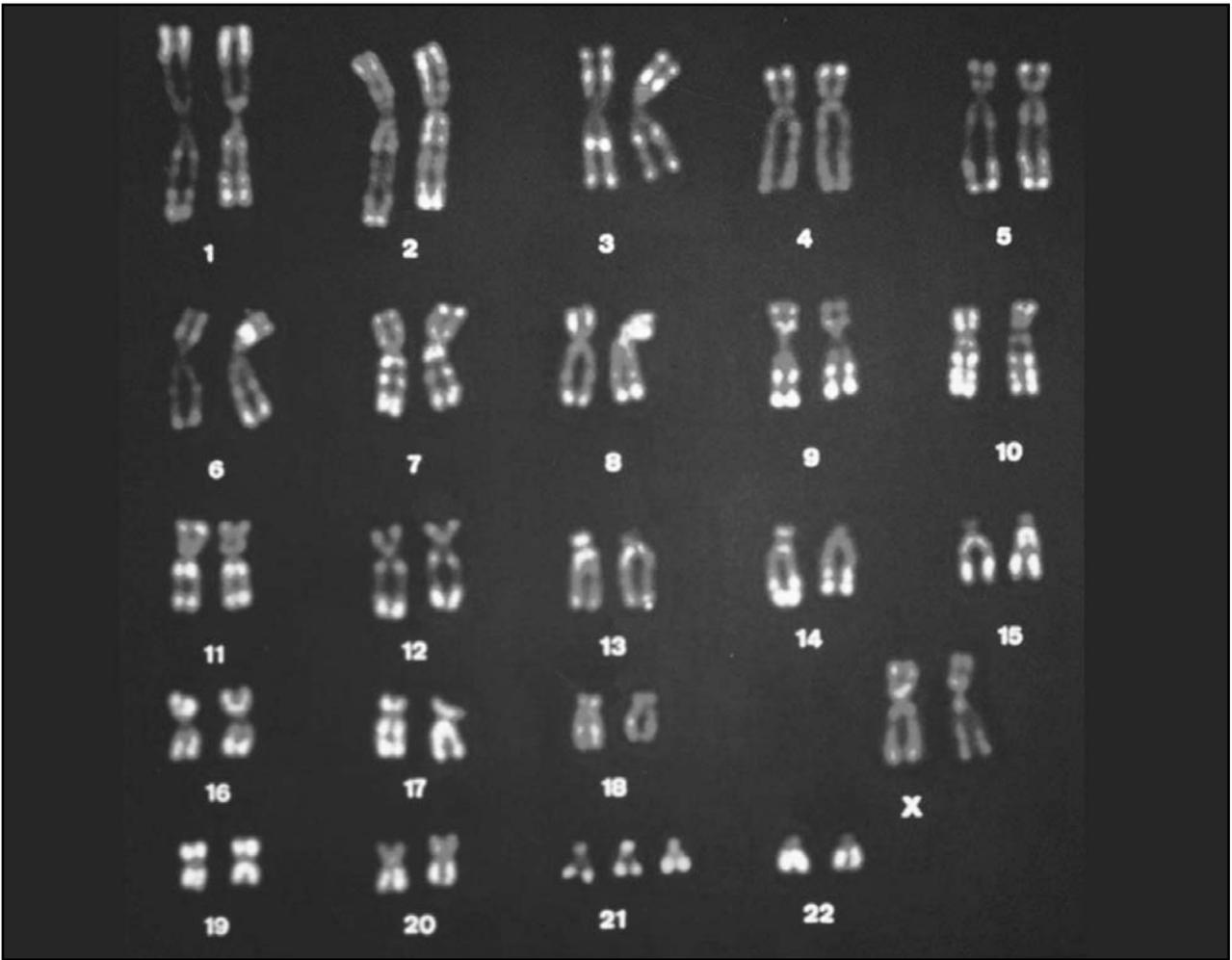
Chromosomes are the units of genetic information that exist within every cell of the body. Twenty-three distinctive pairs, or 46 total chromosomes, are located within the nucleus (central structure) of each cell. When the sperm cells from the father and egg cell from the mother are formed, they both undergo a reduction of their total number of chromosomes from 46 to 23. This process is called meiosis. When a baby is conceived by the combination of one sperm cell with one egg cell, the baby receives 23 chromosomes from each parent, for a total of 46 chromosomes. Occasionally, an error occurs in the reduction process. Instead of passing on 23 chromosomes to the baby, a parent will pass on 24 chromosomes. This event is called non-disjunction and occurs in 95% of Down syndrome cases. The baby, therefore, receives an extra chromosome at conception. In Down syndrome, this is an extra chromosome 21. The total number of chromosomes in individuals affected with Down syndrome is 47 instead of 46.

In approximately 1-2% of Down syndrome cases, the original egg and sperm cells contain the correct number of chromosomes, 23 each. The problem occurs sometime shortly after fertilization; during the phase where cells are dividing rapidly. One cell divides abnormally, creating a line of cells with an extra copy of chromosome 21. This form of genetic disorder is called mosaicism. An individual with this type of Down syndrome has two types of cells: those with 46 chromosomes (the normal number), and those with 47 chromosomes (as occurs in Down syndrome). Individuals affected with this mosaic form of Down syndrome generally have less severe signs and symptoms of the disorder.

Another relatively rare genetic accident that causes Down syndrome is called translocation. During **cell division**, chromosome 21 somehow breaks. The broken off piece of this chromosome then becomes attached to another chromosome. Each cell still has 46 chromosomes, but the extra piece of chromosome 21 results in the signs and symptoms of Down syndrome. Translocations occur in about 3 to 4% of cases of Down syndrome.

Genetic profile

Down syndrome is usually the result of an extra copy of chromosome 21 (trisomy 21). As described earlier, Down syndrome may occur because of: nondisjunction within the sperm, or more commonly, the egg cell; genetic mosaicism, which occurs after conception; or translocation, which also occurs after conception.



This chart shows the abnormality in chromosome 21 present in Down syndrome. (Account Phototake/NYC. Reproduced by permission.)

Once a couple has had one baby with Down syndrome, they are often concerned about the likelihood of future offspring also being born with the disorder. Women who are 34 and younger have a recurrence rate of 1% for having another Down syndrome child. Women who are 35 and older are at increased risk. The specific risk varies and increases as their age increases. When a baby with Down syndrome has the type that results from a translocation, it is possible that one of the two parents is a carrier of a balanced translocation. When one parent is a carrier of a balanced translocation, the chance of future offspring having Down syndrome is greatly increased. Specific risks must be assessed by a genetic counselor.

Demographics

The incidence of Down syndrome is about 1 in 800 live births. It affects an equal number of male and female

babies. The majority of cases of Down syndrome occur due to an extra chromosome 21 within the egg cell supplied by the mother (nondisjunction). As a woman's age (maternal age) increases, the risk of having a Down syndrome baby significantly increases. By the time the woman is age 35, the risk increases to one in 400; by age 40 the risk increases to one in 110; and, by age 45 the risk becomes one in 35. There is no increased risk of either mosaicism or translocation with increased maternal age.

Causes and symptoms

While Down syndrome is a chromosomal disorder, a baby is usually identified at birth through observation of a set of common physical characteristics. It is important to remember that not all children with Down syndrome will exhibit all of the features discussed. There is great variability in both the number and severity of character-

istics. Babies with Down syndrome tend to be overly quiet, less responsive to stimuli, and have weak, floppy muscles. A number of physical signs may also be present. These include: a flat appearing face; brighter sparkles in the iris of the eye (Brushfield spots); a small head; a flat bridge of the nose; a smaller than normal, low-set nose; small mouth. This causes the tongue to stick out and to appear overly large. They have upward slanting eyes; extra folds of skin located at the inside corner of each eye, near the nose (epicanthal folds); rounded cheeks; and small, misshapen ears. They tend to have small, wide hands; an unusual deep crease across the center of the palm (simian crease); a curved little finger; a wide space between the great and the second toes; unusual creases on the soles of the feet; overly-flexible joints (sometimes referred to as being double-jointed); and, a shorter than normal length.

Other types of problems often accompany Down syndrome. Approximately 30 to 50% of all children with Down syndrome are found to have **heart** defects.

Malformations of the gastrointestinal tract are present in about 5 to 7% of children with Down syndrome. The most common malformation is a narrowed, obstructed duodenum (the part of the intestine into which the **stomach** empties). This disorder, called duodenal atresia, interferes with the baby's milk or formula leaving the stomach and entering the intestine for digestion. The baby often vomits forcibly after feeding, and cannot gain weight appropriately until the defect is repaired. Another relatively common problem is a tracheo-esophageal fistula. This is an abnormal connection between the trachea (windpipe) and esophagus that interferes with both eating and breathing.

Other medical conditions occurring in persons with Down syndrome include an increased chance of developing infections, especially ear infections and **pneumonia**; certain kidney disorders; thyroid disease (especially low or hypothyroidism); **hearing loss**; **vision** impairment requiring glasses (corrective lenses); and a 20 times greater chance than the population as a whole of developing leukemia.

Development in a baby and child affected with Down syndrome occurs at a much slower than normal rate. Because of weak, floppy muscles (hypotonia), babies learn to sit up, crawl, and walk much later than their unaffected peers. Talking is also quite delayed. The level of mental retardation is considered to be mild-to-moderate in people with Down syndrome. The degree of mental retardation varies greatly among children with Down syndrome. While it is impossible to predict the severity of Down syndrome at birth, with proper education, children who have Down syndrome are capable of

learning. Most children with Down syndrome can read and write and are placed in special education classes at school. The majority of individuals with Down syndrome become semi-independent, meaning that they can take care of their own needs with some assistance. Many hold non-complex jobs.

As people with Down syndrome age, they face an increased chance of developing the **brain** disease called Alzheimer's (sometimes referred to as **dementia** or senility). People without Down syndrome have a lifetime risk of 12% for developing **Alzheimer's disease**. In contrast, by age 40-50, almost all persons with Down syndrome will also develop Alzheimer's disease.

As people with Down syndrome age, they also have an increased chance of developing a number of other illnesses, including **cataracts**, thyroid problems, diabetes, and seizure disorders.

Diagnosis

Diagnosis is usually suspected at birth, when the characteristic physical signs of Down syndrome are noted. Once this suspicion has been raised, **genetic testing** (chromosome analysis) can be undertaken in order to verify the presence of the disorder. This testing is usually done on a **blood** sample, although chromosome analysis can also be performed on other types of tissue, including the skin. The cells to be studied are prepared in a laboratory. Chemical stain is added to make the characteristics of the cells and the chromosomes stand out. Chemicals are added to prompt the cells to go through normal development, up to the point where the chromosomes are most visible, prior to cell division. At this point, they are examined under a **microscope** and photographed. The photograph is used to sort the different sizes and shapes of chromosomes into pairs. In most cases of Down syndrome, one extra chromosome 21 will be revealed. The final result of such testing, with the photographed chromosomes paired and organized by shape and size, is called the individual's karyotype. A female with Down syndrome will have a 47, XX+21 karyotype; a male with Down syndrome will have a 47 XY+21 karyotype.

Women who are over the age of 35 are offered prenatal tests to determine if their developing baby is affected with Down syndrome. A genetic counselor meets with these families to inform them of the risks and to discuss the tests that are available to make a diagnosis prior to delivery. Because there is a slight risk of **miscarriage** following some prenatal tests, all testing is optional. Couples must decide whether or not they desire to take this risk to learn the status of their unborn baby. Couples must also decide if they wish to know whether or not the

baby the mother carries has Down syndrome. Some couples choose not to have the test because they are certain they would not choose an abortion if they find theirs is a Down syndrome baby.

Ultrasound is now available for prenatal screening. Some abnormalities associated with Down syndrome, including intrauterine growth retardation, may be detected using ultrasound. The use of ultrasound as a screening test for Down syndrome is limited by the difficulty of producing reliable sonographic images of critical fetal structures.

A counselor needs to inform a woman that her risk of having a baby with Down syndrome increases with her increasing age. Two types of testing are available during a **pregnancy** to determine if the baby being carried has Down syndrome.

Screening tests are used to estimate the chance that an individual woman will have a baby with Down syndrome. All pregnant women under the age of 35 are offered a maternal serum alpha-fetoprotein (MSAFP) screen. This test is normally performed at 15-22 weeks of pregnancy. The MSAFP screen measures a protein and two hormones normally found in maternal blood during pregnancy. A specific pattern of these hormones and protein can give a pregnant woman an increased risk for having a baby born with Down syndrome. Carrying a baby with Down syndrome often causes MSAFP to be lower than normal. Test results reveal only an increased risk and cannot diagnose a baby born with Down syndrome. The MSAFP test can detect up to 60% of all babies who will be born with Down syndrome. Women with an increased risk are offered **amniocentesis**.

The only way to definitively (with about 99% accuracy) establish the presence or absence of Down syndrome in a developing baby is to test tissue from the pregnancy itself. This is usually done either by amniocentesis or **chorionic villus sampling** (CVS). In chorionic villus sampling, usually performed at 10-12 weeks of pregnancy, a tiny tube is inserted into the opening of the uterus to retrieve a small sample of the placenta (the organ which attaches the growing baby to the mother via the umbilical cord, and provides oxygen and **nutrition**). In amniocentesis, a small amount of the fluid in which the baby is floating is withdrawn with a long, thin needle. Both amniocentesis and CVS allow the baby's own karyotype to be determined. Both tests carry a small risk of causing miscarriage. The risk from CVS is 1% and the risk from amniocentesis is 0.5%. This small risk must be considered when deciding to perform these tests. If test information is positive for Down syndrome, a couple must then decide how to use this information to begin to prepare for the arrival of a baby with Down syndrome, to

consider adoption for the baby or to terminate the pregnancy. It must be noted that while the results of prenatal tests can diagnose Down syndrome, they are unable to predict the severity of symptoms.

Treatment

No treatment is available to cure Down syndrome. Treatment is directed at addressing the individual concerns of a particular person. For example, heart defects will many times require surgical repair, as will duodenal atresia or a tracheo-esophageal fistula. Many persons with Down syndrome will need to wear glasses to correct vision. Persons with **hearing** impairment benefit from **hearing aids**.

While some decades ago, all Down syndrome children were quickly placed into institutions for lifelong care, research shows very clearly that the best outlook for children with Down syndrome is a normal family life in their own homes. This requires careful support and education of both parents and siblings. It is a life-changing event to learn that a new baby has a permanent condition that will affect essentially all aspects of development. Some community groups exist to help families deal with the emotional effects of this new information, and to help plan for the baby's future. Schools are required to provide services for children with Down syndrome, sometimes in separate special education classrooms, and sometimes in regular classrooms (this is called mainstreaming or inclusion).

As of 2001, the genetic sequence for chromosome 21 was fully determined, which may open the door to new approaches to the treatment of Down syndrome through the development of gene-specific therapies.

Prognosis

The prognosis in Down syndrome is quite variable, depending on the types of complications (heart defects, susceptibility to infections, development of leukemia) of each individual baby. The severity of the retardation can also significantly vary. Without the presence of heart defects, about 90% of children with Down syndrome live into their teens. People with Down syndrome appear to go through the normal physical changes of aging more rapidly, however. The average age of death for an individual with Down syndrome is about 50 to 55 years.

The prognosis for a baby born with Down syndrome continues to improve. Due to modern medical treatments, including **antibiotics** to treat infections, and surgery to correct heart defects, duodenal atresia and tracheo-esophageal fistula, life expectancy has greatly increased. Community and family support allows people with

KEY TERMS

Cell—A fundamental unit of living tissue. The specialized nature of organs and tissues in a human body reflects the specialized structure and function of its constituent cells.

Chromosome—The structures that carry genetic information. Chromosomes are located within every cell and are responsible for directing the development and functioning of all the cells in the body. The normal number is 46 (23 pairs).

Genetic counseling—A communication process by which personal genetic risk information is translated into practical information for families. Genetic counselors are health care professionals with specialized training and experience in the areas of medical genetics and counseling.

Karyotype—The specific chromosomal makeup of a particular cell.

Mental retardation—A condition where an individual has a significantly lower-than-normal IQ, and thus is developmentally delayed.

Mosaic—A term referring to a genetic situation in which all of an individual's cells do not have the same composition of chromosomes. In Down syndrome, this may mean that some of an individual's cells have a normal 46 chromosomes, while other cells have 47 chromosomes.

Nondisjunction—A genetic term referring to an event that takes place during cell division in which a genetic accident causes an egg or sperm cell to have 24 chromosomes, rather than the normal 23.

Translocation—A genetic term referring to a situation during cell division in which a piece of one chromosome breaks off and sticks to another chromosome.

Trisomy—The condition of having three identical chromosomes, instead of the normal two.

Down syndrome to have rich, meaningful relationships. Because of educational programs, some people with Down syndrome are able to hold jobs.

Most men with Down syndrome appear to be sterile (meaning that they are unable to have offspring). There has been at least one report of a male with Down syndrome who fathered a child. Some women with Down syndrome, however, are capable of having babies.

Approximately 40% of women with Down syndrome are unable to become pregnant. The risk of a woman with trisomy 21 to have a child with Down syndrome is approximately 50%.

Health care team roles

Obstetricians, nurse practitioners, or family doctors often make an initial recommendation that a woman be screened for Down syndrome. Depending on the test, a physician, phlebotomist or ultrasonographer may obtain sample materials. A laboratory technician will process sample materials. A genetic counselor, physician or other person with specialized training usually provides test results to a couple or woman. Counselors must be available to assist a woman or couple to make appropriate decisions about their baby. Pediatricians, family doctors, internists, and geriatric physicians provide care throughout the life of an individual with Down syndrome. Other health professionals, including surgeons, eye specialists and hearing experts, provide services as needed.

Prevention

As of 2001, there is no known way to prevent Down syndrome.

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American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. Fax: (847) 434-8000. <<http://www.aap.org/default.htm>>. kidsdoc@aap.org.

American Association on Mental Retardation, 444 North Capitol Street, NW, Suite 846, Washington, D.C. 20001-1512. (202) 387-1968 or (800) 424-3688. Fax: (202) 387-2193. <<http://www.aamr.org>>.

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Association of Retarded Citizens of the United States, PO Box 6109, 2501 Avenue J, Arlington, TX 76011.

National Association for Down Syndrome, PO Box 4542, Oak Brook, IL 60522. (630) 325-9112. <<http://www.nads.org/>>.

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Dressings *see* **Bandages and dressings**

Drowning *see* **Near-drowning**

Drug abuse *see* **Substance abuse and dependence**

Drug addiction *see* **Substance abuse and dependence**

Drug dependence *see* **Substance abuse and dependence**

Drug dosages

Definition

Drug dosage refers to the determination and regulation of the amount, frequency, and number of times a specific quantity of medication is to be administered. For legal purposes in the United States, a drug is considered to be any substance (other than a food or a device) intended for use in diagnosis, cure, relief, treatment, or prevention of disease, or to affect the structure or function of the body. However, a simple, working definition of a drug is any chemical that affects the processes of the mind or body, and the dose is the amount to be administered at one time.

Purpose

The selection of a drug for use in an individual requires two primary considerations: pharmacodynamics (what the drug does to the body) and pharmacokinetics (what the body does to the drug over time). Pharmacodynamics not only involves considering what the drug does as in lowering **blood pressure**, relieving **pain**, or fighting an **infection**, but where (the site) and how (mechanism of action) the drug acts on the body. Often, what the drug does is immediately obvious, but the exact site and mechanism of action may not be understood until after many years of use.

For a drug to work, it has to get to the place in the body where it is needed, and this requires the science of pharmacokinetics. Sufficient amounts of a drug must stay at the site of its required action until the job is completed, but not so much that severe side effects or toxic reac-

KEY TERMS

Conjugations—The joining of a chemical substance with another to form a new product.

Hydrolysis—The breaking up of a chemical compound by the addition of water.

Lipids—A group of substances composed of fatty, greasy, oily, and waxy compounds that are insoluble in water and soluble in nonpolar solvents or most organic solvents.

Metabolism—The sum of the physical and chemical processes by which living organized substance is built up and maintained and by which large molecules are broken down into smaller molecules to make energy available to the organism.

Oxidation—The chemical reaction whereby electrons are removed from the atoms of a substance for transferal.

Perfused—The act of the passage of a fluid through the vessels of a specific organ or tissue.

Phospholipids—Any lipid or fatty substance that contains phosphorus; the major lipids in cell membranes.

Reduction—The gaining of electrons during a chemical reaction.

Semi-permeable—Permitting passage only of certain molecules.

Therapeutic window—A drug's ability to maintain a specific level of action over a specific period of time.

tions are produced. Many drugs get to their site of action through the bloodstream. Therefore, how much time they need to work and how long their effects will last can depend on how fast they get into the bloodstream, how much gets into the bloodstream, how fast they leave the bloodstream, how easily and efficiently they are broken down (metabolized) by the **liver**, and how soon they are eliminated by the **kidneys** and intestines.

Drugs affect only the speed of biologic functions and do not change the basic character of existing processes nor generate new functions. This means that drugs can either speed up or slow down biochemical reactions in the body, as in how fast or slow a nerve may transmit a message, or how fast or slow a muscle may contract. Although drugs can change the rate of a biological

process, they cannot re-establish a system that is injured beyond repair.

Every person responds to a drug differently. Thus, it is difficult to determine what dosage of a drug should be administered to each individual. Since drugs undergo testing in animals and trials in humans, an average dose is determined from these studies. An appropriate response to a drug requires the appropriate concentration of the drug at the site of action. The appropriate concentration and dosage regimen depend on individuals' clinical state, the severity of their disorder, the presence of a diseased state, the use of other drugs, as well as other considerations. Drug administration must be determined by each individual's needs, which requires an accurate evaluation of drug dosage.

Precautions

All drugs can harm as well as help, so the safety and effectiveness (efficacy) of a drug are relative. Since most drugs cannot maintain a specific level of action for a certain period of time (therapeutic window), their effect can sometimes be either too strong or too weak, depending on the individual's condition who is receiving the drug.

Unwanted drug effects are called side effects or adverse reactions. A drug may affect several functions even though it is prescribed for only one. As an example, most **antihistamines** are targeted for the function of relieving allergy symptoms, yet one of the many side effects is sleepiness. In turn, this side effect is utilized to target the function of an inability to sleep when offered as a sleep aid.

The best drugs are both safe and effective. However, some drugs may be used despite having a very narrow margin of safety because there might be no safer alternative. Although it is impossible to know everything about every drug, understanding the general principles of drug action is an essential precaution in drug administration.

Description

Utilization of drug treatment for any condition requires the drug to be capable of getting into the body's system (administration), moving into the bloodstream (absorption), and traveling to the specific site where it is needed (distribution). Following the administration, absorption, and distribution, the drug leaves the body (elimination) either in the urine or by conversion to another substance.

Administration of drugs can occur by many different means. Drugs be taken by mouth (oral/p.o.); by injection into a vein (intravenous/IV); by injection into a muscle (intramuscular/IM); beneath the skin (subcutaneous/SQ);

placed under the tongue (sublingual); inserted in the rectum (rectal); instilled in the eye (ocular); sprayed into the nose (nasal); sprayed into the mouth (inhalation); applied directly to the skin for a local effect (topical); or applied to the skin for a systemic effect by a patch (transdermal).

Absorption is the process of drug movement from the administration site to the general (systemic) circulation. Although oral administration is the most convenient, the safest, the least expensive, and the most common route, it has its restrictions. The presence of other drugs and food in the **stomach** affect how drugs are absorbed. Some drugs must be taken on an empty stomach, while others should be taken with food.

For distribution into the general circulation, a drug taken orally is absorbed from the gastrointestinal tract by passing through the intestinal wall and then to the liver. Whereas a drug given IV immediately passes into the general circulation to produce a quicker and more consistent effect, a drug given by most other routes must travel across several semi-permeable **cell membranes** before reaching the systemic circulation. These membranes are biologic barriers that selectively prevent the passage of drug molecules and are composed of mostly cholesterol and phospholipids. These **lipids** provide stability to the membrane and determine its permeability characteristics. Drugs cross a biologic barrier by passive diffusion (moving from an area of high concentration to one of low concentration), facilitated passive diffusion (a carrier component combines with the drug to cause rapid diffusion across the membrane), active transport (the cell expends energy to move a drug), or pinocytosis (the cells ingest extracellular fluid and its contents).

Bioavailability refers to the rate and extent to which a drug is absorbed into the bloodstream and thereby gains access to the site of action. The properties of the actual dosage form of a drug, either tablet, capsule, suppository, transdermal patch, or solution, largely determine drug bioavailability.

Drug products may be chemically equivalent, containing the same compound in the same amount, but have dissimilar effects even at the same dose, due to different inactive ingredients, which affect absorption. When drug products contain the same active ingredients and also produce virtually the same **blood** levels over time, they are termed bioequivalent. If drug products given to the same person in the same dosage regimen produce the same therapeutic effect, they are therapeutically equivalent. Bioequivalent products are expected to be therapeutically equivalent.

A drug product is the actual dosage form of a drug. Drug products contain other substances (additives) that are adjusted to affect the rate and extent of the drug's

absorption. Some drug products are designed to release the active ingredient slowly over a long period of time and are called controlled-release dosage forms. This occurs by coating the drug product with a polymer (a chemical substance) of varying thickness that dissolves layer by layer at different times in the gastrointestinal tract. Other additives such as enteric coatings prevent the drug from irritating the stomach lining. Drugs filled with liquids are usually absorbed faster than those filled with solids.

Although a drug rapidly circulates through the body in the bloodstream, this does not mean that it immediately moves into the tissues. Drugs are distributed to different tissues at different rates, depending on their ability to cross membranes, the rate of blood flow to a particular tissue, and the tissue mass. Most drugs do not spread evenly throughout the body; some tend to stay in the plasma (watery tissue of the blood) and muscle, others concentrate in specific areas such as the kidneys, liver, and thyroid. A balance between entry and exit rates (distribution equilibrium) is reached more rapidly in highly vascularized areas than in areas that are poorly perfused. There are drugs that bind tightly to blood **proteins** and leave the bloodstream very slowly, and others that exit quickly to the tissues. Some tissues build up high levels of a drug and serve as reservoirs of extra drug, which prolongs their distribution. Those drugs that accumulate in fatty tissues exit slowly and will continue to circulate in the bloodstream for days following the last administration.

It is possible for drugs to reach the **central nervous system** (CNS) through the **brain** capillaries and the cerebral spinal fluid (CSF). However, despite the fact that the brain receives approximately one-sixth of the blood circulation, distribution of drugs to brain tissues is restricted. Fat-soluble drugs can enter the brain and exert their effects rapidly, but the water-soluble drugs enter the brain slowly. The CNS is well perfused so the major factor of drug distribution rate in it is permeability, whereas for most tissues, perfusion is the major determinant of distribution.

The liver is the principal site of drug **metabolism**, and some of the metabolites are active forms of the drug administered. An inactive substance that produces an active metabolite, once it is absorbed, is called a pro-drug. All drugs are either metabolized or excreted intact. Enzymes in the liver assist with chemical reactions (oxidation, reduction, hydrolysis), and some enzymes attach substances to the drugs, producing reactions called conjugations, which enable a drug to be excreted in the urine.

Excretion refers to the processes by which the body eliminates a drug without further chemical change, and

the major organ of excretion is the kidney. The kidneys filter drugs from the bloodstream and excrete them into the urine. Thus, the major limiting factor of excretion is kidney function, and decreasing kidney function is seen in the elderly, or people with high blood pressure, diabetes, and recurring kidney infections. A laboratory determination of kidney function permits the dosage of a drug to be altered as necessary. The liver does excrete some drugs through bile. These particular drugs enter the gastrointestinal tract and end up in the feces if they are not reabsorbed into the bloodstream or decomposed. Individuals with liver disease may need to have the drug dosage adjusted accordingly, although there is no corresponding liver function test comparable to that for kidney function. Likewise, some drugs can be excreted in breast milk, saliva, sweat, or exhaled air.

Once in the body, drugs can affect it in many ways. Interactions with other cells, tissues, or organs may result in side effects or adverse drug reactions. Many drugs bind or attach to cells by means of receptors on the cell surface. Receptors have a specific structure, which permits only those substances that fit it precisely to attach to it. The majority of cells have these surface receptors with which drugs can selectively bind to change the activity of the cell. These receptors possess a natural, physiologic purpose, and drugs take advantage of them.

A class of drugs called agonists activates or stimulates the receptors to trigger a response that either increases or decreases the cell's function. Another class of drugs called antagonists blocks the access of agonists to the receptors. Antagonists are used primarily to block or diminish cell responses to agonists normally present in the body, and this is usually in reference to neurotransmitters.

Other targets of drug action are enzymes, protein substances needed in the body to assist with the control of chemical reactions during metabolism. Drugs that target enzymes are classified as inhibitors or inducers (activators).

Affinity and intrinsic activity are two other drug properties that must be considered in dosage. Affinity refers to the attraction or strength of the bond between a drug and its target, regardless of whether it is a receptor or an enzyme. Intrinsic activity refers to the ability of the drug to produce its desired effect after it is bound to its target. Agonists drugs have both properties because they must bind effectively and produce a response. Antagonists drugs, however, only have an affinity for a target site since their purpose is to block agonists.

Other properties that are important in determining drug dosage include potency, efficacy, tolerance, and

resistance. Potency refers to the amount of drug needed to produce a certain effect; it is usually expressed in milligrams (mg). Greater potency does not necessarily mean that one drug is better than another because side effects, toxicity, duration of effectiveness, and cost must also be considered. Efficacy refers to the maximum therapeutic response that a drug can produce and, once again, this is only one factor in the consideration of which drug to use at what dosage. Tolerance to a drug can occur when the body adapts to the continued presence of the drug. It is also possible for tolerance to occur if the number of receptors decreases or their affinity for the drug decreases. The term resistance is generally used to refer to a situation in which an individual no longer responds well to a drug. In these cases, the drug dosage may be increased or an alternative drug may be utilized.

Preparation

Before administering a new drug or a medication that is prescribed on an as-needed basis, a patient must be assessed in terms of factors that may be pertinent. An initial prediction of increased risk for adverse drug effects can be made by the patient assessment. It is essential to double check the medication ordered, the dosage to be given, the times the drug is to be administered, how it is to be administered, the expiration date on the drug, and that the correct patient receives the correct drug. Many IV medications are now being mixed in the pharmacy to prevent errors in calculations for a patient. It is important that the health care provider discusses with the patient what the medication is, why it is being given, and reviews some potential side effects.

Aftercare

A patient should be continually assessed during the administration of a medication for signs and symptoms of any untoward reaction, as well as to determine if the medication has had the desired effect.

Complications

Adverse reactions are one of the main complications of drug administration. Some patients may experience an allergic reaction to a medication that could range from mild to severe. They may experience itching, exhibit a rash, have localized swelling, difficulty breathing, or suffer a complete vascular collapse. Other complications could include a resistance to the drug with a subsequent progression of the initial condition. If the patient's status does not seem to be improving, this should be reported to the physician or nurse practitioner. Severe side effects

could be detrimental to the patient, necessitating laboratory tests to monitor the patient's condition.

Results

Results expected with drug administration will vary according to why the drug was given. In all cases, it is essential to determine what end result is expected from the administration of a drug.

Health care team roles

The health care team shares responsibility for providing optimal intervention in the administration of drugs. Since nurses spend more time with patients and are more likely to focus on the patient as an individual, this places them in an optimal position to assess a patient's response to a drug. Any pertinent changes should be immediately reported to the physician or nurse practitioner. The nurse must also ensure that the patient is well informed about the drug being administered.

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Linda K. Bennington, C.N.S.

Drug interactions

Definition

Drug interactions are changes in the effect of one drug due to the effect of either another drug taken at the same time (drug-drug interactions) or food consumed while the drug is being taken (drug-food interactions).

Description

Some drugs are deliberately combined for administration because there are beneficial effects to be derived. Generally, drug interactions are unwanted and harmful. They may either serve to intensify or diminish the desired effect of a particular drug, or worsen its side effects. Although most drug-drug interactions involve prescription drugs, they can occur with nonprescription or over-the-counter (OTC) medications—the most common of these being aspirin, **antacids**, and decongestants.

Individuals under the care of more than one health care practitioner are at highest risk for drug interactions because each practitioner may not be aware of drugs being prescribed by the other. The patient needs to make each practitioner fully aware of all medications being taken. This includes prescription and nonprescription medications, and herbal remedies. A practitioner may not think to ask a patient about OTC medications or herbal supplements, and the patient may not think to inform their practitioner they are taking these substances because they do not think of OTCs or herbals as medications. The more drugs being consumed, the greater the risk of developing a drug interaction. This risk also increases with the amount of drug taken and the tendency of particular drugs to interact adversely with each other. The incidence of adverse drug reactions increases with the age of the patient; the risk is three times greater for older people than for younger adults.

When the effect of one drug in the body is altered by the presence of another, one drug may increase or decrease the effects of the other with harmful results. Two drugs taken together may produce a new and dangerous reaction, or they may be in opposition to each other in their actions. Two similar drugs taken together may produce an effect that is greater than would be expected from one drug. This effect is called potentiation. One drug may also affect the rate at which the **kidneys** excrete another drug by altering the acidity of the urine. This, in turn, affects the excretion of other drugs. **Vitamin C** in large doses can do this. Although not considered a drug by some, alcohol is a drug that does affect bodily processes and is often responsible for drug interactions. OTC drugs can interact with each other as well as with prescription drugs. For example, many cough medicines contain alcohol which, if taken with antihistamine medications, could increase sleepiness and decrease alertness.

Examples of drug interactions include:

- salt substitutes interacting with potassium-sparing diuretics (agents that promote urine secretion) to increase **blood** potassium levels and cause nausea,

Interactions between drugs and commonly used modalities

Modality	Use	Drugs with complementary/synergistic effects	Drugs with antagonistic effects
Cryotherapy: cold/ice packs, ice massage, cold baths, vapocoolant sprays	Decreased pain, edema, and inflammation	Anti-inflammatory steroids (glucocorticoids); nonsteroidal anti-inflammatory analgesics (aspirin and similar NSAIDs)	Peripheral vasodilators may exacerbate acute local edema.
	Muscle relaxation and decreased spasticity	Skeletal muscle relaxants	Nonselective cholinergic agonists may stimulate the neuromuscular junction.
Superficial and deep heat (local application): hot packs, parafin, infrared, fluidotherapy, diathermy, ultrasound	Decreased muscle/ joint pain and stiffness	NSAIDs; opioid analgesics; local anesthetics	—
	Decreased muscle spasms	Skeletal muscle relaxants	Nonselective cholinergic agonists may stimulate the neuromuscular junction.
	Increased blood flow to improve tissue healing	Peripheral vasodilators	Systemic vasoconstrictors (e.g., α -1 agonists) may decrease perfusion of peripheral tissues.
Systemic heat: large whirlpool, Hubbard tank	Decreased muscle/ joint stiffness in large areas of the body	Opioid and nonopioid analgesics; skeletal muscle relaxants	Nonselective cholinergic agonists may stimulate the neuromuscular junction.
Ultraviolet radiation	Increased wound healing	Various systemic and topical antibiotics	—
	Management of skin disorders (acne, rashes)	Systemic and topical antibiotics and anti-inflammatory steroids (glucocorticoids)	Many drugs may cause hypersensitivity reactions that result in skin rashes, itching.
Transcutaneous electrical nerve stimulation (TENS)	Decreased pain	Opioid and nonopioid analgesics	Opioid antagonists (naloxone)
Functional neuromuscular electrical stimulation	Increased skeletal muscle strength and endurance	—	Skeletal muscle relaxants.
	Decreased spasticity and muscle spasms	Skeletal muscle relaxants	Nonselective cholinergic agonists may stimulate the neuromuscular junction.

SOURCE: Ciccone, C.D. *Pharmacology in Rehabilitation*. 2nd ed. Philadelphia: F.A. Davis Co., 1996.

vomiting, **diarrhea**, muscle weakness, and possibly cardiac arrest

- decongestants interacting with diuretics to increase blood pressure
- antacids interacting with anticoagulants (blood thinning drugs) to slow down absorption of the prescribed drug or interacting with absorption of other drugs—such as the antibiotic tetracycline—and thus prolonging an infection
- aspirin increasing the effect of blood thinning drugs
- antihistamines increasing the sedative effects of barbiturates (sleeping pills), tranquilizers, and some **pain** relievers
- iron supplements binding with **antibiotics** in the **stomach**, preventing absorption of the antibiotic into the bloodstream
- antihypertensive medications mixed with digitalis (Lanoxin) resulting in abnormal **heart** rhythms
- anticoagulants mixed with sleeping pills resulting in decreased effectiveness of the anticoagulant
- antibiotics taken by women on the low-dose birth control pill causing decreased effectiveness of the pill

- nonsteroidal antiinflammatory drugs (NSAIDs) causing the body to retain salt and fluid that can oppose or antagonize the effectiveness of a diuretic
- beta-blockers, such as propranolol, counteracting certain drugs taken for asthma

Certain drug-food combinations can produce dangerous side effects as well. Food can speed up or slow down the action of a medication, and some drugs may prevent the absorption of **vitamins** and **minerals** from food. Drugs may also alter the way the body uses nutrients, as well as altering the **taste** sensation. Chemicals in cigarette smoke can increase the enzyme activity of some **liver** enzymes, which, in turn, reduces the effectiveness of some pain relievers and some drugs used for lung conditions. The antibiotic tetracycline is not absorbed appropriately if it is taken within an hour of drinking milk or eating other dairy products or foods containing **calcium**.

To help avoid drug interactions, patients should inform their health care practitioners of any medical problems they have or have had, maintain a list of drugs—both prescription and nonprescription—taken during the few weeks prior to their visit to their practitioner, and give the list to their practitioner. They should also advise their practitioner of any **allergies** or unusual reactions to drugs, food, or other substances, and make

KEY TERMS

Potentiation—Making effective or active, or more effective or active; synergistically augmenting the activity of one drug with another.

note of any special dietary or food restrictions. A woman should always inform her practitioner if she is pregnant, plans to become pregnant in the near future, and if breastfeeding.

Viewpoints

Although drug interactions can create serious health risks, they can be avoided with appropriate education (of the patient) and history-taking (by the health care practitioner). The health care practitioner needs to take the time to ask pertinent questions about an individual's history, including diet, nutritional intake, and medication regimen which should include nonprescription drugs and herbal remedies. Although it is often difficult for the practitioner to spend an appropriate amount of time with patients in this era of health care management, it could ultimately save time and money and prevent serious consequences to the health of the patient. Healthcare providers need to stay informed and up-to-date regarding drug-drug and drug-food interactions.

Professional implications

Healthcare professionals are capable of exerting a measurable impact on the lives of individuals who are taking drugs for either medical or nonmedical reasons. Education is the foundation for patient care with regards to potential drug interactions. It is the responsibility of the care provider to take the time to inform patients of potential interactions with drugs and food, as well as to take a complete patient history. A patient's family should be included in the educational process so they may recognize possible interactions by changes in behavioral patterns or demeanor.

Resources

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Drug monitoring see **Therapeutic drug monitoring**

Drug overdose see **Overdose**

Drug testing

Definition

Drug testing is the assessing of drug use (or non-use) by a person. The drugs for which one tests fall into three main types: illegal drugs, alcohol, and performance-enhancing drugs. Illegal drugs include **marijuana**, cocaine, amphetamines, and phencyclidine (PCP, the hallucinogen known as "angel dust"). Alcohol is, of course, a legal drug for adults, but since such activities as driving under its influence are illegal, it is sometimes very important to test for the level of alcohol in the bloodstream. Performance-enhancing drugs may be legal, but their use by athletes may be forbidden by the rules of an athletic association sponsoring a competition, rules designed to be fair to all the players.

Description

One line of attack in the "war against drugs" in the United States involves compulsory drug testing. Specific drug-test laws vary from state to state, but **drug tests** are commonly administered in schools, athletic competitions, and the workplace. When results of some tests are being evaluated, it is important to keep in mind the fact that sometimes legitimate prescription drugs for such conditions as arthritis and **asthma** can produce test results that falsely suggest illegal drug use.

Some schools test students in general for drug use; others focus on student athletes because drug use increases the risk of sports-related injury, and also because the use of performance-enhancing drugs would give the athletes who use them an unfair advantage over the other athletes. The United States Supreme Court ruled in 1995 that schools may test entire teams of student athletes, even if individual team members are not suspected of using drugs. On the state level, courts are divided on the circumstances under which such testing can legally



A technician performs laboratory urine drug testing.

(Photograph by Edward L. Lallo. The Picture Cube. Reproduced by permission.)

occur. Some states provide more protection than others for the rights of students to privacy and due process.

In the 1970s, the issue of performance-enhancing drug use among athletes came into the forefront. Many athletes use performance-enhancing drugs (ergogenic drugs) such as anabolic steroids, growth hormone, and erythropoietin. Some athletes also use stimulants because of their ability to mask fatigue. Athletes are tested for use of forbidden drugs at many major meets.

The federal government laid the groundwork for drug testing in the workplace when, in the late 1980s, it initiated mandatory drug testing of federal employees, and began to require that government contractors establish drug-testing programs for their workers. Today, many large companies in the United States administer drug tests to their employees, but testing in smaller organizations is significantly less common.

Some workplace drug-testing policies are considerably stricter than others. Federal employees can be subject to compulsory random drug tests, as can private-sector employees with responsibility for the lives and safety of others. It is obviously not as dangerous to the public for the person raking leaves in a park to take illegal drugs

as for an airplane pilot, a truck driver, or a person producing atomic weapons. Much workplace testing is conducted under such circumstances as the following:

- Pre-employment. Employers offer employment on condition of a negative drug test.
- Reasonable suspicion. Employers test an employee after direct observation of drug use or possession, patterns of erratic behavior, or drug-related arrests.
- Post-accident. Employees involved in accidents are sometimes asked to take a drug test immediately after an incident to determine whether alcohol or drug use was a factor.
- Treatment follow-up. Employees returning to work after treatment for substance abuse are often subject to follow-up testing.

Urine is the most common sample used in drug testing. Urine tests for federal employees are first analyzed by laboratories certified by the Substance Abuse and Mental Health Services Administration (SAMHSA), and any samples that come up positive are double-checked by gas chromatograph mass spectrometry, the “gold standard” test that identifies the exact molecular structure of a substance. Some private employers also follow SAMHSA procedures and use federal laboratories for testing, but others use commercial drug-testing kits. These commercial kits have often been criticized for generating a high rate of false positives. The problems associated with urine testing have sparked interest in alternative techniques, such as the testing of hair, sweat, or saliva.

Viewpoints

SAMHSA advocates drug testing in order to help businesses achieve a drug-free workplace. A survey from the United States National Institute on Drug Abuse (NIDA) estimated that employee drug misuse cost the country billions of dollars in lost productivity, as well as in medical expenses and in worker-compensation claims. Mandatory drug testing in the workplace deters those who abuse drugs and alcohol from engaging in this unhealthy behavior at least while they are on the job, and it may deter non-users from ever starting to abuse drugs and alcohol. Also, it can sometimes help those with abuse problems to admit them and so to start getting help, but some abusers are in such deep denial that they cannot be helped in this way.

Opponents of these views point out problems with drug testing. Workplace testing may actually dampen company productivity because it is time-consuming, has the potential to violate the confidentiality that medical personnel are obliged to practice, and undermines staff morale and loyalty. More importantly, it may needlessly

KEY TERMS

Amphetamine—A chemical mixture that can strongly stimulate the central nervous system. Over time, users tend to need stronger doses, and eventually they may develop a physical dependence on it and thus become addicted.

Anabolic steroid—A synthetic or semisynthetic substance that promotes the production within the body of the proteins that build up tissues, especially muscle tissues.

Cocaine—An alkaloid chemical obtained from the leaves of the coca plant (or from some related species). It is addictive, it can cause mental and physical problems, and an overdose can lead to coma and death.

Ergogenic—Giving rise to, or enhancing, work, activity, functioning, and the like.

Erythropoietin—A protein produced mostly in the kidneys, and now available synthetically, that stimulates the production of red blood cells in the bone marrow.

False negative—A test result that erroneously gives a negative finding when the actual condition should have given a positive finding.

False positive—A test result that erroneously gives a positive finding when the actual condition should have given a negative finding.

Gas chromatograph mass spectrometry—A technique by which complex organic compounds are identified by the use of two sophisticated instru-

ments. First, a gas chromatograph heats the compounds until they vaporize into gases which ascend a column and emerge one at a time. Then, each separate fraction of these gases is sent to a mass spectrograph which identifies the fragments of the molecules according to their mass. One thus gets a kind of chemical fingerprint of the substance being tested, and checks in a data base of thousands of such fingerprints of known substances to see which substance one has just tested.

Growth hormone—A substance produced naturally in the body, and now available synthetically, that promotes the development of flesh and bone, and influences the metabolism of proteins, carbohydrates, and fats.

Hallucinogen—A drug that can cause false sensations, such as hearing voices when there are no voices and no other sounds that could reasonably be confused with voices, or seeing persons or things that are not present.

Marijuana—The dried leaves, stems, and flowers of plants of the cannabis family. It is often smoked, sometimes eaten. It can produce distorted perceptions (which the users consider to be a form of elevated consciousness) and sometimes causes outright hallucinations.

Phencyclidine—A chemical used legally as a veterinary anesthetic and illegally as a drug that alters consciousness (a psychedelic drug).

harm the careers of employees whose legitimate use of prescription medicines causes confusing or ambiguous test results. Also, it may identify substances at insignificant doses because of recreational drug use outside working hours, use that has no bearing on employee performance, according to civil-rights groups such as the American Civil Liberties Union (ACLU). The ACLU advises that employees in safety-sensitive positions such as airline pilots should indeed be tested for impairment, and that any individuals found to be impaired should then be referred to special programs called Employee Assistance Programs (EAPs). EAPs can in turn direct these persons to the appropriate substance-abuse programs. The ACLU also recommends more rigorous reference-checking to avoid hiring someone with a history of drug-abuse problems in the first place. However, if the

person no longer has a drug problem, such an approach could illegally and unfairly violate this person's rights.

Many health-care organizations that provide qualified support for drug testing oppose its more radical uses, such as random testing or testing without suspicion. The American Nurses Association (ANA) opposes random drug testing of health-care workers, viewing it in violation of the basic principle of "innocent until proven guilty," but provides qualified support for testing under reasonable suspicion, and with evidence that job performance has been impaired by alcohol or drug usage. Employees who initially test positive for drugs should be offered a reassessment of the test results and should be given the chance to explain what legitimate medications they are taking which might have produced false-positive results. Even when the drug use is confirmed, counseling

and treatment are recommended before any disciplinary action is taken, according to the ANA. The American Hospital Association (AHA) advocates pre-employment testing, suspicion-based testing, testing after certain incidents or injuries, and testing following drug rehabilitation, but not random testing without cause.

Some health-care organizations have also issued position statements on drug-testing policies in the community. The American Academy of Pediatrics has stated opposition to drug testing without cause as a prerequisite to student participation in school activities. And the American Medical Association (AMA) is opposed to the practice of reporting positive drug results for pregnant women to law-enforcement officials. Proponents say such practices protect unborn children, but the AMA states they are an invasion of medical confidentiality and a violation of the provider/patient relationship. Such practices may also discourage some women from seeking **prenatal care**.

Professional implications

Nurses may draw **blood** samples, for example, when testing for alcohol level. They must be certain that they have the **informed consent** of the person from whom they are drawing blood, or else that they have clear-cut legal authorization, such as a court order, to do so. In the case of testing of urine, hair, saliva, and sweat, nurses should instruct the person being tested and then properly store and label the specimen provided. Medical technologists or clinical-laboratory scientists are responsible for running the tests, for reporting the results accurately, and in some cases for estimating the margin of error or assessing the likelihood that the result is a false positive or a false negative. All health personnel must see that the results of such tests are disclosed only to those authorized to have them, and must otherwise maintain strict professional confidentiality.

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- American Medical Association. The Council on Ethical and Judicial Affairs. 515 North State Street, Chicago, IL 60610-4320. (312) 464-4823. <<http://www.ama-assn.org/ama/pub/category/2498.html>>.
- American Nurses Association, ANA, 600 Maryland Avenue, SW, Suite 100 West, Washington, DC 20024-2571. (800) 274-4ANA. <<http://www.nursingworld.org>>.
- American Society of Addiction Medicine. 4601 North Park Avenue, Arcade Suite 101, Chevy Chase, MD 20815-4520. (301) 656-3920. <<http://www.asam.org>>.
- Division of Workplace Programs, Center for Substance Abuse Prevention, Substance Abuse and Mental Health Services Administration. 5600 Fishers Lane, Rockwall II Building, Room 815, Rockville, MD 20857. (301) 443-6780. <<http://workplace.samhsa.gov>>.
- National Clearinghouse for Alcohol and Drug Abuse Information (NCADI) Center for Substance Abuse Prevention. 5600 Fishers Lane, Rockville, MD 20857. (301) 443-0365. <<http://www.health.org>>.
- National Institute on Drug Abuse. 6001 Executive Boulevard, Bethesda, MD 20892. (301) 443-1124. www.nida.nih.gov.
- NSNA, National Student Nurses Association, 555 West 57th Street, New York, NY 10019. (212) 581-2211. <<http://www.nsna.org>>.

Ann Quigley

Drug tests

Definition

Drug tests are analytical procedures that may be performed on **blood**, urine, or gastric fluid for the purpose of identifying an unknown drug or measuring the concentration of a specific drug.

Purpose

Drug tests are usually performed for three reasons. 1) To identify an abuse drug. The majority of drug abuse

involves one or more of the following substances and these comprise a typical drug of abuse panel: amphetamines, cannabinoids, cocaine, ethanol, opiates (morphine and codeine compounds), and phencyclidine (PCP). Over 85% of drug abuse cases involve those drugs or one of the following: barbiturates, benzodiazepines, methadone, propoxyhene, LSD, methaqualone, and antidepressants. 2) To identify a drug which may have been ingested or administered in a toxic or lethal dose either accidentally or on purpose. In addition to poisons such as pesticides and heavy metals such as arsenic, drugs are often implicated in accidental **overdose** and suicide situations. The three most commonly encountered drugs seen in overdose situations are ethanol, salicylate (aspirin), and acetaminophen. 3) To determine whether the amount of a drug in the blood is within therapeutic limits. This process, called **therapeutic drug monitoring** (TDM), is used to insure that the dose and dose interval of the drug are sufficient to maintain a therapeutic blood concentration throughout drug therapy without risk of toxicity. TDM is also performed to verify that a patient is complying with the physician's orders.

Description

Drug abuse testing

Drug screening may be performed on urine, blood serum or plasma, or gastric fluid, but urine is the sample of choice for symptomatic cases because drugs and their metabolites concentrate in the urine. Clinical or emergency department settings require the use of a screening method because the identity of the drug is not usually known. Drug screening methods may be designed to detect a class of related drugs. For example, a drug test for amphetamines may detect methamphetamine, dexamphetamine, methylenedioxymethamphetamine (Ecstasy), and phenylpropanolamine. The latter drug is a decongestant that sometimes cross reacts with the antibodies used in the amphetamine assay (analysis). Although drug screening may be sufficient to treat the patient, medicolegal implications are usually involved and this necessitates the need for positive sample identification and confirmatory **drug testing**. The confirmatory test need not be more specific than the screening test, but must utilize a different method of detection. This obviates the chance of a false positive test result caused by an interfering substance unless the interferent affects both methods. Drug screening programs are also used in occupational settings as a condition of employment, and extensively by the criminal justice system for criminal investigations and monitoring persons who have been convicted of drug related offenses. These situations require stringent adherence to procedures for documenting chain-of-custody of

the specimen and confirmatory testing. Federal drug testing worksites must follow the Department of Transportation (DOT) chain-of-custody procedures for collection and transport of urine samples for drug testing. Laboratories certified by the U.S. Substance Abuse and Mental Health Services Administration (SAMHSA) must use the gas chromatography with mass spectroscopy (GC-MS) method to confirm a positive drug screening test. This method is the gold standard for drug identification because it determines the mass spectrum of the drug which is a fingerprint of its chemical composition.

Specimen collection and transport

Urine specimens should be collected in a room with separate areas for workspace and toilet. The sink should be located in the workspace area. The patient or client must be positively identified via two forms of photoidentification or a passport. A form such as a DOT Custody Control Form should be used for chain-of-custody documentation. This form should include labels for the collection bottle and bag, and signature lines for all persons who will receive the specimen. At minimum the client must be observed entering and leaving the toilet area and should be instructed to remove outer garments and empty his or her pockets. The toilet should contain a bluing agent and the client should be instructed not to flush the toilet. The collection container should be unwrapped in the client's presence and affixed with a temperature measuring strip. The sample should be examined by the collector for adulteration and rejected if not within prescribed limits for volume (at least 30 mL) and temperature (90-100°F). An acceptable sample is labeled across the lid and side so the seal will be broken if the lid is removed. The laboratory should perform a test for urinary creatinine, pH, or specific gravity to check specimen integrity.

Blood samples are collected by venipuncture using standard precautions for reducing exposure to blood-borne pathogens. It is not necessary to restrict fluids or food prior to collection. Blood should be collected in tubes containing no additive. Risks of venipuncture include bruising of the skin or bleeding into the skin.

The EMIT principle

The most commonly used drug screening method is immunoassay. There are several immunoassay methods available including the enzyme multiplied immunoassay technique (EMIT), solid phase immunoassay fluorescence polarization immunoassay (FPIA), and cloned enzyme donor immunoassay (CEDIA). In addition, thin layer chromatography is sometimes used as a screening test. This method is more time consuming than immunoassay but is more comprehensive. The EMIT

method is the most commonly used platform for drug of abuse screening. All EMIT assays follow the same scheme regardless of the drug being tested. EMIT assays measure enzyme activity. In a typical EMIT assay, urine is mixed with an antibody specific for the drug (e.g., methadone) and an enzyme-conjugated form of the drug. The enzyme used in EMIT testing is glucose-6-phosphate dehydrogenase. If not bound by the antibody, the enzyme will catalyze the oxidation of glucose-6-phosphate in the reagent forming 6-phosphogluconate and NADH. The production of NADH causes an increase in the absorption of 340 nm light. If no drug is present in the urine sample, all of the antibody will bind to the enzyme-conjugated drug. The antibody will block the catalytic site of the enzyme preventing the formation of NADH. If the drug is present in the urine sample, it will bind to some of the antibody, reducing the amount of antibody available to bind to the enzyme-conjugated drug. Therefore, the activity of the enzyme will be proportional to the concentration of drug in the urine sample.

In order to give maximum sensitivity the concentration of antibody is less than the concentration of the enzyme-conjugated drug. The labeled drug competes with any drug in the urine for binding sites on the antibody. If no drug is present in the sample, there will still be some unbound enzyme-conjugated drug that will produce NADH. However, the rate of enzyme activity will be less than that of the cutoff calibrator solution.

The enzyme activity of the sample is compared to that of a cutoff calibrator. The concentration of drug in the calibrator is set to a level recommended by SAMHSA for a positive test result. If the patient's sample result is greater than that of the cutoff calibrator, the drug test is presumed to be positive. Results below the cutoff calibrator are interpreted as negative. Activity less than the cutoff can result from endogenous drug present at very low levels in the absence of substance abuse. For example, poppy seeds used in baking contain minute amounts of opiates that cause some reactivity with enzyme immunoassays for opiates. Generally, the level of opiate detected will be below the cutoff value. Typically, the low calibrator and positive and negative urine control samples are assayed at least once per day along with the urine specimens.

EMIT is approved by the FDA only for urine specimens. Samples should be collected in clean plastic containers and refrigerated if not run within one hour. They can be refrigerated for up to three days or frozen, if longer storage is required. The pH of the sample must be between five and eight.

Confirmatory drug testing

Confirmation of a positive drug test by immunoassay is performed by a chromatographic method. Confirmatory methods include gas chromatography (GC), gas chromatography with mass spectroscopy detection (GC-MS), thin layer chromatography (TLC), and high performance liquid chromatography (HPLC). The methods most commonly employed in clinical practice are GC and TLC. In forensic laboratories and SAMHSA approved **toxicology** laboratories confirmation is done using GC-MS. All chromatography techniques require extraction of the drug from the biological fluid. This is accomplished by adjusting the pH of the sample to minimize ionization of the drug and addition of an organic solvent. The nonionized drug molecules will be more soluble in the organic phase and can be separated from water-soluble interfering substances. Extraction also serves to concentrate the drugs. In general, a pH of nine promotes extraction of alkaline and neutral drugs, and a pH of 4.5 promotes extraction of neutral or acidic drugs. Most abuse drugs with the exception of barbiturates and some benzodiazepines are extracted at an alkaline pH. Chromatography is a method used to separate molecules of similar structure. The process of separation depends upon nature of the chromatographic medium. Separation can result from partitioning (solubility differences), adsorption, size exclusion, ion exchange, and affinity bonding.

Gas chromatography

Gas chromatography is performed using a glass column packed with a liquid separation medium such as polyethylene glycol or an open glass capillary that is coated with a liquid polymer separation medium. GC measures only those substances that are volatile or can be separated into volatile compounds. GC separates molecules primarily on the basis of solubility. The sample is introduced into the instrument injection port and is vaporized by a high temperature. The vapors are carried by an inert gas (usually nitrogen) into a temperature-controlled column where they separate based upon their boiling point. Molecules of low boiling move faster through the column and elute first. When the drugs leave the column they are most often detected by a process called flame ionization. A small hydrogen-air flame is used to excite the molecule, causing release of an outer shell electron. This produces a current that is proportional to the concentration of the molecules. The instrument produces a recorder tracing of a peak when a compound is detected. The peak height or area is proportional to the drug concentration. The time between introduction of the sample and the appearance of the peak is called the retention time. Under standardized conditions, the retention

times of unknown substances can be compared to those of drug standards to identify the drug in the sample. GC is the reference method for measuring ethanol in blood and is sufficiently sensitive and specific to identify most drugs extracted from biological samples.

GC-MS is a form of gas chromatography. The detector used is a mass spectrometer. This device usually uses an electron beam to break the eluted drug into ion fragments. The ions are kept apart by application of a vacuum and are separated according to their mass to charge (m/z) ratio in the mass analyzer, which is usually a quadrupole mass filter. This device produces alternating direct current voltage and radio frequency waves that attract and repel the ions. Ions of different m/z ratios move at different rates as the frequencies change and leave the filter at different times. The ions are detected by a dynode as they leave the filter. When the ion strikes the dynode it causes the element to release a shower of electrons. This current is used to produce a peak corresponding in height to the concentration of the ion. A recorder tracing of all of the ion fragments constitute the mass spectrum of the drug. As no two drugs have the identical mass spectrum this method conclusively identifies the drug. For drug identification the GC-MS is used in a mode called total ion chromatography, which displays the complete mass spectrum of the eluate and allows comparison to a computerized library of drug standards. For quantitative analysis the selected ion monitoring (SIM) mode is used. This mode measures the principal ions of the drug and can more accurately quantify the drug at lower concentrations.

When testing for abuse substances the timing of specimen collection is very important because drugs are metabolized and eliminated at different rates. Dosage, length of use, and individual differences in absorption, **metabolism**, and elimination cause the window of detection to vary. Approximate detection times are shown below for some commonly abused drugs:

- amphetamines: one to two days
- short acting barbiturates (eg. Seconal): one day
- long-acting barbiturates (eg. Phenobarbital): two to three weeks
- benzodiazepines: three days
- THC: three days for acute intermittent use; up to one month for heavy, chronic use
- cocaine: two to four days
- ethanol: three to four hours
- morphine and codeine: two days
- phencyclidine: one to two days
- propoxyphene: six to 48 hours

Therapeutic drug monitoring (TDM)

The same dose and dosing schedule for a drug can be therapeutic for some patients, and subtherapeutic or toxic for others. Age, gender, smoking, genetics, protein binding, concurrent medications, and renal and hepatic function cause variation in drug absorption, distribution, and clearance, which affects blood levels of the drug. The study of the behavior of a drug in the body is called pharmacokinetics. Pharmacokinetics describes the relationship between drug dose and blood concentrations. When two or more measurements are made after the drug reaches steady state, the results can be used to determine the dose and dosing interval needed to achieve the desired blood level. Tests for therapeutic drugs are performed for four reasons. 1) To determine whether the dose and dosing interval are able to maintain the desired blood level of the drug. 2) To permit empirical adjustment of the dose when the drug level falls outside the therapeutic range. 3) To verify that the patient is complying with the prescribed treatment. 4) To evaluate the magnitude of an intentional or accidental drug overdose.

In practice, only those drugs that have toxic potential near the therapeutic range need to be monitored. Drugs that should be monitored include many anticonvulsants, aminoglycoside **antibiotics**, antiasthmatics, antiarrhythmics, antineoplastics, antidepressants, and immunosuppressive drugs used in organ transplantation. As orally ingested drugs are metabolized and eliminated between doses, blood levels are time dependent. Shortly following absorption and distribution of the drug in the body, the blood level will peak. As the drug is metabolized and eliminated the blood level will fall until replaced by the next oral dose. When serial measurements of drug are plotted, the result is a dose response curve made up of repeating peaks and troughs. Accurate timing of sample collection is required to properly interpret blood drug test results. For most drugs, there is not a great difference between peak and trough blood drug levels, and measurement of trough drug concentration is sufficient to evaluate the patient. In cases where the trough-peak range is large, both trough and peak levels need to be considered. This is the case when monitoring aminoglycoside antibiotics. When measuring trough blood levels of a drug the sample should be collected just before the next dose is given. Collection time for peak blood levels depends upon the drug and route of administration. For aminoglycoside antibiotics peak levels are usually drawn 30 minutes following an IV (intravenous) dose and 60 minutes following an IM (intramuscular) dose.

KEY TERMS

Immunoassay—A method for measuring biological substances such as drugs, proteins, and hormones. It utilizes antibodies specific for the substance being tested.

Enzyme—A protein that accelerates the rate of a biochemical reaction.

Enzyme immunoassay—A procedure employing an enzyme bound to an antigen or antibody. The antibody binds to the antigen of interest and the enzymatic reaction measures the concentration of the antigen.

Chromatography—A technique used to separate closely related biological molecules which exploits one or more of the following differences: solubility, molecular size, adsorption, ion exchange, affinity bonding.

Gas chromatography—A chromatographic method that utilizes a gas for the carrier or mobile phase and a liquid for the stationary phase.

Gas chromatography with mass spectroscopy—A method that employs a gas chromatograph to separate the molecules and a mass spectrometer to identify and quantify the separated compounds.

High performance liquid chromatography—A chromatographic method that utilizes a liquid mobile phase or carrier and a liquid stationary phase. Sample is forced through the stationary phase by a high pressure pump.

Thin layer chromatography—A chromatographic method that uses a thin layer of silica gel and a liquid mobile phase which migrates upward through the silica gel by capillary action. Molecules are carried by the mobile phase and separate on the basis of solubility.

Therapeutic drug monitoring—The measurement of a drug in blood serum or plasma in order to determine the adequacy of dosing and prevent drug toxicity.

Trough level—A drug assay performed on a sample collected before the next dose is absorbed.

Peak level—A drug assay performed on a sample following complete absorption and distribution.

Therapeutic drug measurements

Both immunoassay and chromatographic methods are used to quantify therapeutic drugs. EMIT, CEDIA, and FPIA assays are the most commonly used immunoassays. Gas chromatography and high-performance liquid chromatography are the most commonly used chromatographic methods.

FLUORESCENCE POLARIZATION IMMUNOASSAY (FPIA). This method measures the plane polarized fluorescence of fluorescein-labeled antigen without the need for an enzyme conjugate. Fluorescein conjugated to a drug competes with the drug in the sample for a limited number of antibody molecules. Plane-polarized UV light is transmitted through the sample. Both the unbound and antibody-bound, fluorescein-labeled drug absorb the UV light and the fluorescein becomes excited. The unbound labeled drug is rotating rapidly and emits light that is unpolarized. The labeled drug that is bound by antibody rotates more slowly and will emit light that is plane polarized. The detector responds to plane-polarized light only because a polarizing filter is placed between the cuvet and detector. Antibody binds to more fluorescein labeled drug when there is less drug in the patient's serum. This slows down its rotation giving a greater plane polarized signal. Therefore, plane-polarized fluorescent intensity is inversely proportional to the drug concentration in the patient's sample.

CLONED ENZYME DONOR IMMUNOASSAY (CEDIA). A technique related to EMIT is CEDIA (cloned enzyme donor immunoassay). The method uses a drug conjugated to a fragment of the enzyme β -galactosidase which is called the enzyme donor (ED). The ED reagent also contains the substrate, chlorophenol red- β -D-galactopyranose. This is mixed with urine or serum and a second reagent containing a monoclonal antibody against the drug and a second fragment of β -galactosidase called the enzyme acceptor (EA). If drug is present in the sample it neutralizes the antibody. The two enzyme fragments associate forming an active enzyme which splits the substrate, liberating the red dye. Absorbance is directly proportional to drug concentration. If drug is not present, the antibody binds to the ED fragment preventing formation of active enzyme.

HIGH PERFORMANCE LIQUID CHROMATOGRAPHY (HPLC). HPLC is a chromatography method that uses liquid mobile and stationary phases. The mobile phase is usually a buffer to which a polarity modifier such as acetonitrile has been added. The stationary phase consists of a stainless steel column of silica gel that is bonded to a nonpolar liquid. The most common column packing for clinical use is octadecylsilane (C18). The stationary phase is less polar than the mobile phase, and this causes

compounds which are lower in polarity to be retained longer than more polar molecules. The column is packed very tightly to give thousands of surfaces upon which partitioning can occur. Therefore, a pump is used to move the mobile phase through the column. To obtain a flow rate of 1.5-2.0 mL/min it is not uncommon to develop a pressure of 1,200-2,500 pounds per square inch at the start of the column. The separated molecules enter an optical flowcell after eluting from the column. UV (ultra-violet) light is passed through the flowcell and a photomultiplier tube or photodiode array detects the transmitted light. When a drug enters the flowcell it will absorb a portion of the incident UV light causing an increase in absorbance (optical density). This signal is applied to a chart recorder, which produces a peak that is proportional in height and area to the concentration of the drug. HPLC is time consuming and is usually reserved for assays of drugs for which there is no available immunoassay. It has the advantage of being able to separate drug metabolites from parent compounds and separate compounds that are nonvolatile (for example, anabolic steroids).

Results

Results for drug of abuse tests should be negative (ie. below the low calibrator cutoff). Results for therapeutic drugs should fall within the published therapeutic range for the drug and treatment. Some typical therapeutic limits for commonly measured drugs are shown below:

- Acetaminophen: 10-30 mg/L; toxic level >200 mg/L.
- Amikacin: trough 1-4 mg/L; peak 25-35 mg/L; toxic trough >10 mg/L; toxic peak >35 mg/L.
- Carbamazepine: 4-12 mg/L; toxic level >15 mg/L.
- Digoxin: 1.5-2.0 µg/L; toxic level >2.5 µg/L.
- Ethosuximide: 40-100 mg/L; toxic level >150 mg/L.
- Gentamicin: trough 1-2 mg/L; peak 8-10 mg/L; toxic trough >2 mg/L; toxic peak >12 mg/L.
- Kanamycin: trough 4-8 mg/L; peak 25-35 mg/L; toxic trough >10 mg/L; toxic peak >35 mg/L.
- Lidocaine: 1.5 - 6 mg/L; toxic level >6 mg/L.
- Netilmicin: trough 1-2 mg/L; peak 8-10 mg/L; toxic trough >2 mg/L; toxic peak >12 mg/L.
- Phenobarbital: 15-40 mg/L; toxic level >40 mg/L.
- Primidone: 5-12 mg/L; toxic level >15 mg/L.
- Procainamide: 4-10 mg/L; toxic level >12 mg/L.
- Salicylates: 100-300 mg/L; toxic level >400 mg/L.
- Theophylline: 8-20 mg/L; toxic level >20 mg/L.
- Tobramycin: trough 1-2 mg/L; peak 8-10 mg/L; toxic trough >2 mg/L; toxic peak >12 mg/L.
- Valproic acid: 50 - 100 mg/L; toxic level >100 mg/L.
- Vancomycin: trough 5-10 mg/L; peak 20-40 mg/L; toxic peak >80 mg/L.

Health care team roles

Therapeutic drug tests are ordered by physicians. Blood and urine samples may be collected by a nurse or phlebotomist. In the case of drug of abuse testing performed on behalf of an employer or government agency, drug testing is supervised by a medical officer appointed by the institution. Urine samples are collected and transported by nontesting personnel who should have special training in chain-of-custody procedures. Drug testing is performed by a clinical laboratory scientist, CLS (NCA) or medical technologist, MT (ASCP) or by a clinical laboratory technician, CLT (NCA) or medical laboratory technician, MLT (ASCP). Clinical toxicologists, clinical chemists, and clinical pharmacologists may be responsible for interpreting therapeutic drug tests and recommending dosage adjustments to the physician. Psychiatrists, psychologists, nurses, and social workers who are trained in drug abuse treatment are involved in evaluation, treatment, and counseling of drug abusers.

Resources

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Robert Harr

Drugs used in labor see **Uterine stimulants**

Dual energy x-ray absorptiometry (DXA) scan see **Bone densitometry**

Duchenne muscular dystrophy see **Muscular dystrophy**

Dynamic spatial reconstructor

Definition

The dynamic spatial reconstructor (DSR) is a unique computed tomography (CT)-based scanner valuable for three-dimensional imaging and visualization of high temporal resolution three-dimensional cardiac cycles. Developed in the 1970s and early 1980s, the DSR is the “multi-source, multi-detector high speed synchronous 3D CT scanner for high temporal and spatial resolution scanning of the **heart, lungs,** and circulation” according to the Mayo Clinic, where the scanner was developed and is located. It is considered a research prototype and is not available commercially.

Purpose

The DSR was developed as a non-invasive diagnostic device to detect **lung cancer** and heart disease in their early stages. It emerged as an answer to the tremendous challenge of using CT to provide 3D reconstruction of moving objects such as the cyclic motion of the beating heart. Due to its efficacy, it has become the standard in the field of three-dimensional real-time imaging by which other non-invasive imaging modalities are measured in their effectiveness for achieving various diagnoses.

Description

Only a single DSR exists, at the Mayo Clinic site (Rochester, Minnesota), due to its prohibitive cost and size. The physical machine comprises:

- a gantry 15 ft (4.57 m) in diameter and 20.5 ft (6.24 m) in length, weighing about 17 U.S. tons
- fourteen x-ray guns featured within a hemicylindrical arrangement (surrounding the patient or subject overhead and on the sides) and targeted at an adjacent hemicylindrical fluorescent screen
- fourteen rotating two-dimensional television cameras and eight video disc recorders for recording the x-rays
- electronics and software algorithms for image acquisition

The DSR is theoretically capable of acquiring image data for up to 240 contiguous 0.9 mm thick segments in time periods down as far as 1/60 of a second. The process can then be repeated as rapidly as 60 times per second. Due to limiting physical factors of the machine, however, these values are somewhat diminished in practice. The 14 rotating television cameras, possessing 240 scan lines apiece, receive x-ray photons from the 14 x-ray

point sources directly opposite them at a frequency of 1/60 second, which happens to be a physiologically appropriate frequency for internal investigations involving moving organs such as the heart.

Though the DSR is capable of diagnosing a myriad of heart and lung disorders, its cost (and thus limited capability for service) has prevented it from becoming a routinely useful clinically diagnostic tool. Nevertheless, over the years since its inception in 1983, the DSR has made possible the collection and analysis of unique, important data that has been especially employed in cardiac dynamics research and in assuring the legitimacy of other imaging modalities.

An example of typical research usage is estimating the spatio-temporal distribution of the velocity of the left ventricular wall from experimental data obtained on the DSR. Essentially, a dense velocity field may be computed by applying a differential technique. This velocity field is obtained by mathematically applying the three following assumptions to the images: conservation of mass, incompressibility, and smoothness of the velocity field. In the case of this study, the results were in terms of the evolution of the field over time and maximum velocities, which were found to be in good agreement with the known physiological behavior of the heart.

The DSR is not without its problems, however. In addition to its enormous cost and size, another difficulty plaguing the machine is that the gantry rotates only 1.5° per 1/60 second, which hinders the homogeneous distribution in orientation angle of images per time period.

In order to keep the DSR more modern, some alterations have been implemented over the years since its launch, such as converting the old cameras (image isocron) to CCD (charge coupled device) cameras, larger lenses, and utilizing digitized images with corresponding algorithms. The DSR has thus been used to examine cardiopulmonary mechanics and pulmonary ventilation. Studies have confirmed the functionality of volumetric CT (DSR) in accurately resolving lung volumes, cardiac chamber volumes, myocardial muscle mass, and regional lung density, among others.

Operation

In general, the greater the number of viewing angles used in collecting data tends to generate better images, at least up to a point. At least 4/60 of a second of scanning is typically desirable for creation of a reasonably good image reconstruction by the DSR. However, the DSR operator, or the research team doing the experiment, must consider the organ of interest in terms of its speed of movement within the body. This is so that interesting and

KEY TERMS

Computed tomography (CT)—Also known as CAT (computed axial tomography) scans. Computed tomography scans are completed with the use of a 360-degree x-ray beam and computer reconstruction of images using appropriate algorithms. Two-dimensional slices are acquired and stacked up computationally to yield a three-dimensional density map of areas of interest. These scans allow for high resolution cross-sectional views of body organs and tissues.

relevant data can be taken at an appropriate rate, based on the similarity between the DSR temporal resolution and the tissue velocities and periodicity, in order to obtain optimal images.

Maintenance

Maintenance is performed as needed on this unique instrument.

Health care team roles

The DSR is mainly a research machine, so health care roles are generally relegated to interpretation of data sets by a doctor or technician trained to work with the apparatus.

The DSR is used at its sole site in the Mayo Clinic. It is generally used by researchers in fields such as cardiac dynamics which require in vivo 3D data for specific studies or by doctors who wish to measure how well another imaging modality (i.e. electron CT) performs in comparison. It is used on humans as well as a wide range of animals for research.

Training

Very few people are needed to operate the DSR since there is only one. Operating the scanner requires very specialized training that would be provided by technicians and technologists on site at Mayo if the need arises for its use.

Resources

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The Mayo Clinic. 200 First Street SW, Rochester, MN 55905 507-284-2511. <<http://www.mayo.edu>>.

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Bryan Ronain Smith

Dysarthria

Definition

Dysarthria is a group of speech impairments due to weakness, incoordination, spasticity, rigidity, or irregular movements caused by damage to the nervous system.

Description

Speech abilities depend on the coordinated function of muscles of respiration, phonation (larynx), and articulation. These functions are controlled by a complex neural circuitry involving the structures and pathways of the peripheral nervous system (cranial and spinal nerves) and **central nervous system** (cerebral cortex, basal ganglia, substantia nigra, cerebellum, brainstem). Damage to any portion of the speech neural circuitry can lead to dysarthria. As a result, speech may be distorted and difficult to understand. Dysarthria is frequently accompanied by **dysphagia**, or swallowing difficulty, as similar neural circuits are necessary for swallowing function. Depending on which portion of the nervous system is affected, dysarthria can be accompanied by other speech, language, motor and sensory disturbances. Dysarthria can occur in adults and children who have neurologic conditions affecting the speech circuitry.

Causes and symptoms

Many neurologic etiologies that affect the speech neural circuitry can lead to dysarthria. Among the most common etiologies are stroke, degenerative conditions (e.g., **Parkinson's disease**, amyotrophic lateral sclerosis, Huntington's disease, cerebellar degeneration, **multiple sclerosis**), trauma, **cerebral palsy**, tumor, infections, and toxic conditions. Because dysarthria can arise from so many different neurologic conditions, the prevalence of the disorder is difficult to estimate.

The symptoms of dysarthria vary depending upon which portion of the neural circuitry is damaged.

KEY TERMS

Articulation—The pronunciation of speech sounds.

Central nervous system—Portions of the nervous system within the confines of the meninges and bones.

Dysphagia—Swallowing difficulty.

Dysphonia—Hoarse, breathy, or strained voice.

Etiology—The cause or causes of a disease or condition.

Peripheral nervous system—Portions of the nervous system that exit the meninges; the nerves.

Phonation—Sound that emanates from the larynx; voice.

Prosody—Intonation and rhythm of speech.

Resonance—The nasal quality of speech.

Articulation may be slurred, imprecise, distorted, or irregular. The resonance quality of speech may be hypernasal (over nasally sounding) or hyponasal (under nasally sounding). The voice may be breathy, strained, hoarse, or strangled to the point of stopping. Selective dysphonia (strained or breathy voice quality) can be observed. The prosody or melody of speech may be flattened, excessive, or choppy. The rate of speaking is usually slowed, but some individuals may actually speak at an excessive rate. Respiration for speech may be weak or forced. Tremor, spasms, or excessive movements of the speech muscles may disrupt the flow of speaking. Different combinations of symptoms can lead to significant loss of speech intelligibility (how easily speech is understood). Patterns of these symptoms tend to be observed in relation to the part of the nervous system that is damaged.

Diagnosis

A physician will perform a clinical neurological examination to determine a diagnosis in individuals with suspected neurologic disease. When an accompanying speech disorder is noted, the physician will refer the patient to a speech-language pathologist trained in the administration of speech examination protocols to identify the pattern of dysarthria and determine a course of treatment if warranted. Although most dysarthria tests depend on the clinician's perceptual analysis and judgment of the patient's speech characteristics, some acoustic and physiologic measurements can be complet-

ed using computerized analyses. Clinicians evaluate patterns of speech characteristics related to articulation, resonance, phonation, respiration, and prosody to determine a course of intervention. Assessment of dysarthria, which occurs in acute through chronic stages of the neurologic condition, takes one to two hours to complete.

Treatment

Treatments provided by physicians that may improve aspects of dysarthria include pharmacologic treatments for neurologic conditions, surgical intervention (e.g., injection of botulinum toxin into the vocal folds), or prosthetic management (for example, palatal lift, a prosthesis used to improve speech for a patient with an incompetent soft palate). Patients with dysarthria often work with a speech-language pathologist who will use behavioral methods to alleviate the consequences of dysarthria for communication. When patients have a neurologic condition from which recovery is anticipated (e.g., stroke), clinicians will use drills and practice with speech activities to restore speech skills or identify strategies to improve speech intelligibility. In degenerative neurologic conditions, when it often becomes impossible to rehabilitate speech, patients with dysarthria may adopt alternative and augmentative communication strategies including writing, communication pointing boards, computers, or speech-generation devices to compensate for the severe speech impairment.

Prognosis

The prognosis for recovery of dysarthria relates to the nature of the neurologic disorder that has caused the disease. When patients develop degenerative neurologic conditions, speech is likely to deteriorate as well. When the patient has a static or recovering neurologic condition (e.g., stroke), some improvement in speech abilities is likely depending on the extent of the nervous system injury.

Health care team roles

Nursing and medical staff providing medical care for individuals with dysarthria implement strategies recommended by speech-language pathologists to foster communication with patients. The rehabilitation team (e.g., physical therapist, occupational therapist, physiatrist, social worker) assists with neurological recovery and implements strategies to maximize communication skills.

Prevention

The way to prevent dysarthria is to prevent the neurologic event that causes dysarthria.

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American Speech-Language-Hearing Association. 10801 Rockville Pike, Rockville, MD 20852. (800) 638-8255. <<http://www.asha.org>>.

National Institute of Deafness and other Communicative Disorders: Health Information: Aphasia. National Institutes of Health, 31 Center Drive, MSC 2320, Bethesda, MD, 20892-2320. <http://www.nidcd.nih.gov/health/pubs_vsl/>.

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Anastasia Marie Raymer, Ph.D.

Dyslexia *see* **Language disorders**

Dysmetria *see* **Movement disorders**

Dysphagia

Definition

Dysphagia is a disorder of swallowing.

Description

Dysphagia is a disruption in the ability to move food or liquid from the mouth through the pharynx and esophagus into the **stomach** safely and efficiently. Swallowing disorders can occur at any point in the life span from infancy through old age. It is estimated that approximately 6,228,000 Americans over age 60 have dysphagia, and that it occurs in 32% of all patients in intensive care units. If untreated, dysphagia can result in **dehydration**, weight loss, malnutrition, **pneumonia**, and, in rare cases, death.

In order to understand dysphagia, it helps to understand the normal swallow. A normal swallow rapidly carries a bolus of food or liquid through the mouth, pharynx, and esophagus, leaving these structures substantially clear of residue at its completion. It involves a complex interaction of sensory stimuli and motor responses that encompass both voluntary and involuntary behaviors.

A normal swallow consists of four phases: the oral preparatory phase, the oral phase, the pharyngeal phase, and the esophageal phase.

The oral preparatory phase readies the food or liquid for swallowing. The lips close and seal to contain the material in the mouth. Solid food is chewed and mixed with saliva. The tongue gathers the liquid or solid material into a bolus and holds it. During this phase, the entry into the airway is open and nasal breathing continues.

The oral phase begins when the tongue starts to move the bolus backward toward the pharynx. It ends when the head of the bolus passes into the pharynx.

The pharyngeal phase begins when the bolus enters the pharynx and ends when it passes into the esophagus. In this phase, sensory stimuli interact with reflex and volitional movements to trigger the swallow response, which includes:

- elevation and retraction of the soft palate to prevent material from entering the nose
- elevation and forward movement of the hyoid and larynx, which moves them out of the path of the bolus as it travels downward, thus helping to prevent it from entering the airway below
- closure of the larynx, which stops respiration momentarily and prevents the bolus from entering the airway below
- retraction of the tongue base and contraction of the posterior pharyngeal wall, which build pressure to propel the bolus downward
- progressive top to bottom contraction of the pharyngeal constrictor muscles, placing additional downward pressure on the bolus
- opening of the pharyngoesophageal segment to allow the bolus to pass into the esophagus

The esophageal phase of the swallow begins when the bolus enters the esophagus and ends when it passes into the stomach. Muscular contractions push the bolus downward through the lower esophageal sphincter into the stomach.

Causes and symptoms

Causes

Dysphagia occurs when any element of the normal swallow is disrupted. Oral structural abnormalities, muscular weakness, or incoordination may interfere with holding material in the mouth, forming it into a cohesive bolus, and propelling it backward into the pharynx. Lack of control over the material in the mouth might cause it to fall over the back of the tongue prematurely, while the airway is unprotected, or it might result in material remaining in the mouth after the swallow, when it could fall into the pharynx. If the bolus enters the pharynx before or after the swallow, while the airway is open and unprotected, there is a danger that aspiration will occur. Similarly, structural abnormalities, weakness, or incoordination in the pharynx or larynx may interfere with protection of the airway during the swallow or with the downward propulsion and emptying of the bolus into the esophagus. Finally, structural abnormalities, weakness, or incoordination in the esophagus may interfere with the progress of the bolus through the esophagus into the stomach.

Common etiologies of dysphagia include:

- strokes
- head injuries
- cervical **spinal cord** injuries
- progressive neurologic diseases
- **head and neck cancer** and the surgery or radiation used to treat it
- congenital syndromes and abnormalities
- esophageal stenosis
- esophageal tumors
- esophageal motility disorders
- achalasia
- gastroesophageal reflux disease

Medications may also cause or exacerbate dysphagia. **Antipsychotic drugs** that cause extrapyramidal symptoms like tardive dyskinesia may cause dysphagia, and some anticholinergic drugs may impair swallowing ability.

Symptoms

Common symptoms of dysphagia include:

- inability to control food or saliva in the mouth
- residue in the mouth after the swallow
- coughing during or after the swallow

- gurgly or wet vocal quality associated with swallowing
- unexplained weight loss
- increased time to consume a meal
- complaints of globus
- recurring pneumonia
- heartburn

Diagnosis

Diagnosis of dysphagia generally involves a clinical screening evaluation (sometimes called a bedside evaluation) and an instrumental evaluation. The clinical screening evaluation includes review of the medical history; current medical status; examination of oral anatomy and oral motor functioning; perceptual evaluation of laryngeal functioning; and observation of eating and drinking unless the risk of aspiration is very high and the individual is deemed too medically fragile to tolerate it. If the clinical screening evaluation suggests the presence of a dysphagia, it is usually followed by an instrumental evaluation.

The instrumental evaluation that is most widely used for diagnosing oropharyngeal dysphagia is the videofluoroscopic modified barium swallow (MBS) study. The MBS study allows the observation of structures and movements as the individual swallows controlled amounts of various consistencies (usually thin and thick liquid, a paste or pudding consistency, and solid food) while seated in an upright position. It provides information about transit times through the mouth and pharynx, motility problems, and the presence and etiology of aspiration. The MBS is done in the radiology department and requires the patient's cooperation. Thus, it may be contraindicated for patients who are unable to cooperate with instructions, or who are too medically fragile to be transported.

Videoescopy, or flexible fiberoptic examination of swallowing (FEES), is another procedure used to examine for oropharyngeal dysphagia. A flexible scope is inserted through the nose into the pharynx, allowing observation of the pharynx before and after the pharyngeal swallow is triggered. It does not allow observation of the oral or esophageal phases of the swallow, and, because the image is blocked by the constriction of the pharynx around the scope during the pharyngeal swallow, the presence and etiology of aspiration may be inferred but cannot be observed. This procedure can be done at the bedside and requires minimal cooperation from the patient, making it useful for patients who cannot tolerate an MBS study.

KEY TERMS

Achalasia—Failure of the pharyngoesophageal segment to relax sufficiently to allow swallowed material to pass from the esophagus into the stomach.

Anterior faucial arches—Also called the glosso-palatine arches, these pillar-like structures run from the palate down to the tongue laterally in the back of the mouth.

Anticholinergic drugs—Drugs that affect the parasympathetic system.

Aspiration—Entry of food or liquid into the airway below the level of the true vocal folds. Aspiration of large amounts or of small amounts over a period of time may result in pneumonia.

Cervical auscultation—Listening to the sounds of swallowing, usually via a stethoscope.

Dilatation—The stretching of a structure by swallowing increasingly larger sized rubber catheters filled with mercury.

Electromyography—Measures the timing and amplitude of selected muscle contractions.

Esophageal stenosis—Narrowing of the esophagus.

Esophagus—The tube that carries food or liquid from the pharynx to the stomach.

Globus—The feeling that there is a lump in the throat.

Hyoid—A small bone at the root of the tongue to which many lingual muscles are attached. It provides a stable base for tongue movement.

Larynx—Commonly called the voice box, this structure of muscle and cartilage sits at the top of the trachea.

Manometry—Measures of pressure changes that occur in the pharynx and/or esophagus during the swallow.

Motility—Movement.

Pharyngoesophageal segment—Also called the cricopharyngeal muscle or the upper esophageal sphincter (UES), this segment is normally in tonic contraction in awake individuals to prevent air from entering the esophagus during respiration and to reduce the risk of reflux from the pharynx into the esophagus.

Pharynx—The hollow muscular tube, commonly called the throat, that runs from the base of the skull to the opening of the esophagus.

Reflux—Backward flow of food and stomach acid from the stomach into the esophagus.

Scintigraphy—A nuclear medicine test requiring the patient to swallow measured amounts of radioactive substance. It can reveal the amount of aspiration and residue, but does not allow visualization of structures or movements.

Tardive dyskinesia—A disorder characterized by abnormal involuntary movements.

The instrumental evaluation most frequently used for esophageal dysphagia is the standard barium swallow or upper gastrointestinal series. This differs from the MBS study in that the patient is required to swallow a much larger amount of barium, typically while lying in the prone position. It allows observation of structures and of the movement of the material through the esophagus and into the stomach. When gastroesophageal reflux disease is suspected, continuous pH monitoring that measures the pH level of the contents of the lower esophagus is considered the best single test for its diagnosis.

Other instrumental evaluations that are sometimes used, either alone or in combination with the more standard techniques, include: ultrasound of the oral cavity, scintigraphy, **electromyography**, cervical auscultation, and manometry.

Treatment

Treatment of oropharyngeal dysphagia depends on the etiology and the severity of the problem. An essential component of treatment is education of the patient, family, and other caregivers regarding the nature of the swallowing problem, its potential complications, and the importance of following recommendations to prevent such complications. Treatment may also involve one or more of the following:

- An **exercise** program to improve the strength, range of motion, speed, and/or coordination of movements.
- Diet modifications that eliminate food or liquids of consistencies that are at high risk of being aspirated.
- Teaching of specific postures or strategies designed to reduce or eliminate the risk of aspiration when swallowing.

- Use of an alternate means of feeding, such as a gastric tube, either temporarily while other treatment strategies are attempted, or permanently if other treatment is unsuccessful.
- Esophageal dysphagia is usually medically, rather than behaviorally, managed. Dilatation is the typical treatment for esophageal stenosis. Surgery is most often used for esophageal tumors. Medications are used to treat motility disorders. Achalasia may be treated with smooth muscle relaxant drugs, dilatation, or surgery. Gastroesophageal reflux disease may be managed through dietary and lifestyle modifications, specifically: decreasing or eliminating certain foods from the diet, elevating the head of the bed for sleeping, avoiding lying down within two hours of eating, and eliminating smoking. Drugs and surgery are also used to treat this disorder.

Prognosis

The prognosis for recovery from dysphagia varies from excellent to poor depending on its severity, etiology, and the ability of the individual to comply with treatment recommendations.

Health care team roles

Identification, diagnosis, and management of dysphagia is a multidisciplinary effort. In most settings, speech-language pathologists perform screening evaluations, collaborate with a physician (usually a radiologist or otolaryngologist) in instrumental evaluations, design and implement a treatment program for oropharyngeal dysphagia, and provide education to the patient, family, and other staff members. The dietitian monitors the patient's nutritional status. The nursing staff, often the first to recognize dysphagic symptoms, encourages daily compliance with the recommended treatment program. Occupational and physical therapists work on feeding, adaptive devices, and sitting balance. (In some settings an occupational therapist is the primary swallowing therapist.) Physicians monitor and treat the patient's overall medical status. They are typically the primary treatment providers for esophageal dysphagia.

Prevention

Prevention of dysphagia requires prevention of the conditions that cause dysphagia, such as stroke, head trauma, or head and neck **cancer**. Prevention of complications from dysphagia involves adherence to the individualized treatment program, which usually specifies the precautions that should be taken. Although these will vary for each individual, they generally include eating and drinking only those foods and liquids of the recommended consistencies, sitting upright for oral intake, taking small amounts at a slow rate, ensuring that the mouth is clear after a swallow and at the end of a meal, using recommended strategies on every swallow, maintaining good **oral hygiene**, and remaining upright for 30 minutes after eating or longer if there is an esophageal dysphagia.

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Dystonia see **Movement disorders**

E

E. coli food poisoning see **Food poisoning**

Ear exam with an otoscope see **Otoscopic examination**

Ear instillation

Definition

An ear instillation is a solution of topical medicine prepared for administration into the ear canal. Medicine instilled into the ear is absorbed through the skin of the ear canal and membranes of the eardrum.

Purpose

Ear instillations are used primarily to treat wax build-up and inflammations or infections of the ear.

Precautions

Do not place the medicine dropper tip or cotton swabs directly into the ear canal, as this can traumatize the skin of the ear canal. Do not touch anything with the tip of the medicine dropper to prevent contamination. If the patient experiences **pain** from eardrops, stop using the medicine and contact the physician.

Description

To instill eardrops, have the patient lie on his or her side with the affected ear up. Gently pull the lobe of the ear up and back to open the ear canal (down and back for children under the age of three). Hold the medicine dropper just above the entrance to the ear canal and squeeze out the correct number of drops. Release the ear and have the patient remain still for five minutes to allow absorption of the eardrops. Repeat the procedure on the other ear if ordered.

Preparation

The hands should be washed before administering ear drops. Check the medication label each time to avoid medication errors. Be sure it is the right medicine, the right dose (strength), the right time, the right person and the right method. Look at the expiration date on the label. Do not use outdated medicine. Warm the eardrops to body temperature by rolling the bottle in the hands for several minutes before the instillation.

Aftercare

Have tissues or a warm washcloth available to wipe off residual medicine that may drip out of the ear when the patient sits up. A small piece of clean cotton ball may be placed into the outer portion of the ear canal to absorb excess medicine if desired. Discard soiled tissues and cotton in a bag that can be closed and discarded. Wipe the tip of the ear dropper with a clean tissue and recap the bottle. The hands should be washed again after completing the procedure.

Complications

Excessive use of eardrops can cause irritation and inflammation of the skin and membranes of the ear.

Results

Ear instillations will produce the desired results within a few days. Contact the physician if the patient experiences ear pain at the time of medicine instillation, or if the condition does not improve.

Health care team roles

Ear instillations are usually administered by a licensed nurse (R.N. or L.P.N.) in the health care setting. The patient or members of the patient's family can be taught to instill ear medicines in the home setting.

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Ear irrigation

Definition

Ear irrigation is the process of flushing the external ear canal with sterile water or sterile saline. It is used to treat patients who complain of foreign body or cerumen (ear wax) impaction.

Purpose

The purpose of ear irrigation is to remove earwax that is obstructing the ear canal or to remove a foreign object lodged in the ear canal. Ear irrigation is most commonly performed on those who experience a wax buildup that has impaired **hearing** and irritated the outer ear canal. Ear irrigation is performed in the emergency department as a first-line treatment for a foreign object in the ear canal, because it is less invasive than using an instrument. If the object is a live insect, oil is inserted into the ear to kill the insect; then, the ear canal is irrigated to remove the dead insect. Some foreign objects may be removed from the ear using irrigation alone, but most require a combination of both irrigation and the use of instruments by the physician.

Precautions

The ear canal should be examined with an **otoscope** prior to ear irrigation. Ear irrigation is contraindicated if the eardrum is ruptured, because the procedure may force **bacteria** through the perforation into the inner ear. Ear irrigation is also contraindicated in patients with **fever**

and ear **pain**, as these symptoms may indicate an inner ear **infection**. If a foreign object is made of vegetable matter (e.g., a bean or pea), irrigation is contraindicated because the water will cause the object to swell and complicate extraction of the object.

Description

Ear irrigation can be performed using a 50–60-cc syringe (20–30-cc syringe for children). Some nurses prefer to attach a large bore IV (intravenous) catheter (with the needle removed) to the syringe for easier direction of the fluid. Using this method, the fluid is aspirated into the syringe and squirted into the ear canal. Another method uses IV solution and tubing, with a disposable ear irrigation connector that fits onto and over the outer ear. When using this method, the IV is turned on and the fluid flows by gravity into the ear to create the irrigation. When using the IV method, the bag should be about 6 inches (15 cm) or less above the patient’s head to create the proper fluid pressure.

After positioning the patient, the earlobe of the affected ear should be held back, and up (back and down for an infant). The tip of the irrigation syringe or catheter should be placed at the entrance to the ear. The tissue of the ear should not be touched. The ear canal should not be occluded, or the solution will not be able to run back out of the ear. Gently aiming the flow of the irrigation solution towards the upper aspect of the external ear canal, the nurse should syringe or run in the IV fluid at a slow, steady rate, allowing the fluid to escape out of the ear canal and into the basin. If using a dental pik apparatus, the lowest setting should be used. Exerting too much pressure can force the foreign object or the wax occlusion deeper into the ear canal. The return fluid should then be checked before the syringe is refilled—or after 100cc of fluid for an adult, and 30cc of fluid for a child. The nurse should investigate whether the wax or foreign object has been flushed from the ear. When the occlusion has been removed, 500cc of irrigation fluid should be used for an adult—100cc for a child, or as ordered by the physician. The procedure should be interrupted if the patient complains of pain or dizziness.

Preparation

The patient should be positioned with his or her head bent slightly forward and tilted toward the unaffected ear. His or her shoulder and neck should be covered with a water-resistant pad and a bath towel. The patient should be given kidney-shaped basin to hold under the affected ear. Children, the elderly, or patients who cannot sit up may be positioned on the back with the head tilted slightly toward the unaffected ear. Again, the shoulder should be covered

and/or the pillow with a water resistant pad and a bath towel. If necessary, the nurse should obtain assistance to hold the basin under the ear during the ear irrigation.

The nurse should wash his or her hands and put on gloves. The normal saline or sterile water irrigation solution should be heated. This can be accomplished by placement of the solution bag (bottle) in hot water, or using a microwave. Then, the temperature of the solution should be checked before the irrigation is started. The solution should be body temperature or slightly warmer (98.6–100°F [37–37.8°C]). Cool irrigation solution is more likely to make the patient dizzy. If using an irrigation syringe, the cap should be removed, and the first 60 cc should be drawn into the syringe. If using an IV catheter, the needle should be removed and the plastic catheter attached to the syringe or the IV tubing. All air from the syringe and tubing must be removed. Further, when an ear irrigation kit is used, the pieces should be opened and assembled. The IV tubing must be primed and filled, and the irrigation apparatus should be connected. The patient should have a dry wash cloth on hand in case the irrigation fluid runs toward his or her face or eyes. The patient should be informed before the irrigation begins. The patient should be instructed to speak up if he or she experiences pain or discomfort.

Aftercare

The patient should tilt his or her head toward the affected ear for a few minutes. This will allow excess fluid to run out. The irrigation apparatus should be removed and the patient assisted with drying off. The outer ear should be wiped with cotton balls or cotton swabs. However, the swabs should not be placed into the ear canal. Irrigation fluid should be discarded into a hopper. Disposable equipment and gloves should be placed in a trash bag that can be sealed and discarded. Finally, the nurse should wash his or her hands once the procedure is completed.

Complications

Complications of an ear irrigation are rare, but may include trauma to the external ear canal, external ear infection, pain, nausea, or vertigo. Forceful irrigation with high pressure can rupture the eardrum and force bacteria into the inner ear.

Results

Proper ear irrigation will most often result in the removal of the impacted earwax. If the wax is not washed out with 500cc of irrigation fluid, ear drops containing peroxide will be prescribed by the physician; these are to

be used for several days, to soften the earwax before further irrigation. If **foreign bodies** cannot be removed with ear irrigation, suction or instruments to remove the foreign object may be employed by the physician.

Health care team roles

Ear irrigations are performed by a **registered nurse** (R.N.) in the health care setting. The patient or family of the patient may be taught, by the physician or nurse, to do ear irrigations in the home setting if a patient has frequent problems with ear wax build-up.

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ECG see **Electrocardiography**

ECG unit see **Electrocardiography unit**

Echocardiography

Definition

Echocardiography is a diagnostic test that uses ultrasound waves to produce an image of the **heart** muscle and the heart’s valves.

Purpose

Echocardiography is used to diagnose certain cardiovascular diseases, and is one of the most widely used



Echocardiogram, in which one can see the four chambers of the heart. (Photograph by Ken Eward. *Science Source/Photo Researchers*. Reproduced by permission.)

diagnostic tests for heart disease. Ultrasound waves that rebound or echo off the heart can show the size, shape, and movement of the heart's valves and chambers, as well as the flow of **blood** through the heart. Echocardiography may show abnormalities such as a poorly functioning heart valve or damage to the heart tissue from a heart attack. Echocardiography is especially useful for assessing disorders of the heart valves. It not only allows doctors to evaluate the heart valves, but can also detect abnormalities in the pattern of blood flow. For example, echocardiography can show the backward flow of blood through partially open heart valves (that should be fully closed). This backward flow of blood through a valve is known as regurgitation. By assessing the motion of the heart wall, echocardiography can help detect the presence and assess the severity of **coronary artery disease**, as well as help determine whether chest **pain** is related to heart disease. Additionally, echocardiography can help detect hypertrophic cardiomyopathy, in which the walls of the heart thicken in an attempt to compensate for heart muscle weakness.

Echocardiography is also used to evaluate heart murmurs (abnormal heart sounds), determine the causes of congestive **heart failure**, assess enlarged hearts or hearts with septal defects (holes between pumping chambers), and to monitor the heart in patients with diseases that may affect heart function (e.g., lupus, lung diseases). The biggest advantage to echocardiography is that it is noninvasive (it doesn't involve breaking the skin or entering body cavities) and has no known risks or side effects. Echocardiography is often used in conjunction with other diagnostic tests for the heart, such as **electrocardiography**.

Echocardiography is usually performed in the cardiology department at a hospital, but may also be performed in a cardiologist's office or an outpatient imaging center. Because the ultrasound scanners used to perform

echocardiography are portable (handheld) or mobile, echocardiography can be performed in the emergency department or at the bedside of patients who cannot be transported to the cardiology department.

Precautions

Echocardiography is a safe, noninvasive procedure, and there are no special precautions.

Description

Echocardiography creates an image of the heart using ultra-high-frequency sound waves—sound waves that are too high in frequency to be heard by the human ear. The technique is very similar to ultrasound scanning commonly used to visualize the fetus during **pregnancy**.

An echocardiography examination generally lasts between 15-30 minutes. The patient lies bare-chested on an examination table. A special gel is spread over the chest to help the transducer make good contact and slide smoothly over the skin. The transducer, also called a probe, is a small handheld device at the end of a flexible cable. The transducer, essentially a modified microphone, is placed against the chest and directs ultrasound waves into the chest. Some of the waves get echoed (or reflected) back to the transducer. Since different tissues and blood reflect ultrasound waves differently, these sound waves can be translated into a meaningful image of the heart that can be displayed on a monitor or recorded on paper or tape. The patient does not feel the sound waves, and the entire procedure is painless.

Occasionally, variations of the echocardiography test are used. For example, Doppler echocardiography employs a special microphone that allows technicians to measure and analyze the direction and speed of blood flow through **blood vessels** and heart valves. This makes it especially useful for detecting and evaluating regurgitation through the heart valves. By assessing the speed of blood flow at different locations around an obstruction, it can also help to precisely locate the obstruction.

An **exercise** echocardiogram, or **stress** echo, is an echocardiogram performed during exercise, when the heart muscle must work harder to supply blood to the body. This allows doctors to detect heart problems that might not be evident when the body is at rest and needs less blood. For patients who are unable to exercise, certain drugs can be used to mimic the effects of exercise by dilating the blood vessels and making the heart beat faster.

During the examination the sonographer can take measurements and, using the ultrasound scanner's computer, make calculations, including calculating blood

flow speed. Most ultrasound scanners are equipped with videotape recorders or digital imaging/archiving devices to record the real-time examination, and with medical image printers to print out hard copies of still images.

Preparation

The patient removes any clothing and jewelry above the chest.

Aftercare

No special measures need to be taken following echocardiography.

Complications

There are no known complications associated with the use of echocardiography. There is a slight risk of having a heart attack during an exercise echocardiogram, due to the stress put on the heart during the test, mostly for patients with a history of heart attack or other risk factors.

Results

A normal echocardiogram shows a normal heart structure and the normal flow of blood through the heart chambers and heart valves. However, a normal echocardiogram does not rule out the possibility of heart disease.

An echocardiogram may show a number of abnormalities in the structure and function of the heart, such as:

- thickening of the wall of the heart muscle (especially the left ventricle)
- abnormal motion of the heart muscle
- blood leaking backward through the heart valves (regurgitation)
- decreased blood flow through a heart valve (stenosis)

Health care team roles

Echocardiography should be performed by a registered diagnostic cardiac sonographer—an ultrasonographer specially trained in cardiac ultrasound. The results should be interpreted by a cardiologist trained in the application of cardiac sonography. The Intersocietal Commission for the Accreditation of Echocardiography Laboratories provides a self-evaluation process for echocardiography labs to become accredited. Accreditation involves staff evaluation and training, equipment assessment, and peer review.

KEY TERMS

Doppler imaging—A mode of ultrasound imaging that uses the physics principle of the Doppler effect (sound frequency waves shift relative to the observer, allowing velocity measurement) to produce color or gray-scale images of blood flow velocity and heart motion.

Heart murmur—An abnormal sound originating from the heart, usually detected by stethoscope. Murmurs are often caused by abnormalities of the heart valves.

Lupus—Also known as systemic lupus erythematosus, it is an autoimmune disease that may affect connective tissues and possibly the heart.

Noninvasive—Pertaining to a diagnostic procedure or treatment that does not require the skin to be broken or a body cavity to be entered.

Regurgitation—Backward flow of blood through a partially closed heart valve.

Transducer—A device that converts electrical signals into ultrasound waves and ultrasound waves back into electrical impulses; also called a probe.

Ultrasound—Sound waves at high frequencies beyond the level of human hearing; frequencies of approximately 2 to 10 megahertz are often used for diagnostic ultrasound imaging.

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American Heart Association National Center. 7272 Greenville Avenue, Dallas, Texas 75231. (800) AHA-USA1. <<http://www.americanheart.org>>.

American Institute of Ultrasound in Medicine. 14750 Sweitzer Lane, Suite 100, Laurel, MD 20707-5906. (301) 498-4100. <<http://www.aium.org>>.

American Registry of Diagnostic Medical Sonographers. 600 Jefferson Plaza, Suite 360, Rockville, MD 20852-1150. (800) 541-9754. <<http://www.ardms.org>>.

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Echoencephalography see **Ultrasonic encephalography**

Edema

Definition

Edema is the medical term for swelling. It is an abnormal retention of fluid in body tissue.

Description

Edema that is visible and localized often accompanies a soft-tissue injury, a sprain, or a fracture. However, it is also a component of generalized retention of fluid such as occurs in congestive **heart failure** (CHF). By weight, 60% of the human body is composed of water. In a remarkable process that is, under normal circumstances, a nearly perfect balance, water is exchanged between the **blood** and the tissues. As it circulates blood through the body, the pressure from the **heart** presses water out of capillaries and into body tissues. Osmotic (water-drawing) properties of certain blood **proteins** cause this process to reverse and fluid to be reabsorbed from the tissues back into the capillaries. To maintain equilibrium, the **kidneys** draw off excess fluid and salt, which are then excreted as part of the urine. When fluid is not released from the tissues, the result is edema.

Causes and symptoms

The causes and severity of edema cover a wide spectrum, including:

- mild edema that accompanies female hormone imbalance during the menstrual cycle
- allergies in which the chemical histamine is released by the **immune system**, resulting in fluid leaking into the tissues, which creates swelling
- injuries that do damage to capillaries, causing fluids to seep out into the tissue and not be reabsorbed by the damaged capillaries
- hormonal imbalance caused by taking certain hormonal medications such as **corticosteroids**, high estrogen contraceptives, or androgens (male hormones)
- beriberi (vitamin B₁ deficiency) and dietary protein deficiency, often found with malnutrition
- the venous congestion that accompanies cirrhosis of the **liver** and eventually decreases osmotic pressure
- kidney failure, which eventually allows salts and water to be retained in the tissues rather than being excreted
- nephritic syndrome, a condition in which large amounts of blood protein are lost and the blood loses its ability to draw fluid back out of the tissues
- congestive heart failure, a common condition, especially in the elderly, in which the heart functions less efficiently due to **coronary artery disease**, high **blood pressure**, or congenital or disease-caused abnormality in the heart

Other than traumatic injuries or allergic reactions, swelling typically develops quite slowly and often goes unnoticed at its onset. It is estimated that fluid in the body can increase by 15% without being visible. Frequently it is manifested at that point only by an increase in weight. When edema does become apparent, it is usually found in the lower part of the body, in the feet, ankles, legs, and lower back. A finger pressed into edematous skin will leave an imprint that slowly disappears as the fluid again refills that tissue.

Severe edematous conditions can cause fluid to gather in body cavities. Ascites, common with cirrhosis of the liver, is characterized by large amounts of fluid amassing in the peritoneal cavity of the abdomen. When liquid fills the pleural cavity adjacent to the **lungs**, it is termed pleural effusion; the liquid presses upon the lungs, causing difficulty in breathing. Pulmonary edema, which occurs when air sacs in the lungs become waterlogged, also causes respiratory complications.

Diagnosis

Diagnosis of the cause of edema is based upon **physical examination** and laboratory testing, plus a complete medical history. For patients with a history of CHF or



Gross lymphoedema in the arm of an elderly woman following radiotherapy treatment for breast cancer. (Photograph by Dr. P. Marazzi. National Audubon Society Collection/Photo Researchers, Inc. Reproduced by permission.)

kidney disease, weights are frequently taken to watch for fluid retention.

Treatment

The simple act of elevating the legs sometimes will reduce edema. However, the primary means of treating edema is in determining the cause of the fluid retention and attempting to remedy that. Giving **antihypertensive drugs** to people with high blood pressure will sometimes eliminate the edema. Often, though, the underlying cause of the edema is not easily remedied, such as in the case of CHF. Treatment of CHF may include:

- limiting the salt in the diet
- taking diuretics, medications that stimulate the kidneys to excrete the excess salt and water
- taking angiotensin-converting enzyme inhibitors (ACE inhibitors) and vasodilator drugs, which cause **blood vessels** to expand and allow blood to flow easier, decreasing the work required of the heart
- taking beta blockers, which improve the functioning of the left ventricle of the heart

- taking digitalis, a drug that expands the ability of the heart to pump blood through the body
- having surgery to replace abnormal heart valves; in extreme cases, heart transplant may be needed

Prognosis

The outcome for edema depends heavily upon its cause. The best outlook for the relief of edema is when the underlying condition is treatable.

Health care team roles

Edema is most often noticed by either the patient, by a primary care physician or nurse-practitioner during a routine examination, or by nursing staff caring for the patient in a health care facility or at home.

Both registered nurses (RNs) and licensed practical nurses (LPNs) must complete a prescribed course in nursing and pass a state examination. RNs typically have a degree in nursing. Good nursing care of the patient with edema will include observation, elevating the legs if the

KEY TERMS

Capillaries—The term for any of the vessels that carry blood between the smallest arteries, or arterioles, and the smallest veins, venules.

Congestive heart failure—A condition in which the heart cannot circulate enough blood to meet the needs of the body.

Corticosteroids—A group of medications that have similar properties to the corticosteroid hormones that the adrenal glands produce naturally.

Fracture—A partial break in a bone.

Histamine—A chemical present in cells that is released during an allergic reaction and that causes the symptoms of inflammation, including swelling.

Osmosis—The passage of a fluid such as water through a sieve-like tissue called a semipermeable membrane from a less concentrated, or weaker, solution to a more concentrated, or stronger one.

Soft-tissue injury—Damage to tissue that encloses bones or joints, such as muscles, tendons, or ligaments.

Sprain—The tearing or stretching of ligaments holding bone ends together in a joint, usually caused by sudden, violent pulling.

lower extremities are swollen, monitoring **vital signs** and weights, and providing education about the cause of the edema.

Clinical laboratory scientists have specialized training and must pass a state examination. They draw blood samples or do the necessary tests on fluids withdrawn from fluid-filled body cavities.

Radiologic technologists have specialized training and must pass a state examination. They take x rays and other tests to visualize and monitor the course of disease processes that contribute to the edema.

Prevention

Prevention of edema is dependent upon treatment of the basic reason for the edema. Losing weight, stopping smoking, and reducing **stress** can all aid in reducing blood pressure. Proper **nutrition** can help to maintain a healthy circulatory system.

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EEG see **Electroencephalography**

EEG unit see **Electroencephalography unit**

EKG see **Electrocardiography**

EKG unit see **Electrocardiography unit**

Electrical stimulation see **Electrotherapy**

Electroanalgesia

Definition

Electroanalgesia is a method of **pain management** that involves the introduction of a weak electric current at the site of **pain**.

Purpose

The purpose of electroanalgesia is to reduce or eliminate pain.

Precautions

There are few contraindications for the use of electroanalgesia. It should not be used with pregnant women or patients with **pacemakers**, **heart** problems, **hearing aids** or hearing-aid implants. The low-level current can often interfere with the working of pacemakers and **hearing** aids.

Description

Electroanalgesia is a relatively new treatment method (since the late 1960s) to mitigate or eliminate pain. The concept, however, dates to the time of Aristotle, when patients who were experiencing pain were urged to stand in shallow water on top of electric fish (probably rays). It was not until 1965 when Dr. Ronald Melzack and Dr. Patrick Wall suggested the gate control theory that a legitimate scientific basis for electroanalgesia was

found. This theory, and the endorphin release theory, became the foundational rationale of electroanalgesia.

The gate control theory is the most widely held explanation for why electroanalgesia works. It says that by stimulating nerve sensors in the skin through electricity, a gate is closed in a part of the **spinal cord**, preventing pain messages from being carried to the **brain**. The patient has no perception of pain, although the message of pain at its site of origin still exists.

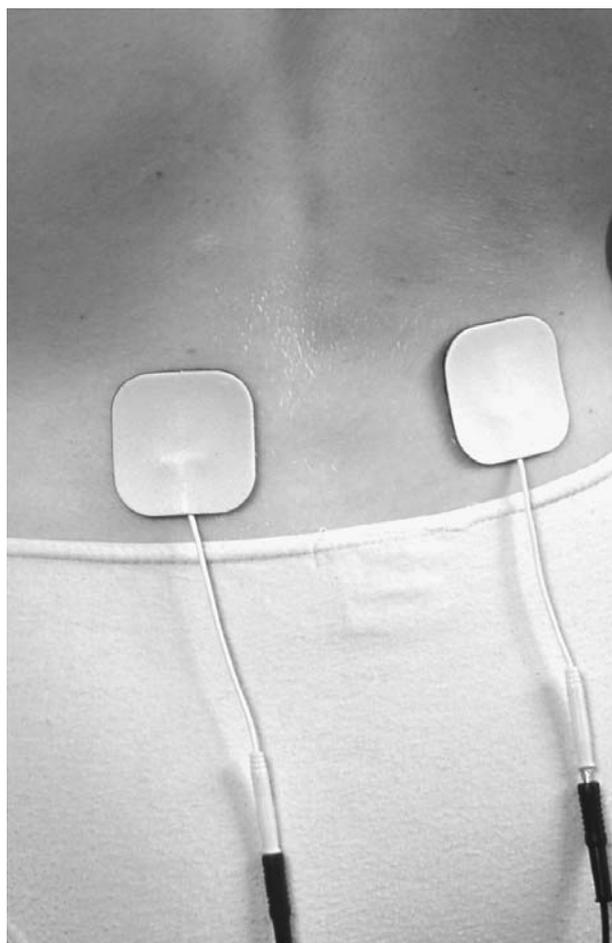
The endorphin release theory, in contrast, says that electricity stimulates the production of endorphins and enkaphalins—natural, morphine-like protein peptides—in the brain. These peptides block pain messages like conventional medications do but without the side effects associated with introducing pain control with opioids, for instance. Electroanalgesia cannot create a physical dependency like pain medications can.

Electroanalgesia may be used to relieve pain found in migraine and tension headaches, lower back, phantom limb syndrome, various forms of arthritis, **cancer**, angina pectoris, dysmenorrhea, posthepatic neuralgia, diabetic neuropathy, **bursitis**, sports injury, **wounds**, and after surgery. It can also be used to mitigate dental pain.

There are two forms of electroanalgesia: transcutaneous electrical nerve stimulation (TENS) and percutaneous electrical nerve stimulation (PENS). Electrical dental analgesia (EDA) is a form of TENS therapy and has been approved by the FDA since 1996.

TENS therapy uses one-inch (2.5 cm) diameter conductor electrode pads with adhesive backings. These electrode pads are placed on the skin near the site of the pain. The locus of the pain is the only reference for placement of these electrode pads. Studies have shown that endorphins are only released at pulse repetition rates (PPR)—or frequencies—of 8 Hz or less. Wider pulses spread the current over a greater area; most TENS units emit pulse widths ranging from 50–400 microseconds. Each TENS treatment will consist of the determined frequency (number of Hz) delivered for a certain length of time (perhaps one or two hours a day and sometimes more often at night) for a specified period of time (seven days; 14 days; 24 days). In low-frequency high-intensity stimulation, “quick probe treatments” may be delivered for 10 seconds each time; however, one “treatment” consists of several sets of five or six of these 10-second stimulations, and several “treatments” may be given consecutively. High-frequency TENS has been shown to suppress spontaneous and abnormal activity in a damaged nerve, and frequencies of 80 Hz or higher may be the treatment of choice in certain circumstances.

PENS therapy is a combination of acupuncture and electroanalgesia. In PENS treatment, fine stainless steel



An electrical current is passed between the two transcutaneous electrical nerve stimulation (TENS) pads on the skin. The current blocks the nerve signaling pathway and prevents pain signals from reaching the brain and being felt. (Photograph by Sheila Terry. Science Source/Photo Researchers. Reproduced by permission.)

acupuncture probes (rather than electrode pads) are attached to bipolar leads coming from an electrical generator. These probes are inserted into the soft tissue like acupuncture needles and the electricity running through them stimulates the pain sensors within and just beneath the skin. As with TENS, the level and length of stimulation, number of treatments, and number of treatment days, is determined. (In one study an alternating frequency of 15 Hz and 30 Hz was administered for 30 minutes three times a week.) Also as in TENS, the probes are inserted at or near the locus of pain rather than at traditional acupuncture points. Because a patient's skin is punctured, universal sterile procedures must be used.

A similar therapy to PENS is electroacupuncture. In this treatment method probes carrying the electric current are inserted at traditional acupuncture sites rather than at the pain locus.

KEY TERMS

Dysmenorrhea—Painful menstruation.

EDA—Electrical dental analgesia.

Endorphins—Natural, morphine-like substances in the brain.

Enkephalins—Natural, morphine-like substances in the brain.

PENS—Percutaneous electrical nerve stimulation.

TENS—Transcutaneous electrical nerve stimulation.

EDA is administered through small pads placed inside the mouth or on the outside of the cheeks. The patient controls the amount of electroanalgesic administered and feels only a pins-and-needles sensation rather than pain. Once the dental procedure is over and the EDA pads are removed, the patient has no residual numbing as often occurs with the use of local anesthetics.

Neither PENS nor electroacupuncture were approved by the FDA by 2001, and often are not covered by standard medical insurance. TENS and EDA have been approved. However, all of these electroanalgesic therapies should be used as a supplement to conventional treatment and should not be the primary or alternate course of treatment. Since pain is an indication of many serious conditions, pain should not be ignored or eliminated until the source of the disorder is found. Then, any number of pain management therapies including electroanalgesia may be used.

Preparation

There is no preparation for this procedure, except to identify the location of the pain. For TENS treatment, the patient should be given three separate treatments in the practitioner's office. An assessment of the patient's pain level after treatment, measured against a standard scale, must be discussed and recorded. The patient can then be instructed in the use of the apparatus for self-treatment at home. Once several treatments are completed, the patient should be evaluated. If the pain has stopped or reached a plateau, treatment should cease. If the pain is gone, even after only one minute of treatment during the first treatment, treatment should cease for that day. Often the patient feels immediate relief; sometimes, it is delayed over a day or two. It is important to remember that with progressive pathologies such as cancer and degenerative diseases like arthritis, pain most likely will return. The

patient will need repeated treatments which are often taken at home under the patient's control.

For PENS therapy, the patient receives treatment in the practitioner's office. The practitioner must locate the areas of pain and place the steel probes into the soft tissue at specific points near the pain.

Aftercare

With proper use, there is no need for aftercare from these procedures.

Complications

The only complications with electroanalgesic therapies are the risk of **infection** in invasive techniques (probes) and continuation of therapy after pain is eliminated or has reached its lowest threshold. In these instances, continuing treatment may cause the pain to return.

Results

Before treatments begin, the physician and patient must come to an agreement on the goals of therapy. Normal expected results are to diminish or eliminate pain; however, goals must be reasonable and workable according to the patient's condition. Often, patients report more freedom of movement, better sleep patterns, and considerable reduction in the need to use oral **analgesics** following electroanalgesic therapies.

Health care team roles

PENS therapists require special training in the use of the equipment and insertion of probes. There is an art to the therapy, much like the art associated with acupuncture.

TENS training is less delicate but still necessary. Since this therapy is relatively new, many physicians have written a prescription for a TENS unit, or given a unit to a patient without proper **patient education** about the use of the unit and the necessity for determining the appropriate frequency to obtain the necessary results. By administering the first three treatments in the office, the practitioner can determine the appropriate settings for the patient and his or her particular type of pain before sending the unit home with the patient.

Because dental patients control the amount of electronic anesthesia they receive, dentists and dental assistants must be trained in the use of the EDA units so they can instruct the patient how to dispense their individual level of pain suppression.

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Janie F. Franz

Electrocardiography

Definition

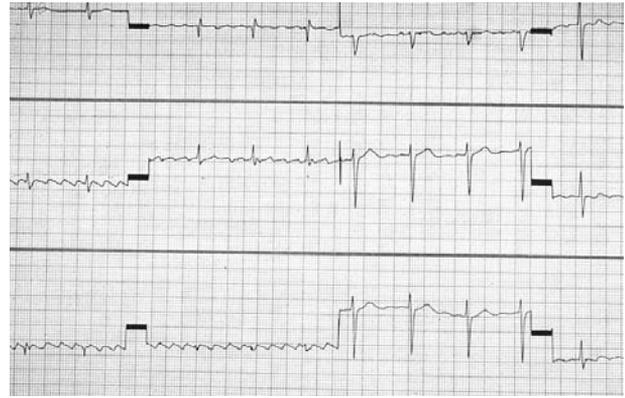
Electrocardiography is a commonly used, noninvasive procedure for recording electrical changes in the **heart**. The record, which is called an electrocardiogram (ECG or EKG), shows the series of waves that relate to the electrical impulses which occur during each beat of the heart. The results are printed on paper or displayed on a monitor. The waves in a normal record are named P, Q, R, S, and T, and follow in alphabetical order. The number of waves may vary, and other waves may be present.

Purpose

Electrocardiography is a starting point for detecting many cardiac problems. It is used routinely in physical examinations and for monitoring a patient's condition during and after surgery, as well as in the intensive care setting. It is the basic measurement used in **exercise** tolerance tests and is also used to evaluate symptoms such as chest **pain**, shortness of breath, and palpitations.

Precautions

No special precautions are required; however, patients are asked not to eat for several hours before a **stress test**.



An EKG strip indicating atrial flutter. (Custom Medical Stock Photo. Reproduced by permission.)

Description

The patient disrobes from the waist up, and electrodes (tiny wires in adhesive pads) are applied to specific sites on the arms, legs, and chest. When attached, these electrodes are called leads; three to twelve leads may be employed.

Muscle movement may interfere with the recording, which lasts for several beats of the heart. In cases where rhythm disturbances are suspected to be infrequent, the patient may wear a small Holter monitor in order to record continuously over a 24-hour period. This is known as ambulatory monitoring.

In 2001, the role of prehospital EKG in caring for patients with acute coronary syndromes was examined by the University of California San Diego School of Medicine, University of California San Diego Medical Center, San Diego, California, USA. Reported benefits of the prehospital 12-lead EKG include prompt initiation of reperfusion therapy (restoration of **blood** flow), and overall improved management and outcome of patients with acute **myocardial infarction**. Concerns remain regarding the best means of providing real-time field interpretation of the prehospital EKG and the potential for field time delay, triage concerns, and treatment of patients. Questions are raised regarding the overall clinical and cost benefit of expanding this resource.

Preparation

The skin is cleaned to obtain good electrical contact at the electrode positions and, occasionally, shaving the chest may be necessary.

KEY TERMS

Ambulatory monitoring—ECG recording over a prolonged period during which the patient can move around.

Arrhythmia or dysrhythmia—Abnormal rhythm in hearts that contract in an irregular way.

ECG or EKG—A record of the waves which relate to the electrical impulses produced at each beat of the heart.

Ectopic beat—Abnormal heart beat arising elsewhere than from the sinoatrial node.

Electrodes—Tiny wires in adhesive pads that are applied to the body for ECG measurement.

Fibrillation—Rapid, uncoordinated contractions of the upper or the lower chambers of the heart.

Lead—Name given the electrode when it is attached to the skin.

Reperfusion therapy—Restoration of blood flow to an organ or tissue; following a heart attack, quickly opening blocked arteries to reperfuse the heart muscles to minimize damage.

Aftercare

To avoid skin irritation from the salty gel used to obtain good electrical contact, the skin should be thoroughly cleaned after removal of the electrodes.

Complications

No complications from this procedure have been observed.

Results

Normal results

When the heart is operating normally, each part contracts in a specific order. Contraction of the muscle is triggered by an electrical impulse. These electrical impulses travel through specialized cells that form a conduction system. Following this pathway ensures that contractions will occur in a coordinated manner.

When the presence of all waves is observed in the electrocardiogram, and these waves follow the order defined alphabetically, the heart is said to show a normal sinus rhythm, and impulses may be assumed to be following the regular conduction pathway.

The heart is described as showing arrhythmia or dysrhythmia when time intervals between waves, or the order or the number of waves do not fit this pattern. Other features that may be altered include the direction of wave deflection and wave widths.

In the normal heart, electrical impulses—at a rate of 60–100 times per minute—originate in the sinus node. The sinus node is located in the first chamber of the heart, known as the right atrium, where blood reenters the heart after circulating through the body. After traveling down to the junction between the upper and lower chambers, the signal stimulates the atrioventricular node. From here, after a delay, it passes by specialized routes through the lower chambers or ventricles. In many disease states, the passage of the electrical impulse can be interrupted in a variety of ways, causing the heart to perform less efficiently.

Abnormal results

Special training is required for interpretation of the electrocardiogram. To summarize in the simplest manner the features used in interpretations, the P wave of the electrocardiogram is associated with the contraction of the atria. The QRS series of waves, or QRS complex, is associated with ventricular contraction, with the T wave coming after the contraction. Finally, the P-Q or P-R interval gives a value for the time taken for the electrical impulse to travel from the atria to the ventricle (normally less than 0.2 seconds).

The cause of dysrhythmia is ectopic beats. Ectopic beats are premature heart beats that arise from a site other than the sinus node—commonly from the atria, atrioventricular node, or the ventricle. When these dysrhythmias are only occasional, they may produce no symptoms or simply a feeling that the heart is turning over or “flip-flopping.” These occasional dysrhythmias are common in healthy people, but they also can be an indication of heart disease.

The varied sources of dysrhythmias provide a wide range of alterations in the form of the electrocardiogram. Ectopic beats, which begin in the ventricle, display an abnormal QRS complex. This can indicate disease associated with insufficient blood supply to the heart muscle (myocardial ischemia). Multiple ectopic sites lead to rapid and uncoordinated contractions of the atria or ventricles. This condition is known as fibrillation. In atrial fibrillation, P waves are absent and the QRS complex appears at erratic intervals, or “irregularly irregular.”

When the atrial impulse fails to reach the ventricle, a condition known as heart block results. If this is partial, the P-R interval (the time for the impulse to reach the ventricle) is prolonged. If complete, the ventricles beat

independently of the atria at about 40 beats per minute, and the QRS complex is mostly dissociated from the P wave.

Health care team roles

The electrocardiograph is conducted by a fully trained technologist and may be done in the cardiologist's office, a testing facility, or at a hospital patient's bedside. The technologist, or perhaps a nurse or nurse practitioner, will take the patients' medical history, educate them about the procedure they are about to undergo, and help them relax. The results of the electrocardiograph will be interpreted by a qualified physician, usually a cardiologist.

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The American College of Cardiology. Heart House, 9111 Old Georgetown Road, Bethesda, MD 20814-1699. (800) 253-4636. <<http://www.acc.org>>.

American Heart Association. 7272 Greenville Ave., Dallas, TX 75231-4596. (800)242-1793. <<http://www.amhrt.org>>.

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Electrocardiography unit

Definition

The **electrocardiography** unit, also called an electrocardiograph, is an apparatus that indirectly measures

the heart's electrical activity and records it as a graphic tracing.

Purpose

Electrocardiography is used to detect heart-function abnormalities. It indirectly detects the heart's electrical activity over time by measuring the electrical potential at the body's surface. If the heart's activity varies from normal, signs of this are seen in the surface electrical potentials. The electrocardiography unit produces a visual representation of the electrical potential, called an electrocardiogram (EKG or ECG), that is often recorded as a continuous line along a strip or special graph paper. When used to diagnose a **heart** ailment or check the effectiveness of a heart treatment, doctors, nurses, and other technicians read the strips, looking for telltale signs of various cardiac problems.

Because the electrical activity of the heart is the basis for its workings, many heart problems show up in an EKG tracing. The machine can detect **coronary artery disease**, where the **blood vessels** carrying **blood** to the heart have hardened and no longer work effectively; a heart attack, either current or previous; and arrhythmias, a heart beating at an abnormal speed or rhythm.

Description

The electrocardiography unit is a machine that transfers the very faint electrical signals of the heart into a visual representation of that activity. The unit commonly includes multiple electrodes and leads (often 12, but as few as three), a galvanometer to measure the electrical signal, an amplifier and filter to convert the faint electrical signal to one that can be seen, a computer screen or oscilloscope to display the output, and an ink-and-paper arrangement to produce hard copies of the signal.

In the simplest arrangement, three pairs of bipolar electrodes, where one is positively charged and the other negatively charged, are placed on particular areas of the patient's body. The electrodes are adhesive pads filled with conductive gel that are attached to the patient's skin. Wires called leads connect the electrodes to the unit. The electrical signal measured by each group of electrodes is also called a Lead. When used to identify the signal, the term is often capitalized.

Electrode placement

The first pair of electrodes has the positive electrode placed on the left arm and the negative on the right arm; this produces Lead I. The second pair has the positive electrode placed on the left leg and the negative on the right arm; this produces Lead II. Lead III comes from the

third pair, where the positive electrode is placed on the left leg and the negative on the left arm. If an imaginary line is drawn between each pair of these electrodes it forms a triangle where the electrical difference (measured in volts) can be detected across each side of the figure. This arrangement is known as Einthoven's triangle, after the inventor of the electrocardiograph.

Finer measurements of electrical potential can be made if additional sets of electrodes are used. The first additional set of electrodes is known as the augmented connections because the signals are significantly weaker than Leads I–III and have to be additionally increased, or augmented, by the machine. These Leads are unipolar, meaning that they measure the electrical difference between that electrode and a group of others. Lead aV_R measures the signal between the right arm (the positive electrode) and the average of the signals from the left arm and the left leg (two negative electrodes). Leads aV_L and aV_F are similarly arranged, with the left arm and the left leg having the positive electrode, respectively. All six of these limb leads measure electrical activity in the frontal plane of the heart, through the middle from top to bottom.

A second additional set of electrodes are the unipolar chest Leads, also known collectively as the modified chest Lead (MCL). These Leads measure electrical potentials across the horizontal plane of the heart. They are unipolar, measuring the electrical difference between the positive electrode and the average of the collective signal from the right arm, left arm, and left leg. There are six leads placed across the chest, numbered V1–V6 from the patient's right to left. V1 and V2 are put on either side of the sternum, in the fourth intercostal space (the space between the fourth and fifth rib). V4 is placed in the fifth intercostal space (between the fifth and sixth rib) on the line that divides the clavicle in half. V3 is placed halfway between V2 and V4. Both V5 and V6 are placed horizontal to V4, with V5 on the line that runs down the body from the inner armpit and V6 on the line that divides the armpit.

Waveform production

When the electrodes are placed as described, the electrical activity of the heart is printed in line patterns known as waves or waveforms. Waves come in two types—positive deflection (movement above the baseline or isoelectric line) and negative deflection (movement below the isoelectric line). Positive deflection is created when electrical activity flows toward the positive electrode; a negative deflection is produced when current flows away from the positive electrode (toward the negative). No heart activity produces a baseline or isoelectric

waveform. The isoelectric line is normally the beginning and ending of all waveforms.

EKGs are recorded on strips of graph paper that are fed through the machine at a constant rate (25 mm/sec or 1 in/sec) to allow for easy estimates of beats per time period and for points of comparison between the isoelectric line and the wave. At this standard feed rate, each small block of the graph paper represents 0.04 seconds, each larger dark box (having a 5×5 group of small boxes within it) is 0.2 seconds.

The normal heartbeat begins with an electrical impulse in the part of the heart with the fastest innate beat, the sinoatrial (SA) node. The electrical activity travels through the heart tissue, in a process known as depolarization, from the upper right of the organ to the lower left. Five major waves are produced: the P wave; the Q, R, and S waves (known as the QRS complex); and the T wave.

The P wave results from the depolarization of both atria and is a rounded, upward deflection that usually lasts about 0.10 seconds (about two small blocks of graph paper). The PR interval (PRI) is the time needed for the electrical impulse to travel from the atria to the ventricles. Normally, this lasts about three to five small squares (or 0.12 to 0.20 seconds).

The QRS complex has three recognized events and is the conduction of the impulse through the bundle of His and throughout the ventricles and atrial repolarization. The first downward deflection after PRI is the Q wave. It is followed by the largest deflection seen, the upward deflection of the R wave. Immediately after the R wave is a downward deflection called the S wave. The QRS complex generally happens in less than 0.12 seconds (three small squares) and all three waves are not always present, even in people with normal heart function.

The time interval between ventricular depolarization and repolarization is known as the ST segment and it is normally isoelectric (baseline). The full cycle is completed with the T wave, which is the result of the ventricles repolarizing. This wave is often a slightly asymmetrical, rounded positive deflection that finishes at the baseline.

Operation

To perform a resting EKG, the patient is placed on a table and the 12 electrodes are attached as described above. Sometimes, to improve connection, the areas of the skin where the electrodes will be placed are shaved or have conductive gel applied. Because some types of heart conditions are only evident when the heart is under **stress**, EKG analysis can also be performed with the patient on a treadmill.



An electrocardiography unit uses electrodes to measure the electrical activity of the heart and translates it into a line on paper and a computer screen. Doctors, technicians, and others can use the line tracing to look for a number of cardiac problems. (Custom Medical Stock Photo. Reproduced by permission.)

Sometimes a patient's symptoms occur at unpredictable intervals and are not **exercise** related. Heart activity can then be followed by a special portable EKG machine known as a Holter monitor. This EKG has three electrodes and stores the information for the monitoring period (generally from 24 hours to five days).

Diagnosing heart problems

In general, there are five aspects of the EKG that can reveal potential or present heart abnormalities: the heart rate, the heart rhythm, the P wave, the PR interval, and the QRS complex.

The heart rate is determined by counting the number of QRS complexes (for ventricular rate) or P waves (for atrial rate) over six seconds (30 large boxes on the graph paper). Normal is between 60 to 100 beats per minute (bpm). Less than 60 bpm is considered a slow or bradycardic rate and greater than 100 bpm is considered a fast, or tachycardic rate.

The heart rhythm, as revealed by the waveform pattern, can be classified either regular or irregular. To determine whether the ventricular rhythm is regular, a meas-

urement is made from R-to-R wave. A measurement from P-to-P wave determines the regularity of the atrial rhythm. If the interval is the same between waves, the rhythm is regular, if different, the rhythm is irregular.

Numerous changes in the P wave, PR interval, and QRS complex are possible. They depend on the actual damage to the heart, such as those that accompany a heart attack (**myocardial infarction** or MI). First, as the heart becomes ischemic, or starved for oxygenated blood, repolarization of the ventricles becomes abnormal; this depresses the ST segment more than 1 mm below baseline and the T wave becomes inverted. Next, if there is no treatment of the ischemia, actual damage to the heart tissue will occur. This can be seen through an elevation of the ST segment of more than 1 mm above baseline.

If the heart attack actually occurs (one or more coronary arteries becomes completely blocked), at least three possible indications can appear on the EKG. First, if it hasn't already happened, the ST segment will become elevated and the T wave will invert. Changes in the ST segment will remain for up to four weeks after the attack and the T wave could remain inverted for a year. If all

KEY TERMS

Bipolar—A type of lead having one positive and one negative electrode

Bradycardia—An abnormally slow heartbeat.

Bundle of His—A group of special heart muscle fibers that transmit electrical impulses to the ventricles, beginning the contractions that pump blood into the aorta and pulmonary artery.

Depolarization—The movement of an electrical charge through nerve or muscle tissue, changing its voltage.

Einthoven's triangle—The triangular arrangement of EKG electrodes on a patient, generally including the right arm, the left arm, and the left leg.

Electrode—The point of connection between the EKG unit and the patient.

Isoelectric—The baseline electrical level of the body.

Lead—A conductive connector between the electrode and the EKG unit or the signal derived from a group of electrodes.

Repolarization—The process in which a nerve or muscle cell returns to its normal electrical state after depolarization.

Tachycardia—An abnormally fast heartbeat.

Unipolar—A type of lead having one positive and multiple negative electrodes.

three of the layers of the heart have been affected by the attack, the Q wave will deflect more negatively. To be considered abnormal, the Q wave must be at least 0.04 seconds long (one small box) and be at least 25% of the height of the R wave. The Q wave will start large and shrink some over time, but will always be present after a so-called “Q-Wave” MI.

It is important to rule out artifacts as the cause of a patient's abnormal EKG. Common artifacts are patient movement, loose or defective electrodes, clammy skin, excessive chest hair, or improper grounding. The rule of thumb is to look to the patient and treat their distress, not what is showing on the monitor.

Maintenance

Electrocardiograph technicians are in charge of maintenance of EKG machines. Their tasks include

changing graph paper and ink, maintaining the electrodes and leads, and monitoring the machine for malfunction.

Health care team roles

Specially trained assistants known as electrocardiograph technicians often operate and maintain EKG machines in larger hospital and cardiology group practice settings. In small settings, nurses and medical assistants perform the test. A doctor usually does the final interpretation of the tracing.

Training

Many persons learn how to use an EKG machine through on the job training. However, training programs are available through outsourcing companies or in vocational and community colleges. The usual length of these college-based programs is 465 hours (four months). Program content includes classroom instruction in anatomy and physiology with an emphasis on the cardiac and vascular system, **medical terminology**, cardiovascular medications, patient care techniques, interpretation of cardiac rhythm, **medical ethics**, and a clinical practicum.

Resources

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Electroencephalography

Definition

Electroencephalography, or EEG, is a neurological test that involves attaching electrodes to the head of a

patient to measure and record electrical activity in the **brain** over time.

Purpose

The EEG, also known as a brain wave test, is a key tool in the diagnosis and management of epilepsy and other seizure disorders. It is also used to assist in the diagnosis of brain damage and diseases such as strokes, tumors, encephalitis, mental retardation, and **sleep disorders**. The results of the test can distinguish psychiatric conditions (**schizophrenia**, paranoia, depression) from degenerative mental disorders such as Alzheimer's and Parkinson's diseases. An EEG may also be used to monitor brain activity during surgery to assess the effects of anesthesia, and also to determine brain death.

Precautions

An EEG is generally performed as one test in a series of neurological evaluations. Rarely does the EEG form the sole basis for a particular diagnosis.

Description

Before the EEG begins, a nurse or technologist attaches approximately 16 to 21 electrodes to the patient's scalp with a conductive, washable paste. The electrodes are placed on the head in a standard pattern based on head circumference measurements. Depending on the purpose for the EEG, implantable, or invasive, electrodes are occasionally used. Implantable electrodes include sphenoidal electrodes, which are fine wires inserted under the zygomatic arch, or cheekbone; Depth electrodes, or subdural strip electrodes, are surgically implanted into the brain and are used to localize a seizure focus in preparation for epilepsy surgery. Once in place, even implantable electrodes do not cause **pain**. The electrodes are used to measure the electrical activity in various regions of the brain over the course of the test period.

For the test, the patient lies on a bed, padded table, or comfortable chair and is asked to relax and remain still while measurements are being taken. An EEG usually takes no more than one hour, although long-term monitoring is often used for diagnosis of seizure disorders. During the test procedure, the patient may be asked to breathe slowly or quickly. Visual stimuli such as flashing lights or a patterned board may be used to stimulate certain types of brain activity. Throughout the procedure, the **electroencephalography unit** makes a continuous graphic record of the patient's brain activity, or brainwaves, on a long strip of recording paper or computer screen. This graphic record is called an electroen-

cephalogram. If the display is computerized, the test may be called a digital EEG, or dEEG.

The sleep EEG uses the same equipment and procedures as a regular EEG. Patients undergoing a sleep EEG are encouraged to fall asleep completely rather than just relax. They are typically provided a bed and a quiet room conducive to sleep. A sleep EEG lasts up to three hours, or up to eight or nine hours if it is a night sleep.

In an ambulatory EEG, patients are hooked up to a portable cassette recorder. They then go about normal activities and take normal rest and sleep for a period of up to 24 hours. During this period, the patient and patient's family record any symptoms or abnormal behaviors, which can later be correlated with the EEG to see if they represent seizures.

An extension of the EEG technique, called quantitative EEG (qEEG), involves manipulating the EEG signals with a computer using the fast Fourier transform algorithm. The result is then best displayed using a colored gray scale transposed onto a schematic map of the head to form a topographic image. The brain map produced in this technique is a vivid illustration of electrical activity of the brain. This technique also has the ability to compare the similarity of the signals between different electrodes, a measurement known as spectral coherence. Studies have shown the value of this measurement in diagnosis of Alzheimer's and mild closed head injuries. The technique can also identify areas of the brain having abnormally slow activity when the data are both mapped and compared to known normal values. The result is then known as a statistical or significance probability map (SPM). This allows differentiation between early **dementia** (increased slowing) or otherwise uncomplicated depression (no slowing).

Preparation

Full instructions should be given to EEG patients when they schedule their test. Typically, individuals on medications that affect the **central nervous system**, such as anticonvulsants, stimulants, or antidepressants, are told to discontinue their prescription for a short time prior to the test (usually one to two days). However, such requests should be cleared with the treating physician. Patients may be asked to avoid food and beverages that contain **caffeine**, a central nervous system stimulant. Patients may also be asked to arrive for the test with clean hair free of spray or other styling products to make attachment of the electrodes easier.

Patients undergoing a sleep EEG may be asked to remain awake the night before their test. They may be given a sedative prior to the test to induce sleep.



This woman is undergoing an electroencephalogram (EEG) to diagnose Alzheimer's disease. On the computer screen at the right are the colored scans of the electrical activity in her brain. Alzheimer's patients show a specific abnormality in their EEGs. (Photograph by Catherine Pouedras, Photo Researchers, Inc. Reproduced by permission.)

Aftercare

If the patient has suspended regular medication for the test, the EEG nurse or technician should advise the patient when to begin taking it again.

Complications

Being off medication for one to two days may trigger seizures. Certain procedures used during EEG may trigger seizures in patients with epilepsy. Those procedures include flashing lights and deep breathing. If the EEG is being used as a diagnostic for epilepsy (i.e., to determine the type of seizures an individual is experiencing) this may be a desired effect, although the patient needs to be monitored closely so that the seizure can be aborted if necessary. This type of test is known as an ictal EEG.

Results

In reading and interpreting brainwave patterns, a neurologist or other physician will evaluate the type of brainwaves and the symmetry, location, and consistency

of brainwave patterns. Brainwave response to certain stimuli presented during the EEG test (such as flashing lights or noise) will also be evaluated.

The four basic types of brainwaves are alpha, beta, theta, and delta, with the type distinguished by frequency. Alpha waves fall between 8 and 13 Hertz (Hz), beta are above 13 Hz, theta between 4 and 7 Hz, and delta are less than 4 Hz. Alpha waves are usually the dominant posterior rhythm in older children and adults when awake and relaxed. Beta waves are normal in sleep, particularly for infants and young children. Theta waves are normally found during drowsiness and sleep and are normal in wakefulness in children, while delta waves are the most prominent feature of the sleeping EEG. Spikes and sharp waves are generally abnormal; however, they are common in the EEG of normal newborns.

Different types of brain waves are seen as abnormal only in the context of the location of the waves, the patient's age, and the patient's conscious state. Overall, pathology typically increases slow activity, such as theta or delta waves, but decreases fast activity, such as alpha and beta waves.

Not all decrease in wave activity is abnormal, however. The normal alpha waves seen in the posterior region of the brain are suppressed merely if the patient is tense. Sometimes the addition of a wave is abnormal. For example, alpha rhythms seen in a newborn can signify seizure activity. Finally, the area where the rhythm is seen can be telling. The alpha **coma** is characterized by alpha rhythms produced diffusely, that is, by all regions of the brain.

Some abnormal beta rhythms include frontal beta waves that are induced by sedative drugs. Marked asymmetry in beta rhythms suggests a structural lesion on the side lacking the beta waves. Beta waves are also commonly measured over **skull** lesions, such as **fractures** or burr holes, activity known as a breach rhythm.

Usually seen only during sleep in adults, the presence of theta waves in the temporal region of awake, older adults has been tentatively correlated with vascular disease. Another rhythm normal in sleep, delta rhythms, may be recorded in the awake state over localized regions of cerebral damage. Intermittent delta rhythms are also an indication of damage of the relays between the deep gray matter and the cortex of the brain. In adults, this intermittent activity is found in the frontal region while in children it is in the occipital region.

The EEG readings of patients with epilepsy or other seizure disorders display bursts, or spikes, of electrical activity. In focal epilepsy, spikes are restricted to one hemisphere of the brain. If spikes are generalized to both hemispheres of the brain, multifocal epilepsy may be present. The EEG can be used to localize the region of the brain where the abnormal electrical activity is occurring. This is most easily done using a recording method, or montage, called an average reference montage. With this type of recording, the signal from each electrode is compared to the average signal from all the electrodes. The negative amplitude (upward movement, by convention) of the spike is observed for the different channels, or inputs, from the various electrodes. The negative deflection will be greatest as recorded by the electrode that is closest in location to the origin of the abnormal activity. The spike will be present but of reduced amplitude as the electrodes move farther away from the site producing the spike. Electrodes distant from the site will not record the spike occurrence.

A final kind of abnormal result is the presence of slower-than-normal wave activity, which can either be a slow background rhythm or slow waves superimposed on a normal background. A posterior dominant rhythm of 7 Hz or less in an adult is abnormal and consistent with encephalopathy. In contrast, localized theta or delta

KEY TERMS

Encephalitis—Inflammation of the brain.

Fast Fourier transfer—A digital processing of the recorded signal resulting in a decomposition of its frequency components.

Ictal EEG—An EEG done to determine the type of seizure characteristic of a person's disorder. During this EEG, seizure medicine may be discontinued in an attempt to induce a seizure during the testing period.

Sphenoidal electrodes—Fine wire electrodes that are implanted under the cheek bones, used to measure temporal seizures.

Subdural electrodes—Strip electrodes that are placed under dura mater (the outermost, toughest, and most fibrous of the three membranes (meninges) covering the brain and spinal cord); used to locate foci of epileptic seizures prior to epilepsy surgery.

Zygomatic arch—Cheekbone; a quadrilateral bone forming the prominence of the cheek; articulates with the frontal, sphenoid, and maxillary, and temporal bone.

rhythms found in conjunction with normal background rhythms suggest a structural lesion.

Health care team roles

Electroencephalography is often performed by specially trained electrodiagnostic technologists. Training for such a position can be on the job but often involves study at a one to two-year college or vocational program. A typical program would include:

- human anatomy and physiology
- neurology and neuroanatomy
- **neurophysiology**
- medical terminology
- computer technology and instrumentation

Certification of electrodiagnostic technologists specializing in electroencephalography and the related area of evoked potentials is available through the American Board of Registration of Electroencephalographic and Evoked Potential Technologists.

A physician such as neurologist, neurosurgeon, or internist does the final review and diagnosis based on the

results of the EEG. The doctor can be present for the testing or may review saved tracings. Other health care professionals, such as nurses, aid in **patient education** concerning this procedure.

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Michelle L. Johnson, M.S., J.D.

Electroencephalography unit

Definition

The **electroencephalography** (EEG) unit is used to record the electrical output of the **brain** to produce a record called an electroencephalogram.

Purpose

Measurements taken by an electroencephalography unit are used to diagnose and classify disorders of the brain including seizures, encephalopathy, encephalitis, some psychiatric diseases, and brain death.

Description

The EEG unit includes a set of electrodes, amplifiers and filters, and a recording unit. Generally, surface electrodes are used for EEG recording, using 21 electrodes placed according to standard positions on the subject's scalp. However, implantable electrodes are also used for particular applications. For example, sphenoidal electrodes, which are fine wires inserted under the zygomatic arch, or cheekbone, are used when a patient is suspected of having temporal seizures. Depth electrodes, or subdural strip electrodes, are surgically implanted into the brain and are used to localize a seizure focus in preparation for epilepsy surgery.

The electrical signals from the brain are very weak, typically on the order of 10 to 100 microvolts. As a result, the amplifiers are used to increase the signal for display or recording, and the filters are used to eliminate artifacts and electrical noise produced by other sources such as muscles. The recording unit can be a paper and pen arrangement, although digital display is now standard.

Operation

The first step in performing an EEG is correct placement of the electrodes. The International Federation of Societies for EEG and Clinical Neurophysiology (IFSECN) has established a system of placement called the 10-20 Electrode Placement System. This system places the 21 electrodes at scalp positions that are at 10% and 20% of the head circumference, thus taking into account differing head size. Each electrode position is identified with a key letter that specifies the region of the brain and a positioning number. For example, prefrontal electrodes are labeled Fp, while central electrodes are C and occipital are O. Even numbers are on the right side of the head and odd numbers are on the left, with lower numbers anterior and higher numbers posterior. Midline electrodes are labeled with a "z" rather than a number.

Finding the exact point of placement of the electrodes involves measuring distances from various head landmarks, such as the nasion (the midpoint of the frontonasal suture) and the inion (the posterior occipital protuberance), and from one preauricular point (in front of the ear) to another. The electrodes are placed either at the intersection of these lines or at 10% or 20% of these various measurements about the head. For example, Cz is placed at the intersection of the nasion-inion line and the line that connects the preauricular points, while Fpz is 10% above the nasion and Oz is 10% above the inion. Standardized placement ensures that the results will be consistent and more easily compared to normal tracings.



The electrodes taped to this boy's scalp monitor his brain activity (brain waves) by detecting the electric impulses generated by the brain's activity. (Science Source/Photo Researchers. Reproduced by permission.)

Electrodes are applied to the head using electrode gel, which acts as a malleable extension of the electrode. Often, precleaning the scalp electrode site with a water-based, conductive agent is suggested for good contact. For long-term recordings, electrodes can be even more securely anchored using collodion (a mixture of pyroxilin, ether, and alcohol). This mixture quickly dries to a clear, tenacious film using compressed air.

Once the electrodes are attached, the machine is calibrated in two phases, through square-wave calibration and biological calibration. Square-wave calibration involves sending a standard pulse and altering the time constants of the low-frequency filters (LFF) and high-frequency filters (HFF) such that the resulting wave has the desired square-wave shape. Standard settings for LFF is 1 Hertz (Hz) and for HFF is 70 Hz. (Frequencies below 1 Hz can be artifacts due to sweat or other sources. The EEG typically does not have components above 70 Hz.)

Biological calibration involves sending one channel (the signal from a pair of electrodes) through all the amplifier inputs and comparing the signal with the displayed response; the two are adjusted until they are identical. Other adjustments that may be needed are damping the pen and setting sensitivity, which is usually started at 7 microvolts per millimeter and adjusted depending on the amplitude of the signal.

Generally, recordings are taken for at least 20 minutes to obtain an artifact-free result. The EEG unit records a series of waveforms that are not intrinsically normal or abnormal but must be interpreted based on the patient's age, awake-sleep state, and topographical location of the wave. Information can also be determined by looking for missing right-to-left symmetry. Further tests include the response of the subject to stimulation (such as visual flash or hyperventilation) or state changes (drowsiness or sleep). Although not always abnormal, the

KEY TERMS

Collodion—A syrupy liquid used to attach EEG electrodes to the scalp for long-term monitoring.

Inion—The bump of bone located on the back lower part of the head, a landmark used for measurements in the placement of EEG electrodes.

Nasion—The midpoint of where the frontal and nasal bones of the skull meet, a landmark used for measurements in the placement of EEG electrodes.

Sphenoidal electrodes—Fine wire electrodes that are implanted under the cheek bones, used to measure temporal seizures.

Subdural electrodes—Strip electrodes that are placed under dura mater (the outermost, toughest, and most fibrous of the three membranes [meninges] covering the brain and spinal cord); used to locate foci of epileptic seizures prior to epilepsy surgery.

Zygomatic arch—Cheekbone; a quadrilateral bone forming the prominence of the cheek; articulates with the frontal, sphenoid, and maxillary, and temporal bone.

presence of spikes and sharp waves can also aid in the diagnosis of the patient.

Maintenance

Electrodiagnostic technologists are in charge of daily maintenance of EEG machines. The tasks include changing graph paper and ink (if necessary), maintaining the electrodes and leads, and monitoring the machine for malfunction. Repair often involves outsource contracts or the use of personnel from the hospital engineering department.

Health care team roles

The EEG unit is often run by specially trained electrodiagnostic technologists, although sometimes it is done by nurses or other allied health professionals. Nurses are often used to supervise patients during extended EEG monitoring for seizure study. Neurologists and other physicians make the final diagnosis based on the results of EEG studies.

Training

Training to run an EEG unit can be on the job but often involves study at a one- to two-year college or vocational program. The formal postsecondary school training in this area is offered by hospitals and two-year community colleges. As of 2001, there were 12 formal programs approved by the Joint Review Committee on Education in **Electroneurodiagnostic Technology** of the Commission on Accreditation of Allied Health Programs (CAAHP). The programs usually last from one to two years with laboratory training, and often include the following classroom courses:

- human anatomy and physiology
- neurology and neuroanatomy
- neurophysiology
- medical terminology
- computer technology and instrumentation

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Electrolyte balance

Definition

Electrolytes are positively or negatively charged particles that readily dissolve in water. The predominant positively charged electrolytes in the body are sodium, potassium, **calcium**, and magnesium, while negatively charged electrolytes include chloride, phosphates, and bicarbonate.

Description

Salts are chemical compounds composed of atoms that carry electrical charges. Dissolved in water, the components in a salt exist as ions. Collectively, these ions are called electrolytes. Electrolytes are dissolved in different compartments of body water including: the serum portion of the **blood**, inside the cells (intracellular), and outside the cells (extracellular). The concentration of these electrolytes varies considerably from one area to the other. However, there is a narrow concentration limit of these electrolytes that the body must maintain within each of these compartments. The body transfers electrolytes intracellularly and extracellularly as required to maintain electrolyte balance. Electrolyte concentrations of extracellular fluid can be measured in a blood sample.

Function

The kidney filters electrolytes in blood and maintains a balance by excreting the proper amount in the urine. An electrolyte's concentration in a solution of dissolved salts can be measured as the amount in milliequivalents (mEq) per volume of solution (i.e. per liter). Electrolytes have many functions and roles in the body. The concentration of electrolytes must be maintained within a narrow range within the blood, otherwise deleterious physiological effects may occur. Several of the most important electrolytes will be discussed individually in the following sections.

Role in human health

Sodium balance

The largest portion of the body's sodium reserves is in the extracellular fluid, which includes the blood plasma. The **kidneys** function to control the sodium excreted in the urine; thus the level of sodium in the body is relatively constant on a daily basis. An upset between intake of sodium (through dietary consumption) and output (in urine and sweat) creates an imbalance, affecting the total amount of sodium in the body. Variations in the total

amount of sodium are related to the volume of water found in the blood.

A decrease in the overall amount of sodium does not necessarily cause the concentration of blood sodium to fall, but may decrease blood volume. Low blood volume, such as occurs with hemorrhage, signals the kidneys to conserve both water and sodium through stimulation of aldosterone. This helps to return blood volume toward normal, by increasing the amount of extracellular fluid sodium. With an excess of sodium in the body, blood volume may rise. This increase in blood volume initiates an accumulation of extracellular fluid, often in the feet, ankles, and lower legs, resulting in a condition known as **edema**.

The body maintains extracellular fluid sodium concentration homeostasis through the thirst mechanism and regulation of kidney water excretion by antidiuretic hormone (ADH). When sodium concentration—as opposed to too much total sodium—is too high, thirst prompts water intake and, at the same time, the ADH signals to the kidneys to conserve water, by increasing water absorption by the organs and passing less water into the excretory system.

Common disorders

The electrolytes involved in disorders of salt balance are most often sodium, potassium, calcium, phosphate, and magnesium. The concentration of blood chloride is usually similar to the blood sodium concentration, while bicarbonate is related to **acid-base balance**.

Sodium balance

HYPONATREMIA. The most common electrolyte disorder is hyponatremia, it occurs in almost 1% of all patients hospital admissions. Hyponatremia is a condition characterized by low sodium in the blood, below 136 mEq per liter of blood. In hyponatremia, the sodium concentration has been overdiluted by an excess of water or a loss of sodium in the body. Hyponatremia may result from intravenous administration of water to hospitalized patients or can also occur with small amounts of water consumption in those who have impaired kidney function and several other conditions such as **liver cirrhosis**, **heart failure**, underactive **adrenal glands** as with Addison's disease, and various antidiuretic hormone disorders. Over 50% of hospitalized patients with **AIDS** have been reported to suffer from hyponatremia. Lethargy and confusion are typically the first signs of hyponatremia. Muscle twitching and seizures may occur as hyponatremia progresses with risk of stupor, **coma**, and death in the most severe cases. Due to the effects on the **central nervous system**, mortality risk is considerably greater in

acute hyponatremia than in chronic hyponatremia. Other factors that reduce survival are the presence of debilitating illnesses such as **alcoholism**, hepatic cirrhosis, **heart** failure, or malignancy.

HYPERNATREMIA. Hyponatremia is a condition characterized by a high concentration of sodium in the blood, above 145 mEq per liter of blood. There is too little water compared to the amount of sodium in the blood, often resulting from a low intake of water. Profuse sweating, vomiting, **fever**, **diarrhea**, or abnormal kidney function may result in hyponatremia. With age, there is a decreased thirst sensation; therefore, hyponatremia is more common in the elderly. Aging reduces the kidney's ability to concentrate urine; therefore, taking diuretics may further exacerbate hyponatremia. Hyponatremia is very serious, particularly in the elderly. Almost half of individuals hospitalized for this condition will die, although it is often secondary to other illnesses.

Major causes of high sodium levels include:

- limited water access, particularly when combined with any other cause
- excess water loss due to profuse sweating, vomiting, fever, diarrhea
- disorders of other electrolytes
- head trauma or neurosurgery involving the pituitary gland
- use of drugs including lithium, diuretics, demeclocycline
- diabetes insipidus
- sickle cell disease

As with hyponatremia, the major symptoms of hyponatremia result from **brain** dysfunction. Severe hyponatremia can lead to confusion, muscle twitching, seizures, coma, and death. The effects on central nervous system hyperosmolality and the seriousness of the underlying illness lead to greater mortality in acute hyponatremia compared to chronic hyponatremia.

Calcium balance

The body's calcium reserves are predominately stored in bones, although the blood and cells also contain calcium. Calcium is necessary for proper functioning in many areas of the body including nerve conduction, **muscle contraction**, and enzyme functions. Like other electrolytes, the body controls calcium levels both in blood and cells. Calcium from the diet is absorbed in the gastrointestinal tract while the excess is excreted in the urine. A minimum of 500-1000 mg of calcium is required daily in order to maintain a normal calcium concentration. Normally, the body transfers calcium to the blood from the bones to maintain calcium homeostasis. If cal-

cium intake falls short of the requirement, too much calcium will be mobilized from the bones, weakening the bones and contributing to **osteoporosis**.

Parathyroid hormone and calcitonin regulate the amount of calcium in the blood. There are four **parathyroid glands** located in the neck that increase secretion of parathyroid hormone when the calcium concentration falls too low. Consequently, the gastrointestinal tract is stimulated to absorb more calcium from the blood, release a greater amount of calcium from the bones, and to excrete less in the urine. At the same time, parathyroid hormone induces the kidneys to activate **vitamin D** which increases uptake of calcium from the gastrointestinal tract. Calcitonin is a hormone produced by the parathyroid, thyroid, and thymus glands. It acts to lower the calcium concentration in blood by enhancing uptake of calcium into the bones.

Common disorders

Calcium balance

HYPOCALCEMIA. A low calcium blood level is referred to as hypocalcemia. Calcium is measured in extracellular fluid in two forms: total calcium concentration and ionized calcium concentration. About 50% of the total calcium concentration in the plasma exists in ionized form, which is the form that has biological activity at **cell membranes**. The remainder is either bound to the plasma **proteins** (about 40%) or complexed in the non-ionized form (about 10%) with anions such as phosphate. In hypocalcemia the total calcium concentration falls below 2.4 mEq/l in the extracellular fluid. Hypocalcemia can result from a number of problems. The most common reason is an inability to mobilize calcium from the bones or a chronic loss of calcium in the urine.

Other causes of hypocalcemia include:

- low blood albumin concentration
- hypoparathyroidism
- vitamin D deficiency
- renal failure
- magnesium depletion
- acute pancreatitis
- hypoproteinemia
- septic shock
- hyperphosphatemia
- drugs such as those used to treat hypercalcemia; anti-convulsants
- excessive secretion of calcitonin

An abnormally low blood calcium concentration may not produce any symptoms. However, over time the lack of calcium in the blood can affect brain function causing neurologic symptoms such as **memory** loss, depression, confusion, delirium, and hallucinations. Once calcium levels return to normal, these symptoms are reversible. Very severe cases of hypocalcemia can lead to seizures, tetany, and muscle spasms in the throat, affecting breathing. The condition is usually first discovered during routine blood tests because often there are no symptoms evident.

HYPERCALCEMIA. A high calcium blood level is referred to as hypercalcemia. The blood calcium concentration rises above 10.5 mg per deciliter of blood. Increased gastrointestinal tract absorption or increased intake of calcium may lead to hypercalcemia. Individuals who consume large amounts of calcium or who take calcium containing **antacids** can develop hypercalcemia. Absorption of calcium can be increased in the gastrointestinal tract with an **overdose** of vitamin D. The condition is usually first discovered during routine blood tests because hypercalcemia often doesn't have any symptoms at all.

If symptoms occur, typically the earliest are:

- constipation
- loss of appetite
- nausea and vomiting
- abdominal pain

Large amounts of urine may be produced by the kidneys. Due to excess urine production, fluid levels in the body decrease and may lead to dehydration. Severe hypercalcemia may induce brain dysfunction symptoms such as weakness, confusion, emotional disturbances, delirium, hallucinations, and coma. Additionally, abnormal heart rhythms and death may follow. In chronic conditions, **kidney stones** or calcium-containing crystals that can cause permanent damage may form.

Potassium balance

Potassium plays a major part in cell **metabolism** and in nerve and muscle cell function. Most of the body's potassium is located intracellularly, not extracellularly or in the blood. Too high or low concentrations of blood potassium can have serious effects such as an abnormal heart rhythm or cardiac arrest. The potassium concentration in the blood is maintained with the assistance of intracellular potassium. Like other electrolytes, potassium balance is regulated through gastrointestinal tract absorption of potassium in food, and by excretion of potassium by the kidneys. Some potassium is lost in the gastrointestinal tract, but most is lost through urine.

Some conditions and drugs influence potassium balance intracellularly, also affecting blood concentrations.

High sources of dietary potassium are:

- bananas
- melons
- tomatoes
- oranges
- potatoes and sweet potatoes
- green leafy vegetables such as spinach, turnip greens, collard greens, kale etc.
- most peas and beans
- potassium supplements
- salt substitutes (potassium chloride)

Common disorders

Potassium balance

HYPOKALEMIA. A low potassium blood level is referred to as hypokalemia. It occurs when the blood potassium concentration falls below 3.8 mEq per liter of blood. Hypokalemia is common in the elderly. Common causes include decreased intake of potassium during acute illness, nausea and vomiting, and treatment with thiazide or loop diuretics. About 20% of patients receiving thiazide diuretics develop hypokalemia, which is dose-dependent but usually mild. Since several foods contain potassium, hypokalemia is not typically due to a low intake. It is usually due to malfunction of the kidneys or abnormal loss through the gastrointestinal tract. People with heart disease have to be especially cautious regarding hypokalemia (particularly when taking digoxin), because they are prone to developing abnormal heart rhythms.

Potassium usually can be replaced relatively easily by eating foods rich in potassium or by taking potassium salts (potassium chloride) orally.

HYPERKALEMIA. A high level of potassium in the blood is referred to as hyperkalemia. It occurs when the blood potassium concentration rises above 5.0 mEq per liter of blood. Hyperkalemia typically results when the kidneys excrete too little potassium.

Some common causes are due to:

- drugs which block potassium excretion (angiotensin converting enzyme [ACE] inhibitors, triamterene, and spironolactone)
- Addison's disease
- kidney failure

KEY TERMS

Antidiuretic hormone (ADH)—A hormone that encourages the kidney to retain water when body stores are low.

Bicarbonate—A salt of carbonic acid produced by neutralizing a hydrogen ion.

Dehydration—A deficit of body water that results when the output of water exceeds intake.

Diuretic—An agent or drug that eliminates excessive water in the body by increasing the flow of urine.

Edema—An increase in blood volume instigates an accumulation of extracellular fluid resulting in swelling of the feet, ankles, and lower legs.

Electrolyte—A substance such as an acid, bases, or salt. An electrolyte's water solution will conduct an electric current and ionizes. Acids, bases, and salts are electrolytes.

Homeostasis—An organism's regulation of body processes to maintain internal equilibrium in temperature and fluid content.

Hypoparathyroidism—A condition resulting from an absence or deficiency in parathyroid hormone. It is characterized by hypocalcemia and hyperphosphatemia.

Tetany—A general stiffening and spasms of the muscles that can occur in severe cases of hypocalcemia.

- a sudden release of potassium from the cell reservoir in such cases as when a large amount of muscle tissue is destroyed (crush injury) or severe burn injuries, or an overdose on crack cocaine

The kidney's ability to excrete potassium is overwhelmed due to a rapid influx into the blood, resulting in life-threatening hyperkalemia. Generally, hyperkalemia is more dangerous than hypokalemia. A blood potassium concentration above 5.5 mEq/liter starts to affect the electrical conducting system in the heart. If the concentration continues to increase, the heart rhythm becomes irregular which may cause the heart to eventually stop.

Mild hyperkalemia often may not produce any symptoms. Symptoms may include an irregular heartbeat that could be experienced as palpitations. Hyperkalemia is typically first diagnosed during a routine blood test or by examining changes in an electrocardiogram. Severe

deficiencies may lead to muscular weakness, twitches, and **paralysis**.

Magnesium balance

Magnesium influences the function of many enzymes. Dietary intake is essential to maintain normal levels. The body's magnesium stores are predominately found in bone with little appearing in the blood. Excess is excreted in the urine or stool.

Common disorders

Magnesium balance

HYPOMAGNESEMIA. A low level of magnesium in the blood is known as hypomagnesemia. The level of magnesium in the blood decreases below 1.6 mEq per liter of blood. Metabolic and nutritional disorders are usually the culprit of hypomagnesemia, most often when intake of magnesium is decreased during starvation or intestinal malabsorption compounded with greater kidney excretion.

Symptoms of hypomagnesemia may include:

- loss of appetite
- nausea and vomiting
- sleepiness
- weakness
- personality changes
- muscle spasms
- tremors

When hypomagnesemia occurs along with hypocalcemia, the magnesium must be replaced before successful treatment of the calcium disorder.

HYPERMAGNESEMIA. A high level of magnesium in the blood is referred to as hypermagnesemia. The blood magnesium concentration rises above 2.1 mEq per liter of blood. Hypermagnesemia is quite rare unless people with kidney failure are given magnesium salts or consume magnesium-containing drugs such as antacids. Weakness, low **blood pressure**, and impaired breathing can result and the heart may stop if the concentration increases above 12 to 15 mEq per liter.

Phosphate regulation

Phosphorus occurs in the body almost solely in the form of phosphate, which is composed of one phosphorus and four oxygen atoms. Phosphate is found mostly in bones, although a significant amount is found intracellularly. It plays a role in energy metabolism and acid-base regulation, and it is used as a building block for DNA. Phosphate is excreted in the urine and stool.

Sources of phosphate include:

- spinach, turnip greens, collard greens, kale, and other green leafy vegetables
- milk and dairy products
- nuts
- chocolate
- many peas and beans
- dark-colored soft drinks

Resources

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Electrolyte tests

Definition

Electrolytes are positively and negatively charged ions that are found within the cells and extracellular fluids, including **blood** plasma. A test for electrolytes includes the measurement of sodium, potassium, chloride, and bicarbonate. These ions are needed to assess renal, endocrine, and acid-base function, and are components of both renal function and comprehensive metabolic biochemistry profiles. Other important electrolytes routinely measured in serum or plasma include **calcium** and **phosphorus**. These are measured together because they are both affected by bone and parathyroid diseases, and often move in opposing directions. Magnesium is another electrolyte that is routinely measured. Like calci-

um, it will cause tetany (uncontrolled muscle contractions) when levels are too low in the extracellular fluids.

Purpose

Tests that measure the concentration of electrolytes are needed for both the diagnosis and management of renal, endocrine, acid-base, water balance, and many other conditions. Their importance lies in part with the serious consequences that relatively small changes that diseases or abnormal conditions may cause. For example, the reference range for potassium is 3.6-5.0 mmol/L. Potassium is often a STAT test because values below 3.0 mmol/L are associated with arrhythmia, tachycardia, and cardiac arrest, and values above 6.0 mmol/L are associated with bradycardia and **heart failure**. Abnormal potassium cannot be treated without reference to bicarbonate, which is a measure of the buffering capacity of the plasma. Sodium bicarbonate and dissolved carbon dioxide act together to resist changes in blood pH. For example, an increased plasma bicarbonate indicates a condition called metabolic alkalosis, which results in too high a blood pH. This may cause hydrogen ions to shift from the cells into the extracellular fluid in exchange for potassium. As potassium moves into the cells, the plasma concentration falls. The low plasma potassium, called hypokalemia, should not be treated by administration of potassium, but by identifying and eliminating the cause of the alkalosis. Administration of potassium would result in hyperkalemia when the acid-base disturbance is corrected. Sodium measurements are very useful in differentiating the cause of an abnormal potassium. Conditions such as the overuse of diuretics (drugs that promote lower **blood pressure**) often result in low levels of both sodium and potassium. On the other hand, Cushing's disease (adrenocortical hyperfunction) and Addison's disease (adrenocortical insufficiency) drive the sodium and potassium in opposing directions. Chloride levels will follow sodium levels with the exception of acid-base imbalances, in which chloride may move in the opposing direction of bicarbonate. In essence, diagnosis and management of a patient with an electrolyte disturbance is best served by measuring all four electrolytes.

Description

Sodium is the principal extracellular cation and potassium the principal intracellular cation. Sodium levels are directly related to the osmotic pressure of the plasma. In fact, since an anion is always associated with sodium (usually chloride or bicarbonate), the plasma osmolality (total dissolved solute concentration) can be estimated using the following formula: Osmolality in

milliosmoles per kilogram water = serum sodium \times 2 + Glucose/18 + BUN/2.8 where BUN is the blood urea nitrogen concentration. Since water will often follow sodium by diffusion, loss of sodium leads to **dehydration** and retention of sodium leads to **edema**. Conditions that promote increased sodium, called hypernatremia, do so without promoting an equivalent gain in water. Such conditions include diabetes insipidus (water loss by the **kidneys**), Cushing's disease, and hyperaldosteronism (increased sodium reabsorption). Many other conditions, such as congestive **heart** failure, cirrhosis of the **liver**, and renal disease result in renal retention of sodium, but an equivalent amount of water is retained as well. This results in a condition called total body sodium excess, which causes **hypertension** and edema, but not an elevated serum sodium concentration. Low serum sodium, called hyponatremia, may result from Addison's disease, excessive diuretic therapy, the syndrome of inappropriate secretion of antidiuretic hormone (SIADH), **burns**, **diarrhea**, vomiting, and **cystic fibrosis**. In fact, the diagnosis of cystic fibrosis is made by demonstrating an elevated chloride concentration (greater than 60 mmol/L) in sweat.

Potassium is the electrolyte used as a hallmark sign of renal failure. Like sodium, potassium is freely filtered by the kidney. However, in the distal tubule sodium is reabsorbed and potassium is secreted. In renal failure, the combination of decreased filtration and decreased secretion combine to cause increased plasma potassium. Hyperkalemia is the most significant and life-threatening complication of renal failure. Hyperkalemia is also commonly caused by hemolytic anemia (release from hemolysed red blood cells), diabetes insipidus, Addison's disease, and digitalis toxicity. Frequent causes of low serum potassium include alkalosis, diarrhea and vomiting, excessive use of thiazide diuretics, Cushing's disease, intravenous fluid administration, and SIADH.

Calcium and phosphorus are measured together because they are both likely to be abnormal in bone and parathyroid disease states. Parathyroid hormone causes resorption of these **minerals** from bone. However, it promotes intestinal absorption and renal reabsorption of calcium and renal excretion of phosphorus. In hyperparathyroidism, serum calcium will be increased and phosphorus will be decreased. In hypoparathyroidism and renal disease, serum calcium will be low but phosphorus will be high. In **vitamin D** dependent rickets (VDDR), both calcium and phosphorus will be low; however, calcium is normal while phosphorus is low in vitamin D resistant rickets (VDRR). Differential diagnosis of an abnormal serum calcium is aided by the measurement of ionized calcium (i.e., calcium not bound by protein). Approximately 45% of the calcium in blood is bound to protein, 45% is ionized, and 10% is complexed to anions

in the form of undissociated salts. Only the ionized calcium is physiologically active, and the level of ionized calcium is regulated by parathyroid hormone (PTH) via negative feedback (high ionized calcium inhibits secretion of PTH). While hypoparathyroidism, VDDR, renal failure, hypoalbuminemia, hypovitaminosis D, and other conditions may cause low total calcium, only hypoparathyroidism (and alkalosis) will result in low ionized calcium. Conversely, while hyperparathyroidism, malignancies (those that secrete parathyroid hormone-related protein), multiple myeloma, **antacids**, hyperproteinemia, dehydration, and hypervitaminosis D cause an elevated total calcium, only hyperparathyroidism, malignancy, and acidosis cause an elevated ionized calcium.

Serum magnesium levels may be increased by hemolytic anemia, renal failure, Addison's disease, hyperparathyroidism, and magnesium based antacids. Chronic **alcoholism** is the most common cause of a low serum magnesium owing to poor **nutrition**. Serum magnesium is also decreased in diarrhea, hypoparathyroidism, **pancreatitis**, Cushing's disease, and with excessive diuretic use. Low magnesium can be caused by a number of **antibiotics** and other drugs and by administration of intravenous solutions. Magnesium is needed for secretion of parathyroid hormone, and therefore, a low serum magnesium can induce hypocalcemia. Magnesium deficiency is very common in regions where the water supply does not contain sufficient magnesium salts. Magnesium acts as a calcium channel blocker, and when cellular magnesium is low, high intracellular calcium results. This leads to hypertension, tachycardia, and tetany. Unfortunately serum total magnesium levels do not correlate well with intracellular magnesium levels, and serum measurement is not very sensitive for detecting chronic deficiency because of compensatory contributions from bone. Ionized magnesium levels are better correlated with intracellular levels because the ionized form can move freely between the cells and extracellular fluids.

Measurement of electrolytes

Electrolytes are measured by a process known as potentiometry. This method measures the voltage that develops between the inner and outer surfaces of an ion selective electrode. The electrode (membrane) is made of a material that is selectively permeable to the ion being measured. For example, sodium electrodes are made from a special glass formula that selectively binds sodium ions. The inside of the electrode is filled with a fluid containing sodium ions, and the outside of the glass membrane is immersed in the sample. A potential difference develops across the glass membrane that is dependent upon the difference in sodium concentration (activity) on the inside

and outside of the glass membrane. This potential is measured by comparing it to the potential of a reference electrode. Since the potential of the reference electrode is held constant, the difference in voltage between the two electrodes is attributed to the concentration of sodium in the sample. Ion selective membranes can be made from materials other than glass. For example, the antibiotic valinomycin is used to make potassium-measuring electrodes. Neutral carrier ionophores selective for lithium, calcium, and magnesium are also used for measurement of these substances in laboratory medicine. Ion selective electrodes can be used to measure whole blood, serum, or plasma since they respond to the electrolyte activity in the water phase of the sample only. One important aspect of electrolyte measurement is an artifact (erroneous result) called pseudohyponatremia that may occur when sodium is measured using a diluted blood sample. This happens when the plasma contains excessively high **lipids** or protein. These solids displace plasma water from the specimen, resulting in a low measurement of sodium that does not occur with an undiluted sample.

Total calcium and magnesium are usually measured by colorimetric procedures called dye binding assays. Calcium is displaced from protein by dilute acid or alkali and reacts with a dye (arsenazo III or cresolphthalein complexone) to form a colored product. When cresolphthalein complexone is used, 8-hydroxyquinoline is added to bind magnesium which also reacts with this dye. Magnesium is commonly measured by its reaction with a dye called Calmagite. A calcium chelator such as EGTA is added to prevent interference from calcium. Both calcium and magnesium may be measured by atomic absorption spectrophotometry. This procedure is more complex than colorimetric methods, but is also more accurate. Phosphorus is measured by reacting it with ammonium molybdate at an acid pH. The rate of ammonium phosphomolybdate formation is measured at 340 nm and is proportional to the inorganic phosphorus concentration (mono- and dihydrogen phosphate) of the sample.

Precautions

Electrolyte tests are performed on heparinized whole blood, heparinized plasma, or serum, usually collected from a vein or capillary. Venipuncture is performed observing **universal precautions** for the prevention of transmission of bloodborne pathogens. In order to prevent hemoconcentration, the tourniquet must be removed from the arm as soon as the blood starts to flow. The needle gauge must be sufficient in width to prevent mechanical damage to the red blood cells that will result in hemolysis (rupture of the membrane of the red blood cells). Because the concentration of potassium, magne-

sium, and phosphorus within red blood cells is much higher than in the plasma, hemolysis will cause falsely elevated results for these analytes. Plasma is often preferred over serum for measuring potassium, as the process of blood clotting can release potassium from platelets. Heparin is the only anticoagulant acceptable for electrolyte testing, as all other anticoagulants act by chelating calcium. Samples for ionized calcium should be collected using balanced (low) heparin which has a concentration of 20 U/mL. Higher concentrations bind calcium. Ionized calcium samples should be transported and stored on ice under anaerobic conditions and measured within 30 minutes of sample collection as pH changes in the blood will affect the ionized calcium.

Special procedures are followed when collecting a sweat sample for electrolyte analysis. This procedure, called pilocarpine iontophoresis, uses electric current applied to the arm of the patient (usually an infant) in order to convey the pilocarpine to the sweat glands where it will stimulate sweating. Care must be taken to ensure that the collection device (macroduct tubing or gauze) does not become contaminated and that the patient's parent or guardian understands the need for the electrical equipment employed.

Preparation

Usually no special preparation is necessary by the patient. Samples for calcium and phosphorus and for magnesium should be collected following an eight-hour fast.

Aftercare

Discomfort or bruising may occur at the puncture site, or the person may feel dizzy or faint. Pressure to the puncture site until the bleeding stops reduces bruising. Applying warm packs to the puncture site relieves discomfort.

Complications

Minor temporary discomfort may occur with any blood test, but there are no complications specific to electrolyte testing.

Results

Electrolyte concentrations are similar whether measured in serum or plasma. Values are expressed as mmol/L for sodium, potassium, chloride, and bicarbonate. Magnesium results are often reported as milliequivalents per liter (meq/L) or in mg/dL. Total calcium is usually reported in mg/dL and ionized calcium in mmol/L. Since

KEY TERMS

Tetany—Inappropriately sustained muscle spasms.

severe electrolyte disturbances can be associated with life-threatening consequences such as heart failure, **shock**, **coma**, or tetany alert values are used to warn physicians of impending crisis. Typical reference ranges and alert values are cited below.

- Serum or plasma sodium: 135-145 mmol/L Alert levels: less than 120 mmol/L and greater than 160 mmol/L.
- Serum potassium: 3.6-5.4 mmol/L (plasma, 3.6-5.0mmol/L); Alert levels: less than 3.0 mmol/L and greater than 6.0 mmol/L.
- Serum or plasma chloride: 98 - 108 mmol/L.
- Sweat chloride: 4-60 mmol/L.
- Serum or plasma bicarbonate: 18-24 mmol/L (as total carbon dioxide, 22-26 mmol/L); Alert levels: less than 10 mmol/L and greater than 40 mmol/L.
- Serum calcium: 8.5-10.5 mg/dL (2.0-2.5 mmol/L); Alert levels: less than 6.0 mg/dL and greater than 13.0 mg/dL.
- Ionized calcium: 1.0-1.3 mmol/L.
- Serum inorganic phosphorus: 2.3-4.7 mg/dL (children, 4.0 - 7.0 mg/dL); Alert level: less than 1.0 mg/dL.
- Serum magnesium: 1.8-3.0 mg/dL (1.2-2.0 meq/L or 0.5-1.0 mmol/L).
- Ionized magnesium: 0.53-0.67 mmol/L.
- Osmolality (calculated) 280-300 mosm/Kg.

Health care team roles

A physician orders electrolyte tests and interprets the results. A nurse or phlebotomist usually collects the blood sample by venipuncture. In some instances the nurse performs the electrolyte test using a point-of-care instrument consisting of a single use cartridge of ion-selective electrodes and a battery operated analyzer. In the laboratory setting electrolyte tests are performed by clinical laboratory scientists/medical technologists or clinical laboratory technicians/medical laboratory technicians. Nurses, nurse practitioners, and physician assistants may find themselves involved in explaining results to patients and advising them regarding treatment or dietary correction of any problems identified.

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Electromyography

Definition

Electromyography (EMG) is used to detect, process, and record electrical muscle activity in order to aid in the diagnosis of neuromuscular disease.

Purpose

EMG is performed most often to help diagnose different neuromuscular diseases causing weakness. EMG can determine whether a particular muscle is responding appropriately to stimulation, and whether a muscle remains inactive when not stimulated. Although EMG is a test of the motor system, it may help identify abnormalities of nerves or spinal nerve roots that may be associated with **pain** or numbness. EMG may also be useful in determining the cause of certain symptoms, including numbness, atrophy, stiffness, fasciculation, cramps, deformity, and spasticity. EMG results can help determine whether symptoms are due to a muscle disease or a neurological disorder, and, when combined with clinical findings, usually allow a confident diagnosis.

EMG can help diagnose many muscle and nerve disorders, including:

- muscular dystrophy
- congenital, mitochondrial, and metabolic myopathies
- myotonias
- compression neuropathies, such as carpal tunnel syndrome
- peripheral neuropathies
- radiculopathies

- nerve lesions
- amyotrophic lateral sclerosis (Lou Gehrig's disease)
- polio
- spinal muscular atrophy
- Guillain-Barré syndrome
- ataxias
- myasthenias

EMG is also used in gait and motion analysis. EMG is performed dynamically (while the patient executes certain movements) to evaluate gait and movement problems. Clinical applications include assessment of patients with **cerebral palsy**, traumatic **brain injury**, **spinal cord injury**, motor neuron lesions, evaluation of athletic injuries, examination of gait abnormalities associated with stroke, and preoperative assessment of patients having corrective orthopedic surgery.

EMG is one of the tests administered during **polysomnography** studies. EMG is used to measure neuromuscular activity during sleep to aid in the diagnosis of **sleep disorders**, such as restless legs syndrome.

Precautions

No special precautions are needed for this test. Patients with a history of **bleeding disorders** should consult with their treating physician before the test. If a muscle biopsy is planned as part of the diagnostic work-up, EMG should not be performed at the same site, as it may affect the microscopic appearance of the muscle.

Description

EMG is performed using an electromyography unit consisting of electrodes and a computer-based recording unit. Electrodes are used to detect electrical activity generated by stimulating the muscles. Muscles are stimulated by signals from nerve cells called motor **neurons**. This stimulation causes electrical activity in the muscle, which in turn causes contraction. This electrical activity is detected by the EMG electrode and recorded by the electromyography unit computer.

During an EMG test, the electrode is applied or inserted into the muscle to be tested. Surface, needle, and fine-wire electrodes may be used, depending on the type of stimulation required. Needle electrodes may cause some discomfort, similar to that of an injection. Recordings are made while the muscle is at rest, and then during the contraction. The person performing the test may move the limb being tested, and direct the patient to move it with various levels of force. The electrode may be



Electromyography is often used in biofeedback therapy and in diagnosing neuromuscular disorders. (Custom Medical Stock Photo. Reproduced by permission.)

repositioned for further recording. Other muscles may be tested as well. A typical session lasts from 30–60 minutes.

A slightly different test, the nerve conduction velocity test, is often performed at the same time with the same equipment. In this test, stimulating and recording electrodes are used, and small electrical shocks are applied to measure the ability of the nerve to conduct electrical signals. This test may cause mild tingling and discomfort similar to a mild shock from static electricity. Evoked potentials may also be performed for additional diagnostic information. Nerve conduction velocity and evoked potential testing are especially helpful when pain or sensory complaints are more prominent than weakness.

Preparation

No special preparation is needed. The doctor supervising and interpreting the test should be given information about the symptoms, medical conditions, suspected diagnosis, neuroimaging studies, and other test results.

Aftercare

Minor pain and bleeding may continue for several hours after the test. The muscle may be tender for a day or two. Pain-relieving medications may be prescribed to relieve muscle soreness.

Complications

There are no significant risks to this test, other than those associated with any needle insertion (pain, bleeding, bruising, or **infection**).

Results

The end result of an EMG test is an electromyogram, a computer display or printout of EMG waveforms.

KEY TERMS

Fasciculation—Small involuntary muscle contractions visible under the skin.

Motor neurons—Nerve cells that transmit signals from the brain or spinal cord to the muscles.

Motor unit action potentials—Spikes of electrical activity recorded during an EMG that reflect the number of motor units (motor neurons and the muscle fibers they transmit signals to) activated when the patient voluntarily contracts a muscle.

Nerve conduction velocity testing (NCV)—A type of test that uses an electromyography unit to evaluate electrical potentials from peripheral nerves by measuring how long it takes for a nerve impulse to reach a muscle after stimulation with an electrical current.

Polysomnography—A group of studies (that includes EMG) performed while a patient is sleeping to diagnosis sleep disorders.

There should be some brief EMG activity during needle insertion. This activity may be increased in diseases of the nerve and decreased in long-standing muscle disorders where muscle tissue is replaced by fibrous tissue or fat. Muscle tissue normally shows no EMG activity when at rest or when moved passively by the examiner. When the patient actively contracts the muscle, spikes (motor unit action potentials) should appear on the recording screen, reflecting the electrical activity within. As the muscle is contracted more forcefully, more groups of muscle fibers are recruited or activated, causing more EMG activity.

The interpretation of EMG results is not a simple matter, requiring analysis of the onset, duration, amplitude, and other characteristics of the spike patterns.

Electrical activity at rest is abnormal; the particular pattern of firing may indicate denervation (for example, a nerve lesion, radiculopathy, or lower motor neuron degeneration), myotonia, or inflammatory myopathy.

Decreases in the amplitude and duration of spikes are associated with muscle diseases, which also show faster recruitment of other muscle fibers to compensate for weakness. Recruitment is reduced in nerve disorders.

Health care team roles

EMG is performed by clinicians with special training in electroneurodiagnostic medicine. Usually, a neu-

rologist or psychiatrist conducts the EMG study. Some physical therapists trained in EMG may also administer the test. A trained electroneurodiagnostic technologist prepares patients for EMG testing, obtains medical histories, maintains equipment, records and calculates test results, and assists with testing.

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American Association of Electrodiagnostic Medicine. 421 First Avenue SW, Suite 300, East Rochester, MN 55902. (507) 288-0100. <<http://www.aaem.net>>.

American Society of Electroneurodiagnostic Technologists. 204 West 7th Street, Carroll, IA 51401-2317. (712) 792-2978. <<http://www.aset.org>>.

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Electroneurodiagnostic technology

Definition

The practice of electroneurodiagnostic (END) technology involves the use of devices such as an electroencephalograph (EEG) unit to evaluate the function of a

patient's **brain** or other component of the nervous system in order to diagnose tumors, strokes, epilepsy, sleep problems, and other nervous disorders.

Description

END technologists use various devices to aid in the evaluation and examination of the nervous system. These devices receive and record the electrical impulses produced by the brain or other parts of the nervous system. Characteristic changes in the nerve impulses can determine whether a patient has an organic basis for a mental or behavioral problem, such as a tumor or **Alzheimer's disease**. The devices can also diagnose particular diseases such as neuropathies (disease of the nerves), myopathies (diseases of the muscles), epilepsy, or stroke. These tests can evaluate the condition of critically ill patients, to determine the presence of cerebral death, and help assess the probability of a patient recovering from a **coma**.

One test commonly performed by END technologists is **electroencephalography**. This test monitors the electrical output of the brain, displays it on a monitor, and records it on a strip of paper for review by a neurologist or other physician. The technologist is often responsible for taking the patient's medical history, helping the patient relax by explaining the procedure of the test, and applying the electrodes to the designated sites on the person's head. To get medically useful results, the technologist must use the appropriate machine settings and correct for interference coming from sources other than the patient's brain.

EEG studies can be done within the hospital or clinic, or on an ambulatory basis (typically over a 24-hour period) while the patient continues everyday activities. For ambulatory monitoring, the technologist is responsible for **patient education** and answering questions, correctly attaching the electrodes, and upon completion of the monitoring, removing the recorder and obtaining a read-out. Technologists review the entire read-out and select specific areas for examination by the neurologist.

Another specialized form of EEG is long term monitoring for epilepsy (LTME). This procedure is used to accurately diagnose the type of seizure occurring in patients who are not responding to medication. In many cases, the patient is admitted to the hospital for 24-hour-a-day monitoring so that seizures can be captured on videotape and EEG recording. Monitoring is performed to diagnose seizure type or to localize seizure onset within the brain for possible epilepsy surgery. Technologists place electrodes on the patient's head, as in a standard EEG, and behavior is recorded by closed circuit camera

onto videotape. Additional wire electrodes are sometimes inserted near the ear by the neurologist; these electrodes provide better information about temporal lobe seizures than scalp electrodes alone. Antiepileptic drugs are generally reduced or tapered off before or during the admission, which can last from one to several days. Often a family member is asked to stay with the patient, so that a seizure alarm can be triggered.

A second group of procedures commonly performed by END technologists are evoked potential tests. These tests separate the response of the patient's nervous system to various specific stimuli from background activity and record the results. The technologist is responsible for attaching electrodes to the patient and setting the machine to deliver the desired type and intensity of stimulus. Often the technologist performs a step-wise increase in the intensity of the stimulus and records the response of the patient's brain, spinal nerves, or sensory receptors to the input. Commonly, the stimulus is magnetic or electrical in origin, although visual and auditory stimuli are also used.

Technologists also perform nerve conduction studies (NCS), in which an electrode is placed over a peripheral nerve and a muscle, and a record is made of the response of the muscle to stimulation of the nerve. Various nerve and muscular problems have characteristic responses to repeated or increased intensity of stimuli, and the results from these tests can aid in differential diagnosis. NCS is often performed in conjunction with an electromyogram. That test is performed by a physician, although the END technologist can help with the process.

Another test often performed by END technologists is electronystagmography (ENG). ENG records the electrical potentials of the eyes. This test is used to document induced or spontaneous nystagmus, involuntary rapid movements of the eyeballs. An ENG can differentiate between inner ear and **central nervous system** causation for complaints of dizziness.

A subset of END technologists specialize in administering sleep disorder studies and are called polysomnographic technologists. During these testing procedures, called **polysomnography**, technologists monitor brain waves, respiration, and **heart** activity. They must understand the usual effect upon each of these systems with the different stages of sleep. Often a detailed report of each evening's readings is required for review by the supervising physician, separating the recorded results into the various sleep stages. As the primary medical personnel present for overnight monitoring, they may also have additional responsibilities in overseeing the well-being of patients staying at the sleep center.

KEY TERMS

Electroencephalography—The recording of changes in electric output in various areas of the brain using electrodes commonly placed on the scalp.

Electronystagmography—The electronic recording of eye movements that can document induced or spontaneous nystagmus.

Evoked potential testing—The electronic measurement of sensory and physical responses to specific stimuli.

Nerve conduction studies—The electronic measurement of the muscular response to the stimulation of a particular nerve.

Polysomnography—The recording of changes in electric output of the brain, in respiration, and in heartbeat during sleep.

Technologists' duties may also include clerical and technical work such as scheduling appointments, ordering supplies, and maintaining equipment. More senior END technologists may have administrative duties such as supervising and training less experienced technicians, managing the END laboratory, arranging work schedules, and keeping records. Additionally, some more senior personnel can perform research or have teaching duties.

Work settings

END technology is practiced in general hospitals, psychiatric hospitals, health maintenance organizations (HMOs), and in private clinic or office practice settings. In the hospital, technologists may work within a dedicated room in the neurology department, may push portable equipment to the patient's bedside, or may do both kinds of monitoring. One area of rapid growth is the performance of intraoperative neurodiagnostic tests by END technologists. These tests require an understanding of the effects of anesthesia on brain activity and involve working in the operating room with general and neurosurgeons.

Education and training

Although many current END technologists were trained on the job, employers are now favoring candidates who have completed formal training in the area. Some hospitals require applicants for trainee positions to have postsecondary training, whereas others only expect

a high school diploma. Employers will look for courses taken in health, biology, anatomy, and mathematics in applicants for training positions. Often those who do not have formal training are transfers from other allied health professions, such as licensed practical nurses.

The formal postsecondary school training in this area is offered by hospitals and two-year community colleges. As of 2001, there were 12 formal programs approved by the Joint Review Committee on Education in Electroneurodiagnostic Technology of the Commission on Accreditation of Allied Health Programs (CAAHP). The programs usually last from one to two years with laboratory training, and often include the following classroom courses:

- human anatomy and physiology
- neurology and neuroanatomy
- neurophysiology
- medical terminology
- computer technology and instrumentation

Training to perform polysomnograms may require a full year of additional study.

Advanced education and training

The American Board of Registration of Electroencephalographic and Evoked Potential Technologists awards the credentials of Registered EEG Technologist, Registered Evoked Potential Technologist, and Certification in Neurophysiologic Intraoperative Monitoring (CNIM). These certifications are based on the successful completion of both an oral and a written exam. On-the-job training is required to sit for the exam. Continuing education hours are required every two years for certificate renewal and the certificates are good for 10 years. The Board of Registered Polysomnographic Technologists certifies polysomnographic technologists as Registered Polysomnographic Technologists, which involves on-the-job training and a passing score on a written examination.

Continuing education opportunities are available through various organizations including the American Society of Electroneurodiagnostic Technologists and the American Association of Electrodiagnostic Medicine.

Future outlook

The *2000-01 Occupational Outlook Handbook* of the U.S. Department of Labor states that demand for this occupation will grow more slowly than average through the year 2008. Reasons for the slower growth include more sophisticated equipment and cross-training of other

allied health professionals to perform these procedures. However, states with high concentrations of older patients, such as Florida, anticipate a better than average growth in this allied health area.

Resources

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ORGANIZATIONS

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The American Society of Electroneurodiagnostic Technologists, 204 West 7th Street, Carroll, IA 51401-2317. (712) 792-2978. <<http://www.aset.org>>.

American Society of Neurophysical Monitoring, 7510 Clairemont Mesa Blvd., Suite 100, San Diego, CA, 92111. (800) 479-7979. <<http://www.asnm.org>>.

Association of Polysomnographic Technologists, c/o Applied Measurement Professionals, P.O. Box 14861, Lenexa, KS, 66285-4861. (913) 541-1991 ext. 474. <<http://www.aptweb.org>>.

Board of Registered Polysomnographic Technologists, 475n Riverside Drive, Seventh Floor, New York, NY, 10115. (212) 367-4370. <<http://www.brpt.org>>.

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Electroneurography

Definition

Electroneurography is the measurement of the speed of conduction of impulses down a peripheral nerve. The test is done to detect and roughly quantify the extent of nerve damage.

Purpose

Electroneurography, also known as nerve conduction studies (NCS), nerve conduction velocity (NCV), or stimulation myelographic study (SMS), is used to detect the presence of a neuropathy in a particular nerve. Anatomically, there are three conditions that significantly decrease nerve conduction velocities:

- demyelination (loss of myelin covering of the nerve)

- conduction blocks (damage that stops continued movement of nerve impulse)
- axonal loss (nerve cell death)

Electroneurography is used to detect and evaluate a wide variety of diseases or conditions involving nerve damage. It is a routine test after traumatic nerve damage such as **carpal tunnel syndrome** or to investigate suspected peripheral nerve dysfunctions or neuropathies. Nerve problems caused by viral infections such as HIV-1 or HSV-1 are also common indications for this procedure. Electroneurography can detect nerve damage that occurs as a side effect of systemic problems, including **diabetes mellitus**, B vitamin deficiency, multiple nutrient deficiency due to malabsorption of digested food, kidney failure, amyloidosis, and **alcoholism**.

Electroneurography can also evaluate nerve damage caused by several bacterial infections or toxicities such as diphtheria, leprosy, and botulism **poisoning**. This test is also used to diagnose and follow the progression of many diseases of the nervous and muscular systems such as amyotrophic lateral sclerosis (ALS), myasthenia gravis, muscular dystrophies, and **multiple sclerosis (MS)**.

Precautions

There are no contraindications for this test. It is non-invasive and very low risk.

Description

Electroneurography is based on the observation that when a nerve is electrically stimulated, a reaction will occur somewhere down the nerve or in the muscle served by the nerve. By using appropriate electrode placement, the reaction to the electrical stimulus is recorded. Examining the characteristics of the reaction and the timing of the reaction reveals both the velocity of conduction and the latency (time between stimulus and response) of the tested nerve.

This test requires that the nerve being tested is relatively close to the skin surface, although needle electrodes can be used to test deep nerves. Two sets of electrodes are used to perform the test, stimulating and recording. Normally, the stimulating electrodes are metal or felt pads placed on the surface of the skin, about 0.6 to 1.1 inches (1.5 to 3 cm) apart. Correct placement requires a strong understanding of neurological anatomy and varies from nerve to nerve. Conduction cream can be applied to maximize the effectiveness of the connection. Usually, the cathode (typically the black-colored electrode) is placed down the nerve from the anode (typically the red-colored electrode) in the direction of conduction.

The test works most effectively if maximal stimulation of the nerve is achieved. This is determined through step-wise increases in the stimulus output, and setting the stimulus 25–50% above this level. However, the greater the stimulation, the greater the chance of the stimulus being perceived as painful by the patient. Nevertheless, the duration of the discomfort is relatively short, and less than maximal stimulation produces results that cannot be interpreted and are therefore not medically useful. Stimulation is most difficult in patients who are obese, edemic (retaining water), or have unusually thick or calloused skin. Increasing stimulus duration, altering the placement of the cathode, or using needle electrodes can overcome stimulation problems.

Recording electrodes are placed according to the type of response that is being sought. If muscular reaction is the goal, the active recording electrode is placed over the belly (thickest area) of the muscle being tested, while the second recording electrode, called a reference electrode, is placed on a tendon. Placement is correct if the graphic representation of the response shows an initial negative deflection (upwards) in the graph of the response. If a nerve is being tested, the active electrode is placed directly over the nerve. The reference electrode is placed distally (pointing away from the electrode). Recording electrodes that test motor response are often metal, circular discs, while sensory recording electrodes come in many shapes such as buttons, rings, clips, discs, or bare wire.

The test will run from about 20 minutes to about two hours, depending on the number of nerves being tested and if **electromyography**, a test commonly performed in conjunction with electroneurography, is being done. The cost of the test is about \$500 and is usually covered by insurance.

Preparation

Low body temperature can greatly distort the results of electroneurography. Particularly in cold weather, it is important to warm the muscles being tested and to maintain normal body temperature throughout the testing procedure.

Aftercare

There are no aftercare procedures for this test. Patients may immediately resume normal activities.

Complications

There are no complications resulting from this test.

Results

Among the possible results from this test are measurements of motor response, sensory nerve response, and nerve conduction velocities.

Motor response

The motor (muscular) response is characterized by its waveform, amplitude, duration, and distal latency. The waveform is relatively simple, with a large negative deflection (upwards) followed by a large positive deflection (downward), producing a peak, although the exact shape depends on the placement and type of electrode. The amplitude (expressed in millivolts) is the value from the baseline to the peak of the negative response. Amplitude value depends on the number and synchronization of the muscle fibers that are being stimulated. The use of a maximal stimulation of the nerve ensures all possible fibers will be recruited.

The duration of the motor response is the time from the beginning of the negative deflection to the completion of the positive deflection. In disease states, along with decreased amplitude, the duration of the response will be increased if the muscle fibers do not fire together. The distal latency is the time it takes from stimulus to the beginning of the negative deflection, and is measured in milliseconds. If bilateral measurements are taken, this value will be increased on the side having damage to the nerve or neuromuscular junction. Each motor response characteristic is more difficult to read if electrode placement covers more than one muscle, emphasizing the need to isolate one muscle whenever possible.

Sensory nerve response

Like motor response, sensory nerve responses, or action potentials, are characterized by a particular waveform, amplitude, duration, and distal latency. The normal waveform includes a negative deflection (upward), a larger positive deflection (downward), followed by a negative rebound back to baseline, forming an S-shaped wave, although the exact shape differs with the type of electrodes, placement, or the use of three electrodes. Amplitude is measured from the peak of the negative response to baseline and is measured in microvolts.

Like motor responses, high amplitude and short duration in a sensory nerve response indicate large numbers of axons firing simultaneously. Disease states can reduce amplitude and increase duration. Distal latency is measured from stimulus to negative peak and is expressed in milliseconds. When taking sensory nerve

responses, it is important to isolate the recording electrodes away from innervated muscles, as the motor response will swamp the much smaller sensory nerve response.

Nerve conduction velocity

Nerve conduction velocities to a muscle can be calculated if it is possible to stimulate a nerve in two places along its length. Two latency measurements are made, a distal latency and a proximal latency (in milliseconds, msec). The distance between the two stimulation points is then measured (in millimeters, mm) and divided by the difference between the two latency values. This value is the conduction velocity of the nerve in meters per second. For sensory nerves, only one stimulation point is used, and the velocity is calculated by dividing the distance between the active and reference electrodes (in mm) by the latency (in msec).

Once results have been calculated, these are compared to a table of standard values. Tables have been devised that sort results by different characteristics such as the patient's age, sex, height, nerve length, or a combination of these factors. An example of a commonly used table is one published by the Cleveland Clinic Foundation. This table sorts results by patient age and is based on standard electrode distances for the measurement of different nerve velocities. In general, demyelination is indicated if conduction velocities have fallen below 50% of normal. Even significant loss of axons commonly reduces conduction velocities by only about 30%, based on a loss of the fastest conducting fibers.

When analyzing the results of this test, it should be taken into consideration that electroneurography tests the best surviving nerve tissue. This characteristic means that results can be normal despite extensive nerve damage. Nevertheless, abnormal results can provide extremely useful information, including distinguishing between demyelination and loss of axons and pinpointing the exact location of a nerve injury.

Health care team roles

Electroneurography is often performed by specially trained electrodiagnostic technologists. Training for such a position can be on the job but often involves study at a one- to two-year college or vocational program. A typical program would include:

- human anatomy and physiology
- neurology and neuroanatomy
- neurophysiology
- medical terminology

KEY TERMS

Amplitude—The distance from the baseline to the peak of the motor or sensory response represents the approximate number of healthy muscle fibers or nerves available.

Demyelination—Loss of the insulating cover of the nerve cell. Demyelination significantly reduces measured nerve conduction velocity.

Latency—The amount of time between stimulus and motor or sensory nerve response.

Waveform—The shape of the electrical response recorded by the active recording electrode.

- computer technology and instrumentation

Certification of electrodiagnostic technologists specializing in electroneurography and the related area of evoked potentials is available through the American Board of Registration of Electroencephalographic and Evoked Potential Technologists.

A physician such as a neurologist, neurosurgeon, or internist does the final review and diagnosis based on the results of electroneurography. The physician can be present for the testing or may review saved tracings. Other health care professionals such as nurses aid in **patient education** concerning this procedure.

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Electronic fetal monitoring

Definition

The electronic fetal monitor (EFM) is a device that records an unborn baby's **heart** rate and the presence or absence of the mother's uterine contractions.

Purpose

The EFM is used to assess fetal well being during routine prenatal visits. It is also used during labor and delivery when high-risk factors exist or when a clinical condition develops beforehand that places the fetus at risk. High risk factors for EFM during labor include:

- low gestational age
- high maternal age
- placenta or cord problems
- meconium in the amniotic fluid
- hypertension
- proteinuria
- facial nerve palsy

A fetus having trouble in labor often exhibits characteristic changes in heart rate after a contraction (late decelerations). Trouble is also indicated by significant slowing of the heart rate during a contraction (variable deceleration). If the fetus is not receiving enough oxygen to withstand the stress of labor, and delivery is many hours away, a cesarean section (C-section) may be necessary.

Description

The monitor produces a continuous paper record of the fetal heart rate (FHR) and records uterine contractions. FHR is captured on the top part of the paper print-out; uterine activity, when monitored, appears on the lower part of the tracing.

Electronic fetal monitoring can be performed externally or internally. The external ultrasound approach is non-invasive and uses sensors (electrodes) placed on the mother's abdomen with an elastic belt. Another belt holds the contraction monitor.

External electronic fetal monitoring includes a non-stress test, which measures FHR accelerations with normal movement of the fetus. Sometimes the fetal movement is encouraged by giving the mother a small meal or something to drink. Fetal acoustic stimulation and moving the fetus by rubbing the abdomen gently may also be used.

Two contraction stress tests, which measure the placenta's ability to provide enough oxygen to the fetus during pressure, are also used with electronic fetal monitoring. The nipple stimulation contractions **stress test** involves the mother self-stimulating her nipple while contractions and FHR are monitored. Another test, called oxytocin stimulation, involves the administration of the hormone oxytocin intravenously until three uterine contractions are observed within ten minutes, during which time the FHR is monitored.

Sometimes, it is difficult to hear the baby's heartbeat with the monitoring device. Other times, the monitor may show subtle signs of a developing problem. In either case, the physician may recommend the use of an internal monitor, which provides a more accurate record of the baby's heart rate. The internal monitor (or fetal scalp electrode) uses an electrode attached to the baby's scalp through the cervix during an internal vaginal exam. The internal monitor can only be used when the cervix is dilated.

In 1995, a technical bulletin issued by the American College of Obstetricians and Gynecologists (ACOG) reported that the prudent use of intermittent auscultation (listening) of fetal heart rate is equivalent to continuous electronic fetal monitoring in a low-risk **pregnancy**. Intermittent auscultation involves listening to the FHR every 15 minutes during active labor until complete cervical dilation. From complete dilation to delivery, the FHR should be obtained every five minutes and timed to obtain the FHR during a contractions and for 30 seconds afterwards. In complicated pregnancies, however, continuous EFM is recommended during labor. EFM is used in most deliveries directed by physicians.

Preparation

There are no special preparations required for external fetal monitoring. Preparation for placement of an internal scalp lead (ISL) is the same as for a routine vaginal exam.

Complications

In general, no risks are associated with external fetal monitoring. However, the test can initiate labor and is generally not given to mothers at risk for **preterm labor** or with a condition that requires a cesarean section. Internal monitoring poses risks associated with improper placement of the electrodes.

Some data indicate that EFM leads to unnecessary C-sections. Another drawback includes loss of maternal mobility when used during labor, which may slow labor.



A fetal monitoring belt can be used to monitor a fetus through the abdominal wall and uterus. (Custom Medical Stock Photo. Reproduced by permission.)

Results

The normal fetal heart rate (FHR) ranges from 120 to 160 beats per minute (bpm). Just as an adult's heart rate rises with movement, FHR rises when the baby moves. A reactive heart rate tracing (also known as a reactive non-stress test, or NST) is considered a positive sign of fetal well being. A non-reactive NST may or may not imply fetal well being. The monitor strip is considered to be reactive when the FHR rises at least 15 to 20 bpm above the baseline heart rate for at least 20 seconds. This must occur at least twice in a 20-minute period.

Results are considered abnormal if the FHR drops below 120 or rises above 160 for sustained periods. In either of these cases the baby may be exhibiting fetal distress. A mean FHR of less than 110 bpm may indicate bradycardia (slow heart beat). A mean FHR of over 160 bpm may indicate a tachycardia (rapid beating of the heart). However, some babies who are having problems may not exhibit such clear signs.

During a contraction, the flow of oxygen from the mother through the placenta to the baby is temporarily stopped. It is as if the baby has to hold its breath during

each contraction. Both the placenta and the baby are designed to withstand this condition. Between contractions, the baby should be receiving more than enough oxygen to do well during the contraction.

One sign that a baby is not getting enough oxygen between contractions is a drop in the baby's heart rate after the contraction (late deceleration). The heart rate recovers to a normal level between contractions, only to drop again after the next contraction. This is a more subtle sign of distress. Trouble is also indicated by significant slowing during a contraction (variable decelerations).

Fetal monitoring is not a perfect test. Fetal assessment in labor is subject to differences in interpretation and consequent intervention; therefore, institutional policies and procedures should be followed.

Health care team roles

Electronic fetal monitoring is primarily conducted by specialists in obstetrics and gynecology. Qualified registered nurses and **advanced practice nurses** may assist in or conduct electronic fetal monitoring.

KEY TERMS

Auscultation—Listening to sounds within organs to help in diagnosis in treatment.

C-section—A cesarean section; delivery of a baby through an incision in the mother's abdomen instead of through the vagina.

Late deceleration—Transient fetal bradycardia exceeding 100 beats per minute which reaches its height more than 30 seconds after the peak of the uterine contraction.

Non-stress test—A record of the fetal heart rate in the absence of contractions (stress).

Reactive stress test—A positive sign of fetal well being. The FHR rises at least 20 beats per minute above the baseline heart rate for at least 20 seconds, occurring at least twice in a 20-minute period.

Variable deceleration—Fetal bradycardia below 100 beats per minute denoting compression of the umbilical cord at the height of a uterine contraction.

Training

Applying the external monitor is simple, but requires practice in the proper placement of the monitoring devices. The interpretation of the tracings, however, requires continued vigilance in education and clinical practice. Training should include instruction in auscultation, electronic FHR monitoring, and evaluation of uterine activity.

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Electrophysiology study of the heart

Definition

An electrophysiology study (EPS) of the **heart** is a nonsurgical analysis of the electrical conduction system (normal or abnormal) of the heart. The test employs cardiac catheters and sophisticated computers to generate electrocardiogram (EKG) tracings and electrical measurements with exquisite precision from within the heart chambers.

Purpose

An EPS can be performed solely for diagnostic purposes or to pinpoint the exact location of electrical signals (cardiac mapping) in conjunction with a therapeutic procedure called catheter ablation. A cardiologist may recommend an EPS when the standard EKG, Holter monitor, event recorder, **stress test**, echocardiogram, or angiogram cannot provide enough information to evaluate an abnormal heart rhythm, called an arrhythmia.

An EPS offers more detailed information about the heart's electrical activity than many other noninvasive tests because electrodes are placed directly *on* heart tissue. This placement allows the electrophysiologist to determine the specific location of an arrhythmia and, oftentimes, correct it during the same procedure. This corrective treatment is considered a permanent cure; in many cases, the patient may not need to take heart medications.

EPS may be helpful in assessing:

- certain tachycardias or bradycardias of unknown cause
- patients who have been resuscitated after experiencing sudden cardiac death
- various symptoms of unknown cause, such as chest **pain**, shortness of breath, fatigue, or **syncope** (dizziness/fainting)
- response to anti-arrhythmic therapy

Precautions

Pregnant patients should not undergo EPS because of the exposure to radiation during the study, which may harm the growing baby. Patients who have **coronary artery disease** may need to be treated prior to EPS. EPS is contraindicated in patients with an acute **myocardial infarction**, as the infarct may be extended with rapid pacing. The test is also contraindicated for patients who are uncooperative.

Description

The rhythmic pumping action of the heart, which is essentially a muscle, is the result of electrical impulses traveling throughout the walls of the four heart chambers. These impulses originate in the sinoatrial (SA) node (specialized cells situated in the right atrium, or top right chamber of the heart). Normally, the SA node, acting like a spark plug, spontaneously generates the impulses, which travel through specific pathways throughout the atria to the atrioventricular (AV) node. The AV node is a relay station sending the impulses to more specialized muscle fibers throughout the ventricles (the bottom chambers of the heart). If these pathways become damaged or blocked or if extra (abnormal) pathways exist, the heart's rhythm may be altered (too slow, too fast, or irregular), which can seriously affect the heart's pumping ability.

The patient is transported to the x-ray table in the EPS lab and connected to various monitors. Sterile technique is maintained. A minimum of two catheters is inserted into the right femoral (thigh) vein in the groin area. Depending on the type of arrhythmia, the number of catheters used and their route to the heart may vary. For certain tachycardias, two more catheters may be inserted in the left groin and one in the internal jugular (neck) vein or in the subclavian (below the clavicle) vein. The catheters are about 2 mm in diameter, about the size of a spaghetti noodle. The catheters used in catheter ablation are slightly larger.

With the help of fluoroscopy (x rays on a television screen), all the catheters are guided to several specific locations in the heart. Typically, four to 10 electrodes are located on the end of the catheters, which have the ability to send electrical signals to stimulate the heart (called pacing) and to receive electrical signals from the heart; but not at the same time (just as a walkie-talkie cannot send and receive messages at the same time).

First, the electrodes are positioned to receive signals from inside the heart chambers, which allows the doctor to measure how fast the electrical impulses travel in the patient's heart at that time. These measurements are

called the patient's baseline measurements. Next, the electrodes are positioned to pace. That is, the EPS team tries to induce (sometimes in combination with various heart drugs) the arrhythmia that the patient has previously experienced so the team can observe it in a controlled environment, compare it to the patient's clinical or spontaneous arrhythmia, and decide how to treat it.

Once the arrhythmia is induced and the team determines it can be treated with catheter ablation, cardiac mapping is performed to locate the precise origin and route of the abnormal pathway. When this is accomplished, the ablating electrode catheter is positioned directly against the abnormal pathway, and high radio-frequency energy is delivered through the electrode to destroy (burn) the tissue in this area.

Pediatric patients present challenges in EPS. In 2001, an analysis of 45 pediatric patients who underwent electrophysiologic study was conducted. The researchers concluded that success rates and the prevention of complications in children may be increased by using ultrasound guidance for access of the internal jugular vein for coronary sinus cannulation (insertion of a tube for the transport of fluid) during EPS. Access was successfully obtained in all 45 of the patients without major complications using this technique.

Preparation

The following preparations are made for an EPS:

- The patient may be advised to stop taking certain medications, especially cardiac medications, that may interfere with the test results.
- The patient is kept fasting for six to eight hours prior to the procedure. Fluids may be permitted until three hours before the test.
- **Blood** tests usually are ordered one week prior to the test.
- The patient undergoes conscious sedation (awake but relaxed) during the test.
- A local anesthetic is injected at the site of catheter insertion.
- Peripheral pulses are marked with a pen prior to catheterization. This permits rapid assessment of pulses after the procedure.

Aftercare

The patient needs to rest flat in bed for several hours after the procedure to allow healing at the catheter inser-

KEY TERMS

Ablation—Removal or destruction of tissue, such as by burning or cutting.

Angiogram—X ray of a blood vessel after special x-ray dye has been injected into it.

Bradycardia—Relatively slow heart action, usually considered as a rate under 60 beats per minute.

Cardiac catheter—Long, thin, flexible tube, which is threaded into the heart through a blood vessel.

Cardiologist—Doctor who specializes in diagnosing and treating heart diseases.

Echocardiogram—Ultrasound image of the heart.

Electrocardiogram—Tracing of the electrical activity of the heart.

Electrode—A medium, such as platinum wires, for conducting an electrical current.

Electrophysiology—Study of how electrical signals in the body relate to physiologic function.

Event recorder—A small machine, worn by a patient usually for several days or weeks, that is activated by the patient to record his or her EKG when a symptom is detected.

Fibrillation—Rapid, random contraction (quivering).

Holter monitor—A small machine, worn by a patient usually for 24 hours, that continuously records the patient's EKG during usual daily activity.

Stress test—Recording a patient's EKG during exercise.

Supraventricular tachycardia—A fast heart beat that originates above the ventricles.

Tachycardia—Fast heartbeat.

Thrombophlebitis—Venous inflammation with the formation of thrombus (a clot in the cardiovascular system).

tion sites. The patient often returns home either the same day of the test or the next day. Someone should drive the patient home.

Patient education

To minimize bleeding and pain, instruct the patient to keep the extremity in which the catheter was placed immobilized and straight for several hours after the test.

Complications

EPS and catheter ablation are considered low-risk procedures. There is a risk of bleeding and/or **infection** at the site of catheter insertion. Blood clot formation may occur and is minimized with anti-coagulant medications administered during the procedure. Vascular injuries causing hemorrhage or thrombophlebitis are possible. Cardiac perforations are possible. If the right internal jugular vein is accessed, the potential for puncturing the lung with the catheter exists and could lead to a collapsed lung.

Because ventricular tachycardia or fibrillation (lethal arrhythmias) may be induced in the patient, the EPS lab personnel must be prepared to defibrillate the patient as necessary.

Patients should notify their health care provider if they develop any of these symptoms:

- numbness or tingling in the extremities
- heavy bleeding
- change in color and/or temperature of extremities
- loss of function in extremities

Results

Normal findings indicate that the heart initiates and conducts electrical impulses within normal limits.

Abnormal findings include confirmation of arrhythmias, such as:

- supraventricular tachycardias
- ventricular arrhythmias
- accessory pathways
- bradycardias

Health care team roles

The relatively simple EPS is performed in a special laboratory under controlled clinical circumstances by cardiologists, nurses, and technicians with special training in electrophysiology.

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Electrosurgery machines

Definition

The electrosurgery machine produces high radiofrequency energy sufficient to induce cutting and/or coagulation in body tissues by an electrode during (electro)surgery.

Purpose

The instrument is designed to provide the correct electrical waveforms to deliver to the site of surgery in order to coagulate **blood vessels** and to cut tissues smoothly. Surgeons may use the electrosurgery tool instead of, or in conjunction with, a conventional scalpel. When used properly, the electrosurgery unit damages tissue considerably less than the scalpel, with the added ability to stem bleeding safely.

Description

Commercial electrosurgery machines may differ significantly, but comprise multiple components, which include:

- the electrode(s)

- the electrosurgical unit (ESU), which generates the radiofrequency current
- dispersive pads/electrodes for electrical current dispersion and foot pedals for operation in cut or coagulation mode

A complete circuit must be connected for current to flow, as in any circuit. In the case of electrosurgery, the circuit comprises the electrosurgical power unit, the active electrode (where cutting or coagulation transpire), the dispersive electrode (also known as the "return electrode," for return of current), and the path of least resistance through the patient's own body from the active electrode to the return electrode. When the circuit is complete and current can flow through it without too great of a resistance, the electricity that causes coagulation and cutting is readily applied to appropriate sites at the surgeon's discretion.

The low frequency power input of the wall (i.e. 60 Hz in the United States) is converted by the ESU to a high-frequency (on the order of 400,000 to 1,000,000 Hz) alternating current output that yields the therapeutic effects of electrosurgery. Safety is important with all electrical equipment; consequently the ESU should be grounded to a true earth ground that is electrically isolated from other grounds in the operating room, so that neither the surgeon nor the patient are shocked or electrocuted.

The high-frequency current is transmitted to the patient via the active electrode, which is insulated along its length until the electricity-emitting tip is reached, and which may take the form of:

- a one-piece electrode
- a pencil handpiece
- forceps
- suction tips

The complete circuit discussed above may be achieved through either bipolar or monopolar modalities. Bipolar surgery is as the title implies, involving the use of two poles, or electrodes. The electrodes (active and return) are fixed upon a forceps-shaped tool. When pinched, the surgeon may apply current that traverses only the tissue in between the two electrodes, thereby coagulating it (unless the tissue is completely desiccated, in which case some current may leak into surrounding tissue). Carrying low-voltage current and affecting little tissue, the bipolar instrument is considerably safer than the monopolar device. Neurosurgeons usually opt for the bipolar tool over monopolar for this reason and for its inherent delicacy, among others.

The monopolar instrument is often used in place of the bipolar for three main reasons: it is easier to use, it

KEY TERMS

Coagulate—To clot or cause hemostasis; in electrosurgery, to cause tissue dehydration without cutting.

Hemostasis—Stoppage of bleeding.

possesses the added capability of cutting tissue, and it is able to coagulate larger **blood** vessels. The active electrode, which may be in shape of a blade, loop, ball, needle, or pencil, can be disposable or reusable. Current emitted from this electrode is dispersed over a large area of padding by one of two types of dispersive electrode: conductive or capacitive. This can prove difficult, and is one reason why bipolar is the safer choice. Any erroneous selection or misuse of dispersive pads can result in a dangerous predicament for both the patient and the surgeon. While systems in use as of 2001 generally retain a number of alarms and warning systems built in, health care personnel must remain aware of the dangers implicit in using the equipment.

Operation

Three modes of operation are available, and can be produced on command, dependent upon the waveform issued by the ESU:

- **Cutting:** A high-frequency alternating current yields smooth, rapid cuts that evoke little to no hemostasis. The current stimulates cells to swell and explode.
- **Fulguration:** Sparking the tissue to lead to coagulation. There is no tissue-electrode contact; rather, voltage is raised in order to incite a spark between electrodes in order to coagulate the tissue in between.
- **Desiccation:** The drying out of cells leading to coagulation. Stems from direct contact with the active electrode and leaves a soft brown eschar, or scab.

It is key for all health care personnel involved in electrosurgery to be educated about the specific ESU and electrodes used by physicians at their location. The power settings on the ESU unit do not necessarily correspond to the quantity of power delivered. Thus, personnel must know not to equate numerical power settings with specific units unless explicitly labeled that way, i.e. one must not equate a power setting of “1” with 1 watt (or 100 watts) of power. Even if the amount of power is not known in watts, medical personnel must have an intuitive idea of what the different power settings mean in terms of the ability to cut, to coagulate, and for safety.

Most machines make it easier with the ability to pre-program cutting and coagulation settings so that the surgeon and staff can move swiftly and accurately between settings during surgery.

Smoke can also be an issue with electrosurgery, so many units as of 2001 come equipped with smoke evacuation and filtration systems, which the staff must also learn how to operate through reading manufacturers’ manuals.

Maintenance

Most maintenance on the electrosurgery power unit is generally performed by trained biomedical equipment technicians or biomedical engineers unless nursing staffers are adequately trained. The electrodes, however, must be cleansed and sterilized by the staff immediately following each surgery if they are not disposable.

Health care team roles

Most of the electrosurgical machine configuration and settings are handled by nursing staff and technicians. Often the operating room (O.R.) personnel know more about setting up the machine, its safety controls, and its handling than the surgeons using the equipment. This is because surgical residents are not formally trained in electrosurgical use; thus, since O.R. nursing personnel are usually trained by the manufacturer’s sales representatives, the surgeons tend to rely on nursing staff to set up and manage the equipment. It is therefore very much an integral aspect of the staff’s responsibility to alert surgeons to possible dangers, especially electrical, inherent in using the electrosurgical machine. The electrode insulation mentioned above is a key element in electrosurgical safety, so staff should remain alert for inadequate or defective insulation.

Training

Health care personnel are generally trained by the sales representatives of the electrosurgery unit’s manufacturer to set up and properly maintain the equipment. Without care and knowledge of the electrosurgery apparatus, great harm can be caused to patients undergoing surgery. Special attention should be paid to the manual since each ESU model is unique.

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Bryan Ronain Smith

Electrotherapy

Definition

Electrotherapy is the use of electrical stimulation for therapeutic purposes. Specifically, electrotherapy uses energy waves that are part of the electromagnetic spectrum to produce desired physiological and chemical effects in the body.

Purpose

Electrotherapy is used for three therapeutic purposes: (1) to relieve **pain**; (2) to stimulate physiochemical changes; and (3) to stimulate **muscle contraction**.

Pain relief

Electrotherapy is used to manage both acute and chronic pain. In the gate model of pain, the neural fibers that carry the signal for pain and those that carry the signal for proprioception (body position) are mediated through the same central junction. Because signal transmission along pain fibers is slower than transmission along proprioception fibers, the gate model suggests that intense stimulation of proprioception fibers can block the slower-moving pain signals. Some forms of electrotherapy attempt to stimulate these proprioception fibers to reduce the sensation of pain. Other forms of electrotherapy alleviate pain by introducing **analgesics** and anti-inflammatory medications via electric current to the painful area.

Various types of pain are indications for electrotherapy, including:

- post-operative incision pain
- fracture pain
- pain associated with labor and delivery
- foot pain

- pain associated with tendinitis
- pain associated with certain types of arthritic inflammation
- back and neck pain

Stimulation of physiochemical changes

Electrotherapy is also used to induce physiological and chemical changes. Some forms of electrotherapy induce these changes by introducing heat into the deep tissues; this deep heating increases **blood** flow to and from the problematic region and improves drainage. Other forms of electrotherapy are thought to stimulate the body's production of **corticosteroids** and **vitamin D**. Still others are believed to promote wound healing by stimulating intracellular activity.

Indications for the forms of electrotherapy that induce physiochemical changes include:

- inflammatory orthopedic conditions
- bronchitis
- otitis media
- sinusitis
- prostatitis
- certain immunoregulated dermatologic conditions such as psoriasis
- open lesions and certain types of skin ulcers

Stimulation of muscle contraction

Electrotherapy is used to stimulate the contraction of muscles during rehabilitation. This type of electrical stimulation is used to prevent muscle atrophy and to re-educate muscles after trauma or surgery. This form of electrotherapy can also be used to relieve muscle spasms.

Indications for electrotherapy to stimulate muscle contraction include:

- healthy innervated muscle at risk of atrophy from immobilization or injury
- denervated (lacking natural neural connection) muscle that might atrophy or degenerate
- low back spasm

Precautions

Although each modality of electrotherapy has its specific set of contraindications, cardiac **pacemakers** are a general contraindication for electrotherapy. Electrical signals from electrotherapy devices can interact with the electrical signals from pacemakers and interfere with pacemaker functioning. Pacemaker disruption is particu-

larly acute with such modalities as diathermy and electrical nerve stimulation. However, less interference may occur with such radiation modalities as infrared, ultraviolet, and cold laser treatments (these modalities are discussed in detail below in the Description section).

Contraindications for pain relief electrotherapy include:

- undiagnosed pain (pain is a symptom that might signal a serious condition that may need to be treated directly)
- current use of narcotic medications that can desensitize patients to stimuli
- patient hyposensitivity in particular areas of the body
- pregnancy, except when electrotherapy is used to relieve pain of labor and delivery

For the use of electrotherapy to stimulate physiochemical changes, contraindications include:

- acute inflammation
- hemorrhage
- foreign bodies or metallic implants
- patient hyposensitivity in particular areas of the body
- recent treatment with ionizing radiation therapies
- pulmonary tuberculosis
- severe diabetes
- lupus erythematosus
- photosensitivity or current use of photosensitizing drugs

For the use of electrotherapy to stimulate muscle contraction, contraindications include:

- new fracture
- hemorrhage
- phlebitis

Description

Pain relief

For **pain management**, the two commonly used modalities of electrotherapy are transcutaneous electrical nerve stimulation (TENS) and iontophoresis. TENS relieves pain by stimulating proprioception nerve fibers to block the transmission of competing pain signals. Although both proprioception and pain receptors respond to electrical stimulation, there is some evidence that the proprioceptive nerves respond to different kinds of waveforms from the forms that stimulate pain receptors; TENS uses the electrical waveforms that target proprioceptors.

Electrodes are generally placed at points of pain, trigger points, acupuncture points, or over nerve roots. Parameters determining the character of the TENS stimuli are selected; these parameters include the waveform, frequency, duration, and amplitude of the wave. The duration of each TENS session is usually one hour. A typical patient is prescribed TENS four times daily for initial pain control. With continued use and as pain decreases, the frequency of TENS sessions can gradually be reduced to two sessions or one session daily.

The use of TENS for pain management is covered by insurance, but only for specific types of pain for limited time periods. TENS is typically well-covered for acute postoperative pain management, but TENS use for chronic pain complaints varies by insurer. Although the use of TENS to relieve labor and delivery pain has been documented overseas, this application of TENS is generally not approved by insurers in the United States.

A second form of electrotherapy used for pain relief is iontophoresis. Iontophoresis refers to the transdermal (through the skin) introduction of ionic compounds using direct current. This method of pain management is sometimes covered by insurance. In the United States, iontophoresis is almost always administered using dedicated iontophoresis devices. These machines allow for the fine-tuning of treatment parameters such as the amplitude of the current, the duration of treatment, and the automated ramping up and down of current at the start and end, respectively, of each treatment session. Iontophoresis units also come equipped with electrodes embedded in fiber pads or gel that carry the desired drug. For pain management, the drugs used in iontophoresis are analgesics and anti-inflammatory compounds, and include such medications as dexamethasone, lidocaine, and salicylate.

To begin iontophoresis, the delivery electrode containing the drug is placed in the area where pain is reported. Whether a drug is placed at the site of a negative or a positive electrode depends on the drug's ionic charge. Lidocaine has a positive charge and is placed with a positive delivery electrode, while the negatively-charged compounds of dexamethasone and salicylate are used with a negative delivery electrode.

After securing the delivery electrode, a second electrode, of opposite polarity, is placed on the body at a fixed distance (determined by the particular iontophoresis unit) away from the first electrode. Lead wires are attached to the electrodes, with the positive lead attached to the positive electrode and the negative lead to the negative electrode. The intensity of the electric current is then slowly increased until the predetermined level is reached, and this level is maintained throughout the main treatment session.

Treatment “dosages” are given in terms of milliamperes-minutes—that is, the product of the amplitude of the current (in milliamperes, mA) and the duration of treatment (in minutes). For example, a treatment consisting of two mA for 30 minutes would be a dose of 60 mA-min. Note that such a recommended dose would also allow the therapist to administer a treatment session of three mA for 20 minutes. In general, dosages range from 40 to 80 mA-min, with current intensity ranging from one to four mA, and treatment duration ranging from 20 to 40 minutes.

Stimulation of physiochemical changes

Diathermy and radiation are two forms of electrotherapy that are used to induce physiological and chemical changes in the body. Diathermy refers to the use of high-frequency electromagnetic waves (greater than 10 MHz) as therapeutic stimuli. Shortwave diathermy uses waves of 13, 27, or 45 MHz, while microthermy uses waves of up to 2450 MHz in frequency. Both forms of diathermy generate heat in deep muscle tissue, although microthermy is believed to be absorbed more by superficial fatty tissue.

The patient is placed between the electrodes, and the power level is adjusted until the patient reaches resonance (as determined by automated measurement systems) with a pre-established heating level. Each diathermy session lasts 10–30 minutes, depending on the size of the target area. The heat generated by diathermy is believed to improve blood circulation, relax muscular tension, and promote drainage in the target areas. Because of the lack of large controlled studies of diathermy, it may not be covered by insurance.

Radiation therapies in the context of electrotherapy include infrared, ultraviolet, and cold laser therapies. Infrared therapies—heat lamps, moist heat packs, and chemical heat packs—are used to apply superficial heat to improve circulation in target areas. Ultraviolet lamps are thought to stimulate the body’s production of corticosteroids and vitamin D. For some therapies, ultraviolet radiation is used in conjunction with photosensitive or photoactivated medications. Cold laser treatments—most commonly, the directing of a low-powered helium-neon laser beam over the target area—are used to facilitate wound healing. Cold laser may also be used for pain relief, with the laser directed at acupuncture points, trigger points, and nerve roots. Typically, ultraviolet and cold laser treatments do not exceed two minutes, while infrared treatments can last between 10 and 30 minutes.

Infrared or heat therapies are viewed as conventional treatments and are covered by insurers as part of a short-term **physical therapy** regimen. Ultraviolet thera-

pies, however, are only covered for very specific dermatological conditions such as disabling psoriasis. Cold laser treatments are categorized as investigational, or experimental, therapy and are not covered. Large uncontrolled trials have shown some benefits of cold lasers in promoting wound healing, but smaller controlled trials have shown little or no benefit. Studies of the pain-relieving effects of cold laser suggest no benefit beyond that which can be obtained through conventional treatments.

Stimulation of muscle contraction

The use of electrical stimulation to stimulate muscle contraction is known as neuromuscular electrical stimulation (NMES) or functional electrical stimulation (FES). NMES/FES therapies apply pulses of electrical current to target muscle groups to stimulate active motion, strengthen muscles, and prevent muscle atrophy.

In NMES/FES, electrodes are placed initially on the belly of the muscle that is to be stimulated. AC electrical stimulation is then applied at low levels (threshold levels for muscle movement). Based on muscle responses to the threshold stimulation, electrode positions are adjusted until the motor points of the muscle (optimal positions for generating muscle movement) are found. Electrodes are then secured at these optimal positions.

After the electrodes have been placed, parameters for NMES/FES are programmed into the electrical stimulator unit. Parameters include the amplitude of the electrical pulse, the duration of each pulse, the frequency of pulses, the duration of on/off (activation/rest) periods during the treatment session, ramping modulation (gradual increases and decreases) in stimulation, and duration of the treatment session. The maximum pulse amplitude recommended for NMES/FES is generally the maximum amplitude that can be tolerated by a given patient. Regarding pulse duration, there remains some ambiguity about the optimal duration time of each pulse; current practices suggest that pulse duration be set between 50 and 1000 microseconds. Pulse frequency tends to range from 30 pulses per second to 100 pulses per second. Since continuous electrical stimulation leads to early muscle fatigue, treatment sessions include rest periods between activation periods. The duration of “on” (activation) periods is typically 10–15 seconds; “off” (rest) periods can last up to one or two minutes. Treatment sessions may last between 10 and 20 minutes, and usually do not exceed one hour.

Electrical stimulation can begin after parameters are set. In general, the intensity of the stimulation is increased from contraction to contraction within a given session, and is also increased from session to session, depending on how well the patient tolerates the increases.

KEY TERMS

Denervation—A lack of nerve input into a muscle, organ, or other body part that normally receives neural input.

Innervation—The presence of nerve input into a muscle, organ, or other body part.

Osteogenesis—New bone growth.

NMES/FES is usually approved by insurers for post-surgical rehabilitation and rehabilitation after immobilization (after a limb has been in a cast or splint). This form of electrotherapy is typically not approved for **spinal cord** injuries or for muscles that have been denervated.

Preparation

Preparation for electrotherapy requires first that the physical therapist clarify the problem area and condition with the patient. The physical therapist then selects the appropriate therapeutic modality for the complaint and determines the relevant parameters for each electrotherapeutic modality.

The skin of the target area must be clean. For modalities requiring electrodes, the skin of the target area must also be free of lesions. For TENS therapy, conduction gels are used on the surface of the skin; otherwise, moisture on the tips of the electrodes is sufficient. For ultraviolet therapies, a small area of the skin should be tested to determine the minimal erythema (reddening of the skin) dosage prior to treatment. For some ultraviolet therapies, a photosensitizing medication is given prior to treatment.

If pain relief is the goal, the patient should discontinue the use of pain medications that might obscure the effect of electrotherapy. For iontophoresis, the patient must be queried on possible sensitivities; for example, an allergy to dexamethasone would rule out the use of dexamethasone as an anti-inflammatory ionic substance.

Aftercare

Patient comfort should be monitored throughout the therapeutic session. After treatment, the patient should be queried about excessive levels of discomfort. Excessive discomfort should serve as a guide for modulating electrotherapy parameter settings in the future.

In the case of such direct electrical stimulation as NMES/FES, the skin under the probes should be massaged with a neutral cream after treatment.

Complications

After treatment, the patient should be checked for **burns** from electrodes or poorly placed wires. Heat burns are possible with almost all electrotherapy modalities. These types of burns occur when there is a buildup of heat in regions where electrical resistance is high. Causes of these high-resistance burns include electrodes being placed in sclerotic (scarred) areas; electrodes being placed in areas with wrinkled or folded skin or other areas where electrode contact is poor; or electrodes being poorly moistened.

A complication of iontophoresis is chemical burn. Chemical burns occur when too much sodium hydroxide accumulates at the negative electrode. A pink lesion is apparent immediately after treatment, which becomes an oozing wound two to three hours later. This type of burn can be treated with **antibiotics** and a dressing, but tends to heal slowly. This complication can be prevented by decreasing the intensity of the current or by increasing the area of the negative electrode so that the current is dispersed over a larger area.

Complications arising from cold laser treatment include **dehydration**, protein coagulation (clumping), and thermolysis (melting). While dehydration is reversible, protein coagulation and thermolysis are not. The typical cause of these complications is the use of cold laser at excessively high power.

Results

TENS and iontophoresis should result in a reduction of pain and/or reduced symptoms of inflammation. There may be a concomitant increase in range of motion.

If diathermy and radiation are used, improved drainage may be reported. In addition, depending on the specific therapy, improvement in skin conditions and wound healing are expected. The reduction of pain and inflammation may also be reported.

NMES/FES should maintain or improve muscle strength. If the electrical stimulation is used to alleviate muscle spasm, relief from spasm is an expected result.

Health care team roles

Because the physical therapist has typically received training in electrotherapy during his/her course of studies, he/she is the primary care provider during electrotherapy. The physical therapist delivers the therapeutic care and monitors the patient during electrotherapy. If the patient has been referred by a physician or other health care provider and the provider requests briefings, the

therapist reports on the effects of the therapy and on the patient's progress.

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Genevieve Pham-Kanter

Element deficiencies *see* **Mineral deficiency**

Elimination diet

Definition

An elimination diet functions as a test, determining whether patients may have a sensitivity to certain foods. Initially, patients stop eating foods suspected of causing illness. Then, after a suitable period of time (often 10–14 days), they review their symptoms. If significant improvement has occurred, it is assumed that an allergy or intolerance to certain foods may be involved. These suspect foods are then reintroduced to the diet, one by one. When symptoms return (usually within three days), the problematic food is identified and removed from the diet.

Benefits

Elimination diets are potentially useful in identifying hard-to-detect food intolerances that proponents believe are responsible for a wide range of ailments. These include constipation, headaches, migraine, infections of the ear or sinuses, frequent colds, post-nasal drip, chronic nasal congestion, sore throats, chronic cough, eczema, **hives**, acne, **asthma**, **pain** or stiffness in the muscles or joints, **heart** palpitations, indigestion, ulcers of the mouth, **stomach**, or duodenum, **Crohn's disease**, **diarrhea**, yeast infections, urticaria, **edema**, depression, **anxiety**, hyperactivity, weight change, and generalized fatigue.

Description

The following lists of appropriate and inappropriate foods for an elimination diet represent general guidelines. Elimination diets vary according to practitioner and the specific symptoms or allergy.

Foods that may be prohibited in an elimination diet include those containing:

- Additives: monosodium glutamate, artificial preservatives, sweeteners, flavors, or colors.
- Alcohol: beer, ale, stout, porter, malt liquors, wine, coolers, vodka, gin, rum, whiskey, brandy, liqueurs, and cordials.
- Citrus fruits: oranges, calamondins, tangerines, clementines, tangelos, satsumas, owaris, lemons, limes, kumquats, limequats, and grapefruit.
- Commonly eaten foods: anything consumed more than three times weekly, as well as foods that are craved or that cause a feeling of weakness.
- Corn: as well as corn syrup or sweetener, corn oil, vegetable oil, popcorn, corn chips, corn tortillas.
- Dairy products: milk, milk solids, cheese, butter, sour cream, yogurt, cottage cheese, whey, and ice cream.
- Eggs: both yolks and whites.
- Gluten: any pasta, breads, cakes, flour, or gravies containing wheat.
- Honey.
- Maple syrup.
- Sugar: candy, soft drinks, fruit juices with added sugar or sweetener, cakes, cookies, sucrose, fructose, dextrose, or maltose.

Foods that may be allowed include:

- Cereals: puffed rice or millet, oatmeal, or oat bran.
- Daily multivitamin: this is especially important during extended dieting to replace missing nutrients.
- Fats and oils: soy, soy milk, soy cheese, sunflower oil, safflower oil, flaxseed oil, olive oil, and sesame oil.
- Fruits and vegetables: typically, anything except corn and citrus fruits. Some practitioners suggest fruit be consumed in moderation, and preferably whole as opposed to juices.
- Grain and flour products: rice cakes or crackers, rye or spelt bread (both must be 100% with no added wheat), kasha, rice, amaranth, quinoa, millet, oriental noodles, other exotic grains.
- Legumes: soybeans, string beans, black beans, navy beans, kidney beans, peas, chickpeas, lentils, tofu.

KEY TERMS

Anaphylactic shock—An extreme allergic reaction characterized by swelling, constriction of the bronchi, circulatory collapse, heart failure, and even death.

Urticaria—Itchy pustules that may be caused by a hypersensitivity to food, drugs, or other substances.

Canned beans should be avoided unless they are free of preservatives and sugar.

- Seeds and nuts: must not contain sugar or salt. Nut butters are allowed if they meet this requirement and are organic.
- Water: two quarts daily. Preferably bottled, as tap water contains potential allergens including fluoride and chlorine.
- Other: honey, white vinegar, salt, pepper, garlic, onions, ginger, herbal teas, coffee substitutes, spices or condiments (mustard, ketchup) that are free from sugar, preservatives, and citrus. These products can commonly be found at health food stores.

An important complement to any elimination diet is a food diary, in which all dietary consumption is recorded, along with any subsequent symptoms. Patterns should be evident after about one month of record keeping.

Precautions

As with all therapies, anyone considering an elimination diet should weigh the potential benefits against the risks. The decision, according to some, is comparable to deciding to take a prescribed medication, and should be done only under the supervision of a competent medical practitioner.

Elimination diets should never be used by individuals with severe food **allergies**, as reintroducing a suspect food may provoke an asthma attack, anaphylactic **shock**, or other dangerous reaction. Generally, an elimination diet will be used only when symptoms are believed to be related to just one or two suspect foods.

Patients need to know that following a strict elimination diet is not an easy matter. It is extremely important to read packaged-food labels carefully, because many processed foods contain monosodium glutamate, sugar, and other substances that may be prohibited. It is almost impossible for elimination-diet patients to eat in restaurants, at school, or at the homes of friends. The resulting

isolation must be considered as part of the decision to undertake an elimination diet. Patients should also consider whether they have sufficient time for the extra planning, shopping, and food preparation involved.

Elimination-diet patients should be vigilant to replace any nutrients missing from their restricted diet. For example, **calcium** supplements may be advisable for someone eliminating dairy products from the diet. Needless to say, any prescribed medications should be continued during any diet.

Putting a very young child on an elimination diet may endanger the child's **nutrition** and normal growth. A breastfeeding mother may harm both her own health and that of her infant if she undertakes an elimination diet during **lactation**.

Side effects

The most significant side effects of an elimination diet are nutritional disorders resulting from a prolonged, highly restrictive diet, and the risk of a serious reaction as suspect foods are re-introduced to the diet. Some proponents also caution that patients consuming a very limited variety of foods risk becoming allergic to those very foods. For these reasons, professional supervision and substitution of missing nutrients are both essential.

Research and general acceptance

Elimination diets are widely used by medical doctors, but considerable differences of opinion exist over the range of illnesses that may be caused by food allergies or intolerances. Many physicians and researchers question the role of allergies in migraine, rheumatoid arthritis, **osteoarthritis**, and other conditions. Some doctors suggest that elimination diets should be used only after other diagnostic methods have been tried, including history-taking, skin tests, blind food challenges, and radioallergosorbent testing.

Training and certification

Because of the risks involved, elimination diets should be undertaken only under competent medical supervision. Some patients may wish to consult an allergy specialist.

Resources

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David Helwig

Emergency medical technicians

Definition

An emergency medical technician-paramedic is a licensed and/or certified out-of-hospital health-care provider. EMTs represent the uppermost level of prehospital health care providers and serve as managers of prehospital treatment teams. They work under the direction of a physician—often by two-way radio—to evaluate and manage acutely ill or injured patients in ambulance services or other life-support units.

Description

The emergency medical system is a complex emergency response structure that has strict guidelines for its certification levels of health professionals. Emergency medical technicians are classified under four levels of prehospital certification: First Responder; Emergency Medical Technician-Basic (EMT-B); Emergency Medical Technician-Intermediate (EMT-I), and Emergency Medical Technician-Paramedic (EMT-P). Education and training varies across the four levels, with the emergency medical technician-paramedic having the highest level of training. An emergency medical technician has developed independent reasoning and training to make rapid assessments and interventions that can save people's lives. The EMT-P is considered an extension of the emergency room physician to the patient in the field and has the greatest amount of responsibility.

Provision of initial treatment

The responsibilities of an emergency medical technician are numerous, demanding, and extremely stressful. The EMT's most common responsibilities are related to provision of initial treatment:

- Organization and preparation for emergency calls: Besides having all of the equipment stocked, ambulance maintained and cleaned, and communication devices checked, the emergency medical technician must be psychologically and emotionally prepared to care for distressed patients and family members.
- Immediate and safe response to the emergency scene by knowing the proper location and road systems while maneuvering a heavy and bulky ambulance through traffic.
- Assessment of the safety hazards at the emergency scene, including the safety of the crew, the victims, and the bystanders—as well as understanding the nature of the injuries or illnesses that may be encountered.

- Rapid and efficient evaluation of victims of trauma or illness, using advanced patient assessment skills while recognizing and assigning priority to the most critical injury or illness.
- Delivery of high-quality patient care while utilizing protocols for procedures and interventions established by the emergency medical technician agency, as well as recognizing the need for back-up by an emergency physician.
- Transportation of patients to appropriate institutions if the patients are unstable or needing specialty care (i.e. neurological trauma, cardiovascular intervention). The emergency medical technician makes the decision regarding the best facility for managing the patient's injury or illness.
- Keeping records of all assessment findings and interventions completed on the patient from the field to the receiving facility.

Other responsibilities

Over the years, the scope of the EMTs responsibilities has widened to include educating the public about health issues and participating in injury and disease prevention programs. EMTs are also playing an increasingly important role in medical and **public health** research programs.

Work settings

Emergency medical technicians can work in a variety of settings. Many EMTs work for ambulance agencies. On the other hand, emergency centers, sports facilities, long-term care facilities, and large industries are also employing emergency medical technicians to deliver health care.

Education and training

Prerequisites

Educational requirements for emergency medical technicians differ slightly from state to state. Some EMT programs are designed to accommodate part-time students; others are structured as full-time college-level courses of study. The average length of training for EMTs is 1000 hours, but upgraded standards will probably add a small increase to the number of training hours over the next few years.

Persons considering an EMT-P program must be high school graduates and demonstrate their ability to meet the physical and psychological demands of emergency work. The physical demands are considerable, since EMTs must frequently lift and move patients away



Emergency medical technicians are trained to respond to emergency situations ranging from car accidents to chemical spills. (M. Kowal/Custom Medical Stock Photo. Reproduced by permission.)

from danger zones or into emergency vehicles, without time to call for assistance. Likewise, the sheer number of potential on-the-job hazards, ranging from toxic chemical spills or fire to collapsing buildings or human violence adds to the emotional **stress** of EMT work. In addition to demonstrating their physical stamina and emotional stability, persons entering an EMT-P program must be certified at the EMT-ambulance level. Some programs, however, offer a combination of EMT-ambulance and EMT-P training. Students who have acquired basic EMT training in the armed forces within the past 12 months and have had their work approved by a state agency may be permitted to enroll in an EMT-P program.

Course work

In some states, students enrolled in EMT-P programs are eligible to earn an associate's degree. On the national level, the United States Department of Transportation (U.S. DOT) determines the minimum requirements that must be met for the education of emergency medical technicians. Accredited EMT-P programs include didactic instruction, in-hospital clinical experience, and a supervised field internship in an advanced life-support

unit. The course work should also acquaint students with an understanding of their legal and ethical responsibilities as emergency medical personnel.

The education of a emergency medical technician focuses on three dimensions of human experience and activity:

- The affective domain: assignment of various feelings, morals, and thoughts to information, situations, and scenarios.
- The cognitive domain: recall of information and comprehension of facts, figures, and statistics.
- The psychomotor domain: skill attainment through practice in clinical and controlled laboratory settings.

Advanced skills and knowledge of medical management of patients in the field is a central component of EMT training. Common areas of training are:

- advanced **airway management** techniques, including endotracheal intubation
- intravenous fluid management, including the initiation of intravenous lines and administration of proper fluid replacement

- administration of emergency medications
- cardiac monitoring, interpretation, and intervention
- advanced patient assessment and evaluation
- management of trauma patients
- administration of established advanced cardiac life support, including defibrillation (delivering an electrical **shock**) for abnormal **heart** rhythms
- administration of advanced first aid
- complex immobilization techniques used in acute **fractures**, dislocations, and strains
- proper physical restraining of violent patients, with training focused on safety and de-escalation techniques

Continuing education and specialized training

The education of EMTs does not end with course completion and certification or licensure. The importance of keeping one's skills current is equally important. Every two years, emergency medical technicians must acquire a specific number of continuing education credits in order to maintain certification or licensure in their respective states. Most employers will provide classes for the emergency medical technicians to obtain the necessary continuing education credits.

Specialized certifications are important for the emergency medical technician to complete and update every two years. These certifications include: Advanced Cardiac Life Support (ACLS), Pediatric Advanced Life Support (PALS), Basic Trauma Life Support (BTLS), and Prehospital Trauma Life Support (PHTLS).

Future outlook

The role of emergency medical technicians is expanding because of their ability to independently manage various types of patients. The emergency medical technician has become instrumental in transport of critical care patients from one facility to another via ground transport, helicopter, or larger aircraft. In order for an emergency medical technician to function on an acute care transport vehicle, additional training in critical care medications, **ventilators**, various advanced monitoring systems, and fluid management must be completed.

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KEY TERMS

Defibrillation—A procedure to stop the fibrillation (irregular contraction) of heart muscle by using electric shock.

Emergency medical technician—A licensed and/or certified out-of-hospital health care provider who serves as the manager of the pre-hospital treatment team.

Intubation—Inserting a tube in a patient's mouth or nose to assist delivery of oxygen or air.

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EMG *see* **Electromyography**

Emphysema

Definition

Emphysema is a chronic respiratory disease in which overinflation of the alveoli or air sacs causes a decrease in respiratory function and often dyspnea.

Description

Emphysema is the most common cause of death from respiratory disease in the United States, and is the fourth most common cause of death overall. There are 1.8 million Americans with the disease, which ranks fifteenth among chronic conditions that cause limitations of activity. Around 44% of those with emphysema state that their activities of daily living have been affected by the disease.

Normally functioning **lungs** are elastic, efficiently expanding and recoiling as air passes freely through the bronchus to the alveoli, where oxygen is moved into the **blood** and carbon dioxide is filtered out. When a person inhales cigarette smoke, his or her **immune system** responds by releasing substances that are meant to defend the lungs against the smoke. These substances can also attack the cells of the lungs. Normally, the body inhibits such action by releasing other substances. In smokers and those with the inherited emphysema defect, however, no such prevention occurs, and the lung tissue is damaged in such a way that it loses its elasticity. The small passageways leading to the alveoli collapse, trapping air within the alveoli. The alveoli, unable to recoil efficiently and move the air out, overexpand and rupture. The smaller areas of alveoli destruction are known as blebs and the larger ones are called bullae. As the disease progresses coughing and dyspnea occur. In the later stages the lungs cannot supply sufficient oxygen to the blood. Emphysema often occurs with other respiratory diseases, particularly chronic bronchitis. These two diseases are often referred to as one—chronic obstructive pulmonary disease (COPD).

Emphysema is most common among people aged 50 years and older. Those with inherited emphysema may experience the onset as early as their 30s or 40s. Men are more likely than women to develop emphysema, but female cases are increasing as the number of female smokers rises.

Causes and symptoms

Heavy cigarette smoking causes about 80–90% of all emphysema cases. However, a few cases are the result of an inherited deficiency of alpha-1-antitrypsin (AAT). The number of Americans with this deficiency is relatively small, probably no greater than 70,000. Pipe, cigar, and **marijuana** smoking can also damage the lungs. While a person may be less likely to inhale cigar and pipe smoke, these types of smoke can also impair lung function. Marijuana smoke is even more damaging because it is inhaled deeply and held in the lungs longer by the smoker.

The symptoms of emphysema develop gradually over many years. It is a common occurrence for many emphysema patients to have lost 50–70% of their functional lung tissue before they become aware that something is wrong. Dyspnea, a chronic mild cough (which may be productive of large amounts of dark, thick sputum, and often dismissed as “smoker’s cough”), and sometimes weight loss are associated with emphysema. Initially, a patient may notice shortness of breath only when he or she is exercising. However, as the disease progresses, it will occur during less exertion, and ultimately with no exertion at all. Emphysema patients may also develop an enlarged, or “barrel,” chest. Other symptoms may include skipped breaths, insomnia, morning headaches, nasal flaring, increased difficulties breathing while lying down, chronic fatigue, and swelling of the feet, ankles, or legs. Those with chronic emphysema are at risk for other complications resulting from weakened lung function. These include **pneumonia**, pulmonary **hypertension**, cor pulmonale, and chronic **respiratory failure**.

Diagnosis

A history of heavy smoking alone is not enough for a physician to differentiate emphysema from other respiratory diseases. A physician will combine information on symptoms, medical history, **physical examination**, lung function tests, and **chest x ray** results to make a diagnosis of emphysema. One of the first clues may be a hollow sound heard through a **stethoscope** as the patient’s chest is being tapped. The hollow sound is the result of the enlargement or rupture of the lungs’ alveoli.

A variety of pulmonary function tests may be ordered. In the early stages of emphysema, the only result may be dysfunction of the small airways. Patients with emphysema may show an increase in the total amount of air that is in the lungs (total lung capacity), but a decrease in vital capacity. With severe emphysema, vital capacity is substantially below normal. Spirometry, a procedure that measures respiratory gases and resulting pulmonary function, aids in the diagnosis of emphysema.

A chest x ray is often ordered to aid in the diagnosis of emphysema, though patients in the early stages of the disease may have normal findings. Abnormal findings on the chest x ray include excessive inflation of the lungs and an abnormally increased chest diameter. The diaphragm may appear depressed or flattened. In addition, patients with advanced emphysema may show an enlargement of the **heart**. The physician may observe blisters in the lungs and bulging of the accessory muscles of the **respiratory system**. Late in the disease an EKG will show signs of right ventricular failure in the heart

and increased hemoglobin due to lower oxygen in the patient's blood.

Other tests that may be performed include peak flow measurements, arterial **blood gases**, and pulse oximetry.

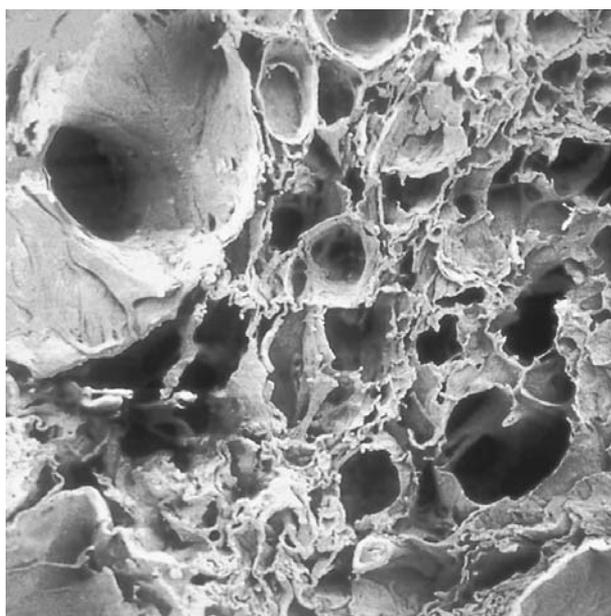
Treatment

Treatment methods for emphysema do not cure or reverse the damage to the lungs. However, they can slow the progression of the disease, relieve symptoms, and help control possibly fatal complications. The first step in treatment for smokers is to quit smoking to prevent any further deterioration of breathing ability. Smoking cessation programs may be effective. Consistent encouragement, along with the help of health care professionals as well as family and friends, can help increase the quit rate.

If the patient and the health team develop and maintain a complete program of respiratory care, disability can be decreased, acute episodes of illness may be prevented, and the number of hospitalizations reduced. However, only smoking cessation has been shown to slow down the progression of the disease; and among all other treatments, only **oxygen therapy** has exhibited an increase in survival rate.

Home oxygen therapy may improve the survival times in those patients with advanced emphysema who also have hypoxemia, or low blood oxygen levels. It may improve the patient's tolerance of **exercise**, as well as improve their performance in certain aspects of **brain** function and muscle coordination. The functioning of the heart may also improve with an increased concentration of oxygen in the blood. Oxygen may also decrease insomnia and headaches. Some patients may receive oxygen only at night, but studies have illustrated that it is most effective when administered for at least 18, but preferably, 24 hours per day. Those patients just beginning the therapy may wish to postpone continuous oxygen administration until it becomes absolutely necessary because of inconvenience and decreased mobility. Portable oxygen tanks prescribed to patients carry a limited supply and must be refilled on a regular basis by a home health care provider. **Medicare** and most insurance companies cover a large proportion of the cost of home oxygen therapy. Patients should be instructed regarding special safety issues involving the transport and presence of oxygen in the home.

A variety of medications may be used in the treatment of emphysema. Usually the patient responds best to a combination of medicines rather than one single drug. Bronchodilators are sometimes used to help alleviate the patient's symptoms by relaxing and opening the airways. There are three primary categories of bronchodilators:



A scanning electron microscopy (SEM) of lung tissue showing the ruptured alveoli (air sacs) that characterize emphysema. (Photograph by Hossler, Custom Medical Stock Photo. Reproduced by permission.)

sympathomimetics (isoproterenol, metaproterenol, terbutaline, albuterol), which can be inhaled, taken by mouth, or injected; parasympathomimetics (atropine); and methylxanthines (theophylline), which may be administered intravenously, orally, or rectally.

Another category of medication often used is **corticosteroids** or steroids (beclomethasone, dexamethasone, triamcinolone, flunisolide). These help to decrease the inflammation of the airway walls. They are occasionally used if bronchodilators are ineffective in preventing airway obstruction. Some patients' lung function improves with corticosteroids, and inhaled steroids may be beneficial to patients with few side effects.

A variety of **antibiotics** are frequently given at the first sign of a respiratory **infection**, such as increased amounts of sputum or a change in the color of the sputum. Expectorants can help loosen respiratory secretions, enabling the patient to more easily expel them from the airways.

Many of the medications prescribed involve the use of a metered dose inhaler (MDI) that may require special instruction to be used correctly. MDIs are a convenient and safe method of delivering medication to the lungs. However, if they are used incorrectly the medication will not get to the right place. Proper technique is essential for the medication to be effective.

For some patients, surgical treatment may be the best option. Lung volume reduction surgery is a surgical pro-

KEY TERMS

Alveoli—Small cells or cavities. In the lungs, these are air sacs in which oxygen enters the blood and carbon dioxide is filtered out.

Arterial blood gases—A test to analyze blood for oxygen, carbon dioxide, and bicarbonate content, as well as blood pH. Used to test the effectiveness of respiration.

Cor pulmonale—A disease characterized by an increase in bulk of the right ventricle of the heart that can lead to heart failure.

Hypoxemia—A condition characterized by deficient oxygen supply in the blood.

Peak flow measurement—Measurement of the maximum rate of airflow attained during a forced vital capacity determination.

Pulmonary—Related to or associated with the lungs.

Pulse oximetry—The noninvasive monitoring or determination of oxygen-hemoglobin saturation of the blood.

cedure in which the most diseased parts of the lung are removed to enable the remaining lung and breathing muscles to work more efficiently. Preliminary studies suggest improved survival rates and better functioning with the surgery. Another surgical procedure used for emphysema patients is lung transplantation. Transplantation may involve one or both lungs. However, it is a risky and expensive procedure and donor organs may not be available.

For those patients with advanced emphysema, keeping the air passages reasonably clear of secretions can prove difficult. Some common methods for mobilizing and removing secretions include:

- **Postural drainage.** This technique helps to remove secretions from the airways. The patient lies in a position that allows gravity to aid in draining different parts of the lung. This is often done after the patient inhales and aerosol medication. The basic position involves the patient lying on the bed with chest and head over the side and forearms resting on the floor.
- **Chest percussion.** This technique involves a caregiver lightly clapping the back and chest of the patient. It may help to loosen thick secretions.
- **Coughing and deep breathing.** These techniques may aid the patient in bringing up secretions.

- **Aerosol treatments.** These treatments may involve solutions of saline, often mixed with a bronchodilator, which are then inhaled as an aerosol. The aerosols thin and loosen secretions. A treatment normally takes 10–15 minutes and is given three or four times a day.

Patients with COPD can be instructed to perform a variety of self-help measures that can help improve their symptoms and ability to participate in activities of daily living. These measures include:

- Avoiding any exposure to dust and fumes.
- Avoiding air pollution, including secondhand cigarette smoke.
- Avoiding other people who have infections like the cold or flu, and getting a pneumonia **vaccination** and a yearly flu shot.
- Drinking plenty of fluids to help loosen respiratory secretions so they can be coughed up more easily.
- Avoiding extreme heat or cold and high altitudes (special precautions can be taken that may enable the emphysema patient to fly on a plane).
- Maintaining adequate nutritional intake; normally, a high-protein diet taken in many small feedings, is recommended.

Many patients are interested in whether any alternative treatments for emphysema are available. Some practitioners recommend supplements of antioxidant nutrients. There have also been some studies indicating a correlation between a low **vitamin A** status and COPD, with suggestions that supplements of vitamin A might be beneficial. Aromatherapists have used essential oils like eucalyptus, lavender, pine, and rosemary, to help relieve nasal congestion and make breathing easier. The herb elecampane may act as an expectorant to help patients clear mucus from the lungs. The patient should discuss these remedies with their health care practitioner prior to trying them, as some may interact with the more traditional treatments already being given.

Prognosis

Emphysema is a serious and chronic disease that cannot be reversed. If detected early effects and progression can be slowed, particularly if the patient ceases smoking immediately. Complications of emphysema include higher risks for pneumonia and acute bronchitis. Overall, the prognosis for patients with emphysema is poor, with a medical survival rate for all COPD patients of four years, and even less for emphysema patients. However, individual cases vary, and many patients can live much longer with supplemental oxygen and other treatment measures.

Health care team roles

Many members of the health care team may treat the patient with emphysema. The patient usually seeks help from a physician first, who will make the diagnosis. In the course of the diagnostic workup, x-ray technicians and respiratory therapists may treat the patient. The nurse plays an important role in assessing the patient, administering medications, in teaching the patient how best to cope with and understand the disease, and—in some cases—provides **home care**. The physical therapist may assist the patient to find ways of increasing their strength and activity tolerance.

Prevention

The best way to prevent emphysema is to avoid smoking. Even patients with inherited emphysema should avoid smoking, as it hastens onset and worsens severity of the disease. If patients quit smoking as soon as evidence of small airway obstruction begins, they can significantly improve their prognosis.

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The National Emphysema Foundation. 15 Stevens St., Norwalk, CT 06856. <<http://www.emphysemafoundation.org>>.

National Heart, Lung and Blood Institute. <<http://www.nhlbi.nih.gov>>.

Deanna M. Swartout-Corbeil, R.N.

Endocarditis

Definition

Endocarditis is an **infection** of the endocardium, the inner lining of the **heart** muscle and its four valves (tricuspid, pulmonary, mitral, and aortic). Abnormal or dam-

aged endocardium is more likely to become infected when **bacteria** enter the bloodstream. When this happens, during surgical or dental procedures, for example, a condition called bacteremia results. The circulating bacteria can then enter the heart, where damaged tissue or other abnormalities allow them to multiply and cause an infection. Endocarditis is a life-threatening disease that interferes with the heart’s ability to pump **blood**. Untreated, it is always fatal.

Description

Endocarditis most commonly occurs in people whose hearts have damaged valves. This may be the result of acquired valvular disease from rheumatic **fever** or other diseases. Patients with mitral valve prolapse, in which a poorly functioning mitral valve regurgitates blood back into the heart, allowing bacteria to multiply, are also at risk for endocarditis. Prosthetic (artificial) heart valves are more likely to become infected as well.

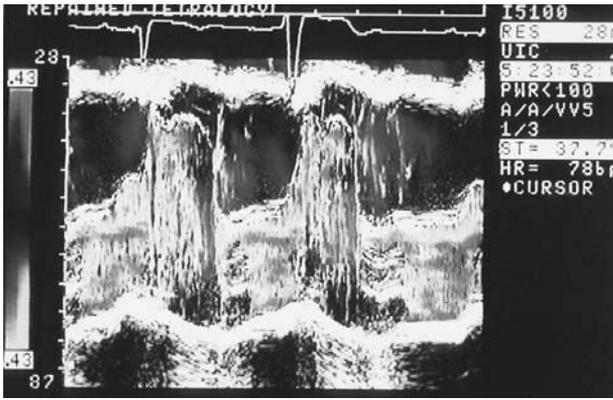
Bacteremia that causes endocarditis can occur in several ways:

- from a localized infection such as a urinary tract infection, **pneumonia**, skin infection, or dental infection
- as a result of certain medical conditions, such as severe periodontal disease, colon **cancer**, or inflammatory bowel disease
- during dental or surgical procedures, such as dental cleaning, tooth extractions, tonsil removal, or endoscopic examinations
- through in-dwelling catheters used for intravenous medications, intravenous feeding, or dialysis
- intravenous drug use using unsterilized, contaminated needles and syringes

The bacteria that cause most endocarditis are gram-positive cocci, such as *Staphylococcus* or *Streptococcus*. Staphylococcal endocarditis occurs most often among intravenous drug users and patients with in-dwelling venous catheters. Gram-negative bacterial endocarditis or fungal endocarditis is much less common; patients are usually intravenous drug users or those with prosthetic heart valves.

Endocarditis patients who appear critically ill are usually suffering from acute bacterial endocarditis, while those with subacute bacterial endocarditis have less severe but persistent symptoms such as weight loss, fatigue, and low-grade fever.

If not discovered and treated, endocarditis can permanently damage the heart valves. If a valve is damaged, it may allow blood to flow backward—a condition known as regurgitation. As a result of a poorly function-



This echocardiogram shows an aortic regurgitation due to endocarditis, an infection of the lining membrane of the cardiac chambers. (Custom Medical Stock Photo. Reproduced by permission.)

ing valve, the heart muscle has to work harder to pump blood and may become weakened, leading to congestive **heart failure**.

Another danger associated with endocarditis is that the overgrowth of bacteria colonizing heart valves may break off and form emboli that can become lodged in arteries. An embolism to an artery supplying the **brain** can cause a stroke; an embolus lodged in the **blood vessels** of the **lungs** may cause pneumonia.

Causes and symptoms

Most cases of infective endocarditis occur in patients between the ages of 15 and 60, with a median age at onset of about 50 years. Men are affected about twice as often as women. Other risk factors for endocarditis are congenital heart problems, heart surgery, past history of endocarditis, and intravenous drug use.

Patients with acute bacterial endocarditis are generally critically ill. Patients with subacute bacterial endocarditis tend to have a low-grade fever, which rarely rises above 102°F (38.9°C), chills, weakness, cough, difficulty breathing, headaches, arthralgias (aching joints), and loss of appetite, although these symptoms vary with individual patients.

Emboli may also cause a variety of symptoms, depending on their location. Emboli throughout the body may cause Osler's nodes, which are small, reddish, painful bumps most commonly found on the inside of fingers and toes. Emboli may also cause petechiae, which are tiny purple or red spots on the skin resulting from hemorrhages under the skin's surface. Tiny hemorrhages resembling splinters may also appear under the fingernails or toenails. If emboli become lodged in the blood

vessels of the lungs, they may cause coughing or shortness of breath. Emboli lodged in the brain may cause a stroke, with such symptoms as numbness, weakness, or **paralysis** on one side of the body or sudden blindness or double **vision**. Emboli may also damage the **kidneys**, causing nephritis. Sometimes the capillaries on the surface of the spleen rupture, causing it to become enlarged and tender. Patients with any of these symptoms require immediate medical attention.

Diagnosis

Clinicians diagnose endocarditis by taking a history and performing a **physical examination**, during which they may observe such signs as fever, an enlarged spleen, signs of kidney disease, or hemorrhaging. The clinician may also detect a heart murmur. A heart murmur may indicate abnormal flow of blood through one of the heart chambers or valves. Laboratory analysis of the patient's blood identifies the bacteria or other microorganisms that may be causing the infection.

The diagnostic workup also involves **echocardiography** to check for abnormalities in the structure of the heart wall or valves. Conventional echocardiography uses ultrasound to view the structures of the heart. This diagnostic procedure is transthoracic; the ultrasound transducer is placed on the chest wall.

One of the hallmarks of endocarditis that may be observed during echocardiography is vegetation, which is the abnormal growth of tissue, composed of blood platelets, bacteria, and a clotting protein called fibrin, that grows around a valve. Another indicator is regurgitation, or the backward flow of blood, through one of the heart valves. A normal echocardiogram does not exclude the possibility of endocarditis, but an abnormal echocardiogram can confirm its presence. If an echocardiogram cannot be performed or its results are inconclusive, a modified technique called **transesophageal echocardiography** is sometimes performed. This technique involves passing an ultrasound device into the esophagus to get a clearer image of the heart.

Treatment

When infective endocarditis is suspected, the patient is admitted to the hospital and antibiotic treatment is started before the results of the **blood culture** are available. The choice of **antibiotics** depends on which infecting microorganism is suspected. Once the results of the blood culture become available, the physician will prescribe specific antibiotics known to be effective against the specific microorganism involved.

Today the treatment of endocarditis is more complicated as a result of antibiotic resistance. Over the past few years, especially as antibiotics have been overprescribed, more and more strains of bacteria have become increasingly resistant to a wider range of antibiotics. For this reason, a few different types of antibiotics—or even a combination of antibiotics—may be necessary to treat the infection successfully. Antibiotics are usually prescribed for about six weeks but may be given for an even longer period of time if the infection is resistant to treatment.

Once the fever and acute symptoms have resolved, most patients are able to continue antibiotic therapy at home. During this time, patients make regular visits to the health care team to ensure that the antibiotic therapy is working, that it is not causing adverse side effects, and that there are no complications such as emboli or congestive heart failure.

Patients must be advised to alert the health care team to any symptoms that could indicate serious complications. For instance, difficulty breathing or **edema** (swelling) in the legs could indicate congestive heart failure. Headache, joint **pain**, blood in the urine, or stroke symptoms could indicate an embolus; and fever and chills could indicate that the treatment is not working and the infection is worsening. Finally, **diarrhea**, rash, itching, or joint pain may suggest an adverse reaction to the antibiotics. Patients experiencing any of these symptoms should be advised to seek immediate medical attention.

In some cases surgical intervention may be needed to treat congestive heart failure, recurring emboli, infection that does not respond to treatment, poorly functioning heart valves, and endocarditis involving prosthetic (artificial) valves. The most common surgical treatment involves debriding (cutting away) damaged tissue and replacing the damaged valve.

Prognosis

Untreated infective endocarditis progresses and is always fatal. However, when diagnosed and properly treated within the first six weeks of infection, the infection can be completely cured in about 90% of the cases. The prognosis depends on a number of factors, such as the patient's age and overall physical condition; the severity of the diseases involved; the exact site of the infection; how vulnerable the microorganisms are to antibiotics; and the nature of the complications.

KEY TERMS

Aortic valve—The valve between the left ventricle of the heart and the aorta.

Congestive heart failure—A condition in which the heart muscle cannot pump blood as efficiently as it should.

Echocardiography—A diagnostic test using reflected sound waves to study the structure and motion of the heart muscle.

Embolus—A bit of foreign material, such as gas, a piece of tissue, or tiny clot, that circulates in the bloodstream until it becomes lodged in a blood vessel.

Endocardium—The inner wall of the heart muscle, which also covers the heart valves.

Mitral valve—The valve between the left atrium and the left ventricle of the heart.

Osler's nodes—Small, raised, reddish, tender areas associated with endocarditis, commonly found inside the fingers or toes.

Petechiae—Tiny purple or red spots on the skin associated with endocarditis, resulting from hemorrhages under the skin's surface.

Pulmonary valve—The valve between the right ventricle of the heart and the pulmonary artery.

Transducer—A device that converts electrical signals into ultrasound waves and ultrasound waves back into electrical impulses.

Transesophageal echocardiography—A diagnostic test using an ultrasound device passed into the esophagus of the patient to create a clear image of the heart muscle.

Tricuspid valve—The valve between the right atrium and the right ventricle of the heart.

Vegetation—An abnormal growth of tissue around a valve that can develop following a bacteremia. Vegetation is composed of blood platelets, the infecting bacteria, a few white blood cells, and fibrin, a protein involved in clotting.

Health care team roles

Endocarditis is generally diagnosed by a primary care physician, emergency medicine physician, or cardiologist. Nurses, ECG technicians, laboratory technologists and other allied health professionals have important roles in the diagnosis of endocarditis as well as institution

of timely treatment. Nurses and other practitioners involved in triage or screening in the emergency department, clinic, office, or other treatment setting must accurately assess patients with indications of endocarditis.

ECG technicians and laboratory technologists are responsible for performing the diagnostic tests, ECG, and blood cultures to confirm the diagnosis and causative microorganism. In the hospital, nurses and allied health professionals are responsible for closely monitoring patients for complications.

Prevention

Some individuals are especially prone to endocarditis. These include patients with past history of endocarditis, those with congenital heart problems or heart damage from rheumatic fever, and patients with prosthetic heart valves. Intravenous drug users are also at increased risk. Patients at high risk for endocarditis need to take a dose of prophylactic antibiotics before undergoing procedures likely to cause bacteria to enter the bloodstream, such as most dental procedures. The American Heart Association recommends two grams of amoxicillin (children: 50 mg/kg) taken by mouth one hour before dental appointments. Patients who are allergic to penicillin can take clindamycin, cephalexin, or azithromycin instead.

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Barbara Wexler

Endocrine system

Definition

The endocrine system is a widespread group of glands and organs that acts as the body's control system for producing, storing, and secreting chemical substances called hormones.

Description

The primary glands that compose the endocrine system are the hypothalamus, pituitary, thyroid, parathyroid, adrenal, pineal, ovary, and testes. The **pancreas**, considered both an organ and a gland, is also part of the system. The thymus is sometimes considered an endocrine-system organ. Although not part of the endocrine system, other organs that secrete hormones are the **heart, brain, lungs, kidneys, liver**, skin, and placenta. The word "endocrine" means that in response to specific stimuli, the hormones produced by the glands are released into the bloodstream.

Function

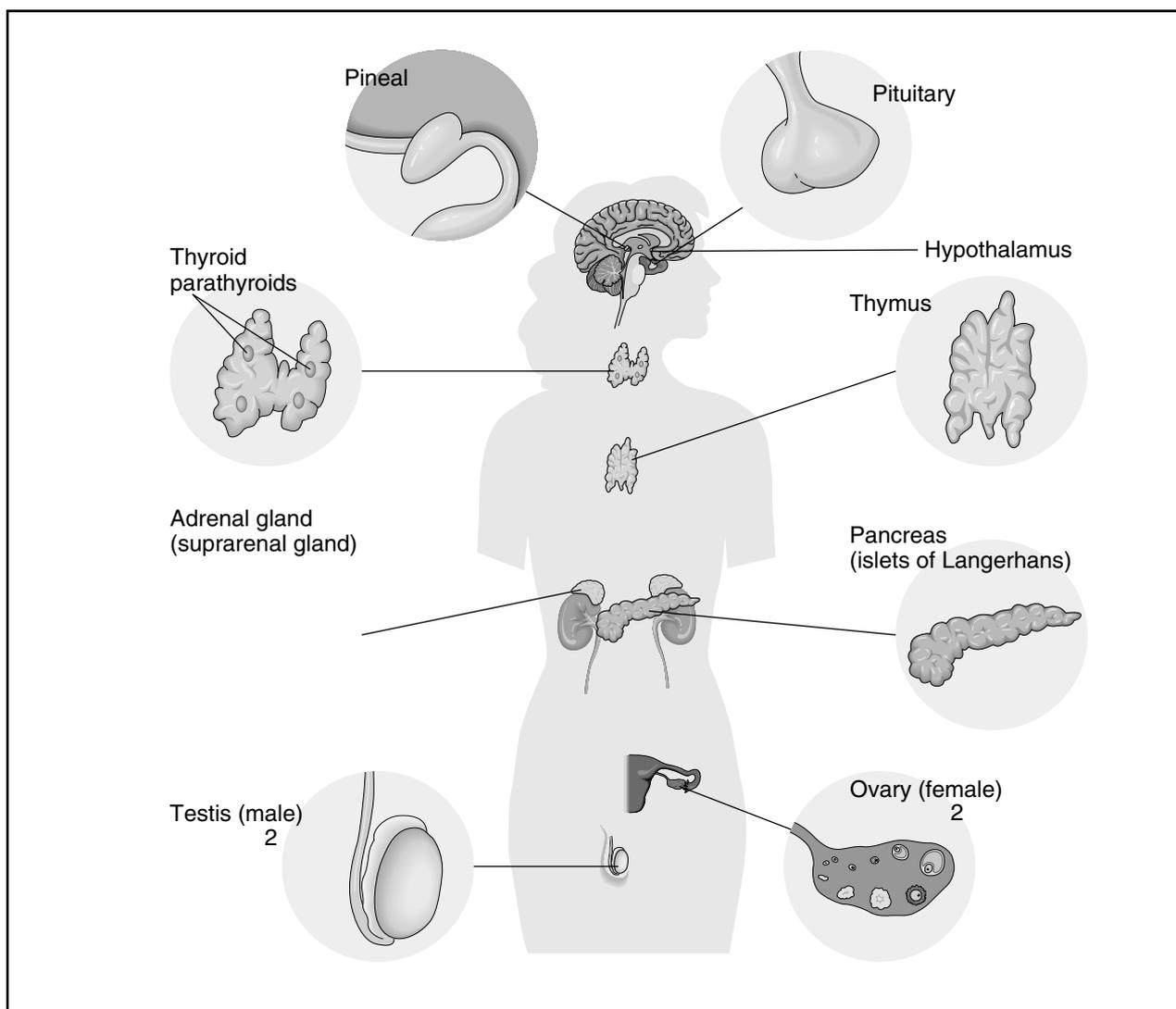
Hormones are compounds produced by the endocrine glands. They generally control the growth, development, and **metabolism** of the body; the electrolyte composition of body fluids; and reproduction. The specific functions of the endocrine glands and pancreas are unique.

Pituitary gland

The pituitary is the master gland of the endocrine system. Located at the base of the brain, the gland, which is about the size of a marble, consists of two parts: anterior and posterior. The anterior pituitary produces hormones that either stimulate other glands (such as adrenal, testis, ovary, and thyroid) to produce target-gland hormones, or directly affect the target organs.

Three of these hormones—adrenocorticotropic hormone (ACTH), gonadotropins, and thyroid-stimulating hormone (TSH)—act on other glands. ACTH stimulates the adrenal cortex to produce corticosteroid hormones and small amounts of male and female sex hormones. Gonadotropins are two hormones that regulate the production of male and female sex hormones and the egg (ova) and sperm (spermatozoa) cells. TSH stimulates the **thyroid gland** to produce and release thyroid hormone.

Another pituitary hormone, growth hormone (GH), has a central role in controlling the growth and development of the body and its components, including organs, tissue, and muscle. It also affects the metabolism of **car-**



The structures of the endocrine system. (Delmar Publishers, Inc. Reproduced by permission.)

bohydrates, protein, and fat. For example, GH increases glucose levels in the **blood** by reducing the amount of glucose used by muscle cells and adipose tissue and by promoting glucose production from certain liver molecules. Other functions of GH include increasing the amount of amino acids that cells take from the blood and stimulating the breakdown of **lipids (fats)** in adipose tissue. The pituitary hormone prolactin acts with other hormones in female breast development and helps regulate breast-milk production (**lactation**).

Two hormones, vasopressin and oxytocin, are stored but not produced in the posterior pituitary. Vasopressin, also called arginine vasopressin (AVP), helps the body to conserve water by increasing reabsorption of water from the kidneys. Oxytocin stimulates contractions in the uterus during **childbirth** and activates milk ejection caused by an infant sucking on the breast.

Adrenal glands

The adrenals are small glands on top of the kidneys. The adrenals have two parts: an outer layer called the cortex, and an inner layer called the medulla. The adrenal cortex produces a variety of hormones called **corticosteroids**, including hydrocortisone (cortisol), which helps increase blood glucose levels. It also reduces the amount of glucose absorbed by muscles and adipose tissue. Another function of cortisol is to protect the body from the adverse effects of **stress**, including emotional and physical trauma.

The adrenal medulla produces adrenaline and norepinephrine, substances that increase the heart rate and **blood pressure** during times of stress. Their action is referred to as the “fight-or-flight” response.

Thyroid gland

The thyroid gland is composed of two sections in front of the windpipe and below the voice box. It produces two hormones, thyroxine (T4) and tri-iodothyronine (T3), which together are called the thyroid hormones. They help regulate growth and development and help in childhood brain development. The thyroid also contains cells that produce the hormone calcitonin, which helps to maintain normal **calcium** levels in the blood.

Parathyroid glands

The parathyroid complex is composed of four small glands, each the size of a pea, and each located on the four corners of the thyroid gland. They secrete parathyroid hormone, which regulates calcium levels in the blood.

Pancreas

The pancreas is located in the upper abdomen, just behind and below the **stomach**. It has two functions: to produce various enzymes that aid in digestion; and to produce insulin and glucagon, hormones that are key to the body's management of glucose (sugar) in the blood.

The primary purpose of insulin is to lower blood-glucose levels in the body. It helps form glycogen, **proteins**, and lipids, which are stored in the body (usually in the liver, muscles, and adipose tissue) to be used for energy. Glucagon increases blood-glucose levels, an action opposite to that of insulin. A strict balance between the glucagon and insulin is required to maintain proper blood-sugar levels.

Hypothalamus

Located deep inside the brain, the hypothalamus maintains direct control of the **pituitary gland**. It acts as the central "control room" of the endocrine system, directing the activities of the other parts of the system. These activities include regulating eating and drinking, sexual behavior, blood pressure, heart rate, body temperature, emotions, and the sleeping/waking cycle. When the brain receives information indicating that hormonal changes are needed somewhere in the body, the hypothalamus secretes chemicals that stimulate or suppress hormone production in the pituitary gland.

Pineal and thymus

The pineal is located in the center of the brain. This gland secretes melatonin, a hormone that helps regulate the sleeping/waking cycle. Disturbances in the production of melatonin causes jet lag, experienced by many long-distance travelers. Melatonin also influences devel-

opment of the male and female sex glands. The thymus processes lymphocytes in infants and is partly responsible for immune-system development.

Ovaries and testes

The ovaries and testes, also called the sex glands, produce cells and hormones essential to reproduction and development of the body, including male and female sex characteristics. The three types of sex hormones are estrogens, progestogens, and androgens (including testosterone).

The main role of estrogens is to coordinate development and function of the female genitalia and breasts. Estrogens are also associated with the start of the menstrual bleeding cycle. Estrogen production in the ovary ceases during **menopause**. Estrogen is also produced in men (by the testes), though at lower levels than occur in women.

Progestogens are produced in the ovaries during part of the menstrual cycle, and in the placenta during **pregnancy**. They cause changes in the lining of the uterus to prepare it for pregnancy, and they act with estrogens to stimulate mammary-gland development in the breasts to prepare for lactation. Progesterone is the main progesterone hormone.

The primary androgen produced in the testes is the steroid testosterone. While mainly associated with male development, testosterone is produced in small amounts in women by the ovaries. During pregnancy, testosterone helps to develop the internal and external male sex organs. In males, testosterone promotes the growth of the sex organs and develops or stimulates male characteristics, such as deepening voice; growth of facial, pubic, and other body hair; and muscle growth and strength. In adult males, testosterone maintains the masculine characteristics and sexual potency and regulates sperm production.

Role in human health

A wide variety and dozens of symptoms can indicate a hormonal imbalance in the body. However, a specific group of symptoms give an initial indication of a problem in the endocrine system. For example, excessive thirst, frequent urination, and unexplained weight loss are classic signs of **diabetes mellitus**, the most common endocrine disorder. Many primary-care physicians still treat endocrine problems, especially diabetes, themselves. However, the primary care doctor often makes a preliminary diagnosis and then refers the patient to an endocrine-system specialist, called an endocrinologist.

Disorders of the endocrine system often, but not always, result from an over- or underproduction of a par-

ticular hormone. Too much or too little of a hormone can be harmful. The endocrine organs use a feedback mechanism to regulate hormone levels. It acts much like a household thermostat, increasing production of a specific hormone when it detects too little in the blood, or decreasing production when it detects too much or the right amount. Tight control of hormone levels is needed for the body to function properly. The endocrine organs secrete hormones directly into the bloodstream, where special proteins usually bind to them, helping to maintain them as they travel through the body.

Common diseases and disorders

There are two basic classes of endocrine disorders: problems associated with hormone-production levels, and problems caused by tissues that are unable to respond to hormones. Hormone-production disorders are broken into two groups: insufficient hormone production, called hypofunction; and too much hormone production, called hyperproduction. Endocrine-system disorders include the following:

- Diabetes mellitus is a disease that includes type 1 and type 2 diabetes. Type 1 is an autoimmune disease caused when the **immune system** destroys certain insulin-producing cells in the pancreas. This causes the pancreas to produce little or no insulin. Type 1 diabetes usually develops in children and young adults, but it can appear at any age. Symptoms include increased thirst and urination, unexplained weight loss, blurred **vision**, and extreme fatigue. There is no cure; insulin, first used in 1921, remains the only treatment. Type 2 diabetes accounts for 90% to 95% of diabetes cases. It usually develops in adults over age 40 and is usually associated with **obesity**. In type 2, the pancreas produces insulin, but the hormone is not used effectively by the body, a condition called insulin resistance. Several years after onset, insulin production decreases below the level needed to maintain glucose homeostasis. The result is the same as for type 1 diabetes: glucose builds up in the blood because the body cannot use it efficiently. Symptoms develop gradually and include increased thirst and urination, weight loss, fatigue, nausea, blurred vision, frequent infections, and **wounds** or sores that heal slowly. Insulin resistance is treated with drugs such as thiazolidinediones (rosiglitazone and pioglitazone) and biguanides (metformin). When insufficient insulin is produced, type 2 diabetes appears. However, research indicates progression of insulin resistance to type 2 diabetes can usually be halted or slowed with the insulin-resistance medications, or by lifestyle changes that result in weight loss.
- Hypothyroidism is caused by the thyroid gland producing too little thyroid hormone. It can lead to severe hypothyroidism, a disorder that usually develops after age 40. Symptoms include intolerance to cold, lethargy, fatigue, weight gain, and mental sluggishness. Congenital hypothyroidism is present at birth and has the same symptoms. If left untreated, it can lead to mental retardation. The standard treatment for both hypothyroid disorders is thyroid hormone-replacement medications such as levothyroxine (Synthroid, Unithroid, Levoxyl, and Levothroid) and triiodothyrene.
- Hyperthyroidism is due to an excess of thyroid hormones and affects women more frequently than men. Symptoms include nervousness, weight loss, intolerance to heat, **diarrhea**, heart palpitations, and insomnia. Some patients experience protruding eyes and trembling. Treatments include medications to inhibit thyroid-hormone production, and removal or destruction of the thyroid gland with radioactive iodine. The most common cause of the excessive thyroid production is Graves' disease, an autoimmune disorder of the thyroid gland.
- Addison's disease is caused by underactivity or immune-system destruction of the adrenal gland. It can be life-threatening if left untreated. Symptoms include weakness, fatigue, nausea, **dehydration**, **fever**, and hyperpigmentation (darkening of the skin without sun exposure.) The standard treatment is with corticosteroid hormones and adequate dietary salt.
- Cushing's syndrome and Cushing's disease are different disorders with similar symptoms: obesity, weakness, easily bruised skin, acne, and **hypertension** (high blood pressure.) Cushing's syndrome is usually caused by excessive production of glucocorticoid hormones in the adrenal gland. However, it can sometimes be caused by benign or cancerous tumors of the adrenal gland. Cushing's disease usually results from the overproduction of the adrenocorticotropic hormone in the pituitary gland, due to a benign tumor. Treatment for both disorders can include surgery, radiation therapy, **chemotherapy**, and blocking production of the glucocorticoid hormones with drugs.
- Less common endocrine disorders include acromegaly, gigantism, and hypogonadism. Acromegaly occurs in adults and gigantism in children. Both are caused by a pituitary tumor that spurs overproduction of growth hormone. Hypogonadism causes delayed sexual maturity in children and **infertility** in adults. It is caused by underproduction of follicle-stimulating hormone (FSH) in the pituitary gland.

KEY TERMS

Adipose tissue—Connective tissue in which fat is stored and that has the cells distended by droplets of fat.

Autoimmune—A term that refers to a condition in which antibodies or T cells attack the molecules, cells, or tissue of the body organ or system producing them.

Electrolyte—A nonmetallic electric conductor in which current is carried by ion movement.

Lactation—The secretion of milk by the mammary gland in the breasts.

Lymphocytes—Weak cells produced in the lymphoid tissue.

Menopause—The period when natural menstruation stops, usually between ages of 45 and 50.

Menstruation—The discharge of blood from the uterus that occurs in approximately monthly intervals in females, starting at puberty.

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American Association of Clinical Endocrinologists. 1000 Riverside Avenue, Suite 205, Jacksonville, FL 32204. (904) 353-7878. <<http://www.aace.com>>.

American Diabetes Association. 1701 North Beauregard Street, Alexandria, VA 22311. (800) 342-2383. <<http://www.diabetes.org>>.

American Thyroid Association. Montefiore Medical Center, 111 East 210th Street, Room 311, Bronx, NY 10467. (718) 882-6085. <<http://www.thyroid.org>>.

Endocrine Society. 4350 East West Highway, Suite 500, Bethesda, MD 20814. (301) 941-0200. <<http://www.endo-society.org>>.

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Endodontic therapy see **Root canal therapy**

Endodontics see **Dental specialties**

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Endoscope

Definition

An endoscope is characterized by its often long, thin (sometimes flexible) lighted tube containing fiber-optical instrumentation attached to a viewing device through which one may closely observe, via the naked eye or an attached camera, the surface of a canal or hollow organ in the body.

Purpose

The endoscope is often used as a form of less invasive monitoring of the body instead of, or in conjunction with, surgery. A key aspect of the device is that it is not only capable of traversing the body to allow direct observation, but may also be equipped with endoscopic accessories that allow manipulation and diagnostic/therapeutic procedures to be performed much less invasively than more conventional surgical operations.

Endoscopic surgery minimizes **pain**, hospital stays, and recovery time, which is good for patients. Its use is also promoted by health insurance companies and hospital administrators inclined toward reduced costs as well as to offer the best treatment options technology can provide.

Description

The endoscope is a generalization of a broad variety of fiber-optical scopes used to elucidate diverse aspects of the body to medical practitioners for various purposes. Endoscopes come in two main categories: rigid and flexible. The rigid endoscope is designed with a rigid insertion tube and is preferred over flexible endoscopes when feasible because the rigidity allows use of optics that permit greater resolution and the absence of a visible lattice structure. However, it is more difficult to design and construct a rigid endoscope, which entails using lenses rather than fibers to transmit the image externally to the user or to a camera.

The fiber-optical endoscope can in general be viewed as a simple input/output device that utilizes an objective lens system along with a fiber relay and an ocular for magnification. The objective component is inserted directly into the body with a lighting constituent and focuses an image onto the two-dimensional surface of the array of fibers. These fibers, on the order of 10 micrometers, are bundled in groups of hundreds of thousands. Each pixel of a picture can be associated with a fiber in a one-to-one fashion of input light that is transferred from the objective end through the optical fiber relay, and magnified by the ocular to an output image on camera or seen with the naked eye. The elegant aspect is that these fibers may be twisted and flexed without damaging the image, which proves to be an integral element in many types of endoscopy. The optical layout discussed above has been simplified considerably; for spherical, chromatic, and other optical aberrations must be dealt with in order to manufacture a functional endoscope.

Not only must endoscopes be precisely organized optically, but great care must be taken to ensure their biocompatibility, since they come in close contact with extremely sensitive internal body surfaces. Accordingly, biocompatibility is of prime importance to the United States Food and Drug Administration (FDA), which considers endoscopes to be “short-term mucosal contacting, externally communicating devices and testing [for approval of use] should include, but is not limited to, mucosal irritation, sensitization, cytotoxicity, acute systemic toxicity, and short-term implantation.”

Endoscopes may be used to observe and biopsy as well as to perform actual surgeries through tiny incisions in appropriate sites. The latter generally involves use of miniature video cameras and minute surgical instrumentation, often electrosurgical equipment, forceps, or biopsy attachments.

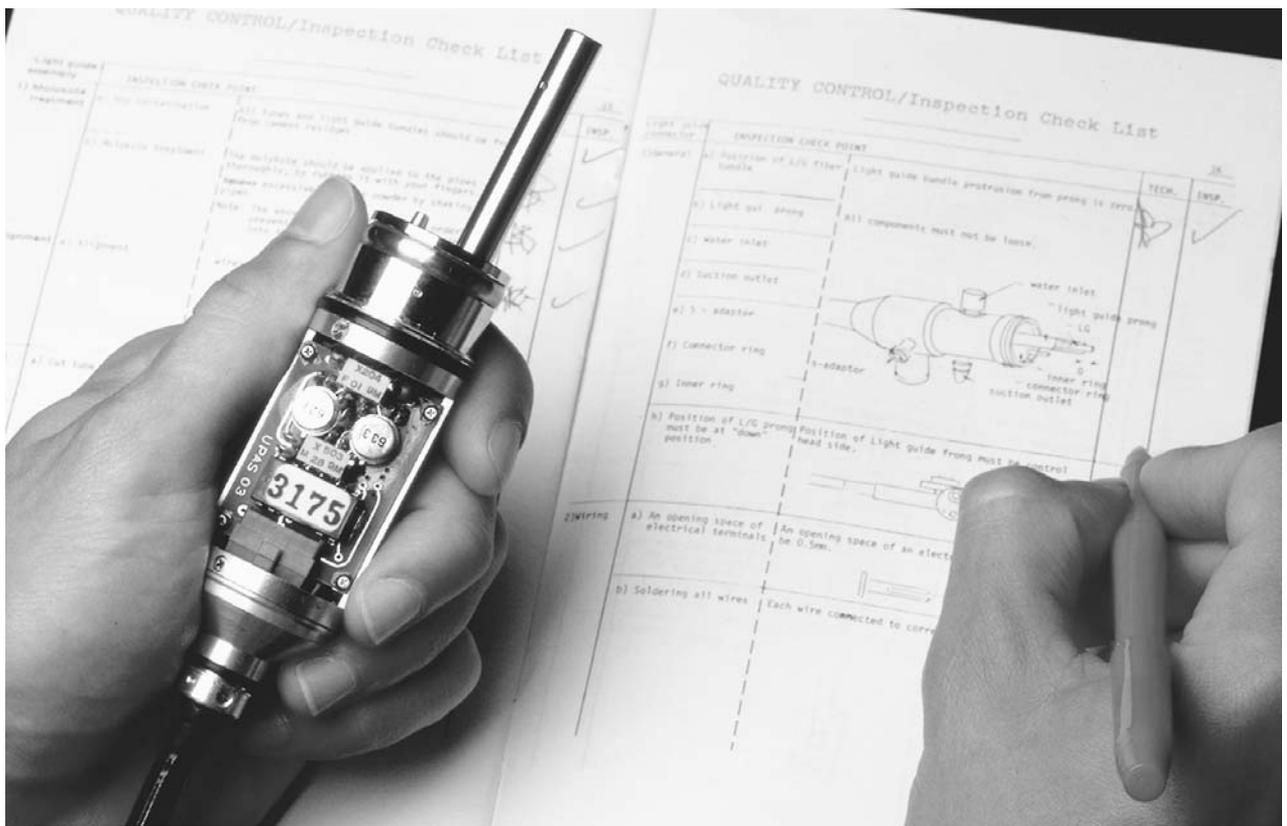
While fiberoptic technology utilizes extremely thin strands of glass or plastic to transmit light through repeated internal reflection along the optical fiber lengths

for image formation and visualization, other forms of endoscopy have surfaced. Electronic endoscopes, which do not require fiber optics (yet possess a field-of-view identical to the fiber-optic endoscope as well as similar controls depressible by finger-tip, i.e. air insufflation, suction, and water injection) are also on the market. These devices boast a mounted computer chip (in reality three chips for red, blue, and green light) on the tip. They are lower-maintenance due to the lack of fiber optics, and images from them can easily be sent to a television monitor for the entire operating room to view. Even more recently (as of July 2001), technology has permitted the development of high-speed 3D endoscopic measurements.

Forms of endoscopy

The abundance of instruments falling under the designation “endoscope” includes the following, with brief descriptions of each:

- **Amnioscope:** Used to examine the fetus through the cervical canal prior to membrane breakage.
- **Angioscope:** Used to examine the interior of **blood vessels**. The scope must thus be very long, slender (generally on the order of 0.5 mm), and flexible to accommodate navigation of minute spaces and dynamic curvature.
- **Arthroscope:** Used to examine intraarticular surfaces of joints. Arthroscopes are rigid and contain stacks of optical lenses while the eyepiece is generally attached to a video camera. Due to the frequency of knee injuries, the arthroscope is most often used to diagnose and help treat knee damage.
- **Bronchoscope:** Aids in exploring the interior of the bronchi, their branches, and tracheal mucosa (the windpipe tissue lining).
- **Choledochoscope:** Used to examine the bile duct (duct carrying bile from the **liver** to the **gallbladder** or from the gallbladder to the **small intestine**) during an open surgical procedure intraoperatively. Both rigid and flexible scopes are employed.
- **Colonoscope:** Used to examine the lower section of the bowel, the **large intestine**, i.e. the colon.
- **Culdoscope:** Used to examine the pelvis and its structures. The scope is normally introduced through a small incision in the posterior vaginal cul-de-sac.
- **Cystoscope:** Used to examine the urinary tract and bladder; it employs similar optics to the arthroscope, yet possesses a longer depth of insertion.
- **Cystourethroscope:** Used to examine the urethra, bladder, and distal ureter.



Endoscope machinery. (Photograph by Christopher Springmann. The Stock Market. Reproduced by permission.)

- **Encephaloscope:** Used to examine **brain** cavities.
- **Endoscopic retrograde cholangiopancreatography:** Used in diagnosis of pancreatic disease through injection of radio-opaque dye into biliary and pancreatic ducts while examining the duodenal area.
- **Enteroscope:** Used to examine the esophagus, small intestine, and **stomach**.
- **Esophagogastroduodenoscope:** Used to examine the esophagus, duodenum, and stomach.
- **Esophagoscope:** Used to examine the channel connecting the pharynx to the stomach.
- **Gastroscope:** Used to examine the stomach lumen.
- **Gonioscope:** Used to examine and help determine the configuration of the angle between the iris and cornea.
- **Hysteroscope:** Used to examine the passage of the uterine cervix and cavity.
- **Laparoscope:** Used to examine the peritoneal cavity through the anterior abdominal wall and is commonly rigid. This scope is the most common type used by the general surgeon.
- **Laryngoscope:** Used to examine the larynx (the sphincter at the entrance of the trachea).
- **Mediastinoscope:** Used to examine the mediastinum (mass of tissues and organs separating the **lungs**, i.e. the **heart**, esophagus, trachea, etc). Often used for visualization of lymph nodes and tumors in the superior mediastinum.
- **Nephroscope:** Used to examine the **kidneys**, i.e. the renal pelvis, calyces, and upper ureter. It is employed during open procedures intraoperatively.
- **Proctoscope:** Used to examine the rectum.
- **Resectoscope:** Used to perform resections of tissue as a part of a diagnostic or therapeutic procedure.
- **Rhinoscope:** Used to examine the nasal cavity.
- **Sigmoidoscope:** Used for direct examination of the sigmoid colon.
- **Thoracoscope:** Used to examine the pleural cavity through an intercostal space (space between adjacent ribs, filled by intercostals muscles).
- **Ureterscope:** Used to examine the ureter.

- Urethroscope: Used to examine the urethra.

Operation

Endoscopic procedures are sometimes performed under **local anesthesia**, especially with regard to upper gastrointestinal endoscopy. However, the majority of patients are sedated entirely. After the appropriate anesthetic has been administered, the physician inserts the endoscope in the anatomically relevant position and views the patient. The anesthesiologist, meanwhile, remains busy watching for **blood pressure** drops and reductions in oxygen saturation; this concern has resulted in a mandate that elderly, cardiovascularly risky, and anemic patients receive extra oxygen during the procedure.

Of paramount importance is the disinfection of used endoscopes. Endoscopic cross-infection is rare, but does occur. According to *Davidson's Principles and Practice of Medicine*, cross-infection has occurred in three ways:

- Transmission of pathogenic organisms from one patient to another, with salmonella the most frequent organism.
- Transmission of **infection**, such as hepatitis B, to staff by needle-stick injury.
- Introduction of opportunistic organisms that colonize the instruments in storage. These may cause serious infection in immunocompromised patients and can cause severe biliary or pancreatic sepsis if introduced during endoscopic retrograde cholangiopancreatography. To eliminate this possibility, many medical practices have become accustomed to disinfecting endoscopes again in the morning before the first patient arrives.

To prevent the above from occurring, health personnel must abide by strict procedures. Endoscopes should be submerged in detergent and water immediately upon removal from a patient. Valves and other removable components (including such endoscopic accessories as biopsy forceps) must be meticulously cleansed with cotton tips and a soft toothbrush, while channels must be washed. Disinfection by immersion in 2% glutaraldehyde (or 10% succine dealdehyde) for at least 20 minutes is strongly recommended since the scrubbing does not wipe out **bacteria** entirely. Also, medical personnel should wear gloves and masks as well as eye protection for positive hepatitis B or HIV patients. The general guideline for endoscopic disinfection is fivefold: cleaning (by mechanical scrubbing); disinfecting (by immersion in glutaraldehyde or some other high-level disinfectant); rinsing (using sterile water); drying (using forced air prior to storage); and storing (without recontaminating equipment, i.e. by hanging it vertically).

Maintenance

Proper care of endoscopes and endoscopic instrumentation should result in:

- enhanced life span of endoscopes and accessory instruments
- reduced repair and replacement costs
- low number of microorganisms, restricting infection possibilities

As indicated above, disinfection is a chief concern in the field of endoscopy. Proper disassembly, cleansing, rinsing, drying, storage, and reassembly of the equipment, all according to the manufacturer's instructions, can help it to remain viable and safe for a long while. Corrosion is a common cause of equipment failure; stainless steel can in fact spot and stain. According to the company Gamma Endoscopy, "when endoscopic instruments do spot or stain common causes are:

- very acid or alkaline pH detergents
- improperly dissolved detergent leaving residual powder
- high mineral content of the water used for cleaning, rinsing, or in the steam autoclave
- residual disinfection solution
- disinfection solutions with an acidic pH
- residual **blood**, organic matter, or irrigation solution (e.g. saline), especially if instruments are not completely disassembled or thoroughly cleaned
- chemical change resulting from prolonged exposure of dissimilar metals to electrolytic solutions (e.g. normal saline, disinfection solutions)
- scratches on instruments that allow corrosive agents to get below the passivation layer, a protective layer on the instrument surface

All moving parts should be lubricated before [reassembly] to prevent 'freezing' of stopcocks and forceps jaws. It is necessary to check the instruction manual to determine which parts to lubricate, and a water-based lubricant may be used when reassembling portions of instruments before sterilization/disinfection. Because sterilization/disinfection mediums may not penetrate tight-locking mechanisms, endoscopic instruments should not be reassembled before sterilization or disinfection."

If all other methods fail, endoscopes may be sent to instrument refurbishment companies that specialize in endoscopic repair.

KEY TERMS

Fiber optics—A technology using glass (or plastic) fibers to transmit data. A fiber optic cable is simply a bundle of these threads, each of which is capable of transmitting light wave data. Fiber optic cables can carry much more data in less space than conventional metal wires (i.e. they have greater bandwidth), are thinner and lighter, and are appropriate for transmission of digital data. It is possible to construct flexible fiber bundles that are spatially aligned for use in endoscopic procedures.

Health care team roles

Physicians perform endoscopic procedures while nurses and other medical personnel aid them. Health personnel prepare the equipment prior to examination and play a critical role in disinfecting it after the procedure has culminated. Endoscopes and accessories should be examined by health care staff for structural integrity, proper function, and cleanliness before use; during the exam; immediately following disinfection procedures; and prior to disinfection/sterilization. It is also recommended that endoscopes and accessories be thoroughly tested before initial use and used in accordance with the manufacturer's manual.

Training

Training varies from procedure to procedure among the widely varying types of endoscopy; however, disinfection training is essentially similar, except that there are major differences in cleansing between rigid, flexible (the most difficult), and electronic endoscopes.

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The Association of Perioperative Registered Nurses (AORN).
AORN, Inc., 2170 South Parker Rd., Suite 300, Denver,

CO 80231-5711. (800) 755-2676 or (303) 755-6300.
<<http://www.aorn.org>>.

OTHER

Endoscope Tutorial. <<http://www.leineroptics.com/endotut.htm>>.

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Endotracheal tube management

Definition

Endotracheal tube management consists of ensuring a patent (open and unblocked) airway, suctioning pulmonary and oral secretions, and providing frequent oral and/or nasal care.

Purpose

The endotracheal tube is the most common artificial airway used for short-term **airway management** or mechanical ventilation. The tube may be inserted either orally or nasally. The patient with a endotracheal tube must be closely monitored to ensure that the tube remains patent, that skin breakdown does not occur from the tube, and that **infection** is prevented.

Precautions

If the patient is restless or agitated, any activities that involve loosening the straps that hold the endotracheal tube in place should be rescheduled for a time when the patient is calm or after a sedative has been given. Otherwise, the tube may be inadvertently removed and the airway lost.

Description

A primary portion of endotracheal tube management is suctioning down the tube every two hours or as needed. This is a sterile procedure. The color and amount of any sputum return should be noted since the endotracheal tube provides a direct connection to the **lungs**, making these patients highly susceptible to infection. The oral cavity should also be suctioned as these patients often have difficulty swallowing saliva.

The patient must also be monitored for skin breakdown in either the oral or nasal cavity (depending on where the tube is inserted). Thorough oral care should be provided every eight hours and as needed. If the patient

has a bite block to prevent them from biting the tube, it must be removed and cleaned or replaced every eight hours. The tube should be repositioned so that it is not continuously exerting pressure in the same area. If the tube is taped to the patient's face, the tape must be removed and replaced on the opposite side of the face at least once per day and as needed.

The endotracheal tube has a cuff that is inflated with air to hold the tube in place in the trachea. The amount of air in the cuff should be checked every eight hours to ensure that the cuff is not exerting too much pressure on the trachea walls. This is often done by the respiratory therapist, but may also be done by the nurse.

Preparation

Any needed supplies for endotracheal tube care should be at the bedside prior to beginning the procedure. This includes a sterile suction kit, a bottle of sterile 0.9% sodium chloride, sterile gloves, a clean bite block if necessary, and tape already torn into appropriately-sized pieces. It is recommended that another health care professional firmly hold the endotracheal tube in place during any activity that requires loosening the straps that hold the tube. The patient should also be preoxygenated with 100% oxygen prior to suctioning.

Aftercare

All waste should be properly disposed of, either in the garbage or a biohazard container. The respiratory status of the patient should be reassessed. The insertion point (in centimeters) of the endotracheal tube should be confirmed to be the same as prior to the procedure, unless the purpose of the procedure was to change the depth of the tube.

Complications

The greatest risk of manipulating the endotracheal tube is that it may be inadvertently removed, causing the patient to experience respiratory distress.

Results

The anticipated outcomes of endotracheal tube management include a continuously patent airway, control of oral and pulmonary secretions, and prevention of infection.

Health care team roles

The nurse and respiratory therapist are equally responsible for endotracheal tube management. Both per-

KEY TERMS

Bite block—Plastic device inserted into the patient's mouth to prevent him/her from biting on the endotracheal tube.

Endotracheal tube—Flexible tube inserted into the trachea via either the oral or nasal cavity for the purpose of providing an airway and supplemental oxygen, as well as providing access for suctioning.

form sterile suctioning and both are responsible for assessing respiratory status. However, it is usually the nurse who repositions the tube and provides oral care.

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Endurance testing

Definition

Endurance testing involves determining the amount of time a person can maintain an activity or perform a task or activity of daily living before becoming fatigued and needing to stop. The level of activity used to test endurance can be minimal to maximal.

Purpose

Endurance testing is often used to assess a person's cardiovascular fitness to determine if cardiovascular disease is present and to evaluate the patient before embarking on a physical fitness program. The goal of **exercise** testing is to produce a sufficient level of exercise **stress** without too much strain on an individual. Exercise tests measure **heart** rate, **blood pressure**, respiratory rate, and breathlessness. The patient also reports on a rating of perceived exertion (RPE), which is a 15-point scale that

grades exertion from extremely light to extremely hard. Clinicians make note of any discomfort or **pain**.

Maximal exercise testing can be used to determine the greatest amount of activity a person can endure and how rigorous the activity can be. Submaximal testing determines the best level for a person to safely engage in during a physical activity program.

Other types of endurance testing are important in determining how independent an individual can be in performing work activities. Such testing is particularly important in work hardening programs. A person who is injured on the job may be referred to a rehabilitation therapist for work hardening treatment. The therapist ascertains whether the individual can perform job tasks, and if not, designs a relevant rehabilitation program. It is often a challenge to accurately duplicate work environments.

Precautions

A person with poor balance or coordination should not undergo endurance testing that involves movements that could cause dizziness or fainting. Persons with cardiac disease, **hypertension**, or diabetes could experience distress during endurance testing and must be closely monitored.

Description

Clients are generally referred to a therapist by a physician treating them for a disease or disability. The physician often includes specific instructions. Endurance testing can be conducted in a variety of ways. A device such as a dynamometer is used to measure strength, and physical endurance can subsequently be charted. A therapist can determine endurance by instructing a client to perform a particular task for a specific length of time or perform the task for a specific number of repetitions. A therapist also can instruct a client to perform a task until becoming fatigued.

Exercise testing protocols

TREADMILL TEST. The treadmill is one of most commonly used endurance tests. Although the Bruce Treadmill Test protocol has been the most widely used, its results have been considered to sometimes overestimate a person's exercise capacity. Although it is best suited for younger and active patients, the Bruce protocol was designed to diagnose cardiovascular disease. During treadmill tests, individuals walk on various inclines at various speeds for increasing lengths of time.

BICYCLE ERGOMETRY. Bicycle tests are a common alternative to treadmill testing. A bicycle ergometer

measures the individual's workload and increases workload in increments for eight to 12 minutes. For patients with lower limb limitations who cannot be tested on a treadmill or bicycle, the upper limb ergometer, a modified bicycle with hand-powered pedals, is used. For wheelchair-bound individuals, some clinicians have fabricated wheelchair ergometers. Such testing is not widely used because of lack of equipment.

TWELVE-MINUTE RUN TEST. This test consists of various run-walk tests. It is typically used to evaluate cardiopulmonary fitness for functional individuals. The patient is asked to cover the longest distance possible in 12 minutes, preferably by running, but by walking if needed.

TWENTY-METER SHUTTLE TEST. This test assesses maximal aerobic capacity and was designed for children, adults, and athletes. The subject runs between two lines spaced 20 meters apart. The examiner increases the pace at which the subject is required to run back and forth. The highest speed reached is the maximal aerobic speed.

ONE-MILE TRACK WALK TEST. This test was designed for many age groups and fitness levels. The examiner records the time an individual can walk one mile.

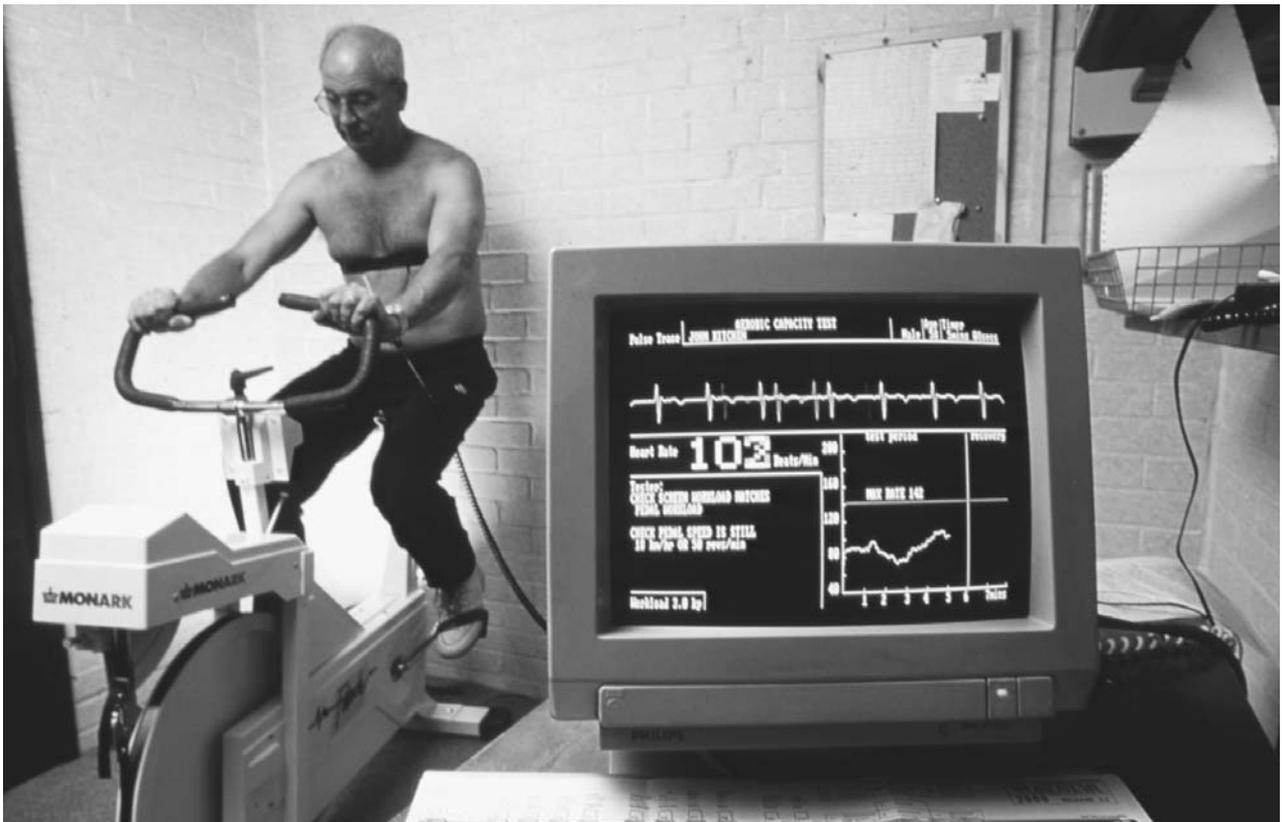
SELF-PACED WALKING TEST. This test was developed for the elderly and for those with low fitness levels. It involves walking at three speeds down a hallway while speed, time, stride frequency, and heart rate are measured. This protocol evaluates a person's walking efficiency and cardiopulmonary capacity. It does not actually test endurance but can provide guidelines for activities of daily living.

Many people are affected by low endurance or loss of stamina for a variety of reasons. After age 50, muscle strength and endurance begin to decline. People with physical disabilities also typically have endurance problems.

A typical treatment plan to build endurance includes such aerobic exercise as walking, jogging, swimming, and bicycling. Aerobic exercise improves cardiovascular health, which also increases endurance. Specific activity goals should be set for the client.

In work-hardening programs, therapists use several assessment devices to determine a person's capacity to return to work. The Baltimore Therapeutic Equipment (BTE) work simulator allows users to replicate most upper-limb motions and tasks involved in many job activities. For example, a client may be asked to repetitively lift a box weighing 40 pounds (18 kg) at any pace until becoming tired.

How well the simulator measures endurance has only been analyzed recently. Clients were found to have



A computer monitors this man's cardiorespiratory system performance as he exerts himself on an exercise bike.
(Photograph by James King-Holmes. Science Source/Photo Researchers. Reproduced by permission.)

an easier time completing tasks in the simulated environment than in the workplace. One occupational therapist who performs work-hardening programs for workers injured on off-shore oil rigs found that employees were able to perform the strenuous work in the air-conditioned clinical setting but did not last long after getting back to the humid conditions of the workplace. To improve the program, the therapist built a facility and duplicated the humid conditions, then tested clients for a full work day.

Preparation

A thorough medical history is taken and all surgeries documented prior to administering an exercise test. Practitioners should inquire about current medications and any physical or cognitive limitations the individual may have. This alerts medical professionals to any underlying problems or possible complications. Other issues that should be considered when determining exercise testing protocol are the person's age, weight, nutritional status, mobility, assistive device use, and work environment.

To conduct an aerobic test, clinicians should ensure that the risk of injury is minimized. The client should be instructed how to properly perform exercises to avoid injury. Practitioners should keep in mind that an exercise test can be too stressful depending on the person's condition. Any medical professional involved in administering exercise testing should be certified in **cardiopulmonary resuscitation (CPR)**.

Proper monitoring depends on individual circumstances. Heart rate is typically measured before, during, and after any testing procedure. The 12-lead electrocardiogram (EKG) is monitored before the test and periodically throughout the test. Following the test, the EKG and **blood** pressure are measured again, and every one to two minutes subsequently until levels return to baseline.

Aftercare

Following completion of a treatment program for building strength and endurance, a client should be educated on a continuing treatment program to be done at home. Strength and endurance will wane if activity is not maintained.

Complications

Occupational and physical therapists in return-to-work programs must take into consideration that work simulation techniques don't entirely duplicate working conditions.

The type of activity performed may also affect endurance. A person may show less endurance when performing an activity that he or she finds unpleasant or perceives as useless. The most effective intervention and treatment programs are associated with clients performing tasks they enjoy or that reflect the individual's self-worth.

Health care team roles

Collaboration among all caregivers plays a big part in any kind of rehabilitation intervention. Referring physicians should communicate with the therapist about the client and what treatment is recommended. Social workers or mental health professionals involved with the client should also be apprised of interventions, because emotional problems could affect test outcomes.

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ORGANIZATIONS

- The American Occupational Therapy Association. 4720 Montgomery Lane, Bethesda, MD 20824-1220. (301) 652-2682. <<http://www.aota.org>>.
- The American Physical Therapy Association. 1111 North Fairfax Street, Alexandria, VA 22314-1488. (703) 684-2782. <<http://www.apta.org>>.

Meghan M. Gourley

Enema administration

Definition

The term enema is used to refer to the process of instilling fluid through the anal sphincter into the rectum and lower intestine for a therapeutic purpose. An enema administration is performed using a flexible plastic rectal tube with several large holes in the tip. This is connected to the tubing from a solution bag or container. An enema can also be performed using a prepackaged solution that comes in a soft plastic bottle with a pre-lubricated rectal tip attached. **Enema** solutions are prepared using plain tap water or saline, soapsuds solutions, oil solutions, or various medication solutions.

Purpose

The most common purpose for administering an enema is to stimulate peristalsis (involuntary contraction) and to evacuate stool from the rectum. A tap water or soapsuds enema dilates the bowel, stimulates peristalsis, and lubricates the stool to encourage a bowel movement. These types of enemas are instilled and held for five to 10 minutes, as tolerated. They are used to treat constipation, to cleanse the bowel before a bowel exam, and to cleanse the bowel before bowel surgery. Another type of enema, the oil retention enema, is prepared in a smaller volume and is retained in the bowel for 30-60 minutes. The purpose of the oil retention enema is to soften the hardened stool and allow normal elimination. Enemas are also used to deliver medication directly onto the rectal mucous membranes to be absorbed into the bloodstream. Steroid enema solutions can be administered to alleviate bowel inflammation in patients with ulcerative colitis.

Antibiotic enema solutions can be administered to treat localized bacterial infections. Medicated hypertonic enema solutions can be used to pull excessive potassium or ammonia from the bloodstream through the rectal wall. These substances are then eliminated with the stool.

Precautions

Enemas should not be used as a first-line treatment for constipation. Frequent use of enemas can lead to fluid overload, bowel irritation, and loss of muscle tone of the bowel and anal sphincter. Never deliver more than three consecutive enemas to treat a patient. A patient with **diarrhea** may not be able to hold an enema. Enema administration must be used with caution in cardiac patients who have arrhythmias or have had a recent **myocardial infarction**. Insertion of the enema tube and solution can stimulate the vagus nerve which may trigger an arrhythmia such as bradycardia. Enemas should not be given to patients with undiagnosed abdominal **pain** because the peristalsis of the bowel can cause an inflamed appendix to rupture. Enemas should be used cautiously in patients who have had recent surgery on the rectum, bowel, or prostate gland. If the patient has rectal bleeding or prolapse of rectal tissue from the rectal opening, cancel the enema and consult with the physician before proceeding. Do not force the enema catheter into the rectum against resistance. This can cause trauma to the rectal tissue. Use only mild castile soap for soapsuds enemas because other soap preparations are too harsh and irritate the rectal tissue.

Description

To administer an enema solution, the clinician should have the patient lie down on the left side, knees bent. Lift the upper buttock so that the rectal opening can be visualized. Place the lubricated tip of the enema catheter at the anal opening, and gently advance the catheter through the anal sphincter into the rectum toward the umbilicus (navel), 3–4 in (7.5–10 cm) for an adult. Insert the tubing 2 in (5 cm) for a child less than six years and 1 in (2.5 cm) for an infant. After alerting the patient, open the enema tubing to allow the solution to flow or squeeze premixed enema solutions slowly into the rectum. If the patient complains of cramping, slow or stop the enema flow and have the patient breathe slowly through the mouth to encourage relaxation. When giving fluid through an enema bag, start with the bag suspended from an IV pole at the patient's hip level. As the tubing is opened, slowly raise the IV pole to promote fluid flow until the bag is 12 inches (30.5 cm) above the hip for an adult. Continue to hold the rectal tube in place throughout the procedure or it will be expelled from the rectum.

If the fluid will not flow in, gently rotate the tubing within the rectum to clear the holes of the tubing from the wall of the bowel or the impacted stool that may be occluding the flow. If ordered to give a high enema, slowly raise the bag no more than 18 inches (46 cm) above the adult patient's hip (12 inches (30.5 cm) above a child's hip and six inches (15 cm) above an infant's hip). This will increase the water pressure to deliver the fluid higher into the bowel. When all of the solution has been administered, clamp the tubing, remove the enema catheter, and release the buttock.

Preparation

Before administering an enema, ensure the patient's privacy by closing the room door. The patient should be encouraged to empty both bladder and bowels before the procedure. Have the patient undress completely from the waist down. Position the patient on the bed on his or her left side with the top knee bent and pulled slightly upward toward the chin. Place a waterproof pad under the patient's hips to protect the bedding and drape a sheet over the patient covering the entire body except the buttocks. Place a bedpan and toilet paper within quick access. Explain the procedure to the patient. Emphasize the importance of breathing slowly through the mouth to encourage relaxation of the rectal sphincter and to avoid oppositional pressure. Let the patient know that while he or she may feel the urge to defecate, most enemas need time to work and he or she should try to hold the fluid for at least five to 10 minutes after instillation (30–60 minutes for retention enemas and longer for some medicated enema solutions). Check the medication label if it is a medicated solution to avoid medication errors. Be sure it is the right medicine, the right dose (strength), the right time, the right person, and the right method. Verify the expiration date on the label. Do not use outdated medicine.

Wash hands thoroughly and put on gloves. To prepare for premixed disposable enema instillations, follow the directions on the package. Most premixed disposable enemas come with the tip already lubricated. Shake the solution bottle. Remove the cap from the tip and expel excess air from the apparatus before use. To prepare solutions to be administered using an enema bag, heat the solution to 105°F. Adult solutions are generally 750–1000cc of solution for a non-retention enema and 150–200cc of fluid for a retention enema. Children's solutions are 250–500cc of solution for a non-retention enema and 75–150cc of solution for a retention enema. Infants' solutions are 150–250cc of solution for a non-retention enema. If preparing a medicated solution, follow the physician's orders. Select a rectal tube appropri-

KEY TERMS

Anal sphincter—A ring-shaped muscle located at the bottom of the anal canal that maintains constriction to keep the anal canal closed to the outside of the body. The anal sphincter relaxes and opens during defecation.

Defecation—The process of eliminating stool from the body.

Hypertonic—A solution that has a higher osmotic pressure than a comparative solution.

ate to the patient's size (#14–30 French rectal tube for an adult, #12–18 for a child, #12 for an infant) and connect it to the tubing from the bag. Fill the enema bag with the solution and open the tubing. Run the solution through the tubing to the tip of the rectal tube to clear air from the line. Clamp the tubing and adjust the bag on an IV pole so that it will hang at the patient's hipline. Put water-soluble lubricant on a clean 4x4 gauze pad and roll the tip of the rectal tube in the lubricant. Coat all of the rectal tube that will be inserted into the rectum to avoid traumatizing the rectal tissue [3–4 inches (7.3–10 cm) for an adult, 2–3 inches (5–7.5 cm) for a child, 1–1 1/2 inches (2.5–4 cm) for an infant].

Aftercare

After administering an enema, remain near the patient in case he or she needs assistance with the bedpan or to get to the bathroom. Medicated enemas that are expelled immediately may need to be repeated, using fresh solution. Follow the directions or consult with the physician. To assist the patient with retaining an enema after instillation, apply gentle pressure to the rectal opening using a 4x4 gauze pad or squeeze the buttocks together. Tuck a 4x4 gauze pad between the buttocks to collect seepage. This maneuver may help the patient feel more secure. Cover the patient after the procedure and instruct him or her to lie still for five to 10 minutes or longer if a medicated solution or retention enema is administered. This will allow time for the solution to take effect. Wash items that might be reused, such as non-disposable enema bags and tubing, in warm soapy water. Rinse and allow them to air dry. Place disposable items, gauze pads, and gloves in a trash bag, then seal and discard it. Assist the patient to the bathroom or with the bedpan after he or she has held the enema solution for the correct amount of time. Hands should be washed after performing the procedure. Note the results of the enema.

Complications

Complications of enema administration are not common but can include irritation, swelling, redness, bleeding, or prolapse of the rectal tissue. If any of these symptoms are apparent, or if the patient complains of pain or burning during enema instillation, stop the procedure and notify the physician.

Results

Most enemas, because of their liquid state, are absorbed quickly and work rapidly. Retention enemas will take 30–60 minutes to achieve full therapeutic effect. Cleansing enemas usually work within 10–15 minutes to cleanse the bowel and relieve constipation. They may, however, need to be repeated one or two times to thoroughly cleanse the bowel in preparation for a bowel exam or bowel surgery. Medicated enemas, such as antibiotic or anti-inflammatory solutions, may need to be repeated daily over a period of a week or more for full therapeutic effect.

Health care team roles

Enemas are administered by a licensed nurse (R.N. or L.P.N.) in the health care setting. Unlicensed staff, however, may be trained to administer non-medicated enemas under the direction of a **registered nurse** in some settings. An alert and cooperative patient may also be allowed to self-administer non-medicated enemas in some health care settings under the direction of a nurse. The nurse should, however, assess the patient and the effectiveness of the enema. The patient, or members of the patient's family, can be taught to administer an enema in the home setting.

Resources

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Mary Elizabeth Martelli, R.N., B.S.

Enemas

Definition

An enema is a procedure wherein liquid is infused into the rectum via a tube either for treatment or to diagnose a condition.

Purpose

Enemas may be given for the following purposes:

- To remove feces when an individual is constipated or impacted.
- To infuse oil into the rectum to help soften feces when the person is constipated or impacted.
- To remove feces and cleanse the rectum in preparation for an examination.
- To remove feces prior to a surgical procedure to prevent contamination of the surgical area.
- To administer drugs such as corticosteroids dissolved in water to stop inflammation and bleeding caused by ulcerative colitis.
- To introduce barium sulfate, a metallic chemical substance that outlines the intestines for diagnostic purposes.
- To act as a carminative, or remove flatus, or gas, from the intestines.
- To irrigate the colon or **large intestine**, thus stimulating peristalsis (sometimes called a colonic irrigation).

Precautions

The rectal tube used for infusion of the enema solution should be smooth and flexible to decrease the possibility of damage to the mucous membrane that lines the rectum. Tap water is commonly used for adults but should not be used for infants because of the danger of electrolyte imbalance. (Electrolytes are substances that conduct electric current in the body fluids. Proper bal-

ance is essential for sustaining life.) The colon absorbs water, and repeated tap water enemas can cause cardiovascular overload and electrolyte imbalance. Similarly, repeated saline enemas can cause increased absorption of fluid and electrolytes into the bloodstream, resulting in overload. Individuals receiving frequent enemas should be observed for overload symptoms that include dizziness, sweating, or vomiting.

Soap suds and saline used for cleansing enemas can cause irritation of the lining of the bowel, with repeated use or a solution that is too strong. Only white soap should be used; the bar should not have been previously used, to prevent infusing undesirable organisms into the individual receiving the enema. Common household detergents are considered too strong for the rectum and bowel. The commercially prepared castile soap is preferred, and should be used in concentration no greater than 5 cc soap to 1,000 cc of water. Enemas should not be administered to individuals who have recently had colon or rectal surgery, a **heart** attack, or who complain of undiagnosed abdominal **pain** (which can be a ruptured appendix), or suffer from an irregular heartbeat.

Description

Traditionally, soap suds enemas (SSEs) have been used, as the soap caused some irritation of the bowel wall. This irritation, paired with distention caused by the volume of fluid instilled, causes bowel contractions and stimulation that usually will lead to expelling feces from the rectum. When the enema is administered, the individual is usually on the left side-lying position, which places the sigmoid colon (lower portion of bowel) below the rectum and facilitates infusion of fluid. The length of time it takes to administer an enema depends on the amount of fluid to be infused. The amount of fluid administered will vary depending on the age and size of the person receiving the enema; however, general guidelines would be:

- Infant: 250 cc (approximately one cup) or less.
- Toddler and preschooler: 500 ml (two cups) or less.
- School-aged child: 500 to 1,000 cc (between a pint and a quart).
- Adult: 750 to 1,000 cc (three-quarters to a full quart).
- Colonic irrigations or carminative enemas are normally administered only to adults and usually less than 200 cc (three-quarters of a cup) of fluid is used. This is instilled and allowed to flow back out five to six times.

KEY TERMS

Carminative—An agent that will remove gases from the gastrointestinal tract.

Electrolyte—A substance that conducts electric current within the body and is essential for sustaining life.

Intestine—Also called the bowels. Divided into large and small intestine, they extend from the stomach to the anus, where waste products exit the body. The small intestine is about 20 ft (6 m) long and the large intestine, about 5 ft (1.5 m) long.

Rectum—The portion of bowel just before the anus. The prefix *recto* is used with a variety of words in relation to conditions that affect the rectum.

Some health care workers differentiate between high and low enemas. A high enema, given to cleanse as much of the large bowel as possible, is usually administered at higher pressure and with larger volume (1,000 cc), and the individual changes position several times in order for the fluid to flow up into the bowel. A low enema, intended to cleanse only the lower bowel, is administered at lower pressure, using about 500 cc of fluid.

Oil retention enemas serve to lubricate the rectum and lower bowel, and soften the stool. For adults, about 150 to 200 cc (approximately two-thirds, to three-quarters of a cup) of oil is instilled, while in small children, 75 to 150 cc (one-third to two-thirds of a cup) of oil is considered adequate. Salad oil or liquid petrolatum are commonly used at a temperature of 91°F (32.8°C). There are also commercially prepared oil retention enemas. The oil is usually retained for one to three hours before it is expelled.

The rectal tube used for infusion of the solution, usually made of rubber or plastic, has two or more openings at the end through which the solution can flow into the bowel. The distance to which the tube must be inserted is dependent upon the age and size of the patient. For adults, insertion is usually 3–4 in (7.5–10 cm); for children, approximately 2–3 in (5–7.5 cm); and for infants, only 1–1.5 in (2.5–3.75 cm). The rectal tube is lubricated before insertion with a water-soluble lubricant to ease insertion and decrease irritation to the rectal tissues.

The higher the container of solution is placed, the greater the force with which the fluid flows into the patient. Routinely, the container should be no higher than

12 in (30 cm) above the level of the bed; for a high cleansing enema, the container may be 12–18 in (30–45 cm) above the bed level, because the fluid is to be instilled higher into the bowel.

Preparation

The solution used in the procedure is measured, mixed, and warmed before administration of the enema.

Aftercare

If necessary, a stool specimen will be collected for diagnostic evaluation. If the enema was given to alleviate constipation, good nutritional education is necessary to prevent the recurrence of constipation in the future. The recommendation is normally with a high fiber diet (between five and six servings per day of whole grain foods) and adequate fluid intake (between seven and eight glasses of water per day). A study reported in the *Canadian Nurse* sought to evaluate whether the use of **laxatives**, enemas, and suppositories could be reduced by using more bran in the diet. It was found that the subjects given bran with their breakfasts each day reduced use of laxatives, enemas, and suppositories by nearly 50%. Regular **exercise** and going to the bathroom when necessary will also help. If constipation is a chronic problem, medical help should be consulted to determine if there is an underlying disorder.

Complications

Habitual use of enemas as a means to combat constipation can make the problem even more severe when their use is discontinued. Enemas should be used only as a last resort for treatment of constipation and with a doctor's recommendation. The use of enemas can cause an irregular heartbeat in some patients.

Results

Optimum results are thorough and appropriate cleansing of the lower bowel when necessary, and the introduction of proper diet and exercise to prevent chronic constipation.

Health care team roles

Healthcare providers will typically become involved in the treatment of constipation or fecal impaction as a side effect of other, debilitating illnesses.

- Primary care physicians (PCPs) will commonly order enemas for the relief of constipation, or for patients at risk for fecal impaction, to prevent more serious com-

plications such as intestinal obstruction, or as a means of cleansing the bowel prior to tests or surgery.

- Registered nurses (RNs) or licensed practical nurses (LPNs) will often be responsible for either administering the enema or assuring that the patient knows how to administer it to themselves. Nurses will monitor the results of the enema to see if it has been effective in cleansing the lower bowel. Nursing staff involved in the administration of enemas need to be aware that this is an intrusive procedure that can be upsetting to patients. Professionalism and understanding are essential. Nurses should educate the patient about the procedure and should also be involved in teaching patients about the importance of diet and exercise in the prevention of chronic constipation.

Resources

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Joan M. Schonbeck

Enteral nutrition see **Nasogastric intubation and feeding**

Enterostomy

Definition

An enterostomy is a procedure in which the surgeon makes a passage into the patient's **small intestine** through an incision in the abdomen, leaving an opening to allow for drainage or to insert a feeding tube. The opening is called a *stoma* from the Greek word meaning mouth. Enterostomies may be either temporary or permanent. They are classified according to the part of the intestine that is used to create the stoma. If the ileum, which is the lowest of the three sections of the small intestine, is used to make the stoma, the operation is called an ileostomy. If the jejunum, which is the middle section of the small intestine, is used, the operation is

called a jejunostomy. Some people use the word "ostomy" as a word that covers all types of enterostomies.

Purpose

Enterostomies are performed to create a new opening for the passage of fecal matter when normal intestinal functioning is interrupted or when diseases of the intestines cannot be treated by medications or less radical surgery. Some situations that may require enterostomies include:

- Healing of inflamed bowel segments. Enterostomies performed for this reason are usually temporary.
- Emergency treatment of gunshot or other penetrating **wounds** of the abdomen. An enterostomy may be required to prevent the contents of the intestine from causing a serious inflammation of the inside of the abdominal cavity (peritonitis). These enterostomies are also usually temporary.
- Placement of a tube for enteral feeding. Enteral feeding is a method for conveying nutritional solutions directly into the **stomach** or jejunum through a tube. Tube enterostomies may be long-term, but are not permanent.
- Removal of diseased sections of the intestines. Ileostomies performed for this reason are permanent. The most common disorders requiring permanent ileostomy are **Crohn's disease**, familial polyposis, and ulcerative colitis. Familial polyposis and ulcerative colitis are serious health risks because they can develop into **cancer**.
- Treatment of advanced cancer or other causes of intestinal obstruction.

Precautions

Enterostomies are usually performed only as emergency treatments for traumatic injuries in the abdomen or as final measures for serious disorders of the intestines. Most patients do not refuse the procedure once the need for it is explained. A small minority, however, refuse enterostomies because of strong psychological reactions to personal disfigurement and the need to relearn bowel habits.

Description

Ileostomy

Ileostomies represent about 25% of enterostomies. They are performed after the surgeon removes a diseased colon and sometimes the rectum as well. The most com-

mon ileostomy is called a Brooke ileostomy after the English surgeon who developed it. In a Brooke ileostomy, the surgeon makes the stoma in the lower right section of the abdomen. The ileum is pulled through an opening (incision) in the muscle layer. The surgeon then turns the cut end of the intestine inside out and sews it to the edges of the hole. He or she then positions an appliance for collecting the fecal material. The appliance consists of a plastic bag that fits over the stoma and lies flat against the abdomen. The patient is taught to drain the bag from time to time during the day. The bag needs to be emptied frequently because the digested food contains large amounts of water. Shortly after the operation, the ileostomy produces one to two quarts of fluid per day. However, after a month or two of adjustment, the volume decreases to one or two pints per day. Nearly 30% of patients receiving the Brooke ileostomy for inflammatory bowel disease develop at least a limited **infection**. Another 20%–25% require at least a minor surgical revision.

KOCK POUCH (CONTINENT ILEOSTOMY). The Kock pouch is a variation of the basic ileostomy and is named for its Swedish inventor. In the Kock technique the surgeon forms a pouch inside the abdominal cavity behind the stoma to collect fecal material. The stoma is shaped into a valve to prevent fluid from leaking onto the patient's abdomen. The patient then empties the pouch several times daily by inserting a tube (catheter) through the valve. The Kock technique is sometimes called a continent ileostomy because the fluid is contained inside the abdomen. It is successful in 70%–90% of cases. Patients with chronic ulcerative colitis usually have all of the diseased tissue removed during the Kock method. The primary benefit of the Kock approach compared with the Brooke method is that discharge is captured without an external appliance. Unfortunately, the complication rate following the Kock technique is much higher than with the Brooke method. Patients receiving both techniques have problems with perineal wound healing in about one-third of cases.

Jejunostomy

A jejunostomy is similar to an ileostomy except that the stoma is placed in the second section of the small intestine rather than the third. Jejunostomies are performed less frequently than ileostomies and are almost always temporary procedures.

Tube enterostomies

Tube enterostomies are procedures in which the surgeon makes a stoma into either the stomach itself or the jejunum in order to insert a tube for liquid nutrients. Tube

enterostomies are performed in patients who need tube feeding for longer than six weeks, or who have had recent mouth or nose surgery. Jejunostomies require a continuous infusion of nutrients whereas tube feeding through the stomach can be given in large single feedings (boluses). As long as the patient's intestinal tract can function, tube feedings are considered preferable to intravenous feeding because it is safer and helps keep the patient's digestive tract functioning.

Preparation

Preoperative preparation includes both **patient education** and physical preparation.

Patient education

If the patient requires a permanent ileostomy, the doctor will explain what will happen during the procedure and why it is necessary. Most patients are willing to accept an ostomy as an alternative to the chronic **pain** and **diarrhea** of ulcerative colitis or the risk of cancer from other intestinal disorders. The patient also can meet with an enterostomal therapist (ET) or a member of the United Ostomy Association, which is a support group for people with ostomies.

Medical preparation

The patient is prepared for surgery with an evaluation of his or her nutritional status, possible need for **blood** transfusions, and **antibiotics** if necessary. If the patient does not have an intestinal obstruction or severe inflammation, he or she may be given a large quantity of a polyethylene glycol (PEG) solution to cleanse the intestines before surgery.

Aftercare

Aftercare of an enterostomy is both psychological and medical.

Patient education

Ileostomy patients must learn to watch their fluid and salt intake. They are at greater risk of becoming dehydrated in hot weather, from **exercise**, or from diarrhea. In some cases they may need extra bananas or orange juice in the diet to keep up the level of potassium in the blood. Poorly digested foods, such as lightly cooked vegetables, certain types of fruit, nuts, and corn can lead to stromal obstruction if the food is not thoroughly chewed.

Patient education includes social concerns as well as physical self care. Many ileostomy patients are worried

about the effects of the operation on their close relationships and employment. If the patient has not seen an ET before the operation, the aftercare period is a good time to find out about self-help and support groups. The ET can also evaluate the patient's emotional reactions to the ostomy.

In some instances the appliance is poorly fitted. This can lead to problems with the skin near the stoma. Certain foods, such as onions and beans, can produce bad odors in the ileostomy bag. The odor primarily develops from **bacteria** working on these digested foods. Frequent bag emptying and the addition of chlorine or sodium benzoate tablets to the bag can significantly reduce odor.

Medical aftercare

If the enterostomy is temporary, aftercare consists of the usual monitoring of surgical wounds for infection or bleeding. If it is a permanent ileostomy, aftercare includes teaching the patient to use the appliance or empty the Kock pouch, to keep the stoma clean, and to readjust bathroom habits. Recovery takes a significant amount of time because major surgery is a shock to the system and the intestines take several days to resume normal functioning. The patient's fluid intake and output will be checked frequently to minimize the risk of **dehydration**.

Complications

Enterostomies are not considered high-risk operations by themselves. Possible complications include:

- Skin irritation caused by leakage of digestive fluids onto the skin around the stoma is the most common complication.
- Diarrhea, both severe and chronic, needs to be brought to the attention of the physician.
- Gallstones or stones in the urinary tract may develop.
- Inflammation of the ileum can occur.
- Odors from an ileostomy can often be prevented by a change in diet.
- Intestinal obstruction may develop.
- Prolapse can occur in which a section of the bowel pushes out of the body.
- Leakage from the ileostomy pouch can occur if the stoma is not at least 2 inches above the level of the skin.
- Variceal bleeding—bleeding from **blood vessels** around the stoma—can occur in patients with portal **hypertension** and other conditions.

KEY TERMS

Crohn's disease—A disease of the intestines that causes inflammation leading to scarring, thickening of the walls of the intestine, and eventual obstruction.

Duodenum—The first of the three segments of the small intestine. The duodenum connects the stomach and the jejunum.

Enteral nutrition—A technique for feeding patients with liquid formulas conveyed directly into the stomach or jejunum through tubes.

Enterostomal therapist (ET)—A specialized counselor, usually a registered nurse, who provides ostomy patients with education and counseling before the operation. After surgery the ET helps the patient learn to take care of the stoma and appliance, and offers long-term emotional support.

Familial polyposis—A disease that runs in families in which lumps of tissue (polyps) form inside the colon. Familial polyposis may develop into cancer.

Ileum—The third segment of the small intestine, connecting the jejunum and the large intestine.

Jejunum—The second of the three segments of the small intestine, connecting the duodenum and the ileum.

Kock pouch—A type of ileostomy in which the surgeon forms an artificial rectum from a section of the ileum. A Kock pouch is sometimes called a continent ileostomy because it is drained with a tube.

Ostomy—A common term for all types of enterostomies.

Stoma—The surgically constructed mouth or passage between the intestine and the outside of the patient's body.

Tube enterostomy—An enterostomy performed to allow the insertion of a feeding tube into the jejunum or stomach.

Ulcerative colitis—A disease of the colon characterized by inflammation of the mucous lining, ulcerated areas of tissue, and bloody diarrhea.

- Ileal **abscess** and fistula can occur, in which the ileum becomes punctured by sutures, recurrent disease, or the effects of a poorly-fitted appliance.

Results

Normal results include recovery from the surgery with few or no complications. About 95% of people with ostomies recover completely, are able to return to work, and consider themselves to be in good health. Many ileostomy patients enjoy being able to eat a full range of foods rather than living on a restricted diet. Some patients, however, need to be referred to psychotherapists to deal with depression or other emotional problems after the operation.

Health care team roles

A variety of allied health personnel will be involved in the care of individuals who require an enterostomy. A surgeon will perform the actual procedure. A nurse will likely be involved in aftercare instructions, and an important member of the allied health care team is the ET. The ET is generally a **registered nurse** who has received specialized training in the area of enterostomy and is typically certified in the field. The ET generally performs the following activities:

- presurgical counseling and education of the patient and family
- care of the stoma immediately following the operation
- training of the patient in the proper use of the appliance and overall long-term self-care
- proper fitting of the appliance
- educating the patient on the daily management of the stoma
- advising the patient on how to cope with skin complications and odor problems
- identifying stomal problems associated with the surgery
- supporting the patient emotionally, physically, and morally
- providing information about the national organization for those who have received an ostomy—the United Ostomy Association

Nutritional therapists may also consult the patient about various nutritional factors and how they might affect the patient who has undergone an enterostomy. In particular, this information will include how various foods lead to diarrhea, or bad odors in the bag. **Wound care** nursing specialists also may be called in when wound healing is not progressing at an appropriate rate.

Resources

BOOKS

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Enzyme immunoassay *see* **Immunoassay tests**

Epidural anesthetic *see* **Anesthesia, local**

Epidural therapy

Definition

An epidural is a local (regional) anesthetic delivered through a small tube into a vacant space outside the **spinal cord**, the epidural space.

Purpose

The anesthetic agents that are infused through the small catheter block spinal nerve roots in the epidural space and the sympathetic nerve fibers adjacent to them. Epidural anesthesia can block most of the **pain** of labor and birth for vaginal and surgical deliveries. Epidural analgesia is also used after cesarean sections to help control post-operative pain.

Precautions

The primary problem associated with receiving epidural anesthesia is low **blood pressure**, otherwise known as hypotension, because of the blocking of sympathetic fibers in the epidural space. The decreased peripheral resistance that results in the circulatory system causes dilation of peripheral **blood vessels**. Fluid collects in the peripheral vasculature (vessels), simulating a condition that the body interprets as low fluid volume. A simple measure that prevents most hypotension is the

infusion of 500-1000 cc of fluid intravenously into the patient prior to the procedure. Ringer's lactate, as opposed to a solution containing dextrose, is preferable because the elevated maternal glucose that accompanies the rapid infusion of solutions containing dextrose can result in hyperglycemia in the newborn with rebound hypoglycemia.

It is important not to place a woman flat on her back after receiving an epidural because the supine position can bring on hypotension. If a woman's **blood** pressure does drop, then the proper treatment is to turn her on her side, administer oxygen, increase the flow of intravenous fluids and possibly administer a medication such as ephedrine if the hypotension is severe. Very rarely, convulsions can result from severe reactions. Seizure activity would be treated with short-acting barbiturates or diazepam (Valium).

Description

Epidural anesthesia, because it virtually blocks all pain of labor and birth, is particularly helpful to women with such underlying medical problems as pregnancy-induced **hypertension**, **heart** disease, and pulmonary disease. Epidural anesthesia for labor is usually initiated at the woman's request, providing the labor is progressing well, or if the mother feels severe pain during early labor.

Preparation

To prepare for the administration of epidural anesthesia, the woman should have the procedure explained fully and sign consent forms if required. An intravenous line is inserted if not already in place. She is positioned on her side or in a sitting position and connected to a blood pressure monitoring device. The nurse/assistant has the following equipment available: oxygen, epidural insertion equipment, fetal monitor, and additional intravenous fluid.

The health care provider cleans the area with an antiseptic solution, injects a local anesthetic to create a small wheal at the L 3-4 area (between the third and fourth lumbar vertebrae) and inserts a needle into the epidural space. Once it is ascertained that the needle is in the correct place, a polyethylene catheter is threaded through the needle. The needle is removed and a test dose of the anesthetic agent is administered. The catheter is taped in place along the patient's back with the end over her shoulder for easy retrieval when further doses are required.

If the patient responds well to the test dose a complete dose is administered. Pain relief should be to the



Epidural anesthesia may be administered to a woman in labor to ease the pain of labor and birth. (*M. English, MD/Custom Medical Stock Photo. Reproduced by permission.*)

level of the umbilicus. The epidural anesthesia lasts approximately 40 minutes to two hours, or longer as required. If necessary, additional doses of anesthetic, or top-up, are injected through the catheter or a continuous infusion on a special pump.

Epidural anesthesia can be given in labor in a “segmented” manner. In this instance, the laboring woman receives a small dose of anesthesia so that the perineal muscles do not fully relax. The baby's head is more apt to undergo internal rotation when the perineal muscles are not lax thus facilitating delivery. At the time of delivery, an additional dose can be administered for perineal relief.

Women who have cesarean deliveries may have additional medication injected into the epidural to control intra-operative pain. Medications used generally are narcotics such as fentanyl or morphine (Duramorph). Side effects include severe itching, nausea, and vomiting. Treatment of these side effects with the appropriate med-

KEY TERMS

Analgesia—A medication that decreases the awareness of pain.

Anesthesia—Loss of sensation through the administration of substances that block the transmission of nerve impulses signaling the feeling of pain and pressure.

Regional anesthesia—Blocking of specific nerve pathways through the injection of an anesthetic agent into a specific area of the body.

ication can be helpful. Despite these problems, epidural analgesia is an effective method to relieve pain after cesarean delivery, allowing the woman to move well, thereby facilitating rapid recovery.

Aftercare

It is important to carefully monitor **vital signs** after the administration of epidural anesthesia. Hypotension can result in fetal death and can also have grave consequences for the mother. The nurse should monitor the patient constantly and use a continuous blood pressure machine to obtain regular blood pressure readings for 20-30 minutes after each administration of anesthesia. The systolic blood pressure should not fall below 100 mm Hg or be 20 mm Hg less than a baseline systolic blood pressure for a hypertensive patient.

It is important to remind the woman to empty her bladder at least every two hours. With epidural anesthesia there is loss of sensation of the need to void. Sometimes, if the bladder fills excessively it could actually block the descent of the baby's head. A catheter can be inserted into the bladder to drain the urine. The nurse needs to closely monitor intake and output and assess the bladder for signs of distension.

Complications

Side effects and complications are rare but sometimes the patient will experience a "spinal headache" due to leakage of cerebrospinal fluid (CSF).

When a woman receives epidural anesthesia for labor pains, at times the labor can be prolonged because of excessive relaxation of the muscles. Also, the baby's head may not rotate—especially if it is in the occiput-posterior position (the back of the head is facing toward the woman's back). The woman may not have the sensation that results in the desire to push during contractions

when she is fully dilated. These complications may result in an increased incidence of births with the use of vacuum extraction, forceps, or even cesarean deliveries. Administering a Pitocin (oxytocin) drip intravenously can counter this problem. Pitocin is a medication that causes the uterus to contract. Allowing the epidural to wear off in the second stage of labor, when the woman is pushing, may avoid this problem, but the return of the labor pains may be overwhelming to the woman.

Occasionally, slow absorption of the medication from the epidural space into the circulation can result in toxic reactions evident by decreased level of consciousness, slurred speech, loss of coordination, drowsiness, nervousness, and **anxiety**. The health care provider should look out for these signs, and also report any elevation in temperature, before a top-up dose is administered.

Results

Epidural anesthesia is a safe and effective method of giving pain relief to women during labor and delivery and also can be used for cesarean births. It is believed that very little of the anesthetic is absorbed throughout the body (systemically), therefore epidural anesthesia is ideal because it does not pass medication on to the baby.

Health care team roles

Epidurals are administered by anesthesiologists and certified nurse anesthetists.

Undergoing the insertion of an epidural can be a frightening experience for the patient because of the injection technique. It is important to offer ample encouragement and support during the entire process.

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Nadine M. Jacobson, RN

Epilepsy see **Seizure disorder**

EPS see **Electrophysiology study of the heart**

Epstein-Barr virus test see **Infectious mononucleosis test**

Esophageal function tests

Definition

The esophagus is the muscular tube through which food passes on its way from the mouth to the **stomach**. The main function of the esophagus is to propel food into the stomach. In order to ensure material does not go the wrong way (reflux), sphincters at either end of the esophagus close when material is not passing through them in the correct direction. Esophageal function tests are used to determine if these processes are normal or abnormal.

Purpose

The esophagus has two sets of constricting muscles (or sphincters) at the top and bottom. Each of these muscular areas must contract in an exact sequence for swallowing to proceed normally. The upper esophageal sphincter normally stops the backflow of stomach contents into the pharynx and larynx. The lower esophageal sphincter guards against stomach acid moving up into the esophagus. The lower sphincter should be tightly closed, except to allow food and fluids to enter the stomach.

The three major symptoms occurring with abnormal esophageal function are difficulty with swallowing (**dysphagia**), heartburn, and chest **pain**. Doctors perform a variety of tests to evaluate these symptoms. Endoscopy, which is not a test of esophageal function, is often used to determine if the lining of the esophagus has any ulcers, tumors, or areas of narrowing (strictures). Many times, however, endoscopy only shows the doctor if there is an injury to the esophageal lining, and the procedure gives no information regarding the cause of the problem. Therefore, in addition to endoscopy, several studies are available that measure esophageal function. There are three basic types of tests used to assess esophageal function:

- Manometry is used to study the way the muscles of the esophagus contract, and is most useful for the investigation of difficulty with swallowing.
- Esophageal pH monitoring measures changes in esophageal acidity, and is valuable for evaluating

patients with heartburn or gastroesophageal reflux disease (GERD).

- X-ray studies investigate dysphagias, either by using a fluoroscope to follow the progress of barium during the process of swallowing, or by using radioactive scanning techniques.

Precautions

Since sedatives may alter test values, they are not administered prior to esophageal function testing. Eating prior to the test will also alter the results. Pregnant patients undergoing x-ray exams should carefully review the risks and benefits of any proposed tests with their doctors. Additionally, patients with bowel obstruction should not participate in any test using barium. Also, esophageal function tests are contraindicated in those patients who are unable to cooperate with the test.

Description

Manometry

This study is designed to measure the pressure changes produced by contraction of the muscular portions of the esophagus. An abnormality in the function of any one of the segments of the esophagus can cause difficulty in swallowing (dysphagia). This exam is most useful in evaluating patients whose endoscopy yields normal results.

During manometry, the patient swallows a thin tube carrying a device that senses changes in pressures in the esophagus. Readings are taken at rest and during the process of swallowing. Medications are sometimes given during the study to aid in the diagnosis. The results are then transmitted to recording equipment. Manometry is most useful in identifying diseases that produce disturbances of motility or contractions of the esophagus. In 2001, a solution containing five drops of peppermint oil in 10 mL of water was found to improve the manometric features of diffuse esophageal spasm (DES). The peppermint oil solution eliminated simultaneous esophageal contractions in all patients in the study.

ESOPHAGEAL PH MONITORING. This procedure measures the esophagus' exposure to acid reflux from the stomach. The test is ideal for evaluating recurring heartburn or gastroesophageal reflux disease (GERD). Excessive acid reflux may produce ulcers, or strictures resulting from healed ulcers, in addition to the symptom of heartburn.

Normally, acid refluxes into the esophagus in small amounts for short periods of time. The lower esophageal

sphincter usually prevents excessive reflux (in patients without disease). Spontaneous contractions that increase esophageal emptying and production of saliva also act to prevent damage to the esophagus.

Researchers have shown that in the esophagus, the presence of acid is damaging only if it persists for prolonged periods. Therefore, esophageal pH monitoring has been designed to monitor the level of acidity over 24 hours, usually in the home. In this way, patients are able to maintain their daily routine, document their symptoms, and correlate symptoms with specific activities. During this period, a thin tube with a pH monitor remains in the esophagus to record changes. After the study, a computer is used to compare changes in acidity with symptoms reported by the patient.

Additional tests, the Bernstein test (also known as the acid perfusion test) and the acid clearing test, may be performed. In the Bernstein test, hydrochloric acid (HCl) is directed into the esophagus. If the patient experiences pain with the administration of the HCl, the test is positive for reflux esophagitis. If there is no discomfort, another cause must be found to explain the patient's symptoms. In the acid clearing test, HCl is also directed into the esophagus. However, in this test, the patient's ability to quickly swallow the HCl is examined. If the patient needs more than 10 swallows, it indicates the patient has problems with esophageal motility.

pH monitoring is usually performed before surgery to confirm the diagnosis and to judge the effects of drug therapy. In 2001, studies showed that integrated esophageal and gastric acidity provided better quantitative measures of GERD pathophysiology than conventional pH parameters. This finding has implications for the evaluation of therapeutic interventions.

X-RAY TESTS. X-ray tests fall into two categories: (1) those performed using barium and a **fluoroscope**; and (2) those performed with radioactive materials. Studies performed with fluoroscopy are especially useful in identifying structural abnormalities of the esophagus. Oftentimes a sandwich or marshmallow coated with barium is used to identify the site of an obstruction. However, fluoroscopy can diagnose or provide important information about a number of disorders involving esophageal function, including craniopharyngeal achalasia (a swallowing disorder of the throat), decreased or reverse peristalsis, and hiatal hernia.

During fluoroscopy, the radiologist can observe the passage of material through the esophagus in real time, and video recordings may also be made. This is particularly useful when the swallowing symptoms appear to occur mostly in the upper region of the esophagus. The most common cause of difficulty swallowing is a previ-

ous stroke, although other diseases of the neuromuscular system (like myasthenia gravis) can produce similar symptoms.

Scans using low-dose radioactive materials are useful because they may demonstrate that food passes more slowly than normal through the esophagus, and how slowly the bolus may be passing. These studies involve swallowing food coated with radioactive material, followed by a nuclear medicine scan. Scans are often used when other methods have failed to make a diagnosis, or if it is necessary to determine the degree of the abnormality.

Preparation

Patients should not eat or drink anything after midnight before the exam. Many medications affect the esophagus; doses may need to be adjusted or even discontinued prior to testing. Patients must inform their physician of any and all medications they take, including over-the-counter medications, and any known **allergies**.

Aftercare

For most of these studies, no special care is needed after the procedure. Patients can often engage in normal daily activities following almost all of these tests. One exception is that patients who undergo a x-ray exam with the use of barium may experience constipation. A cathartic may be given to those patients.

Complications

Exposure of a fetus to x-rays, especially in the first three months, can be extremely harmful to the fetus. Barium swallows may also cause impaction (hardening) of fecal matter. Additionally, although the tubes passed through the esophagus during some of the esophageal function tests are small, and most patients adjust to them quite well, some patients may gag and aspirate (breathe in) some gastric juices.

Results

Normal findings include:

- lower esophageal sphincter pressure ranging from 10–20 mm Hg
- normal peristaltic waves
- normal size, shape, position, patency and filling of the esophagus
- negative acid reflux
- acid clearing in less than 10 swallows

- negative Bernstein test

Manometry is used to diagnose abnormalities related to contraction or relaxation of the various muscular regions of the esophagus. These studies cannot distinguish whether injury to either the muscle or nerves of the esophagus is producing the abnormal results—only the final effect on esophageal muscle is identified. Results should be interpreted in light of the patient’s entire medical history.

For example, there are many diseases that cause poor relaxation of the lower esophageal sphincter. When no cause is found, the condition is called achalasia. Achalasia is a frequent finding in individuals with Down’s syndrome.

Abnormal results of pH tests can confirm symptoms of heartburn or indicate a cause of chest pain (or rarely, swallowing difficulties). Doctors may want to initiate or change medications based on these results, or even repeat the test using different doses of medication. As noted above, these studies are indicated before surgical treatment of GERD.

X-ray tests can serve to document an abnormality, and they are far from perfect. If they are negative, then other studies are often needed.

Health care team roles

The health care team may consist of the physician, the nurse, and others. A radiologist will be required if the procedure involves scans, x-rays, or nuclear medicine studies. Unlicensed assistive personnel (UAPs), such as GI assistants, GI technicians or medical technicians may have direct patient care responsibility. They are supervised by a **registered nurse (RN)**. UAPs can assist the physician and RN during diagnostic and therapeutic procedures. The RN is responsible for the assessment of patient care needs and for determining the capability of assistive personnel to whom a task is delegated. An advanced practice nurse (APN) specializing in gastroenterology may perform a comprehensive history and physical assessment. Depending on the practice, the APN may also order and/or perform diagnostic studies. Otherwise, these tasks are performed by the physician.

Training

An APN is a nurse who has completed an advanced degree in nursing (master’s or doctorate). An APN may be a nurse practitioner or a **clinical nurse specialist**. UAPs may receive on-the-job training in their duties.

KEY TERMS

Achalasia—Failure to relax. Often applied to sphincter muscles, the normal function of which is persistent contractions with periods of relaxation.

Bolus—“A lump.” May describe a mass of food ready to be swallowed, or a preparation of medicine via the oral or intravenous (IV) route.

Cathartic—An active agent which produces bowel movements.

Craniopharyngeal achalasia—A swallowing disorder of the throat.

Diffuse esophageal spasm (DES)—An uncommon condition that results in simultaneous contractions of the esophagus.

Esophagus—The muscular canal between the throat and the stomach.

Heartburn—Acid liquid raised from the stomach, causing a burning sensation in the esophagus.

Hiatal hernia—A condition in which part of the stomach pushes up through the same hole in the diaphragm that the esophagus passes through.

Peristalsis—The contraction of muscles which passes food from the mouth to the stomach and out the anus.

Patient education

If barium is used in the testing, the patient should understand that all of the barium needs to be excreted. At first, the patient’s stools will be white, but once the barium has been completely excreted, the stools will return to normal.

Advise the patient that a **sore throat** is common after tests requiring tube placement. Explain to the patient that sedatives are not given prior to testing involving tube placement, due to the interference with the test results and test administration.

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Illinois Nurses Association—Advanced Practices Registered Nurses (APRNs) statistics. 105 W. Adams Suite 2101. Chicago, IL 60603. <<http://www.illinoisnurses.org/aprn.html>>.

The Society for Gastroenterology Nurses and Associates (SGNA). 401 North Michigan Avenue, Chicago, IL 60611-4267. (800) 245-7462. <<http://www.sgna.org>>.

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Ergonomic assessment

Definition

Ergonomic assessment is a physical therapist's or other specialist's evaluation of a workplace and its furnishings, tools, and tasks in relation to the physical abilities of the worker. It is also known as work activities evaluation and treatment.

Purpose

The professional evaluation is used to identify and report any risk factors that the worker may encounter while employed. By identifying those risks for injury and physical **stress**, the evaluator provides recommendations

for modified design and practice. The ergonomic assessment and its implementation can help make the work environment safer and more physically efficient. It will also help reduce injuries and related expenses while improving the well-being, productivity, and morale of employees. A job analysis (a written description of tasks according to their physical functions and requirements) may be provided, to match the capabilities of the worker to the job's physical requirements. Ergonomic assessment reports and subsequent modifications help the employer to meet insurance company, Occupational Safety and Health Administration (OSHA), or other organizational standards. The physical therapist may be called in to treat an injured worker or make general preventative recommendations. The therapist helps the worker return to work more quickly and safely by advising revisions in the work tasks and environment. The employer receives advice in how to accommodate the abilities of a disabled or recently injured employee in compliance with the **Americans with Disabilities Act** (ADA) requirements.

Precautions

Ergonomic assessments are used to prevent further or recurring injuries. If a worker returns to work while still in recovery or returns to the same dangerous environment, the injury is liable to happen again, perhaps with a worse outcome.

Description

Ergonomic assessment is provided to an employer or employee to identify risk factors in the workplace; provide recommendations of ways to reduce them; and to prevent or treat injuries and accommodate disabilities. The evaluation helps employees perform their jobs in a safe, healthy, and efficient manner, spending less time off due to work-related disorders. The term ergonomics is derived from the Greek roots *erg*, meaning work and *nomos*, meaning natural laws. OSHA defines ergonomics as "the science of fitting the jobs to the people who work in them," stating that "work-related musculoskeletal disorders (MSDs) result when there is a mismatch between the physical capacity of workers and the physical demands of their jobs." Some job-related MSDs include **carpal tunnel syndrome**, tendinitis, and back injuries.

Many industries and work environments expose workers to hazardous conditions and constant physical stress resulting in accident, injury, and such chronic conditions as work-related musculoskeletal disorders (WMSDs), cumulative trauma disorders (CTDs), and repetitive motion injuries (RMIs). Some high-risk groups

are assembly line workers, manufacturing employees, health care workers, and office workers. Jobs requiring continual heavy lifting or constant repetition of the same motion can be especially stressful. Office work—especially that involving constant computer use—can lead to various physical problems. These include eye strain from artificial lighting and computer screens; back problems related to incorrect posture and chairs or work stations; and hand, wrist, or arm injuries due to excessive or incorrect keyboard use.

Once these risks are identified, the recommendations may be in the form of a work risk analysis report that includes a biomechanical description of the job, a description of observed risks, and steps to correct them.

Ergonomic assessment and intervention includes the “Five E’s” of correction and injury prevention:

- **Ergonomic-engineering:** Redesigning the job or workspace to reduce stress. For example, the height or angle of a counter, chair or keyboard may be adjusted.
- **Exposure reduction:** Reducing the amount of time workers are exposed to unavoidable stress by rotating tasks; increasing the variety of tasks performed and how they are performed; and changing physical positions and movements.
- **Exercise:** Stretching the muscles relieves stress and helps to prevent injury. This proves especially important when certain physically stressful tasks must be repeatedly performed.
- **Enforcement of preventative procedures or policies:** Teaching such procedures as proper lifting techniques, are necessary if they are to benefit the employees.
- **Education:** Knowing the proper procedures and the physical reasons for use.

Preparation

A physical therapist may either be employed by a company to treat workers on-site or act as a consultant with various companies. If the treatment is in response to an employee injury, the employer’s insurance company generally pays for the physical therapist’s services. If the therapist is providing general injury prevention consultation the employer usually pays for the service, which is cost-effective because it reduces injury-related expenses. Physical therapists are by the nature of their training well educated in anatomy, posture, body mechanics, and ergonomics, but the physical therapist who provides ergonomic assessment and treatment in the workplace may also have additional training or education in ergonomics and occupational health. Physical therapists are generally used more outside the United States, but

KEY TERMS

ADA—Americans with Disabilities Act.

Biomechanics—The study of biological and muscular activity.

CTD—Cumulative trauma disorder.

Ergonomics—Arranging and studying things people use to derive efficient and safe conditions that produce the best results.

OSHA—Occupational Health and Safety Administration.

RMI—Repetitive motion injury.

WMSD—Work-related musculoskeletal disorders.

would prove beneficial given their expertise in the human body and its activities.

Aftercare

After the ergonomic assessment for each employee’s job assignment and work station has been conducted and the employees have been instructed in proper work place ergonomics and safety, beneficial results depend on application. The employer needs to actually apply recommendations for changes in the work station or job description. Employees also have to continue to put the new techniques they have learned into practice.

Complications

While complications resulting from the ergonomic assessment itself are not likely, there may possibly be complications resulting from an injured employee’s early return to work, even with a modified job description. If the resumed or modified activity causes irritation or risk of reinjury, the employee may need to cease the resumed activities and return to the physical therapist or physician for further treatment. Care should be taken to screen employees for any conditions contraindicating exercise before preventative stretches or other new physical activities are recommended.

Results

The desired outcomes of ergonomic assessment and intervention are quicker return to work by injured employees, a safer and more efficient work environment, prevention of future injuries, and increased understanding of safe work and postural practices. By reducing

injuries, Workers' Compensation claims, and employee absenteeism, adjustments made to the work environment and related activities can lead to reductions in cost to the employer.

Health care team roles

A company doctor, Workers' Compensation doctor, or other physician may refer the patient to a physical therapist for treatment and workplace ergonomic evaluation. The employer also has the option of directly requesting the physical therapist's services. Educational specialists and others with special training in ergonomics and occupational health may be involved in addition to or in place of the physical therapist. Often the physical therapist will be the sole consultant for the employer and employees.

Resources

ORGANIZATIONS

American Physical Therapy Association (APTA). 1111 North Fairfax Street. Alexandria, VA 22314. (703) 684-2782. <<http://www.apta.org>>.

Center for Industrial Ergonomics. Lutz Hall, Room 445, University of Louisville, Louisville, Kentucky 40292. (502) 852-7173. <<http://www.louisville.edu/speed/ergonomics>>.

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Diane Fanucchi, B.A., C.C.R.A.

Esophageal radiography see **Upper GI exam**

Esophagogastroduodenoscopy

Definition

An esophagogastroduodenoscopy (EGD), or upper endoscopy, is a procedure in which a camera mounted on

a small flexible tube is used to view the esophagus, **stomach**, and duodenum (part of the **small intestine**). Small instruments may also be passed through the tube to treat disorders or biopsy lesions.

Purpose

An EGD is performed to evaluate (or treat) symptoms relating to the upper gastrointestinal tract, such as:

- upper abdominal or chest **pain**
- nausea or vomiting
- gastroesophageal reflux disease (GERD)
- difficulty swallowing (dysphagia)
- anemia
- bleeding from the upper intestinal tract

In addition, an EGD may be used to confirm abnormalities indicated by other exams, such as an upper GI series or a CT scan, or may be used to treat certain conditions, such as an area of narrowing (stricture) or bleeding in the upper gastrointestinal tract.

Upper endoscopy is more accurate than x rays for detecting inflammation, ulcers, or tumors. It is used to diagnose early **cancer** and can frequently determine whether a growth is benign or malignant. Biopsies (small tissue samples) of inflamed or "suspicious" areas can be obtained and examined by a pathologist. Cell scrapings can also be taken by the introduction of a small brush; this helps in the diagnosis of cancer or infections. Small instruments can be passed through the **endoscope** and can stretch narrowed areas or remove swallowed objects (such as coins, pins or other **foreign bodies**). In addition, bleeding from ulcers or vessels can also be treated by endoscopic techniques.

Precautions

An EGD is contraindicated in patients with:

- severe upper gastrointestinal (UGI) bleeding
- history of **bleeding disorders** such as platelet dysfunction or hemophilia
- esophageal diverticula
- suspected perforation
- recent UGI surgery

An EGD is also contraindicated for those patients who are unable to cooperate fully with the procedure.

Description

First, patients either gargle a local anesthetic or have one sprayed into their mouth (onto the throat) to numb the gag reflex. Patients are also usually sedated for the procedure by injection of medications into a vein. The endoscopist then has the patient swallow the scope, which is passed through the upper gastrointestinal tract. The lens or camera at the end of the instrument allows the endoscopist to examine each portion of the upper gastrointestinal tract; photos can be taken for reference. Air is pumped in through the instrument to allow proper observation. Biopsies and other procedures can also be performed.

Preparation

The upper intestinal tract must be empty for the procedure, so patients *must not* eat or drink anything for at least six to 12 hours before the exam.

Aftercare

Someone should be available to take the person home after the procedure and stay with them for a while; patients will not be able to drive themselves due to sedation. Pain or any other unusual symptoms should be reported immediately.

It is important to recognize early signs of any possible complication. The doctor should be notified if the patient has:

- fever
- trouble swallowing (dysphagia)
- difficulty breathing (dyspnea)
- increasing throat, chest, or abdominal pain

Complications

The overall complication rate of EGD is less than 2%, and many of these complications are minor (such as inflammation of the vein through which medication is given). However, serious complications can and do occur. Almost half of them are related to the **heart** or **lungs**. Bleeding or perforations are also reported, especially when tumors or narrowed areas are treated or biopsied. Infections have also been transmitted (rarely); careful attention to cleaning procedures should prevent this complication.

Results

Normal results show the esophagus, stomach and duodenum without any strictures, ulcers or erosions,

KEY TERMS

Duodenum—The first portion of the small intestine.

Endoscope—A surgical tool used to view areas that can't be directly observed (like the esophagus or the colon).

Esophagus—The muscular canal between the throat and the stomach.

Pathologist—A doctor who specializes in the anatomic (structural) and chemical changes that occur with diseases. These doctors function in the laboratory, examining biopsy specimens, and regulating studies performed by the hospital laboratories (blood tests, urine tests, etc). Pathologists also perform autopsies.

diverticula, masses, or bleeding. Other abnormal results include esophageal infections, fissures and tears. An increasingly common finding is medication-induced esophageal injury, caused by tablets and capsules that have lodged in the esophagus.

Health care team roles

The health care team may consist of the physician, the nurse, and others. Unlicensed assistive personnel (UAPs), such as GI assistants, GI technicians or medical technicians may have direct patient care responsibility. They are supervised by a **registered nurse (RN)**. UAPs can assist the physician and RN during diagnostic and therapeutic procedures. The RN is responsible for the assessment of patient care needs and for determining the capability of assistive personnel to whom a task is delegated. An advanced practice nurse (APN) specializing in gastroenterology may perform a comprehensive history and physical assessment. Depending on the practice, the APN may also order and/or perform diagnostic studies. Otherwise, these tasks are performed by the physician.

Training

An APN is a nurse who has completed an advanced degree in nursing (master's or doctorate). An APN may be a nurse practitioner or a **clinical nurse specialist**. UAPs may receive on-the-job training in their duties.

Patient education

Instruct the patient not to eat or drink anything until the gag reflex has returned. Normally, the gag reflex will

return in two to four hours after the procedure. To test if the gag reflex has returned, place a spoon on the back of the tongue for a few seconds with light pressure. If the patient does not gag, wait 15 minutes and attempt the maneuver again. Do not use small or sharp objects. Advise the patient that hoarseness and a mild **sore throat** are normal after the procedure. Encourage cool fluids and gargling to relieve the soreness. Because of the introduction of air during the procedure, it is normal to have some bloating, belching and flatulence after an EGD. To prevent pill-induced esophageal injury, advise patients to drink at least 4 ounces of liquid with any pill, and at least 8 ounces of liquid with pills that can cause injury. Patients should remain sitting upright for 30 minutes after taking pills that are likely to cause injury.

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Maggie Boleyn, RN, BSN

Estradiol test see **Sex hormones tests**

Estril test see **Triple marker screen test**

Estrogen fractions test see **Sex hormones tests**

Ethical codes and oaths

Definition

Ethical codes and oaths are statements of the moral principles and values that govern the conduct of a group, profession, or individual. In the health professions, ethical codes embody the ideals of compassion for the suffering and respect for the dignity of all human beings, as well as the highest standards of clinical research and practice.

Ethics as a discipline is the study of moral values and moral reasoning. There are two major approaches to ethics, normative and non-normative. Non-normative ethics describes and studies moral beliefs without making value judgments about right and wrong. Normative ethics tries to define and distinguish between right and wrong.

Description

Ethical codes and oaths are formal statements that serve to remind practitioners of their obligations to their patients and to the larger society. In the United States and Canada, the ethical codes that have been drafted by the various health professions are also regarded as the foundation of the legal obligations of health care professionals—including disciplinary standards. For example, a patient who files a complaint with the ethics committee of a physician's medical society or hospital can take the complaint to the state licensing board as well. Ethics committees in the health professions have the power to suspend or expel members who have violated the ethical code that governs the profession.

The ethical standard set by the professional organization may be simple and forthright like the Hippocratic Oath for physicians, or more thorough and specific as is the code of conduct for nurses. Modern medical codes and oaths are patterned after the Hippocratic Oath and contain the same basic concepts: to work for the good of one's patients; to cause them no harm; to honor the profession of medicine and protect it from corruption; to give no drugs or perform no operation that would cause harm to the patient; and to keep medical information confidential. Whether the code is an ancient or a contemporary version, it gives the health care professional a high standard of conduct for which to strive.

Viewpoints

Historical background

The earliest statement of ethical standards for physicians is the so-called Hippocratic Oath, attributed to the “father of medicine” in the fifth century B.C. In the West, both Judaism and Christianity gave extensive consideration to the importance of the physician’s moral character as well as his clinical duties to patients. In Judaism, **medical ethics** is rooted in the study of specific case histories interpreted in the light of Jewish law. In medieval Christianity, ethical reflection took the form of an emphasis on duty, moral obligation, and right action. In both faiths, the relationship between the medical professional and the patient was regarded as a covenant or sacred bond of trust rather than an economic transaction or a business contract.

Since the eighteenth century, several developments have led to increased concern about the ethical standards of the health professions. These changes include:

- A philosophical emphasis on individual freedom and personal rights rather than on obligations to family or society.
- Advances in scientific knowledge and technology that raise new questions about the nature of human personhood, life, and death.
- Recognition of the vulnerability of the health professions to abuse by government authority. Specific examples include medical experiments on concentration camp inmates in Nazi Germany and the abuse of psychiatry in Stalinist Russia.
- The increased role of economic considerations in health care decisions on the individual as well as the communal level.
- The loss of a universal moral framework accepted by all or most people. Although there are a number of religious and philosophical perspectives on ethical questions that many people accept, none of these perspectives is accepted by everyone.

Present models for making ethical decisions in medicine

Models are outlines or patterns that can be used in ethical decision-making to help the care provider organize his or her thoughts and bring in all relevant considerations. One widely used model for decision-making in medicine holds that any ethical decision must consider four factors:

- Medical indications. These include the diagnosis and treatment of the patient’s condition.

- Patient preferences. This factor assumes that health professionals should respect the patient’s wishes, and wherever possible provide care that does not violate them.
- Quality of life. This factor is to be evaluated from the patient’s point of view, not the medical professional’s perspective.
- The wider context. This factor includes all the other features that may be involved in a specific decision, such as the family’s feelings, legal considerations, socioeconomic issues, religious practices, and others.

Another model that is sometimes used in clinical practice proposes three rules to be followed in ethical decision-making:

- Impartiality. This rule requires the health professional to place him- or herself in the patient’s position and ask whether they would be willing to have the action performed if they were the patient.
- Universality. This rule asks whether the health professional would be willing to apply the same solution to the patient’s situation in all similar cases.
- Justifiability. This rule asks the health professional to consider whether he or she could defend the decision to other people or discuss it in public.

Other considerations

Although there are many medical codes and guidelines within individual medical associations, some observers have proposed a universal code of ethics binding on all health care professions. It has been suggested that a universal code of ethics would unify the medical community and restore society’s trust in its professional care givers.

Another dimension of ethical decision-making in medicine that has received greater attention in recent years is the role of empathy and compassion. The ethical codes that govern health professionals do not specify these characteristics in health care providers, but both care givers and patients increasingly recognize that ethical integrity can be cold and lifeless without emotional rapport. Human beings have feelings as well as capacities for intellectual reflection and analysis. Empathy and compassion help to build trust between care giver and patient, improve communication, and often contribute to healing.

Professional implications

One implication for health professionals is the importance of studying ethical issues during one’s professional education. Many medical, dental, and nursing

KEY TERMS

Empathy—The ability to identify with the feelings or thoughts of another person.

Ethics—A system or set of moral principles; also, the study of values relating to human conduct.

Hippocratic Oath—The ethical oath attributed to Hippocrates that is used as a standard for care by physicians worldwide.

Non-normative ethics—An approach to ethics that emphasizes analysis of moral decisions without making judgments of right or wrong.

Normative ethics—An approach to ethics that attempts to define right and wrong and distinguish between them.

Rapport—A relation between two people that is harmonious and sympathetic.

schools now include courses in their curricula that deal with such topics as moral decision-making, definitions of life and death, the ethical complexities of professional-patient relationships, and the moral safeguards of medical research.

A second implication is recognizing the necessity of interdisciplinary conversation and cooperation. Health professionals can benefit from the insights of scholars in the social sciences, philosophy, theology, law, and history. At the same time, health professionals have much to offer to scholars in other fields gained from their clinical experience.

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Canadian Medical Association. 1867 Alta Vista Drive, Ottawa ON K1G 3Y6. (613) 731-8610x2307 or (888) 855-2555. Fax (613) 236-8864. cmamsc@cma.ca.

Society for Academic Emergency Medicine. 901 North Washington Avenue, Lansing, MI 48906-5137. (517) 485-5484. Fax: (517) 485-0801. saem@saem.org.

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Peggy Elaine Browning

Ethics, medical see **Medical ethics**

Ethics, nursing see **Code of ethics for nurses**

Euthanasia

Definition

Euthanasia is the act of putting a person (or animal) to death painlessly, or allowing a person (or animal) to die by withholding medical treatment in cases of incurable (and usually painful) disease. The word "euthanasia" comes from two Greek words that mean "good death." Euthanasia is sometimes called "mercy killing."

Description

Terms and categories

It is important to distinguish euthanasia from "assisted suicide," which is sometimes used loosely as a synonym for euthanasia. Assisted suicide, which is often called "self-deliverance" in Britain, refers to a person's bringing about his or her own death with the help of another person. Because the other person is often a physician, the act is often called "doctor-assisted suicide." Assisted suicide is illegal everywhere in the United States except the state of Oregon, while euthanasia is illegal in all fifty states. Euthanasia strictly speaking means that the physician or other person is the one who per-

forms the last act that causes death. For example, if a physician injects a patient with a lethal **overdose** of a pain-killing medication, he or she is performing euthanasia. If the physician leaves the patient with a loaded syringe and the patient injects himself or herself with it, the act is an assisted suicide.

Euthanasia is usually categorized as either active or passive, and as either voluntary or involuntary. The first set of categories refers to the means of ending life, and the second set of categories refers to the agent of the decision. Active euthanasia involves putting a patient to death for merciful reasons; passive euthanasia involves withholding medical care, or not doing something to prevent death. In voluntary euthanasia, the patient is the one who wishes to die and has usually requested either active or passive euthanasia. In involuntary euthanasia, someone else makes the decision to terminate the patient's life, usually because the patient is in a **coma** or otherwise unable to make an informed request to die.

Another important term to understand is the so-called doctrine of double effect. This is a legal term that has been underscored by the United States Supreme Court in one of its decisions. The doctrine of double effect states that a medical treatment intended to relieve **pain** but that incidentally hastens the patient's death is still appropriate and legally acceptable. In other words, a doctor who gives a dying patient high doses of morphine to prevent pain, knowing that such high doses may shorten the patient's life by a few days, is protected by the doctrine of double effect.

Historical overview

Although euthanasia has been practiced in various human societies for centuries, it has become a major social issue only in the twentieth century. Some ancient societies allowed infants born with serious birth defects to die, and some allowed the elderly to starve themselves to death as a form of voluntary euthanasia. In addition, it was not unusual for soldiers on the battlefield to give a death blow, or coup de grâce, to a mortally wounded comrade to prevent him from being captured by the enemy as well as to end his suffering. The French phrase literally means "stroke of mercy."

In the nineteenth century, euthanasia became a topic of ethical discussion partly because the discovery of reliable anesthetics and analgesic (pain-killing) medications meant that painless death was now easier to bring about. Prior to this period, the methods of suicide that were available to people were either violent, painful, or uncertain—and sometimes all three. For example, when the heroine of one mid-nineteenth-century French novel commits suicide by taking arsenic, the author describes

her agonizing death in clinical detail. But after the discovery of chloroform, ether, **nitrous oxide**, and similar anesthetics, people began to consider using them to relieve the suffering of the dying as well as the pain involved in surgical operations.

In the twentieth century, a number of social and technological changes made euthanasia a morally acceptable choice to growing numbers of people. The Euthanasia Society of America (which changed its name to the Society for the Right to Die in 1975) was founded as early as 1938. One important change was the increasing size of the elderly population, a development that resulted from the lengthening of the life span brought about by advances in medical science. A second was the invention of respirators, intravenous feeding, dialysis machines, and other means of prolonging a patient's life even in cases of terminal illness. Discomfort at the thought of ending one's life at the mercy of machinery is frequently mentioned in public opinion polls as a justification for euthanasia or assisted suicide. Another important transition was a change in social attitudes in favor of individual freedom and autonomy, rather than emphasizing a person's membership in a family or community. Many people today feel strongly that they are the best judges of their own well-being, and that they should have the "right to die" if necessary.

Viewpoints

Medical professionals

As of 2001, most North American professional societies in the health care professions have stated their opposition to active euthanasia. The American Medical Association (AMA) sponsored the establishment of an Institute for Ethics in the late 1990s, intended to educate American doctors about pain relief, palliative care at the end of life, and alleviation of patients' fears. The AMA has expressed its concern about the expansion of doctor-assisted suicide in the Netherlands—which became legal in April 2001—to include euthanasia without the patient's knowledge or consent. The American Nurses Association (ANA) signed on to the *amicus curiae* (friend of the court) brief submitted by the AMA to the United States Supreme Court in 1997 opposing doctor-assisted suicide. The ANA also stated that the health care professions should emphasize respectful, compassionate, and ethically responsible care at the end of life, including palliative care, so that patients do not seek assisted suicide as an alternative.

KEY TERMS

Active euthanasia—Putting a person to death as an act of mercy, as when a physician gives a patient a lethal dose of a medication.

Assisted suicide—A form of self-inflicted death in which a person voluntarily brings about his or her own death with the help of another, usually a physician, relative, or friend.

Doctrine of double effect—A legal principle that protects physicians treating patients to relieve pain even though the palliative treatment may shorten the patient's life.

Mercy killing—Another term for euthanasia.

Palliative care—A form of health care intended to relieve pain without attempting to cure the disease or condition.

Passive euthanasia—The withholding of medical care, or not taking some other action to prevent death; allowing a person to die.

Self-deliverance—Another term for assisted suicide.

Voluntary euthanasia—A form of euthanasia in which a person asks to die, either by active or by passive euthanasia.

Religious groups

In the United States and Canada, most mainstream Christian and Jewish groups remain opposed to active and involuntary euthanasia, though some permit carefully regulated forms of passive euthanasia. Christian and Jewish bodies emphasize not only God's ultimate power over death and life, and the value of human beings as creatures made in God's image, but also the relationships that bind humans to one another and to God. From this perspective, these religious traditions stand in contrast to the individualism of much of secular culture.

Contemporary Buddhist thought is divided on the issue of euthanasia. Some Buddhist ethicists believe that euthanasia and assisted suicide are both consistent with Buddhist principles, but others disagree. One reason for the disagreement is the fact that Buddhism encountered Western medicine and its ethical dilemmas only relatively recently.

Professional implications

The goals of medicine and health care

Euthanasia and assisted suicide compel medical professionals to reexamine their understanding of the purposes and goals of medical treatment. Those who maintain that preserving life and doing no harm are central to the ethical practice of medicine will have a different view of euthanasia from those who regard the relief of suffering as central.

Professional-patient relationships

The brief that the AMA submitted to the Supreme Court in 1997 included physician-patient relationships among its reasons for rejecting doctor-assisted suicide. Many American and Canadian physicians believe that acceptance of doctor-assisted suicide would undermine the credibility of the health care professions, and destroy trust between doctors and patients. In addition, others have pointed to the potential abuse of a physician's power to end a patient's life.

Interprofessional consultation and cooperation

Euthanasia and assisted suicide are questions that involve public policy, the legal system, and religious institutions as well as the health care professions. The complexity of the social and political considerations, together with the moral concerns, requires better communication among these different groups. One promising development has been the introduction of graduate-level ethics courses that bring together students from law, medical, nursing, and theological schools. Another has been the establishment of research centers and "think tanks" devoted to end-of-life issues.

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Purpose

EP studies, also known as evoked responses, measure the very faint electrical response of the **brain**, brainstem, or peripheral nerves to a mild stimulus, displaying it as a wave on a paper strip or computer monitor. Because the response is of such low amplitude, the responses to many stimuli must be averaged to distinguish the potentials from the background brain activity. The general purpose of this group of tests is to diagnose nerve disorders and to distinguish nonorganic loss of sensation from nerve damage. The tests can locate the site of the lesion and serve to evaluate the condition of a patient's nervous response after treatment or during surgery.

Auditory EP studies are often used to assess the cause of a **hearing loss** or balance problems, especially in children. They are the most common way **hearing loss** is evaluated in **premature infants**. Most auditory EPs record activity from the brainstem, and are therefore called brainstem auditory evoked potentials. This test is also particularly useful in screening for acoustic neuroma (a benign tumor of the nerves of the auditory canal).

Visual EP studies are used to assess eyesight in infants and children, as well as to diagnose disorders of the optic nerve and muscles. They can also distinguish hysterical blindness, a psychiatric disorder, from blindness caused by nerve damage.

Somatosensory EP studies are commonly used in the diagnosis of **multiple sclerosis** and transverse myelitis, although **magnetic resonance imaging** (MRI) has made this test less useful for these purposes. After trauma, somatosensory EP can determine whether loss of sensation in an arm or leg is due to injury in the brain or **spinal cord**.

Auditory, visual, or somatosensory testing can detect tumors and other abnormalities affecting the brain and spinal cord, assess brain stem function in **coma**, and assist in the determination of brain death. Perhaps the most prominent future role of this group of tests is the monitoring of brain activity and signals from the nerves during surgery on the brain, spine, or carotid region, and during **general anesthesia**.

Precautions

There are several benign conditions that can affect the results of evoked potential studies. Visual EP tests should not be performed on persons having severe nearsightedness. Auditory EP studies are contradicted for persons having excessive earwax or severe inflammation of the middle ear. All three types of tests can be adversely affected by muscle spasms in the head or neck of the patient.

Evoked potential studies

Definition

Sensory evoked potential (EP) studies are the measurement of the electrical response of nervous tissue to auditory, visual, and somatosensory stimulation.

KEY TERMS

Amplitude—The distance from the baseline to the peak of the sensory response; represents the approximate number of healthy nerves available.

Latency—The amount of time between stimulus and sensory nerve response.

Waveform—The shape of the electrical response of the brain, brainstem, or peripheral nerve as recorded by the active electrode.

Description

The test is often performed by an electrodiagnostic technologist, a nurse, or another allied health professional. It begins with the location and marking of specific spots on the patient's head for placement of electrodes. These spots are cleaned, and an adhesive conducting paste is applied. Cup electrodes are attached. For somatosensory EP, spots on the arm or leg are also marked and cleaned; electrodes may be taped in place. The patient sits or reclines in a chair throughout the tests.

For a visual EP, electrodes are attached to the scalp over the brain region responsible for **vision**. The patient focuses on a TV screen that displays a checkerboard pattern. The eye not being tested is covered with a patch. For children or others whose attention may wander, goggles are used which show the pattern to one eye at a time. Each eye is usually put through two series of tests where hundreds of sample recordings are collected for averaging. The entire procedure takes approximately one hour.

For auditory EP, electrodes are placed on the top of the head and on the earlobe of the ear being tested. Headphones are used to deliver a series of clicks to one ear at a time. A masking or static sound is played into the other ear. Each ear is usually put through two trials, and the entire procedure takes approximately one hour.

For somatosensory EP, electrodes for recording are placed on the scalp and along the spinal cord, while electrodes for delivering a mild electrical shocks are placed on either the arm or the leg. The shock is not painful, but may cause some twitching and tingling. Multiple trials are done for each nerve tested, and the entire procedure can take up to three hours, if both arm and leg nerves are evaluated.

Preparation

The patient's hair should be clean, with no gels, sprays, or other preparations applied. Jewelry should be removed.

Aftercare

After the tests, the electrodes are removed with acetone and the scalp is cleaned. The patient can resume normal activities.

Complications

There are no complications that result from this group of tests.

Results

Results are recorded as waveforms, either on paper or a digital display. For somatosensory or visual EPs, the traces are displayed so a negative potential at the active electrode produces an upward deflection in the wave. Brainstem auditory EPs, in contrast, are recorded such that a positive potential at the active electrode produces an upward deflection. By using these conventions, the waves of interest are always recorded as upward deflections. In general, EP tests produce both latency (speed of conduction) and amplitude (electrical strength of response) results, with the latency measurements more often clinically significant. Results are often compared to age-specific normal values that are established at each laboratory, with a value of 2.5 to 3.0 standard deviations from the mean interpreted as abnormal. Comparisons between data collected from the left and right sides of an individual patient are also informative.

Health care team roles

Evoked potential studies are often performed by specially trained electrodiagnostic technologists. Training for such a position can be on the job but often involves study at a one- to two-year college or vocational program. A typical program would include:

- human anatomy and physiology
- neurology and neuroanatomy
- neurophysiology
- medical terminology
- computer technology and instrumentation

Certification of electrodiagnostic technologists specializing in evoked potentials and the related area of **electroencephalography** is available through the

American Board of Registration of Electroencephalographic and Evoked Potential Technologists.

A physician such as neurologist, neurosurgeon, or internist does the final review and diagnosis based on the results of EP studies. The doctor can be present for the testing or may review saved tracings. Other health care professionals, such as nurses, aid in **patient education** concerning this procedure.

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Evoked responses see **Evoked potential studies**

Ewing's sarcoma see **Sarcomas**

Exercise

Definition

Exercise is physical activity that is planned, structured, and repetitive for the purpose of conditioning any part of the body or to improve performance in a specific task. Exercise is utilized to improve health, main-

tain fitness, and is important as a means of physical rehabilitation.

Purpose

Exercise is used in preventing or treating coronary **heart** disease, **osteoporosis**, weakness, diabetes, **obesity**, and depression. Range of motion is one aspect of exercise important for increasing or maintaining joint function. Strengthening exercises provide appropriate resistance to the muscles and increase endurance and strength. **Cardiac rehabilitation** exercises are developed and individualized to improve the **cardiovascular system** for prevention of and rehabilitation from cardiac disorders and diseases. A well-structured exercise program can improve general health by increasing strength, endurance, balance, and confidence. Furthermore, an exercise program may delay or minimize the effects of disease and aging. The benefits of exercise not only extend into the areas of physical health, but also enhance emotional well-being.

Precautions

Before beginning any exercise program, evaluation by a physician is recommended to rule out any potential health risks. Once health and fitness are determined and any or all physical restrictions identified, the exercise program should be under the supervision of a health care professional, especially when used as a form of rehabilitation. If symptoms of dizziness, nausea, excessive shortness of breath, or chest **pain** are present during any exercise program, the individual should stop the activity and inform the physician before resuming activity. Exercise equipment must be checked often for wear and durability.

Description

There are two types of rehabilitation to restore or improve function: cardiac and physical rehabilitation.

Cardiac rehabilitation

Exercise is very helpful in prevention of and rehabilitation from cardiac disorders and disease. With an individually designed exercise program set at a safe level, **heart failure** patients can improve their fitness levels substantially. Endurance or aerobic routines, such as running, brisk walking, cycling, or swimming, increase the strength and efficiency of the muscles of the heart. The increase in endurance should also translate into a generally more active lifestyle.



Exercise can be used to restore muscle strength after an illness or injury. A computer monitors this man's performance and provides a visual display of his progress. (Photograph by Geoff Tompkinson. Science Source/Photo Researchers. Reproduced by permission.)

Physical rehabilitation

Physical rehabilitation deals with improving function in specific individuals who have functional impairments secondary to disease, injury, or disuse. This is accomplished by **therapeutic exercise** that focuses on strengthening, coordination, balance, and endurance training. Both types of rehabilitation can incorporate range of motion exercises and strengthening exercises.

RANGE OF MOTION EXERCISE. Range of motion exercise refers to activity aimed at improving movement of a specific joint. This motion is influenced by several structures: configuration of bone surfaces within the joint; joint capsule; ligaments; and muscles and tendons acting on the joint. There are three types of range of motion exercises: passive, active, and active assistive. Passive range of motion is movement applied to the joint solely by another

person or persons or by a passive motion machine. When passive range of motion is applied, the joint of the individual receiving exercise is completely relaxed while the outside force takes the body part, such as a leg or arm, throughout the available range. Injury, surgery, or immobilization of a joint may affect the normal joint range of motion. Active range of motion is movement of the joint provided entirely by the individual performing the exercise. In this case, there is no outside force aiding in the movement. Active assistive range of motion is described as the joint receiving partial assistance from an outside force. This range of motion may result from the majority of motion applied by the exerciser or by the person or persons assisting the individual. It may also be a half-and-half effort on the joint from each source.

STRENGTHENING EXERCISE. Strengthening exercise increases muscle strength and mass, bone strength, and

the body's **metabolism**. It can help attain and maintain proper weight and improve body image and self-esteem. A certain level of muscle strength is needed to do daily activities, such as walking, running, and climbing stairs. Strengthening exercises increase muscle strength by putting more strain on a muscle than it is normally accustomed to receiving. This increased load stimulates the production of **proteins** inside each muscle cell that allow the muscle as a whole to contract with greater force. There is evidence indicating that strength training may be better than aerobic exercise alone for improving self-esteem and body image. Weight training allows immediate feedback through observation of progress in muscle growth and improved muscle tone.

Strengthening exercises can be further categorized in terms of the mode of resistive training, such as isometric, isotonic, or isokinetic.

ISOMETRIC EXERCISE. During isometric exercises muscles contract; however, there is no motion in the affected joints. The muscle fibers maintain a constant length throughout the entire contraction. The exercises are usually performed against an immovable surface or object, such as pressing the hand against the wall. The muscles of the arm are contracting but the wall is not moving as a result of the physical effort. Isometric training is effective for developing total strength of a particular muscle or group of muscles. It is often used for rehabilitation, since the exact area of muscle weakness can be isolated and strengthening can be administered at the proper joint angle. This kind of training can provide a relatively quick and convenient method for overloading and strengthening muscles without any special equipment and with little chance of injury.

ISOTONIC EXERCISE. Isotonic exercise differs from isometric exercise in that there is movement of the joint during the **muscle contraction**. It is exercise with a fixed resistance and variable speed. A classic example of an isotonic exercise is weight training with dumbbells and barbells. As the weight is lifted throughout the range of motion, the muscle shortens and lengthens. Calisthenics are also an example of isotonic exercise. These would include chin-ups, push-ups, and sit-ups, all of which use body weight as the resistance force.

ISOKINETIC EXERCISE. Isokinetic exercise utilizes machines that control the speed of movement within the range of motion. Isokinetic exercise attempts to combine the best features of both isometrics and weight training. It is resistive exercise utilizing a fixed speed and variable resistance. It provides muscular overload at a constant preset speed while the muscle mobilizes its force through the full range of motion. For example, an isokinetic stationary bicycle set at 90 revolutions per minute means

that no matter how hard and fast the exerciser works, the isokinetic properties of the bicycle will allow the exerciser to pedal only as fast as 90 revolutions per minute. Machines known by such brand names as Cybex and Biodex provide isokinetic resistance; they are generally used by physical therapists and are not readily available to the general population.

Preparation

A **physical examination** by a physician is important to determine if strenuous exercise is appropriate or detrimental for the individual. Prior to the exercise program, proper stretching is important to prevent the possibility of soft tissue injury resulting from tight muscles, tendons, ligaments, and other joint-related structures.

Aftercare

Proper cool-down after exercise is important in reducing the occurrence of painful muscle spasms. It has been documented that proper cool-down may also decrease frequency and intensity of muscle stiffness the day following any exercise program.

Complications

Improper warm-up can lead to muscle strains. Furthermore, overexertion with insufficient rest time between exercise sessions may lead to musculoskeletal injury. Stress **fractures** are also a possibility if activities are strenuous over long periods of time. Although exercise is safe for the majority of children and adults, there is still a need for further research to evaluate potential risks of strength training in children. There is a possibility of exercise "burnout," or over-training, if the exercise program is not varied and adequate rest periods are not taken between exercise sessions.

Health care team roles

Significant health benefits are obtained by including a moderate amount of physical exercise in the form of an exercise prescription. Physical activity plays a positive role in preventing disease and improving overall health status. People of all ages, both male and female, benefit from regular physical activity. Regular exercise also provides significant psychological benefits and improves quality of life.

Patient education

Nurses and other allied health professionals can educate their patients by using videotapes, manuals, and Web-based literature. However, it would be recommended that instructional workshops or classes be set up in an

KEY TERMS

Aerobic—Exercise training that is geared to provide a sufficient cardiovascular overload to stimulate increases in cardiac output.

Calisthenics—Exercise involving free movement without the aid of equipment.

Endurance—The time limit of a person's ability to maintain either a specific force or power involving muscular contractions.

Osteoporosis—A disorder characterized by loss of calcium in the bone, leading to thinning of the bones. It occurs most frequently in postmenopausal women.

Exercise electrocardiogram see **Stress test**

Exercise stress test see **Stress test**

Exercise thallium test see **Thallium heart scan**

External fetal monitoring see **Electronic fetal monitoring**

Extracorporeal shock-wave lithotripsy (ESWL) see **Lithotripsy**

Eye and orbit ultrasounds see **Ophthalmologic ultrasounds**

effort to appropriately evaluate patient safety and mechanics during exercise. Physical therapists often work with patients who are recovering from cardiac diseases or strokes.

Training

For nurses and allied health professionals, certifications are available to qualified candidates. Usually a period of study and testing is required in becoming certified. The American College of Sports Medicine provides well established certification programs.

Resources

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American College of Sports Medicine. P.O. Box 1440, Indianapolis, IN 46206-1440. (317) 637-9200.

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Mark Damian Rossi, Ph.D, P.T., C.S.C.S.

Eye examination

Definition

An eye examination is a series of tests performed by an ophthalmologist or an optometrist to determine if there are any pre-existing or potential problems with a patient's **vision**.

Purpose

Eye examinations measure a person's ocular health and visual status, in order to detect abnormalities in the components of the visual system, and to determine how well the person can see. Eye exams may also reveal the presence of non-eye diseases such as high **blood pressure** or diabetes.

Infants should be examined to detect any physical abnormalities. If a problem is noted the infant can be further examined, generally by a pediatric ophthalmologist. A child without symptoms should have an eye exam before age three. Early exams are important because some conditions may result in permanent problems with vision. For example, amblyopia, more commonly known as a lazy eye, should be corrected before permanent damage occurs, usually between the ages of six and nine. If a child continues to be symptom-free, the second exam should take place before first grade. After first grade, the American Optometric Association recommends an eye exam every two years until age 19. From ages 19–40, an examination every two to three years is recommended, and from ages 41–60, an exam every two years is recommended. After that, healthy persons without risk factors are recommended to have annual examinations. Doctors should advise patients at risk for eye disease that they

may need more frequent checkups. Persons with visual problems should seek medical attention right away.

Precautions

The examiner, who may be an O.D., D.O., M.D., ophthalmic nurse, ophthalmic assistant, or ophthalmic technician, should log any medications the patient is taking and any existing health conditions. Some medications can affect vision or interfere with the eyedrops used during the exam. Certain types of eyedrops should not be prescribed if the patient has **asthma**, **heart** problems, or other conditions.

The patient may need transportation if the eyes are dilated. Physicians may advise patients to wear dark glasses to decrease the glare from strong light until the effects of the medication are sufficiently diminished.

Description

An eye examination is performed by an optometrist (who has an O.D. degree) or an ophthalmologist. Ophthalmologists either have an M.D. or a D.O. (doctor of osteopathy) degree. An eye examination, given by an ophthalmologist or optometrist with assistance from ophthalmic nurses, assistants and technicians, costs about \$100 and may or may not be covered by insurance. It begins with a patient history and continues with a series of primary tests. Additional specialized tests are administered as needed. The primary tests can be divided into two groups: those that evaluate the physical state of the eyes and surrounding areas; and those that measure the ability to see. Some variation exists, but most eye examiners and their assistants take a patient history and perform a standard set of primary tests.

Patient history and initial observations

The ophthalmic nurse, assistant, or technician will take eye and medical histories that include the patient's chief complaint, any past eye disorders, current medications, any family history of eye disorders, and any systemic disorders the patient may have. Sample questions may include "How is your vision?" or "Do you have any allergies?" Examiners also should ask about the patient's lifestyle. This information may modify prescriptions. For example, a construction worker needs protective eyewear. Patients should be encouraged to bring all of their currently used corrective lenses to the exam (contacts and glasses). This allows the ophthalmic staff to determine the prescription using a lensometer, and allows the examiner to determine the efficacy of the current prescription.



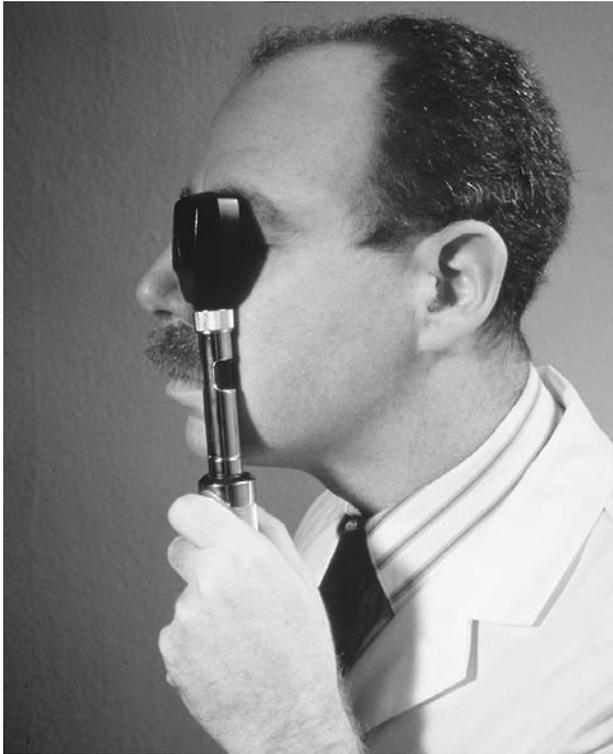
A doctor examines a patient's eyes using an ophthalmoscope. (Photograph by Andy Levin. Science Source/Photo Researchers. Reproduced by permission.)

Visual acuity tests

Visual acuity measures how clearly the patient can see. The examiner measures each eye separately, with and without the current prescription. Examiners use a Snellen eye chart with lines of different-sized letters. Each line has a number at the side denoting the distance from which a person with normal vision can read that line. Other charts are available for children or anyone unfamiliar with the Roman alphabet. Charts should be placed at the recommended distance (usually 20 feet, or 6 m) from the patient. At that distance, persons with normal vision can read the line marked 20/20, and are said to have 20/20 vision. Patients who cannot read that line are assigned a ratio based on the smallest line they can read. The first number (numerator) of the ratio is the distance between the chart and the patient, and the second number (denominator) is the distance where a person with normal vision would be able to read that line. The ratio 20/40 means the patient sees at 20 feet what people with normal vision can see at 40 feet.

When a patient is unable to read any of the lines, the patient is moved closer until the line with the largest letters is readable. A ratio of 5/200 means the person being tested can see at five feet (1.8 m) what a normal person can see at 200 feet (60 m).

If a patient can't read the chart at all, the examiner may hold up fingers and ask the patient to count them at various distances. The examiner records the result as "counting fingers" at the distance of recognition. If the patient cannot count the fingers at any distance, the examiner determines if the patient can see hand movements. If so, the result is recorded as "hand movements." If not, the examiner determines if the patient can detect light from a penlight. Detection of light and its direction is recorded as "light projection." If the patient can detect



Eye examiner using an ophthalmoscope. (Phototake, NYC. Reproduced by permission.)

the light but not its direction, the result is recorded as “light perception.” If the patient cannot detect the light at all, the result is recorded as “no light perception.”

Eye movement examination

The examiner asks the patient to follow an object (often the examiner’s finger) left, right, up, down, and in all four diagonal directions in order to ensure that the eyes are capable of the full range of motion and that the motions are smooth. Next is a peripheral visual field test. The examiner asks the patient to stare at an object, then quickly covers one eye and notes any movement in the eye that remains uncovered. This procedure is repeated with the other eye. This, and another similar test, helps detect an eye turn or problem with fixation. The examiner may also have the patient look at a pen and follow it as it is moved close to the eyes to check convergence.

Iris and pupil examination

The doctor or assistant checks the pupil’s response to light and accommodation (whether it dilates and constricts appropriately). The iris is viewed for symmetry and overall physical appearance. The iris is checked more thoroughly during the slit lamp examination.

Refraction examination

If a patient has visual acuity less than 20/20, the examiner will determine the refractive error and prescribe corrective lenses. To determine refractive error, the examiner utilizes a phoropter. A phoropter is an instrument equipped with many lenses. The examiner uses them to test many combinations of corrections in order to learn which correction allows the patient to see the eye chart most clearly. The phoropter also contains prisms, and sometimes the examiner will intentionally make the patient see double. This maneuver may help in determining a slight eye turn, as well as comparing the acuity of the right and left eye. The exam assesses far (distance) vision and near (reading) vision.

Examiners can also determine a lens prescription by utilizing an automated refracting device. The device measures the necessary refraction by shining a light into the eye and scanning the reflected light. Another way to obtain a prescription is using a hand-held retinoscope. As in the automated method just mentioned, the doctor shines a light in the patient’s eyes and can determine an objective prescription. This is helpful in young children or infants.

Physicians or assistants may instill eyedrops in the patient’s eyes before refraction. The drops relax accommodation so that the refraction is more accurate. This is helpful in children and people who are farsighted.

Ophthalmoscopic examination

These observations are best accomplished after dilating the pupils and require an ophthalmoscope. The ophthalmoscope most frequently used is called a direct ophthalmoscope. It is a hand-held illuminated 15X multi-lens magnifier that allows the examiner to view the back of the inside area of the eye (the fundus). The retina, **blood vessels**, optic nerve, and other structures are examined.

Slit lamp examination

The slit lamp (biomicroscope) is a **microscope** with an adjustable light source. This instrument magnifies and illuminates the external structures of the eyes. The lid and lid margin, cornea, iris, pupil, conjunctiva, sclera, and lens are examined. The slit lamp is also used in contact lens evaluations. With the use of a condensing lens, the biomicroscope provides an excellent view of the internal structures of the eye.

Visual field measurement

A perimeter, an instrument for measuring visual fields, is a hollow hemisphere equipped with a light

source that projects dots of light over the inside surface of the hemisphere. The patient's head is positioned so that the eye being tested is at the center of the sphere and 33 cm. (about 13 in.) from all points on the hemisphere's inside surface. The patient stares straight ahead at an image on the center of the surface of the perimeter, and signals whenever they detect a light with their peripheral, or side, vision. The perimeter records whether flashes are seen or missed and maps the patient's field of vision.

Intraocular pressure (IOP) measurement

Small probes called tonometers are used to measure IOP. Contact tonometers contact the eyeball directly. A colored anesthetic eyedrop is usually instilled immediately before this test. Other tonometers (noncontact tonometers) measure pressure by expelling a puff of air toward the eyeball from a very short distance. The noncontact tonometers are often not as accurate as the contact tonometers.

Additional tests

In addition to the primary tests already described, the examiner should observe the general health of the eye and structures around it. Depending upon the results of all the primary tests, other tests may also be necessary. These can include, but are not limited to, binocular indirect ophthalmoscopy, gonioscopy, color vision tests, and contrast sensitivity. The patient may have to return for additional visits.

Aftercare

Seeing clearly does not necessarily mean the eyes are healthy. Patients should be advised that regular checkups can detect abnormalities. Patients also should be examined if they notice a change in vision, eyestrain, blur, flashes of light, a sudden onset of floaters, distortion, double vision, redness, **pain** or discharge.

External observations

INITIAL OBSERVATIONS AND SLIT LAMP EXAM. Some general observations the doctor may be looking for include: head tilt; drooping eyelids; eye turns; red eyes; eye movement; the iris size, shape, and color; clarity of the cornea, anterior chamber, and lens. The anterior chamber lies behind the cornea and in front of the iris. If it appears cloudy or if cells can be seen in it during the slit lamp exam, an inflammation may be present. A narrow anterior chamber may place the patient at risk for **glaucoma**. Any abnormality indicates a need for medical care.

Internal observations

OPHTHALMOSCOPIC EXAM. The observations include, but are not limited to, the retina, **blood** vessels, optic nerve, macula, and fovea. The macula is a 3–5 mm area of the central retina and is responsible for central vision. The fovea is a small area located within the macula and is responsible for sharp vision. When a person looks at something, they are directing the fovea at the object. Changes in the macular area can be observed with the ophthalmoscope. Retinal tears or detachments can also be seen. An abnormality may indicate a need for medical care.

Visual ability

VISUAL ACUITY. The refraction will determine the refractive status for each eye. Different materials for glasses or **contact lenses** may be suggested.

VISUAL FIELDS. A normal visual field extends about 60° upward, about 75° downward, about 65° toward the nose, and about 100° toward the ear. There is one blind spot close to the center, which corresponds to the area of the optic nerve, which has no light-sensing cells. Defects in the visual field signify damage to the retina, optic nerve, or the neurological visual pathway. An abnormality may indicate a need for medical care.

Results

An eye examination can help maintain or restore clear, comfortable vision. It also aids in disease prevention. After an examination, patients should be more aware of their ocular health and general health.

Health care team roles

Nursing and allied health professionals play an important role in the eye examination and follow-up. Ophthalmic assistants and technicians facilitate the examination by logging the pertinent patient history.

Depending on skill level, ophthalmic assistants may perform measurement of visual acuity under both low and high illumination; assessment of ocular motility and binocularity; and assessment of visual fields and measurement of IOPs with tonometers.

Advanced and intermediate level ophthalmic technicians perform refractions and determine the patient's depth perception. These professionals may also perform corneal topography (mapping).

Some of these professionals seek certification through the American Board of Opticianry/National Contact Lens Examiners and other organizations. These organizations offer seminars and testing that inform pro-

KEY TERMS

Amblyopia—Decreased visual acuity, usually in one eye, in the absence of any structural abnormality in the eye.

Conjunctiva—The mucous membrane that covers the white part of the eyes (sclera) and lines the eyelids.

Cornea—Clear outer covering of the front of the eye.

Floaters—Translucent specks that float across the visual field, due to small objects floating in the vitreous humor.

Fundus—In the eye, fundus refers to the back area that can be seen with the ophthalmoscope.

Glaucoma—Glaucoma results in optic nerve damage and a decreased visual field and blindness if not treated. It is usually associated with increased IOP, but that is not always the case. The three factors associated with glaucoma are increased IOP, a change in the optic nerve head, and changes in the visual field.

Gonioscope—An instrument used to inspect the eye (e.g., the anterior chamber). It consists of a magnifier and a lens equipped with mirrors; it's placed on the patient's cornea.

Iris—The colored ring just behind the cornea and in front of the lens that controls the amount of light sent to the retina.

Macula—The central part of the retina where the rods and cones are densest.

Ophthalmoscope—An instrument designed to view structures in the back of the eye.

Optic nerve—The nerve that carries visual messages from the retina to the brain.

Pupil—The circular opening that looks like a black hole in the middle of the iris.

Retina—The inner, light-sensitive layer of the eye containing rods and cones; it transforms the image it receives into electrical messages which are then sent to the brain via the optic nerve.

Sclera—The tough, fibrous, white outer protective covering that surrounds the eye.

Slit lamp—A microscope that projects a linear slit beam of light onto the eye; it allows viewing of the conjunctiva, cornea, iris, aqueous humor, lens, and eyelid.

Tonometer—An instrument that measures intraocular pressure (IOP).

professionals of technological advances in refraction and eyeglass manufacturing.

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American Academy of Ophthalmology. PO Box 7424, San Francisco, CA 94120-7424. (415) 561-8500. <<http://www.eyenet.org/>>.

American Optometric Association. 2420 North Lindbergh Boulevard, St. Louis, MO 63141. (800) 365-2219. <<http://www.aoanet.org/>>.

Joint Commission on Allied Health Personnel in Ophthalmology. 2025 Woodlane Drive St. Paul, MN 55125-2995. (888) 284-3937. <<http://www.jcahpo.org/>>.

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"Optometric Clinical Practice Guideline: Comprehensive Adult Eye and Vision Examination." *American Optometric Association Online* <<http://www.aoanet.org/cpg-1-caeve.html>>.

Mary Bekker

Eye glasses

Definition

Eye glasses are devices that correct refractive errors in **vision**. Eye-glass lenses are mounted in frames that position the lenses in front of the eyes.

Purpose

Eye glasses are used to correct or improve the vision of patients with nearsightedness (**myopia**), farsightedness (**hyperopia**), **presbyopia**, and **astigmatism**. They are also utilized to correct refractive errors after cataract surgery.

Precautions

Ophthalmic assistants, technicians, and nurses take a careful patient history to determine patient sensitivities to certain frame materials. Patients allergic to certain plastics should avoid frames or lenses manufactured from that type of plastic. Patients allergic to nickel should not wear Flexon frames. Ophthalmic personnel also address

the patient's lifestyle. People at risk for accidents due to professions, sports, or hobbies are advised to choose plastic lenses, preferably polycarbonate. Also, people at risk of receiving electric shocks should avoid metal frames.

Description

Eyes are examined by optometrists (O.D.s) or ophthalmologists (M.D.s), with assistance from ophthalmic assistants, technicians, or nurses. If necessary, prescriptions are given to patients for glasses. An optician generally makes the glasses. Eye glasses can be created in an in-office laboratory or an off-site manufacturing lab.

Patients whose eyes have refractive errors do not see clearly without glasses. This is due to the fact that the light emitted by the objects they see does not come into focus on their retinas. For farsighted (hyperopic) patients, images come into focus behind the retina; for nearsighted (myopic) patients, images come into focus in front of the retina.

Lenses

Lenses work by changing the direction of light so that images come into focus on the retina. The greater the index of refraction of the lens material and the greater the difference in the curvature between the two surfaces of the lens, the greater the change in direction of light that passes through it, and the greater the correction.

Lenses can be unifocal, with one correction for all distances, or they can correct for more than one distance (multifocal). One type of multifocal lens, the bifocal, has an area of the lens (usually at the bottom) that corrects for near objects (about 14 in [35.5 cm] from the eyes); the remainder of the lens corrects for distant objects (about 20 ft [6 m] from the eyes). Another type of multifocal lens, a trifocal, has an area in-between that allows correct viewing of intermediate objects (usually about 28 in [71 cm]), such as computer screens or automobile dashboards.

The greater the index of refraction, the thinner the lens can be. Lenses are made from either glass or plastic (hard resin). Plastic is lightweight and more impact-resistant than glass. Glass is scratch-resistant and provides the best visual acuity. In recent years, however, glass that is thinner and more impact-resistant has been developed.

A plastic called CR-39, introduced in the 1960s, is the plastic of choice of most opticians. Today, eyeglass wearers can also choose between polycarbonate, which is the most impact-resistant material available for eyewear, and polyurethane, which has exceptional optical qualities

and an index of refraction of up to 1.66, much higher than the conventional plastics. Polycarbonate is the most easily scratched of the plastics used for lenses, so an anti-scratch coating is always applied to the lenses. In addition, an improvement in the polycarbonate manufacturing process now produces clear lenses—previously all polycarbonate lenses had a bluish cast.

Patients with high prescriptions should consider high index materials. Aspheric lenses also are useful for high prescriptions. They are flatter and lighter than conventional lenses. These lenses make it possible for patients with higher prescriptions and thick lenses to wear metal and titanium frames, when formerly they could wear only plastic frames.

There are many lenses and lens-coating options for individual needs, including coatings that block harmful ultraviolet (UV) light or UV and blue light. Such coatings are not needed on polycarbonate lenses, which already have UV protection.

There are anti-scratch coatings that increase the surface hardness of lenses and anti-reflective (AR) coatings that eliminate almost all glare. AR coatings may be particularly helpful to people who use computers or drive at night. Polarized lenses that block reflected light also allow better vision in sunny weather. Photosensitive (photochromic) lenses that darken in bright light are handy for people who do not want to carry an extra pair of sunglasses. Photochromic lenses are available in glass, plastic, and polycarbonate.

Frames

Frames can be made from metal or plastic, and they can be rimless. There is an almost unlimited variety of shapes, colors, and sizes. The type and degree of refractive correction in the lens determine to some extent the type of frame most suitable. Some lenses are too thick to fit into metal rims, and some large-correction prescriptions are best suited to frames with small-area lenses, since a smaller lens area minimizes the thickness of a lens with a large correction for myopia.

Rimless frames are the least noticeable type, and they are lightweight because they have only an upper rim to which the nosepiece and temples are attached. The lenses are held in place in the frames by nylon string that encircles the bottom of the lenses and attaches to the upper rim.

Metal frames are less noticeable than plastic and are lightweight. They are available in solid gold, gold-filled, anodized aluminum, nickel, silver, stainless steel, titanium, and titanium alloy. Until the late 1980s, when titanium-nickel alloy and titanium frames were introduced,

metal frames were, in general, more fragile than plastic frames. The titanium frames, however, are very strong and lightweight. An alloy of titanium and nickel, called Flexon, is strong and lightweight and returns to its original shape after being twisted or dented. It is not perfect for everyone, though, because some patients are sensitive to nickel.

Plastic frames are durable, can accommodate just about any lens prescription, and are available in a wide range of prices. They are also offered in a variety of plastics (including acrylic, epoxy, cellulose acetate, cellulose propionate, polyamide, and nylon) and in different colors, shapes, and levels of resistance to breakage. Epoxy frames are resilient and return to their original shape after being deformed, so they do not need to be adjusted as frequently as other types. Nylon frames are almost unbreakable. They revert to their original shape after extreme trauma and distortion; because of this property, though, they cannot be readjusted after they are manufactured.

Preparation

Before eye glasses are prescribed, an optometrist or an ophthalmologist examines the patient's eyes. The exam begins with the physician or ophthalmic assistant taking a detailed medical history from the patient. Then the physician, or in some cases a highly trained ophthalmic assistant, begins the ocular examination by measuring visual acuity and refracting.

During the exam, the physician or ophthalmic assistant also determines ocular motility and alignment, near-point of convergence, near fusional vergence amplitudes, relative accommodation measurements, and accommodative amplitude and facility. Corrective lens prescriptions, if necessary, are then given to patients.

To be correctly fitted for eye glasses, the distance between the patient's eyes (PD) is measured, so that the optical centers of the lenses correlate with the pupillary axis. Bifocal heights also are measured with the chosen frame in place and adjusted on the patient. If not positioned correctly, the patient may experience eyestrain or will not have the optimal visual results.

After the eye glasses are ready for the patient, the dispensing optician, physician, or ophthalmic assistant ascertains the proper fit to ensure the best vision and comfort.

Patients may sometimes need up to two weeks to adjust to a new prescription. However, if problems persist the glasses should be rechecked.

Presbyopic patients may choose over-the-counter reading glasses instead of professionally prescribed eye

glasses. These patients should be advised that the distance between the lenses in these glasses is for a "standard" person. If a patient is sensitive or has more closely set eyes, for example, blurred vision and headaches may result from the use of these glasses. In addition, the prescriptions are equal for both eyes, these glasses do not correct for astigmatism, and they are made with cheaper lens and frame materials. As a result, these over-the-counter reading glasses may not be a patient's best option.

Aftercare

Patients are advised to return to the physician's office if they experience headaches or blurred vision. If these symptoms do not occur, they are instructed to return to the office for a regular **eye examination** in one or two years.

Complications

Matching an individual with the correct frames and lenses usually avoids complications. Ensuring that the lenses are positioned properly will greatly reduce the likelihood of headaches and blurred vision. A thorough patient history minimizes the chance that the patient will select a frame that causes sensitivities or lenses that could harm his or her eyes.

Results

It is normally expected that people will achieve 20/20 vision while wearing corrective lenses.

Health care team roles

Nursing and allied health professionals assist with eyeglass examination and fitting, and with **patient education**. With advances in refracting technology, technicians now have duties that previously were performed only by optometrists or ophthalmologists.

Ophthalmic assistants and technicians facilitate the fitting process by recording the pertinent patient history and measuring the eye for the proper lens fit. Advanced- and intermediate-level ophthalmic technicians perform refractions and determine the patient's depth perception. These professionals also may perform corneal topography (mapping). Some of these professionals seek certification through the American Board of **Opticianry** and the National Contact Lens Examiners or other organizations. These organizations offer seminars and testing that help professionals keep current with technological advances in refracting and eyeglass manufacturing.

Patient education

Patients are told that it may take up to two weeks to adjust to new eye glasses. They also are advised to return to the physician's office if they experience blurry vision and headaches.

AR-coating and other specialized lens coatings need special care to maintain the coat and prevent scratching. Patients are told to carefully clean their lenses with special cloths and cleaners obtained from the physician or optician, never to use paper towels or harsh soap.

Training

Optometrists and ophthalmologists receive training in **optometry** or during a medical residency for these procedures. In some practices, ophthalmic personnel complete part of the eye exam. Ophthalmic assistants, technicians, and nurses can complete specialized training from certified programs to learn how to refract and complete other parts of the eye exam. Opticians receive training in creating lenses.

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American Academy of Ophthalmology. PO Box 7424, San Francisco, CA 94120-7424. (415) 561-8500. <<http://www.eyenet.org>>.

American Board of Opticianry and the National Contact Lens Examiners. 6506 Loisdale Rd., Suite 209, Springfield, VA 22150. (703) 719-5800. <<http://www.abo.org>>.

American Optometric Association. 2420 North Lindbergh Boulevard, St. Louis, MO 63141. (800) 365-2219. <<http://www.aoanet.org>>.

Contact Lens Association of Ophthalmologists, 721 Papworth Avenue, Suite 206, Metairie, LA 70005. (504) 835-3937. <<http://www.claao.org>>.

Optician Association of America. 10341 Democracy Lane, Fairfax, VA 22030-2521. (800) 443-8997. <www.opticians.org>.

Opticians Association of America. 7023 Little River Turnpike, Suite 207, Annandale, VA 22003. (703) 916-8856. <<http://www.opticians.org>>.

KEY TERMS

Astigmatism—A vision condition that occurs when the cornea is slightly irregular in shape. This irregularity prevents light from focusing properly on the retina.

Cornea—The clear outer covering of the front of the eye.

Index of refraction—A constant number for any material that is an indicator of the degree of the bending of the light caused by that material.

Lens—A device that bends light waves.

Polycarbonate—A very strong type of plastic often used in safety glasses, sport glasses, and children's eye glasses. Polycarbonate lenses have approximately 50 times the impact resistance of glass lenses.

Presbyopia—A condition affecting people over the age of 40 where the system of accommodation that allows focusing of near objects fails to work because of age-related hardening of the lens of the eye.

Retina—The inner, light-sensitive layer of the eye containing rods and cones; it transforms the image it receives into electrical messages sent to the brain via the optic nerve.

Ultraviolet (UV) light—Part of the electromagnetic spectrum with a wavelength just below that of visible light. It is damaging to living material, especially eyes and DNA.

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Mary Bekker

Eyedrop instillation

Definition

Eyedrop instillation is the dispensation of a sterile ophthalmic medication into a patient's eye.

Purpose

Eyedrops may be instilled to treat a number of eye disorders or to anesthetize an eye before treatment. An ophthalmic assistant, technician, nurse or physician instills eyedrops during a routine **eye examination** or during treatment for ocular disease. Anesthetic eyedrops are instilled before surgery on the eye. Sometimes ophthalmic professionals instill dyes to help diagnose ocular disease, either by traditional methods, or by intravenous administration, or by the use of strips.

Eyedrops or ophthalmic solutions are used to treat **glaucoma**, uveitis, allergic reactions and infections. Dilatory eyedrops may be instilled during an examination to achieve a better view of the retina.

Precautions

Health care professionals need to ensure that the proper drug is being instilled and that it has not passed its expiration date. Some ophthalmic solutions may be contraindicated or can cause allergic reactions. Eyedrop containers should be clearly labeled and checked before instillation.

The eyedrops should also be monitored for discoloration or sedimentation, which indicate that the ophthalmic solution is decomposing. In that case, a new dose of medicine should be obtained and the affected bottle discarded.

Moreover, the ophthalmic staff member dispensing the drops should double-check the patient's identification and chart to ensure the correct dose is being instilled into the correct eye. The dispensing ophthalmic professional should never touch the tip of the eyedropper to the patient's eye. Touching will contaminate the remaining medication. In case of direct eye contact, the medication should be thrown away.

Description

Sterilization is an important part of eyedrop instillation. Before eyedrops are instilled, the ophthalmic assistant, technician, nurse, optometrist, or ophthalmologist should wash his or her hands thoroughly. The ophthalmic staff member then should gather all necessary supplies. For some eyedrops, the dispenser may want to warm the

drops to body temperature by holding the bottle in his or her hand for about two minutes.

Next, the dispenser should position the patient correctly. The patient should sit back in the examination chair with their head slightly hyperextended. Once the patient is correctly positioned, the dispenser should clean the eyelids from the inner canthus outward with a sterile saline solution to remove any eye secretions or previously instilled medications. The dispenser should wash their hands after these preparations are completed.

Immediately before instillation, the dispenser should depress the patient's lower lid with the finger of one hand and lightly pinch the patient's lower lid to make a pouch for the medication. The upper lid should also be held open to prevent blinking during instillation. The dispenser should tell the patient to look up. Using the other hand, the dispenser should instill the drop into the everted lower lid. The drops should not be instilled on the cornea. This precaution is necessary to avoid startling the patient, or causing unnecessary **pain**.

After the appropriate amount of medication is instilled, the ophthalmic professional should release the lid and remove any excess fluid. The patient should be told to gently close their eyes so as to not release any medication. If another medication is to be instilled, a delay of at least 30 seconds is required between instillations.

Preparation

Patients should have the procedure explained to them before instillation to ensure best results. If patients are treated for certain eye ailments such as conjunctivitis, they should be warned in advance not to wear **contact lenses** or eye makeup.

Before instillation, the ophthalmic staff should double-check the dosage and type of medication. They should also wash their hands thoroughly.

Aftercare

Patients who will be dispensing their own eyedrops after the initial treatment need careful instructions on proper instillation. Allied health professionals should guide patients step by step through the procedure to ensure maximum benefit from the medication.

If patients are treated for infections or conjunctivitis, they should be advised to wash their hands regularly; avoid touching their eyes; avoid wearing eye makeup or contact lenses; and to discard any eye drops or eye makeup used before treatment for the **infection** began. Follow-up appointments for further treatment may also be necessary.

Glaucoma patients using eyedrop medications should be monitored to determine if the drops are effective. Many times a combination of drops is necessary to treat glaucoma.

Complications

Eyedrops cause irritation in some patients that might result in eye redness or burning. Stronger medications can cause more extreme allergic symptoms, such as dizziness and disorientation. Some cycloplegic drops can cause such severe reactions as delirium, a rapid pulse, and difficulty swallowing. Patients should be monitored after instillation, and health care professionals should record any side effects.

Results

Properly instilled eyedrops should effectively treat a number of eye disorders. Dilatory drops facilitate eye refraction and retinal examination.

Health care team roles

Nursing and allied health professionals are usually responsible for eyedrop instillation. Ophthalmic assistants, technicians and nurses ensure that the proper dosage is administered to the correct patient, the medication is fresh, the medication and eyedropper are sterile and in good condition, and the patient is told step-by-step how the procedure is performed. The allied health professional may also need to repatch an affected eye, monitor patients for side effects, chart medications for each patient, and dispose of (used) equipment.

Resources

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ORGANIZATIONS

American Academy of Ophthalmology. PO Box 7424, San Francisco, CA 94120-7424. (415) 561-8500. <<http://www.eyenet.org/>>.

KEY TERMS

Canthus—Either of the angles formed by the meeting of an eye’s upper and lower eyelids.

Conjunctivitis—Inflammation of the thin membrane covering the eye. It is caused by bacteria, virus, allergies, etc.

Cornea—The clear outer covering of the front of the eye.

Cycloplegic drops—Drops used to dilate the pupil and paralyze the eye’s powers of accommodation.

Drops—A term for a liquid medicine taken in specific doses and usually applied by a dropper.

Glaucoma—An eye disease in which increased pressure within the eyeball can result in damage to the optic disk and a loss of vision.

Ophthalmic solutions—Sterile solutions for instillation in the eye.

Uveitis—Inflammation of the uvea. The uvea is a continuous layer of tissue that consists of the iris, the ciliary body, and the choroid. The uvea lies between the retina and sclera.

American Optometric Association. 2420 North Lindbergh Boulevard, St. Louis, MO 63141. (800) 365-2219. <<http://www.aoanet.org/>>.

Joint Commission on Allied Health Personnel in Ophthalmology. 2025 Woodlane Drive, St. Paul, MN 55125-2995. (888) 284-3937. <<http://www.jcahpo.org/>>.

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Mary Bekker

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Factor XI deficiency *see* **Hemophilia**

Factor IX deficiency *see* **Hemophilia**

Factor V Leiden test *see* **Thrombosis risk tests**

Factor VIII deficiency *see* **Hemophilia**

Fad diets

Definition

According to the United States Surgeon General's Report on **Nutrition** and Health, fad diets include "the promotion for profit of special foods, products, processes, or appliances with false or misleading health or therapeutic claims."

Purpose

Fad diets are generally used by consumers to shed a great amount of weight in a short period of time. They are usually based on the erroneous belief that a particular food or food component can cause rapid weight loss or cure a disease. Another tenet of fad diets is that certain foods are harmful and therefore should be avoided completely.

Precautions

Fad diets usually result in a short-term weight loss—but most people gain the weight back after discontinuing the diet. The American Dietetic Association (ADA) has established a few guidelines to help evaluate the reliability of fad diets. They suggest that consumers avoid diets that claim weight loss can be achieved in a very short period of time; that imply that weight can be

lost without any physical activity; or that rely on undocumented studies.

The most reliable way to lose weight safely and maintain weight loss is by eating a variety of foods and exercising consistently. Dieters who follow the guidelines set by the ADA, which include eating a variety of foods, balancing food intake with **exercise**, choosing a variety of fruits and vegetables, limiting saturated fat and cholesterol, and keeping total fat intake to a moderate level will have a healthy lifestyle—which when adhered to will ultimately aid in weight management. Many fad diets, for example, counsel dieters to eliminate certain foods or to eat one specific food for a long period of time. This approach does not promote healthy eating habits, nor does it augur well for permanent weight loss.

Description

Fad diets have been promoted and used for many years. Some of the most popular fad diets today include high-protein diets, liquid diets, the grapefruit diet, food-combining diets, the cabbage diet, and a variety of diet pills.

High-protein diets

High-protein diets began in the 1970s, based on the theory that too many **carbohydrates** in the diet interfere with the body's ability to burn fat. This diet encourages the consumption of large quantities of protein-rich foods such as meat, fish, shellfish, eggs, poultry, and cheese. Some popular high-protein diets include the Atkins diet, the Zone, and the protein-power diet.

Liquid diets

Liquid diets actually began in the early 1930s, but gained more popularity in the 1970s when commercial meal-replacement health shakes began to hit the market. SlimFast and Nestlé Sweet Success are two brands of health shakes that are usually consumed as a replacement

KEY TERMS

Ketones—Acidic by-products of fat breakdown that alter the acid-base balance of the blood.

Nitrogen—A component of protein that is highly toxic when too much protein is consumed and the kidneys are unable to process and excrete it.

Saturated fat—Type of fat that is usually solid at room temperature.

for two meals and a snack during the day. Health shakes normally provide about 200 calories each, with the last meal of the day consisting of low-fat, nutrient-dense foods that offer another 600 calories.

The grapefruit diet

Grapefruit is essentially a fat-free, low-calorie, low-sodium food that is high in **vitamin C**, beta-carotene, and fiber. The grapefruit diet began in the 1930s, when the Hollywood diet made its debut. This regimen consisted of a few vegetables, a small amount of protein, and a grapefruit (which was thought to possess a fat-burning enzyme) at every meal. It is usually followed for a period of three weeks. The diet provides only 800 calories per day, which makes the possibility of weight loss very likely.

Food-combining diets

Food-combining diets are based on the mistaken idea that carbohydrates and **proteins** should not be consumed at the same time, and that fruit should not be eaten with proteins or carbohydrates. There are a variety of food-combining diets, but most recommend eating large portions of fruit for the first several days, which is thought to burn up calories before the body metabolizes them. A few carbohydrates and very little protein are then added during the last part of the diet.

The cabbage soup diet

The cabbage soup diet is a more recent fad that results in a significant amount of weight loss from shedding water. It consists of eating cabbage soup, which contains cabbage, onions, green peppers, tomatoes, celery, and water, for one week. Each day as much soup is eaten as desired, along with one specified food, which can also be eaten in unlimited amounts. The cabbage does not burn fat, but it does promote a sense of fullness.

Diet pills

Diet pills and prescription drugs have become one of the most marketable tools against **obesity**, but their safety and effectiveness is questionable. Both diet pills and prescription drugs can reduce appetite and promote fullness by changing **brain** chemicals. Prescription drugs should be an option only for people who are significantly overweight.

Complications

High-protein diet

This type of diet does slow the rate of carbohydrate absorption, which helps control blood sugar levels and promotes a feeling of fullness. However, high-protein diets also tend to be high in saturated fat and cholesterol, which can contribute to **heart** disease. When high-protein diets are followed for a very long time, they cause the body to burn excessive amounts of fat for fuel. This releases chemicals called ketones into the bloodstream, causing dizziness, headaches, nausea, and bad breath. Too much protein also places extra work on the **kidneys**, forcing them to work harder to excrete the nitrogen present in protein. They also create extra work for the **liver**, which must break the protein compounds into individual amino acids.

Liquid diets

While liquid diets are often convenient and easy to prepare, the transition back to solid foods can lead to weight gain.

Grapefruit diet

While this diet is very low in calories and almost guaranteed to result in some weight loss, limiting dieters to such a small amount of food is very restrictive and eliminates such vital nutrients as **calcium**, **iron**, **folic acid**, and other **vitamins**.

Food-combining diet

Since fruits are so low in calories, it is possible to lose a significant amount of weight in a short period of time. Due to the protein restriction, however, muscle and organ tissues may be broken down for energy.

Cabbage-soup diet

This diet can cause bloating, gas, nausea, and lightheadedness after a few days. It is not recommended by health professionals; but since soup is usually a low-calorie food, eating this soup in conjunction with a healthy diet consisting of a variety of foods can facilitate a healthy weight loss.

Diet pills

These compounds may help start weight loss, but their benefit usually plateaus after a year, after which their effect declines. In addition, they can strain the heart by increasing **blood pressure** and heart rate.

Results

While each of these diets may result in a temporary weight loss, most are unhealthful and deprive the body of needed nutrients. Most dieters regain the weight after they stop following the diet.

Health care team roles

The American Dietetic Association, the United States Surgeon General, the National Academy of Sciences, and the American Heart Association all employ qualified professionals who can educate consumers on the advantages and disadvantages of fad diets. While certain components of fad diets may aid in weight management when used in conjunction with a healthy lifestyle, it is not recommended that they be used alone. People must understand that behavior modification is the most effective way to lose weight and keep it off. Through physical exercise, eating a variety of nutritious foods, and consciously changing eating habits, weight loss can be achieved and maintained.

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Lisa M. Gourley

Fainting see **Syncope**

Fallopian tube x rays see **Hysterosalpingography**

Falls

Definition

Falls are a common source of injury, particularly in the elderly population. They are more likely to occur if impairments in balance, strength, perception, joint range of motion, postural function or coordination are present. Serious injury from falls, such as **fractures**, occur commonly in people with **osteoporosis**, a common degenerative disease involving loss of bone mass. Hip fracture is one of the most serious potential consequences of a fall, with a mortality rate as high as 20%.

Description

Falling is a serious health problem in the United States, especially for the elderly. According to the National Center for Injury Prevention and Control, one in every three adults 65 years of age and older falls each year, with an increasing incidence as a person ages. Falls can result in serious injury, not only posing a burden on the individual who falls, but also on family members and the health care system.

Causes and symptoms

Falls can often be attributed to environmental hazards. Icy sidewalks and uneven terrain are common dangers. In the home, climbing on unstable step stools, sliding in wet showers, or slipping on throw rugs are frequent causes of falls.

Medical factors can also make falls more likely to occur. Orthostatic hypotension, sensory loss, stroke, **dementia**, medications, and neuromuscular disease increase the risk of falling. Deficits in strength, joint range of motion, coordination, sensory perception, and **vision** may further impair balance. Osteoporosis, common in the elderly population, makes a fall more likely to result in serious injury.

Diagnosis

Individuals who are at risk of falling because of a medical condition or medications need to be routinely

Falls among people 65 years of age and older

Falls are the leading cause of accidental deaths in persons over 65 years of age.

Falls are the seventh leading cause of death among people older than 65 years.

In the United States 75% of deaths from falls occur in the 12% of the population that is older than 65 years.

From 75 years of age the rate of death from falls rises for both genders and all racial groups.

Thirty-three percent of healthy community-dwelling elders (older than 65 years) fall annually.

Sixty-seven percent of nursing home residents fall annually.

Between 33% and 67% of older patients in hospital-like environments fall annually.

Complications from falls or prolonged floor contact after falls include fear of falling, dehydration, pressure sores, hypothermia, pneumonia, and rhabdomyolysis.

Whites who fall have twice the hip fracture rate as persons from other racial groups.

Five percent of falls among older people will result in fractures.

The most common fractures as a result of falls among the elderly are humeral, wrist, pelvis, and hip, with the presence of osteoporosis making fractures more likely.

Ten to twenty percent of falls among older people will result in soft-tissue injuries, with 50% of these requiring medical care.

Falls contribute to 40% of admissions to nursing homes.

Seventy percent of emergency room visits by people older than 75 years are due to falls.

SOURCE: National Center for Health Statistics, 1980, 1984.

tested for instability during functional activities. The following characteristics should also be assessed:

- balance
- strength
- sensation
- vision
- joint range of motion
- **hearing**
- postural awareness
- gait

Balance

Balance testing can be done in a rehabilitation facility to assess people's ability to transfer weight and control their center of gravity. Numerous tests such as the Berg balance assessment, functional reach test, get-up-and-go test, and Tinetti tests are useful in a balance evaluation.

Strength

Strength testing should be done to identify weakness, strength asymmetry between sides, and muscle strength imbalance within the same limb.

Sensation

Sensation testing of the lower extremities assesses light touch, pressure, and limb awareness.

Vision

Vision should be assessed by a licensed professional. If corrective lenses are indicated, they should be used during further testing, such as balance and gait assessment.

Joint range of motion

Joint motion assessment evaluates the loss of range of motion and its relationship to impairments in transfers and gait.

Hearing

If **hearing loss** is suspected, it should be tested and corrected, if possible, before rehabilitation is addressed.

Postural awareness

In a rehabilitation center, individuals can be put through a battery of tests that assess perception of the center of gravity with relation to the environment. Specific tests include postural sway tests and perturbation tests.

Gait

Walking can be evaluated by direct observation to assess for gait abnormalities. If a severe gait disturbance is present, further gait analysis using motion analysis, force platforms, and **electromyography** should be done.

Treatment

Individuals who have fallen may have such injuries as fractures, dislocations, bruising, cuts to the skin, and muscle tears that may require casting, surgery, or hospitalization, depending on the severity. Initiation of life-long medications for osteoporosis to reduce the rate of further bone loss may be indicated. Most people, including the frailest elderly, can usually benefit from an **exercise** program that includes strengthening and balance components. Assistance in regaining confidence may also be needed.

Someone who has fallen, once medically stable, needs to be evaluated for:

- balance
- strength
- sensation
- vision
- joint range of motion

- hearing
- postural awareness
- gait

If deficits are noted and the reason for the fall is clear, a treatment plan can be developed that may include:

- balance training
- strength training
- aerobic exercise
- sensory integration
- correction of vision
- change in medication
- flexibility exercises
- hearing aids
- postural exercises
- patient education
- family and caregiver education
- analysis of environmental barriers
- gait retraining

Treatment may include the fabrication of an orthotic for lower limb dysfunction; prescription of an assistive device such as a cane or rolling walker; and education to the patient or caregiver regarding safety in the home.

Prognosis

How quickly and completely a patient recovers after a fall depends on the extent of the injury, the patient's medical condition prior to the fall, and the rehabilitation program. A positive attitude and adequate social support can be critical factors to a patient's recovery. Regaining mobility is critical, especially for the elderly patient who rapidly loses strength and function when immobile. A severe injury such as hip fracture has high morbidity and mortality, partially due to the long bed rest required after the injury.

Health care team roles

Nurses and other allied health professionals need to coordinate rehabilitation activities in an effort to integrate all facets of rehabilitation with functional activities. The rehabilitation team must take an active role in patient, caregiver, and family education, specifically related to restoring mobility and preventing falls in the home.

KEY TERMS

Coordination—The ability to do activities with precision and proficiency.

Electromyography—An evaluation tool that can detect electrical activity of muscles during an activity.

Force platform—A large plate, usually mounted in the floor, that records forces when an individual stands or walks on it.

Motion analysis—Use of an instrumented system to record whole-body and joint movement for later analysis.

Perturbation tests—Tests in which the patient stands on a platform, and a small, rapid movement of the platform is used to disturb balance. Forces and sway are recorded as the individual loses balance and then recovers.

Sensory perception—The ability to perceive touch, pressure, pain, and joint position in the limbs and trunk.

Transfers—The movement from one position to another, such as sit-to-stand, supine-to-sit, wheelchair-to-toilet, etc.

Prevention

Individuals, especially the elderly, should take the following steps to minimize their risk of falling:

- Take someone's arm when icy or slippery surfaces cannot be avoided.
- Remove loose rugs from floors.
- Use only steady stepstools with hand supports when additional height is needed.
- Install hand rails on stairs.
- Wear good walking shoes.
- Assess the home for small objects and cords that can be tripped on as well as unstable pieces of furniture.
- Install grab bars next to toilets and in showers.
- Evaluate home lighting. Use night lights in bathrooms and between the bedroom and bathroom.
- Have vision and hearing checked regularly.
- Report dizziness, fainting, unusual sensations, or sudden loss of function to a physician at once.

- Engage in daily exercise that incorporates aerobics, weight training, and balance and coordination exercises.

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Mark Damian Rossi, Ph.D, P.T., C.S.C.S.

Farsightedness see **Hyperopia**

FAS see **Fetal alcohol syndrome**

Fats, dietary

Definition

Dietary fats are one of the three forms of energy-giving nutrients, providing a rich source of energy.

Purpose

Fats or **lipids** carry unique properties; they are packed with calories (9 kcal per gram, more than double the amount in protein and carbohydrate), and because they are insoluble in water, they help with the absorption and transport of the fat-soluble **vitamins** A, D E, and K. Dietary fat not required immediately for energy is stored in layers of fatty tissue under the skin and around internal organs, where it can be called upon for energy. Fats contain about 95% triglycerides, which are lipids consisting of three fatty acid chains.

Besides providing energy and essential fatty acids necessary for **brain** development and proper growth, dietary fats get considerable attention because of their association with coronary **heart** disease (CHD) and stroke, leading causes of death in the United States. Atherosclerosis, the underlying cause in both, involves changes in the innermost layer of the large arteries. Atherosclerosis often begins in childhood, and while many factors play roles, lesions called plaque form from fat deposits and such other materials as **calcium** and fibrin.

According to a U.S. Department of Agriculture (USDA) food consumption study, fat intake peaked to 70 lb (31.75 kg) per person between 1970 and 1993. Since then, levels have dropped slightly, to around 66 lb (29.9 kg); but one concern is the rising percentage provided by added fats and oils from fried food and snack foods. Current recommendations state that total fat intake should comprise less than 30% of total calories, and saturated fat less than 10%. For a 1500-calorie diet, this standard means less than 1.76 oz (50 g) total fat and 0.59 oz (17 g) saturated fat; for 2500-calorie diets, it is 2.92 oz (83 g) and 0.98 oz (28 g), respectively. People can refer to food labels, which list these amounts.

Precautions

Research shows that two types of dietary fats in particular, saturated fats and trans fats, raise **blood** cholesterol, which increases CHD risk.

Description

The major fats in foods are saturated, polyunsaturated, monounsaturated and trans fatty acids, which are discussed below.

- Saturated fatty acids (SFA) or saturated fats get their name because they hold the maximum number of hydrogens possible in their chains. In general, the longer and more saturated the chain, the harder the fat is at room temperature. Coconut oil is an exception. Foods contain a mixture of fatty acids, but SFA are concentrated in certain animal and vegetable foods, such as beef, chicken, pork, dairy products, palm and coconut oil. Reducing dietary SFAs has the biggest effect on decreasing blood cholesterol.
- Monounsaturated fatty acids (MFA) are getting good press in the fat world, with many experts advocating the Mediterranean eating style that is high in olive oil, fish, and vegetables. Mediterranean countries have low CHD incidence, but it is unknown how much other factors play a role. MFAs lower blood cholesterol when they replace SFAs. Aside from olive oil, other high MFA foods include canola oil, peanut and peanut oil, such nuts as pecans and almonds, and avocados.
- Polyunsaturated fatty acids (PUFA), such as margarine and sunflower oil, were recommended during the 1980s for lowering blood cholesterol. However, research shows PUFAs can lead to toxic products that promote cardiovascular disease, so heavy intake is not recommended. High sources include vegetable seeds and their oils. Research on a type of PUFA called omega-3 fatty acid is demonstrating benefits in such

inflammatory disease as rheumatoid arthritis and atherosclerosis. Seafood contains the most omega-3s, although tofu, soybean, canola oil and nuts all contain one type of omega-3. Two PUFAs, linoleic acid and α -linolenic acid, are called essential fatty acids because they cannot be synthesized in the body. If linoleic acid replaces other forms of fatty acid in the diet, then low-density lipoprotein (LDL) cholesterol decreases and high-density lipoprotein (HDL) cholesterol increases. If linoleic acid replaces saturated fat, total cholesterol decreases but HDL levels also decrease. Safflower oil has the most linoleic acid. α -linolenic acid comes mainly from fish oils. It results in decreased production of triglycerides but has little effect on total cholesterol levels.

- Trans fatty acids are the latest “bad guys,” with recent research showing they raise blood cholesterol. Trans fats are high in processed food products, in which manufacturers add hydrogen to liquid oils (hydrogenation) to increase stability. Major sources include stick margarine, commercial baked goods, and the frying fats used in most snack foods, restaurants and fast-food chains. Food labels will list trans fats as hydrogenated or partially hydrogenated fats. Healthy people should eat no more than 10% of total calories as saturated fats and trans fats. For those with CHD, diabetes or high LDL cholesterol, this percentage drops to 7%.
- Other types of dietary fats exist, including lecithin and cholesterol. Cholesterol, an essential component in brain and nerve cells, is found in animal foods, but is also produced and stored in the **liver**. The role of dietary cholesterol in blood cholesterol levels and CHD is less clear than in the past. Meat, poultry, seafood, egg yolks and dairy products all contain cholesterol, while plant foods such as fruits, vegetables, grains, nuts and seeds do not. Americans should not exceed the recommended level of 0.1 oz (300 mg) per day. The average American woman eats 0.07 oz (217 mg) cholesterol daily, the average man 0.12 oz (337 mg).

Complications

Treating high lipids

If a person’s blood lipid levels are high, dietary treatment is often initiated to lower the low density lipoprotein fraction and total blood cholesterol levels. Current American Heart Association recommendations include reducing saturated fat to less than 7% of calories; limiting cholesterol to < 200; losing weight if appropriate; and increasing soluble fiber to 0.35–0.88 oz (10–25 g) per day. High-density lipoprotein (HDL) levels, also

KEY TERMS

Atherosclerosis—Sclerosis or hardening and thickening of the arterial wall, causing a loss of elasticity.

Coronary heart disease (CHD)—A disease involving the blood vessels surrounding the heart; also called coronary artery disease (CAD).

High-density lipoprotein (HDL)—A plasma lipoprotein containing mostly protein and less cholesterol and triglyceride; high levels of HDL lower CHD risk.

Low-density lipoprotein (LDL)—The major cholesterol carrier in the blood, with high levels associated with increased coronary heart disease risk.

Fatty acid—Fatty acids are a group of carbon chains that make up fat. The body requires some, called essential fatty acids, to form membranes and synthesize important compounds.

Lipids—A group of compounds that include fats, oils and related compounds found in foods and the human body.

Omega-3 fatty acids—Named because their first double bond occurs at the third carbon from the methyl end, the three omega-3s (EPA, LNA and DHA) are believed to benefit inflammatory diseases.

Monounsaturated fatty acid (MUFA)—A fatty acid containing one double bond, which lowers plasma cholesterol when replacing SFAs and is believed to be safer than polyunsaturated fats.

Polyunsaturated fatty acid (PUFA)—A fatty acid that is liquid at room temperature, lowers plasma cholesterol when replacing SFAs, but too much can promote cardiovascular disease

Saturated fatty acid (SFA)—A fatty acid that has no double bonds, is solid at room temperature, and raises blood cholesterol levels.

referred to as the good cholesterol, is related more to genetic and other factors than to diet, although moderate alcohol consumption raises HDL.

Some people also have high plasma triglyceride (TG) levels, which accumulating evidence is showing may be an important heart disease risk factor. Dietary guidelines involve low simple sugars, low-saturated fat diets, restricted alcohol and weight loss if indicated. Drug therapy is often initiated.

Results

A diet containing 30% or less fat is considered compatible with good health. Diets with dietary fat intakes below 15% can negatively affect blood lipids in some people. For people with high blood lipid levels, dietary fat management goals involve moving the total cholesterol and LDL levels to normal. However, because diet modification lowers serum cholesterol levels by about 10–15%, patients whose blood levels remain high often seek drug therapy.

Health care team roles

- Registered dietitians are often sought out by patients and health professionals to assess fat intake and instruct on diet modifications, and for those seeking weight loss through dietary fat restriction.
- Nursing and allied health professionals can provide health histories and check laboratory test results for potential treatment. The American Heart Association provides dietary guidelines and **patient education** materials. All health professionals can play important roles in educating the public about dietary fat.

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Fecal impaction removal

Definition

Fecal impaction removal is the digital (using the finger) means of breaking up and removing a fecal impaction, or mass of hardened, clay-like stool lodged in the rectum.

Purpose

Fecal impaction is the result of extreme constipation. As the patient is unable to expel the stool, it further accumulates into a larger, harder mass that is impossible to pass by normal defecation. This accumulated stool can

extend up into the sigmoid colon, the loop of large bowel above the rectum. Impaction is most common in inactive elderly people, but there are other causes beside inactivity. Among the other causes are:

- medications, including **antacids** that have aluminum as an ingredient; **calcium** and **iron** supplements; a category of anti-hypertensive drugs known as calcium channel blockers; allergy medicines (**antihistamines**); such psychotropic medications as antidepressants and tranquilizers; such hormones as estrogen and progesterin; and medications to reduce spasms such as those used in treating Parkinson's disease
- poor bowel habits; not having a regular schedule for evacuating the bowel
- inadequate fluid intake
- a diet that is lacking in such fibers as bran, fruit, and vegetables
- such rectal disorders as rectocele

In addition to the discomfort this condition creates, untreated fecal impaction can also become a serious health problem, producing a chronically over-dilated bowel, or megacolon, that can require surgical correction. It is possible for rectal tissue to become damaged, ulcerated, or even necrotic (lose its **blood** supply due to the pressure of the stool). The most serious potential complication is that the lower bowel can become completely obstructed. Such intestinal obstruction is potentially fatal.

The possibility that the patient has a fecal impaction should be considered if he or she shows any or all of the following symptoms:

- complaints of inability to have a bowel movement despite frequently feeling the urge to defecate
- upon defecation, the stool appears to be either **diarrhetic** or thin and pencil-like
- abdominal pain
- bloating and a swollen or hard abdomen
- anorexia, or lack of appetite; nausea; and vomiting
- complaints of general malaise, or not feeling well
- the presence of hard stool in the rectum
- increased restlessness in patients suffering from **Alzheimer's disease** or other forms of dementia

Precautions

This digital breaking up and removal of impacted stool can potentially damage the mucous membrane linings in the bowel, and the stimulation to the vagus nerve that has endings in the rectum can cause **heart** irregular-

ities. It is therefore a procedure that is undertaken only with extreme caution. Most often, nurses remove fecal impactions upon receiving a physician's order, or under a physician's supervision.

Description

As gently as possible, the nurse inserts a gloved, lubricated index finger and massages around the edges of the impaction, gradually working the gloved finger into the mass to break it up. The broken-up pieces of stool are dislodged by carefully working them downward toward the end of the rectum. During this procedure, the patient should be checked regularly to assure that there are no untoward effects such as weakness, diaphoresis or clamminess, or changes in pulse rate.

Preparation

The nurse positions the patient on his or her side, with knees flexed and back toward the nurse. A waterproof pad is placed under the patient's buttocks, and a bedpan to hold any removed stool is kept nearby. Occasionally, a patient will request to stand in the bathroom near the toilet during this procedure, but that is not advisable due to possible adverse reactions and the fact that this can be an exhausting process. The nurse then puts on rubber gloves and applies lubricant to the index finger that will be inserted to break up the impaction. Explanation of what is to be done, and reassurance that if the procedure is causing discomfort it will be stopped immediately, should be given before beginning.

Aftercare

After the disimpaction is completed, it may be necessary to administer an enema or give a suppository to complete the stool removal. The most important aspect of care is the prevention of the reoccurrence of problems with elimination.

Complications

Vagus nerve stimulation, causing cardiac irregularities with possible fainting or weakness, is the most serious potential complication. However, rectal bleeding, the result of trauma to the bowel mucosa, can also occur.

Results

Expected results will be the removal of the hardened stool from the patient's rectum, making the patient much more comfortable.

KEY TERMS

Megacolon—A massively swollen colon, usually associated with severe and chronic constipation that can exist as a congenital condition or develop later in life.

Sigmoid colon—The S-shaped part of the colon, part of the large intestine, positioned between the descending colon and the rectum.

Vagus nerve—The tenth and longest cranial nerve, responsible for control of the heart and other internal organs.

Health care team roles

This procedure is rarely undertaken, as normally health care staff try to prevent the occurrence of fecal impaction through medications, diet, and such treatment as **enemas** or suppositories. Such prevention is desirable due to the risks involved. However, if fecal impaction removal must be done, it should be done only by a physician or nurse, as they should be aware of the possible untoward effects.

- A nurse will normally be the person who actually removes impacted stool.
- Both registered nurses (RNs), or licensed practical nurses (LPNs) must complete a prescribed course in nursing and pass a state examination. RNs typically have a degree in nursing. If the physician does not disimpact the patient, usually it will be the job of a RN. However, in some situations, a LPN may be the person responsible for carrying out this procedure.

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Joan M. Schonbeck

Fecal incontinence

Definition

Fecal incontinence is the inability to control the passage of gas or stools (feces) through the anus. For some people, fecal incontinence is a relatively minor problem that is limited to a slight occasional soiling of underwear, but for others it involves a considerable loss of bowel control. This loss can have a devastating effect on a patient's quality of life and psychological well-being. Fortunately, professional medical treatment is usually able to restore bowel control or at least substantially reduce the severity of the condition.

Description

Fecal incontinence, also called bowel incontinence, can occur at any age, but is most common among people over the age of 65, who sometimes have to cope with urinary incontinence as well. The condition is more common among women than men. The problem affects as many as 6.5 million Americans.

The wider **public health** impact of fecal incontinence is considerable. In the United States, more than \$400 million is spent each year on disposable underwear and other incontinence aids. Fecal incontinence is the second most common reason for seeking a nursing home placement. One-third of the institutionalized elderly suffer from this condition. Incontinence sufferers, however, often hesitate to ask their doctors for help because they are embarrassed or ashamed.

Causes and symptoms

Fecal incontinence can result from a wide variety of medical conditions, including childbirth-related anal injuries, other causes of damage to the anus or rectum, and nervous system problems.

Vaginal-delivery **childbirth** is a major cause of fecal incontinence. In many cases, childbirth results in damage to the anal sphincter, which is the ring of muscle that closes the anus and keeps stools within the rectum until a person can find an appropriate opportunity to defecate. Nerve injuries during childbirth may also be a factor in some cases. A study in 2000 by the Brigham and Women's Hospital in Boston, Massachusetts, found that women who had episiotomies were at higher risk for postpartum fecal incontinence. Childbirth-related incontinence is usually restricted to gas, but for some women it involves the passing of liquid or solid stools.

The removal of hemorrhoids by surgery or other techniques (hemorrhoidectomies) can also cause anal

damage and fecal incontinence, as can more complex operations affecting the anus and surrounding areas. Anal and rectal infections, as well as **Crohn's disease**, can lead to incontinence by damaging the muscles that control defecation. New-onset fecal incontinence can also be a sign of **colorectal cancer**. For some people, incontinence becomes a problem when the anal muscles begin to weaken in midlife or old age.

Dementia, mental retardation, strokes, **brain tumors**, **multiple sclerosis**, and other conditions that affect the nervous system can cause fecal incontinence by interfering with muscle function or the normal rectal sensations that trigger sphincter contraction and are necessary for bowel control. One study of multiple sclerosis patients discovered that about half were incontinent. Nerve damage caused by long-lasting **diabetes mellitus** (diabetic neuropathy) is another condition that can give rise to incontinence.

Diagnosis

Medical assessments in cases of fecal incontinence typically involve three steps: assessing the patient's medical history; performing a **physical examination** of the anal region; and testing for objective information regarding anal and rectal function.

Medical history

The medical history relies on questions that allow an evaluation of the nature and severity of the problem and its effect on the patient's life. The information obtained may include: how long the patient has been suffering from incontinence; how often and under what circumstances incontinence occurs; whether the patient has any control over defecation; and whether the patient has obstacles to defecation in his or her everyday surroundings, such as a toilet that can be reached only by climbing a long flight of stairs. For women who have given birth, a detailed obstetric history is also necessary.

Physical examination

The physical examination begins with a visual inspection of the anus and the perineum for hemorrhoids, infections, and other conditions that might explain the patient's difficulties. During this phase of the examination the doctor asks the patient to bear down. Bearing down enables the physician to check whether rectal prolapse or certain other problems exist. Rectal prolapse means that the patient's rectum has been weakened and drops down through the anus. Next, a pin or probe is used to stroke the perianal skin. Normally this touching causes the anal sphincter to contract and the anus to pucker

(the “anal wink”); if it does not, nerve damage may be present. The final phase of the examination requires the doctor to examine internal structures by carefully inserting a gloved and lubricated finger into the anal canal. This allows the doctor to judge the strength of the anal sphincter and a key muscle (the puborectalis muscle) in maintaining continence; to look for such abnormalities as scars and rectal masses; and to learn many other things about the patient’s medical situation. At this point the doctor performs the anal wink test again and asks the patient to squeeze and bear down.

Laboratory tests

Information from the medical history and physical examination usually needs to be supplemented by tests that provide objective measurements of anal and rectal function. One of the most common tests is a **colonoscopy**, which can be included in the physical examination or can be performed in a laboratory setting. Anorectal manometry, another common procedure, involves inserting a small tube (catheter) or balloon device into the anal canal or rectum. Manometry measures, among other things, pressure levels in the anal canal, rectal sensation, and anal and rectal **reflexes**. Tests are also available for assessing nerve damage. An anal ultrasound probe can supply accurate images of the anal sphincter and reveal whether injury has occurred. **Magnetic resonance imaging**, which requires the insertion of a coil into the anal canal, is useful at times.

Treatment

Fecal incontinence arising from an underlying condition such as diabetic neuropathy can sometimes be helped by treating the underlying condition. When that does not work, or when no underlying condition can be discovered, one approach is to have the patient use a suppository or enema to stimulate defecation at the same time every day or every other day. The goal is to restore regular bowel habits and keep the bowels free of stools. Medications such as loperamide (Imodium) and codeine phosphate are often effective in halting incontinence, but only in less severe cases involving liquid stools or urgency. Dietary changes and exercises done at home to strengthen the anal muscles may also help.

Good results have been reported for biofeedback training. In successful cases, patients regain complete control over defecation, or at least improve their control, by learning to contract the external part of the anal sphincter whenever stools enter the rectum. All healthy people have this ability. Biofeedback training begins with the insertion into the rectum of a balloon manometry device hooked up to a pressure monitor. When the bal-

loon is inflated, it simulates the presence of stools in the rectum by causing pressure changes that are recorded on the monitor. The monitor also records sphincter contraction. By watching the monitor and following instructions from the equipment operator, the patient gradually learns to contract the sphincter automatically in response to fullness in the rectum. Sometimes one training session is enough, but often several are needed. Biofeedback is not an appropriate treatment in all cases, however. It is used only with patients who are highly motivated; who are able, to some extent, to sense the presence of stools in the rectum; and who have not lost all ability to contract the external anal sphincter.

Some people may require surgery, and these procedures may themselves have complications. Sphincter damages caused by childbirth, as well as certain other kinds of incontinence-related sphincter injuries, are often effectively treated with surgery. Sometimes surgical treatment requires building an artificial sphincter using a thigh muscle (the gracilis muscle). At one time a **colostomy** was necessary for severe cases of incontinence, but this procedure is now rarely performed.

Prognosis

Fecal incontinence is a problem that usually responds well to professional medical treatment, even among elderly and institutionalized patients. If complete bowel control cannot be restored, the impact of incontinence on everyday life can still be lessened considerably in most cases. When incontinence remains a problem despite medical treatment, disposable underwear and other commercial incontinence products are available to make life easier. Physicians and nurses can offer advice on coping with incontinence, and people should not be embarrassed about seeking their assistance. Counseling and information are also available from support groups.

Health care team roles

A patient may report fecal incontinence to a health care professional, or it may be assessed by the nurse or physician in an inpatient setting. The physician may order diagnostic testing to determine the etiology of the incontinence. It is the nurse’s responsibility to insure the patient maintains adequate levels of hygiene. In addition, the nurse should instruct the patient and/or caregivers regarding measures of coping with incontinence and minimizing its impact.

Prevention

Since fecal incontinence develops for a variety of reasons, there is no single way to prevent it. Patients should

KEY TERMS

Anus—The opening at the lower end of the rectum.

Colostomy—A surgical procedure in which an opening is made in the wall of the abdomen to allow a part of the large intestine (the colon) to empty outside the body.

Crohn's disease—A disease marked by inflammation of the intestines.

Defecation—Passage of stools through the anus.

Hemorrhoids—Enlarged veins in the anus or rectum. They are sometimes associated with fecal incontinence.

Rectum—The lower section of the large intestine that holds stools before defecation.

Sphincter—A circular band of muscle that surrounds and encloses an opening to the body or to one of its hollow organs. Damage to the sphincter surrounding the anus can cause fecal incontinence.

Stools—Undigested food and other waste that is eliminated through the anus.

Suppository—A solid medication that slowly dissolves after being inserted into the rectum or other body cavity.

be encouraged to report incontinence as soon as it occurs, in order to find the most appropriate treatment for it.

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Fecal occult blood test

Definition

The fecal occult **blood** test (FOBT) is a rapid test for detecting the presence of blood hidden in the stool and caused by gastrointestinal bleeding.

Purpose

This test is performed to detect the presence of blood in the feces. It is also routinely used (in conjunction with a rectal examination performed by a physician) to screen for **colorectal cancer**, particularly after age 50. However, a positive result does not necessarily indicate **cancer**, as positive results can be associated with a wide variety of conditions, such as:

- peptic, gastric, or **stress** ulcers
- esophageal varices
- colon or pancreatic cancer
- tumors
- gastritis
- gastrointestinal bleeding
- hemorrhage
- ulcerative colitis
- diverticulitis
- alcohol abuse
- Crohn's disease
- intussusception

Precautions

Certain foods and medicines can influence the test results. Diets rich in red meat, poultry and fish could cause false-positive FOBT results, as can excessive amounts of green leafy vegetables. Certain drugs can also

cause false-positive results; they include aspirin, cortisone, **iron**, potassium preparations, nonsteroidal antiinflammatory (NSAID) drugs, thiazide diuretics, colchicine, and reserpine. False-negative findings may result from the ingestion of large amounts of ascorbic acid (**vitamin C**) from dietary supplements or foods such as citrus fruits. It is also important that the specimen not be contaminated by menstrual discharge.

Description

In most cases, the collection of stool samples can be done at home, using a kit supplied by the physician. The kit contains a specially prepared card onto which a small sample of stool is spread, using a stick provided in the kit. The sample is placed in a special envelope and either mailed or brought to the physician's office or test site for analysis.

Most tests for occult blood test are based upon the fact that hemoglobin, the oxygen-carrying protein in blood, has peroxidase activity. In the presence of hydrogen peroxide, hemoglobin will catalyze the oxidation of a dye such as gum guaiac, benzidine, or o-toluidine, creating a blue color. The dye is present on the card. When hydrogen peroxide is applied to the card and mixed with the stool, the blue color will form if an abnormal amount of blood is present. Rapid immunochemical tests are also available.

Preparation

The patient may be requested to avoid meat, fish and poultry for two or three days prior to the test.

Aftercare

There is no aftercare required for this test.

Complications

There are no complications associated with this test.

Results

As described above, many factors can result in false-positive and false-negative findings. Therefore, it is important to note that a true-positive finding signifies only the presence of blood; it is not necessarily an indication of cancer. The National Cancer Institute states that, in their experience, less than 10% of all positive results are caused by cancer. Alternatively, a negative result (meaning no blood was detected) does not guarantee the absence of colon cancer, which may bleed only occasionally or not at all. The physician will want to fol-

KEY TERMS

Occult blood—Blood in the stool that is not visible or easily detected.

low up on a positive result with further tests, depending upon other factors in the patient's history or **physical examination**. Endoscopic exam is often recommended when the cause of GI bleeding is unknown.

Health care team roles

Nurses should determine if the patient has been experiencing signs of a peptic ulcer (epigastric **pain** between meals), and should note any recent bleeding episodes related to dental problems. The physician, laboratory technician, or scientist should ensure that the sample is analyzed within 48 hours of collection.

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Feedback systems

Definition

A feedback system uses as input the total or partial output of the system. Feedback systems are used to control and regulate processes. They use the consequences of the process (i.e. too much or too little produced) to regulate the rate at which the process occurs (to decrease or increase the rate of the process).

Description

A typical feedback system consists of a sensor, a control center that receives the signals of the sensor, and an effector pathway, meaning a pathway for the commands of the control center as it reacts to the information received from the sensor.

In complex organisms, such as humans, feedback systems constantly monitor and regulate numerous factors, including the levels of gases like oxygen and carbon dioxide, nutrients, hormones, and chemical substances. The feedback systems insure that the amounts of these substances in body tissues and fluids remain unchanged within appropriate limits, despite changes in the external environment.

Feedback systems function with the help of the nervous and endocrine systems. While nerve cells detect changes in the body and quickly respond to the **brain** for a rapid response, hormones of the **endocrine system** regulate the system more slowly. For example, hormones and nerves regulate the progress of labor contractions. When labor begins, nerve cells in the uterus alert the hypothalamus (a control center in the brain). A hormone called oxytocin is released into the **blood**, which causes the uterus to contract.

Feedback control or regulation can be either negative or positive. With negative feedback, the activity of a system is reduced, slowed down or minimized by the presence of high amounts of a substance it produces. An example is the increased breathing resulting from the presence of high levels of carbon dioxide in extracellular fluids. The purpose of breathing is to provide the oxygen required by the body for its functioning (**metabolism**) and to eliminate waste carbon dioxide. In the presence of high levels of carbon dioxide, breathing increases, which increases the supply of oxygen present in the air in the lungs, thus counteracting the high amounts of carbon dioxide, which are harmful to the body. With positive feedback, the activity of a system is increased by the presence of high amounts of a substance it produces. Positive feedback systems thus speed up or maximize the rates of processes. For example, they are used in the production of nerve impulses and blood clotting. In the above example, labor contractions are a positive feedback system. As oxytocin reaches the uterus, causing contractions, more stretching causes an increase in oxytocin levels, which causes more forceful contractions.

Function

Almost all body functions and processes operate using feedback systems. The body maintains its overall chemical and physical internal environment constant

(homeostasis) using a control system activated by several feedback systems. This is because normal cell function depends on maintaining relatively constant intracellular and extracellular environments, such as pH, temperature, and the amounts of all the substances needed by the body. The body keeps these quantities within the range required to maintain life and proper function with the help of feedback systems.

Feedback systems are active at all levels of body organization, whether molecular (e.g. regulation of enzymes); cellular (e.g. regulation of cell volume or chemical contents); organ (e.g. regulation of blood flow in the **heart** or **lungs**); systemic (e.g. **regulation of breathing** in the **respiratory system**), and whole-body (e.g. regulation of body temperature through shivering and sweating). Some examples include:

- Enzymatic feedback inhibition. At the molecular level, a mechanism called feedback inhibition operates to limit the amount of chemical product produced by an enzyme system. An enzyme system consists of several enzymes that act one after the other to convert a substance into an end product the body needs. Overproduction of the end product is prevented by the inhibitory effect of the end product on the first enzyme in the sequence, which is called the regulatory enzyme. As the end product is used up in other chemical conversions, however, its inhibitory effect on the regulatory enzyme decreases, so that more end product can be formed by the enzyme system. In this way, the level of end product is maintained at a fairly constant level.
- The pH of body fluids. The pH is a measure of the acidity of a solution, or of its hydrogen ion concentration. The normal pH of body cells and fluids is 7.4. When this value steps out of the normal range as a result of the presence of chemical substances that either increase it or decrease it, a feedback control system is triggered to remove or increase the amount of substance so as to bring back the pH to its normal value.
- The amounts of small ions. The cells of the body consist of a nucleus surrounded by a fluid cytoplasm that contains several structures (organelles) required for functioning, all enclosed in a membrane. Cells can be thought of as little chemical powerhouses that require specific amounts of chemical substances, among which several small ions (elements that have a positive or negative charge) that need to be made available either inside or outside the **cell membranes**. For example, the potassium ion (K^+ is the major intracellular positive ion (cation) and the sodium ion (Na^+ is the major extracellular cation). Likewise, the major extracellular negative ions (anions) are Cl^- and HCO_3^- . Both the amounts

KEY TERMS

Acidity—Refers to a compound that is acid or sour. When dissolved in water, acids yield hydrogen ions.

Cell—The individual units from which all the tissues and fluids of the body are formed. They consist of a nucleus surrounded by a fluid cytoplasm enclosed in a membrane. Intracellular refers to all substances found inside the membrane and extracellular refers to all substances outside the cell membrane.

Chemoreceptors—Specialized cells that can detect chemical substances in the body and relay that information to the central nervous system. The substances detected may be external, such as when an individual smells or tastes something; or they can be internal, such as the carotid bodies, located in the carotid arteries, that detect the amounts of oxygen or carbon dioxide present in the blood.

Cytokine—A protein secreted by tissues or leukocytes (a type of white blood cell) that has a regulatory function.

Enzyme—A type of protein produced by the body that speeds up chemical reactions. Some enzymes regulate certain functions due to their ability to change their activity by modifying their structure.

Homeostasis—Stability of the body's internal environment, achieved by a system of integrated control systems activated by feedback systems. Homeostasis is thus the maintenance of a constant internal environment (the immediate surroundings of cells) in response to changes occurring in a) the conditions of the external environment and b) the conditions of the internal body environment.

Hormone—A substance secreted by specialized glands in the body that affects the behavior of other cells. Hormones serve as messengers to coordinate activities of various parts of the body.

Ion—Elements consist of positively charged nuclei surrounded by negatively charged electrons. These charges are balanced and the overall charge of an element is zero. An element becomes an ion, that is a charged species, if it gains or losses electrons.

Metabolism—The sum of all the physical and biochemical processes occurring in the body to produce what is required to maintain life. Metabolism includes the transformation of nutrients into energy and the use of energy by the body.

pH—A measure of the acidity of a solution, or of its hydrogen ion concentration. In the human body, the solution can be the blood or the cerebrospinal fluid. The normal pH of body fluids is 7.4.

of these ions and their transport across the cell membranes are controlled by feedback systems.

- Arterial oxygen partial pressure. Another feedback system regulates the oxygen partial pressure $P(O_2)$ and carbon dioxide partial pressure $P(CO_2)$ in the arteries. This is because the cells of the body obtain their energy by combining oxygen with various foodstuffs, producing carbon dioxide as a waste product, so they need a constant supply of oxygen and also need to have the carbon dioxide removed. Normally, if the arterial blood reaching a special chemical sensor (chemoreceptor), called the carotid body, has a partial pressure of oxygen lower than the normal range or an excessive carbon dioxide partial pressure, then there is an immediate and marked increase in breathing.
- Internal body temperature. Body temperature is regulated by a feedback system that maintains it nearly constant at 98.6°F (37°C) throughout the day, week, month or year. As a consequence, a person can remain active

and working in the hot summer months or on cold winter days.

Role in human health

The role of the many feedback systems of the human body is to maintain the homeostasis required for life.

Feedback systems are activated as soon as disturbances occur in the narrow range of conditions which cellular processes need to be able to function at a level required for the continuation of life. For example, the body temperature feedback system will act to make sure that the body's internal temperature is maintained constant in spite of the weather. The Na^+ feedback regulatory system will adjust the body cells and fluids to the dietary intake of sodium (salt) from foodstuffs. The breathing feedback system will likewise seek to maintain proper oxygen and carbon dioxide pressures and amounts when disturbed, say by heavy **exercise**. Another feedback system will regulate blood flow and pressure whenever these quantities are increased or decreased by events

such as disease, injury, or blood donation. In other words, whenever anything happens that changes the narrow range of the normal values of body parameters, feedback regulatory systems step in to counteract the effect of the change. And if the change is too drastic for the feedback system to handle, the result is disease and even death.

Common diseases and disorders

The function and development of all body components are controlled by a variety of feedback systems. Any malfunctioning of a given regulatory feedback system will not only affect the body part or process directly controlled by that system but will also affect those functions controlled by other related feedback systems. For example, at the organ level, it is known that many use hormones and cytokines as effectors in regulatory feedback loops. It is now believed that these feedback systems are involved in some forms of human **cancer**. For instance, the disruption of a negative feedback system by a cancer transformation can result in the loss of growth control or in increased malignant behavior of tumor cells. Also, abnormal positive feedback loops can develop that increase tumor growth by allowing the excessive release of stimulatory factors.

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Female infertility see **Infertility**

Female reproductive system see **Reproductive system, female**

Ferritin test see **Iron tests**

Fertility treatments

Definition

Infertility is a problem with the reproductive system that results in the inability of a man or woman to achieve a **pregnancy** or of a woman to carry a pregnancy to live birth. The accepted definition within the medical profession is the absence of conception after at least one year of regular intercourse without birth control. Regular intercourse refers to intercourse at least two to three times per week. The term is also used to cover women unable to carry a pregnancy to term because of **miscarriage**. Infertility is not sterility, which is the term used to mean conception is not possible under any circumstances. Infertility is not a new disease or condition, but it appears as if there has been an increase in infertility rates in the past few decades. Some factors that may relate to this increase include an increase in the age of women wanting to conceive, an increase in the spread of sexually transmitted diseases, and the rise in the level of toxic chemicals in our environment. Infertility does affect people of all ages, ethnic backgrounds, socioeconomic groups, and both sexes.

Purpose

The purpose of fertility treatments is to achieve a successful pregnancy and outcome. Male factors account for approximately 30-40% of all cases of infertility and female factors cause about 40% of cases. Close to 15% of cases are a result of a combination of male and female factors; whereas in 5-10% of cases, no cause can be found.

Many couples may begin their quest for fertility with their primary care physician, who is usually a medical doctor certified in family medicine. The primary physician can do a physical exam on both individuals but should refer the couple to a specialist in obstetrics and gynecology to initiate the infertility evaluation process. Infertility is described as either primary or secondary. A couple who has never achieved pregnancy is experiencing primary infertility, whereas a couple who has had a pregnancy in the past, regardless of the outcome, is experiencing secondary infertility.

For an egg to be fertilized, sperm produced in the testes must not only be present in sufficient number in the semen but they must be capable of moving far enough and fast enough to travel through the **female reproductive system** (motility), and capable of penetrating the outer layer of an egg. Male infertility may be a result of small quantities of sperm; prenatal exposure to diethylstilbestrol (DES) (a medication given to women to pre-

vent miscarriage in the 1950s); exposure to radiation, certain pesticides or heavy metals (lead); or diseases that reduce the body's ability to produce sperm. Female infertility may be related to irregularities of the fallopian tubes; endometriosis (tissue resembling the lining of the uterus growing in the abdomen); irregular ovulation or lack of ovulation; abnormalities of the uterine cavity; and/or cervical problems such as abnormal mucus.

A couple should consider seeing an infertility specialist (a physician certified in reproductive endocrinology and infertility) for any of the following reasons:

- a woman experiencing irregular menstrual cycles or irregular ovulation
- a woman with a history of three or more miscarriages
- a woman older than 35 years of age
- a woman with a history of pelvic **infection** or previous pelvic surgery
- a woman who needs microsurgery for endometriosis or for tubal damage
- a man with a poor **semen analysis** such as low count, poor motility, abnormal appearance, or requiring microsurgery
- a couple with unexplained infertility whose tests came back normal but still have not conceived after two years
- a couple who needs more advanced treatment, such as injectable ovulation-induction medications or assisted reproductive technology (ART)

There are over 300 fertility clinics in the United States and each one has a varying rate of success. A couple should investigate the services of the ones they are considering to save time, money and emotional upheaval. In 1992, Congress passed the Fertility Clinic Success Rate and Certification Act, which requires the Centers for Disease Control and Prevention (CDC) to publish the success rates of clinics throughout the United States where ART is performed. This report is intended for laypersons who are considering using ART to achieve pregnancy and provide an objective review utilizing a common method of reporting success. Besides success rates, a couple should consider the following:

- Is the physician board certified in reproductive endocrinology?
- How much experience has the physician had with diagnosing and treating infertility?
- What are the fees for office visits and are payment plans available?
- What is the policy regarding cancellation of appointments and filing of insurance claims?

- Will a physician or someone else on staff be available twenty-four hours a day, seven days a week, including weekends and holidays?
- Will lab and ultrasound facilities be open seven days a week?
- Will the couple see the same physician for their visits?
- Will decisions on tests, treatments and referrals be made jointly between the couple and the physician?

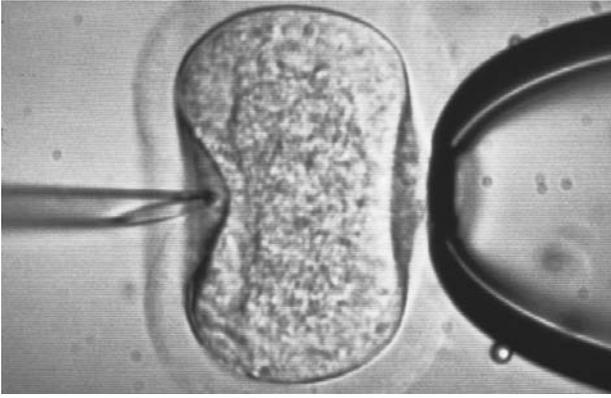
Precautions

Couples involved in fertility treatments face many legal, ethical, psychological, emotional and financial questions. It is imperative to explore these issues before beginning a course of treatment in order to maintain a realistic attitude. It is difficult, if not impossible, to identify problems that may arise during treatment, but it is important to make an attempt to set limits, physically, financially, and emotionally, on what can be handled during the course of treatment. It is likewise crucial to consider potential legal, practical and ethical problems associated with each choice of treatment and to contact resources available to individuals with infertility problems for an objective viewpoint. Just because the treatment is available does not mean it has to be utilized. All individuals have their own ethical standards and limitations and need to investigate all courses of treatment before undergoing them.

Informed consent is a medical term that means a patient gives permission for a test or invasive procedure to be performed, after being informed by the physician in clear language exactly what the test or procedure involves. If at any point in the course of treatment a patient does not understand something, he or she should be encouraged to ask questions; and if the answer is not satisfactory, the patient should know that a second opinion may be solicited.

Prior to undergoing assisted reproductive technology (ART), women should be advised to avoid all **pain** medications other than Tylenol and discuss prescription medications with the specialist. They should not smoke cigarettes or drink alcohol, avoid caffeine-containing beverages, and inform the physician if they have active **genital herpes**. They should also maintain a healthy well-rounded diet and take a multiple vitamin containing **folic acid** every day.

Men should report any fevers within three months before ART treatment, as fevers may adversely affect sperm quality. They should avoid hot tubs or saunas for three months, as the heat can affect sperm function. Men should also avoid alcohol, drug use, and cigarette smoking for three months prior to treatment and during the



A microscopic image of a needle (left) injecting sperm cells directly into a human egg (center). The broad object at right is a pipette used to hold the ovum steady. (Phototake NYC. Reproduced by permission.)

ART cycle as well. Any prescription drugs should be reported to the specialist along with active genital herpes. It is preferable to avoid intercourse for three days but not more than seven days before collection of semen for an ART cycle.

Description

Assisted reproductive technology (ART) is defined by the U.S. Centers for Disease Control and Prevention (CDC) as “all treatments or procedures that involve the handling of human eggs and sperm for the purpose of helping a woman become pregnant.” Types of ART include in vitro fertilization (IVF), gamete intrafallopian transfer (GIFT), zygote intrafallopian transfer (ZIFT), embryo cryopreservation, egg or embryo donation, and gestational carriers. ART does not include intrauterine insemination (IUI) with either partner or donor sperm.

In vitro fertilization (IVF)

This name comes from the fact that fertilization occurs outside the body in a laboratory, instead of in the woman’s fallopian tube. *In vitro* is a Latin term that means ‘in the glass’ and refers to procedures performed outside of a living body in a laboratory or other artificial environment. Thus, IVF involves joining an egg and a sperm in a laboratory dish; if fertilization occurs, the resulting pre-embryo is transferred into the woman’s uterus for possible implantation. IVF was developed as a technique to assist women who had blocked, damaged or absent fallopian tubes to become pregnant. The first successful IVF procedure was performed in the United Kingdom and resulted in the birth of Louise Brown in 1978. Today IVF is utilized to treat infertility caused by

endometriosis; certain types of male factor infertility; tubal factors; and unexplained infertility.

The procedure utilized for IVF may vary somewhat from clinic to clinic, but generally it involves the following:

- Stimulating the woman’s ovaries to produce multiple eggs during a specific time of her menstrual cycle.
- Detecting the presence of multiple eggs through the use of vaginal ultrasound.
- Retrieving eggs from her ovaries (while under intravenous sedation) by means of guiding a needle through the wall of the vagina and into the follicles and aspirating them.
- Determining the maturity of the eggs and adding sperm to them once mature.
- Transferring the embryo into the uterus by a catheter (long, slender tube with a syringe on one end) is relatively simple and requires no anesthesia.

Stimulating a woman’s ovaries to produce multiple eggs may vary by program or patient, but the majority require several days of medications to be given by injection. Two main medications are used in the stimulation phase of an IVF cycle. The first is Lupron, which suppresses the ovaries by shutting down the body’s normal production of luteinizing hormone (LH) and follicle stimulating hormone (FSH). Both of these hormones are essential to produce ovulation. Lupron is given by injection subcutaneously (just under the surface of the skin). It shuts down the ovaries completely so that when the induction drugs are given the follicles will mature evenly. The second type of medication is either pure FSH or FSH in combination with LH. It is given by injection to stimulate the ovaries to produce eggs in a controlled but hyperstimulated manner and at a dosage that will produce the highest number of good-quality eggs. With IVF, egg retrieval may take thirty minutes to one hour.

The transfer process takes only about ten to twenty minutes and results in the transfer of one or more embryos because the presence of multiple embryos makes it more likely that at least one embryo will attach to the uterine lining. The transfer of multiple embryos also increases the chance of **multiple pregnancy**. A couple may choose to maintain additional embryos before the transfer procedure so that they can be frozen, thawed and transferred at a later date. In the United States in 1996, 300 clinics reported doing over 64,000 ART cycles, and 92% of these were IVF.

Gamete intrafallopian transfer (GIFT)

With GIFT, conception takes place in the fallopian tube. This technique should be utilized only when sperm quality is adequate and at least one fallopian tube is open and functional. The steps involved in this technique are similar to those with IVF up to the egg retrieval. As with IVF, egg retrieval occurs under **general anesthesia** and eggs and sperm are transferred immediately to a catheter that is used to inject the eggs and sperm into the fallopian tube during **laparoscopy**. There is no ability to document fertilization or to evaluate embryo quality in a GIFT procedure. This procedure requires two small incisions, one just outside the woman's navel and the other deep in her abdomen where a probe is inserted.

Zygote intrafallopian transfer (ZIFT)

This procedure is a combination of IVF and GIFT. Eggs are retrieved by transvaginal ultrasound aspiration, as with IVF, and are fertilized in a laboratory dish. The next day, before the fertilized eggs begin **cell division**, they are transferred into the woman's fallopian tubes by laparoscopy. This procedure is sometimes referred to as pronuclear stage transfer (PROST). Zygote is a term used to describe an egg that has been fertilized but has not yet undergone cell division, but now it is more commonly referred to as a pronucleus.

Tubal embryo transfer (TET)

This procedure involves the transfer of a more developed embryo than that used in GIFT or PROST. In this case, a fertilized egg that has reached the four- to eight-cell stage of division is transferred into the fallopian tube. This transfer usually occurs about 24 hours after fertilization and the developing embryo then proceeds to move into the uterus as in an unassisted pregnancy.

Techniques utilized to enhance fertilization or implantation include:

- Intracytoplasmic sperm injection (ICSI) uses a microsurgical needle to inject a single sperm directly into the egg to achieve fertilization.
- Microinsemination concentrates sperm into a small drop of fluid and placing it around the eggs to increase chances of fertilization.
- Assisted hatching is a micromanipulation technique performed after fertilization with IVF, designed to improve the implantation of the embryo by making a microscopic hole (with a microsurgical needle or chemicals) in the zona pellucida (the transparent, noncellular, secreted layer surrounding an ovum) to facilitate the release of the embryo from the egg membrane.

The micromanipulation techniques are relatively new procedures that may not be available in all fertility clinics. Their success depends on the quality of the man's sperm, the age of the woman, and the experience of the clinic.

Aftercare

Progesterone supplements are started the day after egg retrieval and continued until the **pregnancy test** is negative or throughout the first trimester of pregnancy. Vaginal suppositories or gel, intramuscular injections, and oral capsules are the form of progesterone used during IVF. Clinics vary regarding instructions about activity after embryo transfer. Some may suggest a few hours of bed rest and others suggest two to three days of minimal physical activity. The patient may also have her own opinion and choose to rest longer. About 10-12 days following embryo transfer, the physician will order a hCG (human chorionic gonadotrophin) test to determine pregnancy. If the test result is borderline, another **blood test** will be taken in two to three days. Five weeks after the transfer, an ultrasound is performed to document a heart-beat and confirm pregnancy.

Complications

Hyperstimulation syndrome is usually mild when it occurs, but it can become potentially serious. This is a result of ovaries that are extremely responsive to the medications, thereby causing them to become quite large. Hyperstimulation syndrome can lead to severe weight gain from fluid accumulation in the abdomen and low output of urine as well as potentially serious changes in blood chemistry. It is rare for a woman to experience such severe hyperstimulation that hospitalization occurs, but the syndrome can become serious enough to require close monitoring of intravenous fluids and weight, urine output, and blood chemistry.

Multiple gestation is another potential complication of ART and one that can have a long-term impact on a family. These pregnancies are physically and emotionally challenging to the mother and also have the potential of severe health risks associated with premature birth, which is quite common with multiple gestation. ART procedures have resulted in multiple gestation pregnancies about 43% of the time in women younger than 35 years. The risks to a woman carrying multiple fetuses include high **blood pressure**, **gestational diabetes**, increased risk of bleeding, premature labor, and cesarean section birth. Risks to the infant include prematurity, low birth weight, and respiratory and eye complications. **Premature infants** are also at higher risk for congenital (from birth) abnormalities and learning disabilities. The

KEY TERMS

Cryopreservation—Maintenance of the viability of excised tissue or organs by storing at very low temperatures.

Ectopic—Arising or produced at an abnormal site or in a tissue where it is not normally found.

Endometriosis—A condition in which tissue more or less perfectly resembling the endometrium (the mucous membrane lining the uterus) occurs outside the uterine cavity, usually in the pelvic cavity.

Follicle stimulating hormone—One of the hormones that promotes the formation of follicles within the ovary for ovulation.

Laparoscopy—Examination of the peritoneal cavity with an endoscope.

Luteinizing hormone—One of the hormones that promotes follicle formation within the ovary for ovulation.

Pronucleus—The haploid nucleus of a sex cell.

Ultrasound—A procedure in which high-frequency sound waves are used to create an image of a baby. Ultrasound can be used alone or with other antepartum testing.

risks of complications to the mother and the fetus increase dramatically with the number of fetuses carried. Couples may sometimes choose to undergo a procedure called multiple gestation reduction (MGR), which involves reducing the number of fetal sacs to improve the chance of having a healthy pregnancy and a healthy baby. This decision is an individual one that must be based on ethical, moral, and personal beliefs as well as medical information.

Another potential complication is the fact that a small number of ectopic, or tubal, pregnancies can occur after embryo transfer in an IVF cycle as a result of embryos traveling out into the fallopian tube from the uterine cavity. The chance of this occurring, however, is less than one percent. Twenty percent of all pregnancies, regardless of how established, are lost, and all patients should be aware of this statistic prior to treatments as well. Individuals who do become pregnant are sometimes unable to enjoy the pregnancy because of the fear surrounding the treatments needed to achieve it and fear of potential problems or adverse outcomes.

Results

If all goes well, the best result would be a healthy pregnancy and a healthy baby. If any of the complications occur, the individuals could undergo the procedure again, but it is essential that they have counseling to determine their expectations and emotional status.

Health care team roles

All health care workers who take part in assisted reproductive technology and care for the patients should be trained in bereavement counseling. Although it is essential to provide the appropriate physical care necessary to achieve pregnancy, the psychological and emotional impact of the treatments and adverse outcomes are much more difficult to handle. Nurses usually spend more time with the patients, and it is their responsibility to be a patient advocate. Patients will often tell the nurse things they would not discuss with the physician. In such a situation, the nurse needs to intercede for the patient to make the physician aware of problems and concerns. Often the patient simply needs a hand to hold during treatments and an understanding heart to listen, which every nurse can provide.

Resources

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- Cooper, S. L. & Glazer, E.S. *Choosing Assisted Reproduction*. Indianapolis, IN: Perspectives Press, 1998.
- Olds, Sally B., London, Marcia L., Ladewig, Patricia A. *Maternal-Newborn Nursing: A Family and Community-Based Approach*. Upper Saddle River, NJ: Prentice Hall Health, 2000.

ORGANIZATIONS

- American Society for Reproductive Medicine (ASRM), 1209 Montgomery Highway, Birmingham, AL 35216-2809. (205) 978-5000. <<http://www.asrm.org>>.
- International Fertility Center, 2601 East Fortune Circle Drive, Suite 102B, Indianapolis, IN 46241. (317) 243-8793. <<http://www.fertilityhelp.com>>.
- Resolve, 1310 Broadway, Somerville, MA 02144-1779. National HelpLine: (617)623-1156. <<http://www.resolve.org>>.

OTHER

- Fertility Net. <<http://www.ferti.net>>.
- Surrogacy.com. <<http://www.surrogacy.com>>.

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Fetal age study

Definition

A fetal age study, also called biometry, is part of an obstetric ultrasound exam. The study uses ultrasonography to take measurements of several fetal anatomic structures, compare the results to expected values, and convert that information into an estimated gestational age of the fetus.

Purpose

Biometry is used to determine fetal age. Serial biometry may be performed to assess fetal growth rate.

Precautions

As imaging technology has improved resolution of the fetal structures, care must be taken that the measurements start and end at the correct locations. The skill and experience of the ultrasound technologist are a critical component in obtaining reliable results. In general, ultrasonography dating of a **pregnancy** is more accurate than dating using the date of the mother's last menstrual period.

Description

Accurate dating of a pregnancy is the foundation on which obstetrical management relies. The date of the mother's last menstrual period is often used to estimate delivery date, but it is accurate to within only about two weeks. By comparison, the biometric crown-rump measurement of the six to 12-week fetus provides the most accurate measurement, within three days of true gestational age. First-trimester biometric measurements may be obtained using either an abdominal or transvaginal transducer. Transvaginal ultrasonography can visualize fetal structures about one week in advance of abdominal sonography. Since the fetal structures are better visualized in the second trimester than in the first, a routine ultrasound is usually performed during that period, usually between 16 and 20 weeks gestation. Early sonography may be performed if a first-trimester pregnancy appears to be threatened, or if there is maternal bleeding, pelvic **pain**, or a concern that the pregnancy may be ectopic. Biometric dating may be used to determine the best time to perform chorionic villi sampling or maternal alpha-fetoprotein levels.

Since many pregnancies are not dated until the pregnancy is more advanced, different structures are measured to obtain fetal age, depending on the suspected gestational age. As gestational age increases, normal variability between fetuses increases. To some degree,

then, biometric accuracy decreases with advancing gestational age. After about the twelfth week of gestation, the fetal position and movements make crown-rump measurements less accurate. Other anatomic structures will then be measured. From 12 to 18 weeks gestation, biometric measurements are usually accurate to within a week of gestational age. After 26 weeks gestation, fetal variability has greatly increased and the dating provided by biometric measurement is less accurate, but the method is still used. By late in the third trimester, measurements are accurate only within a two- to three-week window. In general, once the crown-rump measurement is no longer reasonable to obtain, the averaging of several anatomic measurements is more accurate than the use of one measurement alone. Results outside of the expected outcome should be further evaluated, to check for fetal anomalies.

The four most common measurements taken during biometry are the biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). Because normal fetal variability is present between the 10th and 90th percentiles, the basis for comparison is usually the 50th percentile. However, imaging technology is sufficiently advanced so that almost any fetal structure can be measured and compared against normal ranges.

Fetal growth is based on the fetal size in relation to the expected gestational age. Normal fetal size and weight values are expected between the 10th and 90th percentiles. Fetal size or weight below the 10th percentile is considered small for gestational age (SGA). A fetus with measurements above the 90th percentile is considered large for gestational age (LGA), and may be an indication of fetal response to maternal **gestational diabetes**. The diagnosis of an SGA or LGA fetus impacts the future obstetric management of the pregnancy, and assists in avoiding complications related to these conditions. Imaging technology software can estimate fetal weight using the measurements obtained for size and their relation to fetal mass. Estimated fetal weight may be used to check for fetal growth, or may be used in cases of fetal surgery or when the fetus needs to receive medication or a **blood** transfusion.

Preparation

Biometry is a non-invasive sonographic fetal assessment tool. In early pregnancy, the mother may need to drink water prior to the test, without urinating until after the test has concluded. A full bladder is necessary to allow for transmission of the sound waves. As pregnancy advances, sufficient amniotic fluid is present so that fluid consumption prior to the test is not required. In order to

KEY TERMS

Gestational diabetes—Diabetes that first occurs during pregnancy and resolves once the pregnancy is terminated.

Transducer—The external device or probe used in conjunction with the ultrasound machine. Applied on the outside of the abdomen with a special gel, it bounces sound waves into the area being visualized, and then sends the return waves back to the computerized ultrasound machine for interpretation and visualization on the monitor. A transvaginal transducer is inserted into the vagina in order to be closer to the structures being evaluated.

Trimester—The average length of pregnancy is 280 days. The pregnancy is often divided into three trimesters, as different fetal development takes place in each of the three time periods. The first trimester extends to 14 weeks, the second through 28 weeks, and the third until 40/42 weeks, or term.

perform the ultrasound, a transducer is placed externally to the mother's abdomen. Use of a special gel allows the transducer to glide over the surface of the abdomen during scanning. Because the abdomen is exposed, privacy should be provided either with the use of a curtain or with a closed door. The mother should be asked if she would like her partner or support person with her during the test. A comfortable room temperature and warmed transducer gel assist in putting the mother more at ease. A towel or cloth placed over the mother's clothes protect them from becoming wet from the gel.

Aftercare

When the test is completed, the abdomen should be wiped dry of the transducer gel. If the mother needed to consume water prior to the test, she may need to urinate. She may require assistance in getting up from the ultrasound table. If non-reassuring test results have been conveyed to the mother, she may need a health care professional to stay with her for emotional support and to answer questions.

Complications

Because a fetal age study is noninvasive and observational, no complications are anticipated. If the measurements were not obtained carefully, the wrong gesta-

tional age will be determined. Interventions undertaken based on inaccurate findings could be considered a complication or risk of the procedure.

Results

The biometric results obtained are compared with norms for size and age, in order to estimate fetal age. Results outside of the normal range may indicate an SGA or LGA fetus, and require additional evaluation. Biometry may be used later in pregnancy when the fetal age is unclear. In this case, serial measurements may be taken after a two- to three-week period. The fetal growth during this time period can be compared against normal growth rates to estimate the gestational age. Because of rapid periods of fetal growth, each gestational week is also broken down further into the number of days. For example, the fetus's weight and length at 27 1/7 weeks is different from that for a fetus of 27 6/7 weeks.

Health care team roles

The fetal age study is usually performed by an ultrasound technologist in the imaging department. Non-routine biometry testing may provoke maternal **anxiety** over her baby's well-being. The ability of the technician to provide a calm, professional environment can help put the mother at ease.

Resources

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- Burrow, Gerard N. and Thomas P. Duffy, Editors. *Medical Complications During Pregnancy*, 5th Edition. Philadelphia: W. B. Saunders Company, 1999.
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Fetal alcohol syndrome

Definition

Fetal alcohol syndrome (FAS) is a pattern of birth defects and learning and behavioral problems affecting

individuals whose mothers consumed alcohol during pregnancy.

Description

FAS is the most common preventable cause of mental retardation. This condition was first recognized and reported in the medical literature in 1968 in France and in 1973 in the United States. Alcohol is a teratogen—the term used for any drug, chemical, maternal disease, or other environmental exposure that can cause birth defects or functional impairment in a developing fetus. Some features may be present at birth, including low birth weight, prematurity, and microcephaly. Characteristic facial features may be present at birth, or may become more obvious over time. Signs of **brain** damage include delays in development, behavioral abnormalities, and mental retardation, but affected individuals exhibit a wide range of abilities and disabilities. Only since 1991 has the long-term outcome of FAS been observed. Emotional disorders as well as learning and behavioral problems are common in adolescents and adults with FAS. Fetal alcohol effect (FAE), a term no longer favored, is sometimes used to describe individuals with some, but not all, of the features of FAS. In 1996 the Institute of Medicine suggested a five-level system to describe the birth defects, learning, and behavioral difficulties in offspring of women who drank alcohol during pregnancy. This system contains a number of criteria that must be present, including confirmation of maternal alcohol exposure, characteristic facial features, growth problems, learning and behavioral problems, and birth defects known to be associated with prenatal alcohol exposure.

The incidence of FAS varies among different populations studied, and ranges from approximately one in 200 to one in 2,000 live births. However, a study reported in 1997, utilizing the Institute of Medicine criteria, estimated the prevalence of FAS in Seattle, Washington, from 1975-1981 at nearly one in 100 live births. Avoiding alcohol during pregnancy, especially during the earliest weeks of the pregnancy, can prevent FAS. Not even the smallest amount of alcohol consumed during pregnancy has been proven to be completely safe.

FAS is neither a genetic nor inherited disorder. It is a pattern of birth defects and learning and behavioral problems that result entirely from maternal alcohol use during pregnancy. Alcohol freely crosses the placenta and causes damage to the developing embryo or fetus. Alcohol use by the father cannot cause FAS. If a woman with FAS drinks alcohol during pregnancy, she, too, may have a child with FAS. Not all individuals from alcohol-exposed pregnancies have obvious signs or symptoms of FAS. Individuals of different genetic backgrounds may be

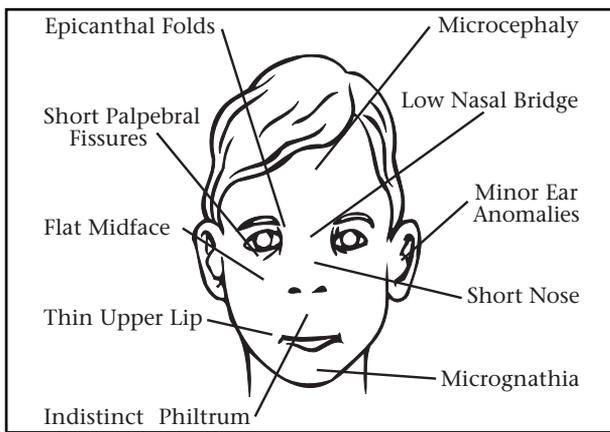
more or less susceptible to the damage that alcohol can cause. The dose of alcohol, the time during pregnancy at which the alcohol is used, and the pattern of alcohol use, all contribute to the different signs and symptoms that can be identified.

There is no racial or ethnic susceptibility to FAS. Individuals from different genetic backgrounds exposed to similar amounts of alcohol during pregnancy may exhibit different signs or symptoms of FAS. Several studies have estimated that between 25% and 45% of chronically alcoholic women will give birth to a child with FAS if they continue to drink during pregnancy. The risk of FAS appears to increase the older a chronically alcoholic woman becomes in her childbearing years and continues to drink. That is, a child with FAS will often be one of the last children born to a chronically alcoholic woman, although older siblings may exhibit milder features of FAS. Binge drinking, defined as the sporadic use of five or more standard alcoholic drinks per occasion, and moderate daily drinking (two to four 12 oz bottles of beer, 8 to 16 ounces of wine, 2 to 4 ounces of liquor) can also result in offspring with features of FAS.

Causes and symptoms

Classic features of FAS include short stature, low birth weight and poor weight gain, microcephaly, and a characteristic pattern of facial features. These facial features in infants and children may include small eye openings (measured from inner corner to outer corner); epicanthal folds (folds of tissue at the inner corner of the eye); small or short nose; low or flat nasal bridge; smooth or poorly developed philtrum (the area of the upper lip above the colored part of the lip and below the nose); thin upper lip; and small chin (micrognathia). Some of these features are nonspecific, meaning they can occur in other conditions, or be appropriate for age, racial, or family background. Other major and minor birth defects that have been reported include cleft palate, congenital **heart** defects, strabismus, **hearing loss**, defects of the spine and joints, alteration of the hand creases, and small fingernails and toenails.

The diagnosis is sometimes more difficult in older adolescents and adults. Short stature and microcephaly remain common features but weight may normalize, and individuals may actually become overweight for their height. The chin and nose grow proportionately more than the middle part of the face, so that dental crowding may become a problem. The small eye openings and the appearance of the upper lip and philtrum may continue to be characteristic. Pubertal changes typically occur at the normal time.



Facial features common in fetal alcohol syndrome. (EPD Photos. Courtesy of Gale Group.)

Newborns with FAS may have difficulties with feeding due to a poor sucking ability, have irregular sleep-wake cycles, decreased or increased muscle tone, seizures, or tremors. Delays in achieving developmental milestones such as rolling over, crawling, walking, and talking may become apparent in infancy. Behavior and learning difficulties typical in the preschool or early school years include poor attention span, hyperactivity, poor motor skills, and slow language development. Attention deficit-hyperactivity disorder (ADHD) is a common associated diagnosis. Learning disabilities or mental retardation may be diagnosed during this time. Arithmetic is often the most difficult subject for a child with FAS. During middle school and high school years, behavioral difficulties and learning difficulties can be significant. **Memory** problems, poor judgment, difficulties with daily living skills, difficulties with abstract reasoning skills, and poor social skills are often apparent by this time. It is important to note that animal and human studies have shown that neurologic and behavioral abnormalities can be present without the characteristic facial features. These individuals may not be identified as having FAS but may fulfill criteria for alcohol-related diagnoses as set forth by the Institute of Medicine.

In 1991 Streissguth and others reported some of the first long-term follow-up studies of adolescents and adults with FAS. Among the approximately 60 individuals they studied, the average IQ was 68. In the general population, 70 is the lower limit of the normal range. However, the range of IQ was quite large, from as low as 20 (severely retarded) to as high as 105 (normal). The average achievement levels for reading, spelling, and arithmetic were, respectively, fourth grade, third grade, and second grade. The Vineland Adaptive Behavior Scale was used to measure adaptive functioning in these individuals. The composite score for this group showed functioning at the level of a seven-year-old, daily living skills

at a level of nine years of age, and social skills at the level of a six-year-old.

In 1996 Streissguth and others published further data regarding the disabilities in children, adolescents, and adults with FAS. Secondary disabilities (that is, those disabilities not present at birth and that might be preventable with proper diagnosis), treatment, and intervention, were described. These secondary disabilities include mental health problems; disrupted school experiences; trouble with the law; incarceration for mental health problems, drug abuse, or a crime; inappropriate sexual behavior; alcohol and drug abuse; problems with employment and dependent living; and difficulties parenting their own children. In that study, only seven out of 90 adults were living and working independently and successfully. In addition to the studies by Streissguth, several other authors in different countries have now reported on the long-term outcome of individuals diagnosed with FAS. In general, the neurologic, behavioral, and emotional disorders become the most problematic for individuals with FAS. Because physical features change over time, correct diagnosis becomes more difficult in older individuals without old photographs and other historical data to review. Mental health problems included attention deficit disorder, depression, panic attacks, psychosis, and suicide threats and attempts, and overall were present in more than 90% of the individuals studied by Streissguth. A 1996 study from Germany reported that more than 70% of the FAS adolescents studied had persistent and severe developmental disabilities. Many had psychiatric disorders, the most common of which were emotional disorders, repetitive habits, **speech disorders**, and hyperactivity disorders.

Diagnosis

FAS is a clinical diagnosis, which means there are no **blood**, x ray, or **psychological tests** that can be performed to confirm a suspected diagnosis. The diagnosis is made based on the history of maternal alcohol use, and detailed **physical examination** for the characteristic major and minor birth defects, and characteristic facial features. It is often helpful to examine siblings and parents of an individual suspected of having FAS, either in person or by photographs, to determine whether findings on the examination might be familial, or if other siblings may also be affected. Sometimes, genetic tests are performed to rule out other conditions that may present with developmental delay or birth defects. Individuals with developmental delay, birth defects, or other unusual features are often referred to a clinical geneticist, developmental pediatrician, or neurologist for evaluation and diagnosis of FAS. Psychoeducational testing to deter-

mine IQ and the presence of learning disabilities may also be part of the evaluation process.

Treatment

There is no treatment for FAS that will reverse or change the physical features or brain damage associated with maternal alcohol use during pregnancy. Most of the birth defects associated with prenatal alcohol exposure, however, are correctable with surgery. Children with FAS should have psychoeducational evaluation to help plan appropriate educational interventions. Common associated diagnoses, such as ADHD, depression, or **anxiety** should be recognized and appropriately treated. Disabilities that present during childhood persist into adult life; however, some of the secondary disabilities may be avoided or lessened by early and correct diagnosis, better understanding of the life-long complications of FAS, and appropriate intervention. Streissguth has described a model in which an individual affected by FAS has one or more advocates to help provide guidance, structure, and support as the individual seeks to become independent, successful in school or employment, and develop satisfying social relationships.

Prognosis

The prognosis for FAS depends upon the severity of birth defects and brain damage present at birth. **Miscarriage** and stillbirth, or death in the first few weeks of life, may be outcomes in very severe cases. Some factors that have been found to reduce the risk of secondary disabilities in FAS individuals include diagnosis before the age of six years; stable and nurturing home environments; never having experienced personal violence; and referral and eligibility for disability services. The long-term data help in understanding the difficulties that individuals with FAS encounter throughout their lifetime, and can help families, caregivers and professionals provide care, supervision, education, and treatment geared toward their special needs.

Health care team roles

Pediatricians, obstetricians, family physicians, or nurse practitioners are most likely to make an initial diagnosis of FAS. A clinical geneticist, developmental pediatrician, or neurologist often confirms an initial diagnosis. Other physicians and surgeons may monitor and treat an affected baby. Nurses provide supportive care. Therapists provide support for parents of babies with FAS.

KEY TERMS

Cleft palate—An abnormal opening in the roof of the mouth, usually in the midline, so that there is a communication between the nose and mouth cavities.

Congenital—Present at the time of birth.

IQ—Abbreviation for Intelligence Quotient. Compares an individual's mental age, as measured by a test, to a true or chronological age and multiplies that ratio by 100.

Microcephaly—Small head circumference. Head circumference is an indirect measure of brain size.

Miscarriage—Spontaneous pregnancy loss.

Placenta—Organ unique to mammals that serves to exchange nutrients and waste between the maternal and fetal circulations; sometimes called the afterbirth.

Strabismus—Failure of the eyes to move together when focusing on an object; sometimes called lazy eye.

Teratogen—Any drug, chemical, maternal disease, or exposure that can cause physical or functional defects in the embryo or fetus of the exposed mother.

Prevention

Prevention of FAS is the key to effectively addressing the problem. Prevention efforts must include public education efforts aimed at the entire population, not just women of childbearing age; appropriate treatment for women with high-risk drinking habits; and increased recognition and knowledge about FAS by professionals, parents, and caregivers.

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Fetal biophysical profile

Definition

The fetal biophysical profile (BPP) is a test performed to measure fetal well-being. It uses ultrasonography to measure fetal breathing, fetal movement, fetal tone, and amniotic fluid volume. A non-stress test is done to assess fetal **heart** rate. Each of these five variables is given a score of zero or two, for a potential total score of 10.

Purpose

The purpose of the BPP is to assess fetal well-being. It is a tool used near or at term by clinicians to assess the potential risk of fetal compromise or demise due to fetal hypoxia or acidosis. Intervention such as maternal hospitalization, or delivery may follow a BPP score of four or below.

Precautions

A reliable BPP score necessitates that a well-trained ultrasonographer perform the test. However, fetal parameters are recorded over a 30-minute time period, with an additional 30 minutes for the non-stress test (NST) component. Information on a very active fetus is obtained inconsiderably less time. The complete BPP can therefore be a time-consuming test. The NST records the relationship of fetal heart rate to fetal movement. It is associated, however, with a false-positive rate as high as 80%, and averaging about 50%.

Description

The BPP is a test scoring five fetal vital sign variables: fetal heart rate, fetal breathing, fetal movement, fetal tone, and amniotic fluid volume. An ultrasound is used to visualize the fetus to measure these variables. The fetal heart rate is assessed through an NST. Each

parameter is given a score of two or zero, based on specific criteria. The total potential score is a 10. The BPP may be ordered following a non-reactive NST; after a suspicious oxytocin challenge/contraction **stress test** (CST); or after term, especially if there is concern about low amniotic fluid volume (oligohydramnios). The first researchers to report the results of scoring these fetal biophysical variables as a group were Manning and colleagues in 1980.

Fetal breathing (FB) is measured by watching for movement of the fetal thorax and diaphragm. This is to assure breathing, and not just chest wall movement. A score of two is given if at least one occurrence of FB lasting at least 30 seconds during the 30-minute test is noted. A score of zero is given if no FB is seen, or if the FB lasted less than 30 seconds.

Fetal movement is defined by gross arm, leg, or body activity. A score of two is given if there are at least three separate limb/body movements during the 30-minute test. A score of 0 is given if there are two or fewer limb/body movements during the test. Facial movement is not scored.

Fetal tone is defined by active extension and flexion of the fetal limbs, trunk, or hand; or if the hand remains in a flexed position during the entire 30-minute test. A score of two is given if the hand and fingers are seen to fully extend and flex into a fist. A score of zero is given if no such movement is recorded, or with slow or partial flexion or extension.

Amniotic fluid volume is estimated for sufficiency. Since fetal anatomic structures do not allow full visualization of all the amniotic fluid, it is estimated by measuring *pockets* of fluid from 0.39 to 0.78 in (1 to 2 cm) in height on ultrasound. A score of two is given if at least one pocket of fluid measures 0.78 in (2 cm) or more in height. A score of zero is given when no such pockets can be measured. Normal amniotic fluid volume peaks at about 750 ml at 32 weeks gestation, stays stable until term at 40 weeks, and then declines to about 400 ml by 42 weeks. Excessive amniotic fluid amounts (hydramnios), such as might be seen in diabetic mothers, may be as high as 1700 to 1900 ml. Oligohydramnios is defined by about 300 ml of fluid volume. The amniotic fluid is produced as the fetus urinates and through lung secretions. The volume is controlled by fetal swallowing and by reabsorption through the membranes. The amniotic fluid index (AFI) is also used to determine sufficiency of amniotic fluid. In this method, the largest vertical column of fluid in each of the four uterine quadrants is measured. Because of the role of the fetus in the production and control of amniotic fluid, it is one variable in fetal well-being assessment.

Fetal heart rate (FHR) variability is measured during a NST. The fetal heart rate is normally variable in nature. Accelerations, or increases in FHR, are usually seen in response to fetal movements and are therefore reassuring. A score of two is given for two or more accelerations of at least 15 beats per minute that last at least 15 seconds each during a 30-minute period. A score of 0 is given if fewer than two accelerations are seen within 30 minutes.

Preparation

Because the BPP is done during the third trimester of **pregnancy**, there is sufficient amniotic fluid to provide contrast to clearly visualize the fetus. No preparation is usually required before the test is performed. The mother may be asked to have a snack prior to the test to encourage a more active fetus. Because the mother's abdomen is exposed, curtains or a closed door should provide privacy. A comfortable room air temperature and the warming of the transducer gel can assist in putting the mother at ease. The mother should be asked if she wants her partner or support person with her during the test. A towel or cloth should cover the mother's clothing to avoid its getting wet from the transducer gel.

Aftercare

The BPP uses an external transducer to visualize the fetus and the amount of amniotic fluid. A towel or cloth can be used to wipe off excess gel and dry the abdomen after the test. In the event that test results indicate fetal compromise, a health care professional should remain with the mother to provide emotional support and answer questions as needed.

Complications

Because the test is noninvasive in nature, complications from the test itself are unexpected. A non-reassuring test may be repeated four to 24 hours later for comparison. Efforts should be made to assess for false negatives or false positives. A low BPP score may be followed by interventions with their own potential complications.

Results

A score of eight or ten out of ten provides a reassuring BPP score. If the score is eight, with a decrease in amniotic fluid volume, delivery may be indicated, with fetal maturity. A score of six arouses suspicions of chronic fetal hypoxia. A repeat test within four to six hours may be ordered. Delivery may be indicated if there is a reduction in the amniotic fluid volume. A score of four is

KEY TERMS

Fetal demise—The death of the fetus in utero.

Transducer—The external device or probe used in conjunction with the ultrasound machine. Applied on the outside of the abdomen with a special gel, it bounces sound waves into the area being visualized, and then sends the return waves back to the computerized ultrasound machine for interpretation and visualization on the monitor.

Variability—The fetal heart rate is expected to change, or be variable in nature. While the adult heart rate remains stable, except with exertion, the rate of the fetal heart continually moves up and down. A flat fetal heart rate is considered an ominous sign.

suspicious of chronic fetal hypoxia. A fetal lung maturity test may be done to assess readiness for delivery. Delivery is indicated if a repeat BPP after 24 hours confirms a score of four or below. A score of zero to two elicits a strong suspicion of chronic fetal hypoxia. The BPP testing period may continue for two hours instead of the usual 30 minutes. If the two-hour score is four or below, delivery is indicated if the fetus has a good chance at extrauterine survival.

Health care team roles

The BPP should be performed by a trained ultrasonographer. The NST may be performed by a nurse or a radiology technician in the antenatal division of an obstetric department, in the radiology department, or in an obstetric office. As with any test, patient **anxiety** is heightened with concerns of fetal compromise. Therefore, the ability of the health care professional to convey accurate information in a calming manner is very important.

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Fetal cell screen

Definition

The fetal cell screen is a procedure performed during **pregnancy** whereby **blood** is drawn from the mother and examined for the presence of fetal cells.

Purpose

The fetal cell screen is used to assess the degree of Rh (also called Rho [D] or D) sensitization in an Rh-negative mother during gestation of an Rh-positive fetus. Fetal red cells carrying the Rh positive antigen can leak into the maternal circulation and immunize the Rh-negative mother, possibly leading to hemolytic disease of the newborn. The potential degree of isoimmunization and severity of hemolytic disease increases with each Rh-incompatible pregnancy. The fetal cell screen quantifies the extent of the leakage and permits determination of how much Rh immune globulin (RhoGAM) to administer in order to prevent the mother from developing anti-D antibodies against the fetus.

Rho immune globulin is normally administered by **intramuscular injection** to Rh-negative mothers at 28-30 weeks of gestation and again within 72 hours postpartum. The dosage is higher for mothers who test positive for fetal red blood cells. The treatment is performed earlier when **amniocentesis** or **chorionic villus sampling** is performed, or following spontaneous or elective abortion.

Aside from Rh-incompatibility cases, the test may be ordered to investigate the severity of maternal-fetal hemorrhage following a trauma, or during post-mortem examination of a stillbirth.

Precautions

Although in principle the fetal cell screen is simple to perform, the procedure is subjective, labor-intensive, and time-consuming; and requires skill, experience, and strict attention to detail.

When possible, the procedure should be scheduled with the laboratory in advance. The specimen may be rejected by the laboratory if it is delivered too long after

being drawn; or if clotted, hemolyzed, or contaminated with heparin (as may happen when drawn at the same time as a sample for **blood gases**).

The possibility that the mother has an inherited blood disorder that might produce fetal hemoglobin should be considered when interpreting a positive result.

Description

The fetal cell screen allows discrimination of fetal from maternal red blood cells in a sample of maternal blood. This procedure is also known as the Kleihauer-Betke test; acid elution for fetal hemoglobin; fetal hemoglobin stain; and fetal-maternal hemorrhage test.

At the hospital or laboratory, 3–7 ml of maternal blood is drawn, usually from a vein on the back of the hand or the inside of the elbow. The venipuncture site is cleaned with antiseptic, a needle is inserted, and the blood sample is collected into a vacutainer containing either EDTA or citrate. The procedure takes about five minutes. The nurse or phlebotomist performing the venipuncture should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. The sample should be kept at room temperature and transported to the laboratory for analysis within 6 hours.

The fetal screen test may be performed as a qualitative serological (antibody-based) test. In this method, a 3% suspension of the mother's blood in physiological saline is mixed with an antibody to the Rho (D) antigen. The antibodies will bind to any Rh-positive fetal cells present. After the cells are incubated with the antibody, the cells are washed to remove any unbound reagent antibody, and one drop of a 3% suspension of reagent Rh positive red cells is added. These cells serve as indicators. They bind to the remaining antigen-combining sites of the antibodies attached to fetal red cells, causing formation of rosettes. The number of rosettes found in five low-power microscopic fields is determined. When greater than or equal to seven rosettes are seen, the test is considered positive. A fetal-maternal bleed of at least 30 mLs is required to give a positive test result. If this test is positive, a quantitative test is used to more accurately determine the quantity of fetal blood in the maternal circulation.

The quantity of fetal cells in the maternal circulation is most often measured using a special staining technique known as the Kleihauer-Betke method. In urgent cases, such as with trauma, results can be returned in as little as one hour. The blood sample is smeared onto a **microscope** slide, fixed with ethanol, and allowed to air dry. The blood film is then treated with a weakly acidic phosphate solution and stained with eosin dye. Under acidic conditions, the adult hemoglobin elutes, or leaks, out of

the maternal cells, and they appear as pale “ghosts,” while the more acid-resistant fetal hemoglobin remains in the fetal red blood cells and becomes stained pink to red. The stained films are viewed under a light microscope, and the number of fetal and maternal cells found in 50 low-power fields is recorded. The number of fetal red blood cells is reported as a percentage of blood cells counted. The greater the amount of fetal blood leakage, the larger the dose of Rho immune globulin to be administered to the mother.

Rho immune globulin is a potent form of anti-D that is given to Rh negative mothers to prevent formation of an antibody to the D antigen. It acts by interfering with the recognition of D antigen by the mother's **immune system**. One dose can prevent immunization from up to 30 mL of fetal blood. The percentage of fetal cells is multiplied by 50 to give the mLs of fetal blood. (Each percent of fetal red cells represents 1/100th of the blood. Assuming an average maternal blood volume of 5000 mL, each percent is equivalent to $5000/100 = 50$ mL.) This number is divided by 30 to give the number of doses needed. If the number to the right of the decimal is lower than 5, one dose is added. Otherwise, two doses are added to the result.

The Kleihauer-Betke is currently the standard method used to detect fetal red blood cells in maternal circulation, although it is labor-intensive, subjective, and not suitable for automation. Since the mid-1990s, automated methods for quantifying fetal cells by flow cytometry have been under development. In these methods, the blood sample is treated with anti-D or anti-fetal hemoglobin antibodies that are labeled with fluorescein isothiocyanate (FITC). The antibodies react only with the fetal cells. In the flow cytometer, the suspended blood cells in the specimen stream through a sample tube in single file past a beam of ultraviolet light and are counted as the light beam is broken. The light also causes the FITC label to fluoresce, and light detectors in the flow cytometer allow differential counting of the fluorescently tagged fetal cells as they pass. Compared to the Kleihauer-Betke test, the automated flow cytometry method offers superior objectivity, sensitivity, specificity, and reproducibility.

Preparation

No special preparation is necessary.

Aftercare

After the blood sample is drawn, pressure should be applied to the puncture site until the bleeding stops to reduce bruising, and a bandage may be applied to the site. The woman may resume normal activities.

KEY TERMS

Amniocentesis—A prenatal screening procedure in which a needle inserted through the abdominal wall is used to take a sample of amniotic fluid from the amniotic sac in the uterus of a pregnant woman.

Chorionic villus sampling (CVS)—A prenatal screening procedure in which a needle inserted through the vagina and cervix or through the abdominal wall is used to remove chorionic villi.

Fetal hemoglobin—The oxygen-carrying pigmented protein of fetal red blood cells, distinct from adult hemoglobin.

Flow cytometry—The measurement of cells or cellular properties as they move in a fluid stream past stationary detectors.

Fluorescein isothiocyanate (FITC)—An organic molecule that can be covalently bound to other molecules, and that emits visible light when exposed to ultraviolet radiation.

Hemoglobin—The oxygen-carrying pigmented protein of red blood cells.

Hemolytic disease of the newborn (HBN)—Also known as erythroblastosis neonatorum, severe neonatal anemia caused by Rh incompatibility and subsequent lysis of red blood cells.

Isoimmunization—The development of antibodies in a species in response to antigens from the same species.

Rh- incompatibility—The development of anti-Rh antibodies in an Rh-negative mother in response to antigens from her Rh-positive fetus.

Rhogam—Trade name for Rho [D] immunoglobulin used to immunize Rh-negative mothers.

Vacutainer—A glass tube fitted with a rubber stopper from which air is evacuated to produce a slight vacuum, used for blood specimen collection.

Venipuncture—The puncture of a vein for therapeutic purposes or to collect a specimen.

Complications

There is no risk to the mother or fetus. Complications associated with venipuncture are negligible when

the procedure is performed correctly. Minor discomfort while blood is drawn or bruising at the puncture site may occur, and there is a slight risk of **infection**.

Results

The percentage of fetal red blood cells in the circulation of normal non-pregnant adults is generally <0.1%. A level of >0.6% fetal cells is reported as positive.

Health care team roles

A physician, usually an obstetrician, orders the test. A nurse, phlebotomist, or laboratory technician collects the blood sample by venipuncture and arranges transport to the laboratory for analysis. The patient should be observed to ensure that bleeding from the puncture site stops.

In the laboratory, a clinical laboratory scientist/medical technologist trained in the Kleihauer-Betke staining procedure prepares, treats, and examines the blood smear, and counts and reports the numbers of maternal and fetal cells. A physician uses the reported ratio of fetal to maternal cells to calculate the amount of Rh immune globulin to be prescribed for the mother.

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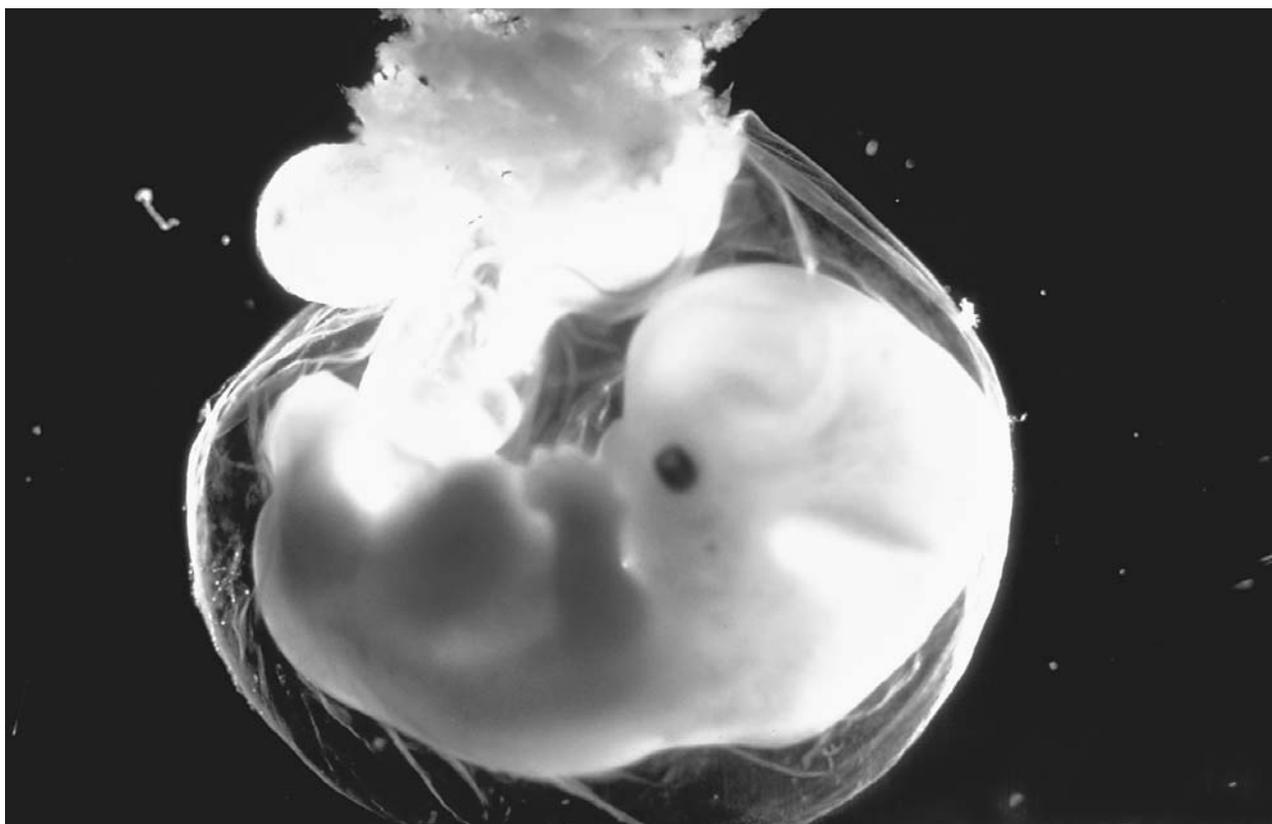
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A human embryo at five to six weeks of development. (Photograph by Petit Fromat/Nestle. National Audubon Society Collection/Photo Researchers, Inc. Reproduced by permission.)

Fetal development

Definition

The progressive growth that occurs between fertilization of an egg to the birth of a baby.

Description

Pre-embryonic stage

The pre-embryonic stage starts with fertilization and lasts through the first two weeks of pregnancy.

FERTILIZATION. During intercourse, the male ejaculates and releases semen into the woman's vagina. The semen contains 50 to 200 million spermatozoa per milliliter that reach the cervix within 90 seconds and the outer end of the fallopian tubes within five minutes. Fertilization results when a single sperm, or spermatozoon, penetrates an ovum. The chromosomal material of the ovum and spermatozoon then combine, forming a zygote.

IMPLANTATION. After fertilization, the zygote travels three or four days through the fallopian tube toward the body of the uterus. During this time, the cell starts to divide. By the time the zygote reaches the body of the uterus, it consists of 16 to 50 cells and is called a morula. The morula collects large cells at the periphery of the ball and becomes an outer casing with a connected inner group of cells surrounded by a fluid space. At this stage, the structure is termed a blastocyst. The blastocyst implants on the inner layer of the uterus, called the endometrium, approximately eight to 10 days after fertilization, where it will obtain nourishment. In as many as 50% of all pregnancies, the zygote fails to reach the implantation stage, in which it becomes an embryo.

Embryonic stage

The embryonic stage spans the third week to the eighth week of pregnancy.

Body organs form out of layers of tissue called germ cells. The three distinct layers of germ cells are called the endoderm, the ectoderm, and the mesoderm. Newborns with a congenital defect originating from one of the three layers should be evaluated for malformations that devel-

KEY TERMS

Fetus—Infant during intrauterine life.

Sonogram—Ultrasound; uses sound waves to take pictures and view the fetus.

oped from the same germ cells. For example, the **heart** and **kidneys** form from the mesoderm. A baby born with a heart defect should also have an x ray or ultrasound of the kidneys.

During the embryonic period, the baby is most susceptible to invasion by teratogens, which are substances that can result in birth defects. Women should be instructed on ways to reduce their contact with teratogens.

Milestones of fetal development

The life of the fetus is commonly calculated from the time of ovulation or fertilization (ovulation age), but the duration of the **pregnancy** is usually calculated from the first day of the last menstrual period (gestational age). The following outline of fetal development milestones is based on 40 weeks of gestation.

END OF FOUR WEEKS GESTATION.

- Fetus reaches a length of 0.75 to 1 cm and weighs 400 mg.
- Spinal cord forms and fuses at the center.
- Lateral wings bend forward meeting at the center and will eventually form the body.
- Head tilts forward and makes up about one-third of the entire structure.
- The rudimentary heart beats a regular rhythm.
- Arms and legs have the appearance of small buds.
- The beginnings of eyes, ears, and a nose are evident.

END OF EIGHT WEEKS GESTATION.

- Fetus reaches a length of 1 in (2.5 cm) and weighs 20 g.
- The heart has a definite septum and valves.
- Extremities have lengthened.
- External genitalia are evident, but gender is not obvious.

END OF 12 WEEKS GESTATION.

- Fetus reaches a length of 2.8-3.6 in (7-9 cm) and weighs 45 g.
- Some movement occurring, but usually too faint for the mother to feel.

- Fetal heart can be heard with an electronic device called a Doppler.

END OF 16 WEEKS GESTATION.

- Fetus reaches a length of 4-7 in (10 to 17 cm) and weighs 55 to 120 g.
- Liver and pancreatic secretions are present.
- Fetus starts to make sucking motions with the mouth.

END OF 20 WEEKS GESTATION.

- Fetus reaches a length of 10 in (25 cm) and weighs 223 g.
- The mother starts to feel fetal movement.
- Fetal heart tones can be heard with a stethoscope.

END OF 24 WEEKS GESTATION.

- Fetus reaches a length of 11-14 in (28-36 cm) and weighs 550 g.
- Eyebrows and eyelashes are clearly formed.
- Eyelids, which fused in the 12th week, start to open.
- Pupils are reactive to light.
- Fetus could possibly be viable if born now and cared for in a neonatal intensive care unit.
- Surfactant, a phospholipid substance essential to lung function, is formed and excreted by cells in the alveoli.

END OF 28 WEEKS GESTATION.

- Fetus reaches a length of 14-15 in (35-38 cm) and weighs 1200 g.
- Testes begin descent into the scrotal sac from the lower abdominal cavity if the fetus is male.
- The **brain** is rapidly developing.

END OF 32 WEEKS GESTATION.

- Fetus reaches a length of 15-27 in (38-43 cm) and weighs 1600 g.
- Fetus hears sounds and responds with movement.
- Delivery presentation (vertex or breech) may be assumed.
- Iron stores begin to develop.

END OF 36 WEEKS GESTATION.

- Fetus reaches a length of 17-20 in (42-49 cm) and weighs 5-6 lbs (1900-2700 g).
- Soles of the feet have only one or two creases.
- The **central nervous system** has greater control over body functions.

END OF 40 WEEKS GESTATION.

- Fetus reaches a length of 19-21 in (48-52 cm) and weighs 7-7.5 lbs (3000 g).
- Fingernails have grown over the fingertips.
- There are creases covering at least two-thirds of the soles of the feet.
- Fetus kicks vigorously and may cause the mother discomfort.

Role in human health

Knowledge of fetal development can assist the mother and other family members in visualizing the fetus at the various stages of development. The parent-infant bonding that results can be an incentive for the mother to engage in healthful behaviors.

Resources**BOOKS**

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March of Dimes. 1275 Mamaroneck Avenue, White Plains, NY 10605. (888)-MODIMES (663-4637).
<<http://www.modimes.org/Default.htm>>.

Nadine M. Jacobson, RN

Fetal lung maturity test *see* **Lipid tests**

Fetoscopy**Definition**

Fetoscopy utilizes an instrument called a fetoscope to evaluate or treat the fetus during **pregnancy**.

Purpose

There are two different types of fetoscopes. One resembles a **stethoscope**, but with a headpiece. It is used externally, on the mother's abdomen, to auscultate (listen to) the fetal **heart** tones. The second type of fetoscope is a fiber-optic **endoscope**. It is inserted into the uterus either transabdominally or transcervically to visualize the fetus, to obtain fetal tissue samples, or to perform fetal surgery.

Precautions

The external fetoscope requires no preparation, nor does it have any associated risks. Its usefulness and accuracy depend on the skill of the practitioner. The endoscopic fetoscope is inserted internally and thus carries risks of **infection** (both maternal and fetal), premature rupture of membranes, premature labor, and fetal death. The American College of Obstetricians and Gynecologists expressed their opinion in a February 28, 2001 press release that fetal surgery should be considered experimental.

Description

The external fetoscope is used to auscultate fetal heart tones for rate and rhythm. The earpieces and the headpiece allow auscultation via both air and bone conduction. It is inexpensive, is not invasive, and does not require electricity. It is difficult to clearly hear the fetal heart tones prior to 18 to 20 weeks gestation. Doppler ultrasound can measure fetal heart tones around weeks 10 to 12. External fetoscopy is compromised in a noisy environment, with an obese mother due to the large abdomen, and in the case of hydramnios.

Endoscopic fetoscopy uses a thin (1 mm) fiberoptic scope. Developed in the 1970s, the endoscope was originally inserted transabdominally to visualize the fetus for gross abnormalities suspected by ultrasound or to obtain tissue and **blood** samples. It was performed after about 18 weeks gestation. Even with practitioner expertise, associated fetal loss was three to seven percent. In the 1980s ultrasound-guided needle sampling of cord blood replaced fetoscopy when samples of fetal blood were required. As laparoscopic and microsurgical techniques have become more common and the instrumentation has become more advanced technologically, the expertise gained has carried over to fetoscopy, improving its use for fetal diagnostic and therapeutic purposes. Fetal surgery performed through an open maternal abdomen has a higher risk of such complications as infection, premature rupture of membranes, **preterm labor**, or fetal death. If surgery is performed via fetoscopy, which requires a very small transabdominal incision, the risks are much smaller. Techniques have advanced enough to allow some fetoscopy to be performed in the first trimester via the cervix. The term obstetrical endoscopy may be used for surgery on the placenta, umbilical cord or on the fetal membranes. The term endoscopic fetal surgery is used for such procedures as the repair of a fetal congenital diaphragmatic hernia, enlarged bladder, and spina bifida.

KEY TERMS

Auscultation—Auscultation uses the sense of hearing to evaluate such internal organs as the heart or bowel. While the practitioner may simply use his or her ears directly, most commonly auscultation is performed with an instrument, such as a fetoscope or stethoscope.

Hydramnios—Hydramnios is the excessive production of amniotic fluid due to either fetal or maternal conditions.

Supine—Lying horizontally on one's back.

Preparation

The use of external fetoscopy requires access to the maternal abdomen, with the mother lying supine or in a semi-seated position. Afterwards, the mother is able to get up and resume a normal activity level.

Preparation for endoscopic fetoscopy will depend on the extent of the procedure, and whether it is performed transcervically or transabdominally. Obtaining a small fetal tissue sample is a smaller procedure by comparison to fetal surgery. Other factors include outpatient versus inpatient stay and anesthesia (both maternal and fetal). For some procedures medication may be administered to temporarily decrease fetal movement to lower the risk of fetal injury. Maternal anesthesia may be local, regional, or general.

Aftercare

External fetoscopy does not require aftercare. The care following fetal endoscopic use will depend on the extent of the procedure and the type of anesthesia used. If done on an outpatient basis, the mother and fetus will be monitored for a period of time to assure well-being before discharge. More extensive surgery will require inpatient hospital care.

Complications

The only potential complication with external fetoscopy is the potential for missing an abnormal heart rate or rhythm. Endoscopic fetoscopy has the potential for infection to the fetus and/or mother, premature rupture of the amniotic membranes, premature labor, and fetal death. When endoscopic fetal surgery is done instead of open-uterus fetal surgery, the risks to the mother and fetus are decreased. This is because the incision is significantly smaller, with less potential blood loss,

decreased uterine irritability, and decreased risk for early pregnancy termination.

Results

The normal fetal heart rate is 120 to 160 beats per minute, regardless of the method used for auscultation (external fetoscopy or Doppler ultrasound). Some variability of fetal heart rate is expected, as the heart rate increases with fetal activity and slows with fetal rest.

Results expected using endoscopic fetoscopy will vary depending on the procedure undertaken. The goal is for the maximum benefit with the minimum of risk or complication to both the mother and fetus.

Health care team roles

Individuals utilizing the external fetoscope include a nurse practitioner, nurse midwife, and obstetrician. For endoscopic fetoscopy, the procedures require a high level of skill and experience by fetal surgeons. During the procedures, a radiology technician may perform an ultrasound and a laboratory technician may be involved in blood sampling. Nurses will participate in both outpatient as well as inpatient procedures.

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- American College of Obstetricians and Gynecologists. 409 12th St., S.W., PO Box 96920. Washington, D.C. 20090–6920. <<http://www.acog.com>>.

OTHER

Florida Institute for Fetal Diagnosis and Therapy. 13601 Bruce B. Downs Boulevard, Suite 160. Tampa, FL 33613. Phone: 888-FETAL-77, (888-338-2577). Fax: (813) 872-3794. <<http://www.fetalmd.com>>.

Neonatology on the Web: Neonatology Teaching Files, Outlines, and Guidelines. <<http://www.neonatology.org/syllabus/index.html>>.

Esther Csapo Rastegari, R.N., B.S.N., Ed.M

Fever

Definition

Fever is defined as an abnormally high body temperature or a regulated rise to a new set point of body temperature. While a body temperature above 100°F (37.8°C) is considered to be a fever by some clinicians, a significant fever is usually defined as an oral temperature of 102°F (39°C) or a rectal temperature of 103°F (39.5°C). Fever is a sign of inflammation and represents the body's response to microbial invasion or to a disease process.

Hyperthermia is defined as abnormally high body temperature caused by disruption of the body's thermoregulatory mechanisms. Hyperthermia occurs when the body's metabolic heat production or environmental heat load exceeds the normal heat loss capacity (or when normal heat loss is impaired).

Description

The normal temperature of the human body fluctuates between 97°F (36.1°C) and 100°F (37.8°C), with the average being 98.6°F (37°C). There is a diurnal pattern of temperature variation in humans, with body temperature being lowest in the morning and highest in late afternoon. In women of childbearing age, there is a small rise in temperature following ovulation during the menstrual cycle, and during the first trimester of **pregnancy**.

The body's thermoregulatory mechanisms include changes in muscle tone, vascular tone, and sweat production, which serve to balance body heat produced by **metabolism** with heat lost to the environment. This balance is regulated by the hypothalamus, a small structure in the **brain** below the thalamus. The body's temperature regulation can be upset by environmental factors (external heat and humidity); by disorders or conditions that inhibit sweat production or evaporation; and by infectious diseases.

Fever occurs when the hypothalamus raises the body's temperature to a new set point. White **blood** cells called monocyte-macrophages release **proteins** called pyrogens when the cells encounter pathogenic microorganisms. The pyrogens act on the hypothalamus, causing it to reset the body's "thermostat" upward. The vessels that supply the skin with blood often narrow as the body's temperature is rising. This process, which is called vasoconstriction, reduces sweating and causes the body to retain more heat than it loses. Vasoconstriction in the skin and extremities allows the body to move blood toward its core, which increases the rate of metabolism and induces shivering. The chills that often accompany a fever are caused by this movement of blood to the body's core, which leaves the skin surface and extremities relatively cool. When the **infection** or disease process resolves, the hypothalamus attempts to reset the body's **thermoregulation** at its normal set point. The body's cooling mechanisms switch on as the blood returns to the extremities and skin surface, and sweating occurs.

Fever is an important component of the immune system's inflammatory response, though its role is not completely understood. A rise in body temperature has several effects. The pyrogens that trigger the resetting of the body's thermostat also increase the production of macrophages, which fight off invading **bacteria** or **viruses**. Higher temperatures also inhibit the growth of some bacteria, while at the same time activating the **immune system**. In addition, the increased **heart** rate that accompanies vasoconstriction also speeds the arrival of white blood cells to the sites of inflammation.

Causes and symptoms

Causes

Fever can be caused by a wide variety of diseases and disorders, including:

- infectious diseases, which may be caused by viruses, bacteria, **fungi**, rickettsiae, or parasites
- **autoimmune disorders**, including systemic lupus erythematosus, rheumatic fever, adult rheumatoid arthritis, Wegener's granulomatosis, polyarteritis nodosa, and Still's disease
- disorders of the **central nervous system** (CNS), including head injuries, multiple sclerosis, tumors of the brain or **spinal cord**, and cerebral hemorrhage
- cancers, including primary cancers of the colon, rectum, kidney, and **liver**, and metastatic cancers of the liver
- cardiovascular disorders, including **myocardial infarction** and pulmonary embolism

- reactions to such medications as methyldopa, quinidine, hydralazine, phenytoin, chlorpromazine, carbamazepine, anti-cancer drugs, and antibiotics
- endocrine disorders, including hyperthyroidism (thyroid storm) and pheochromocytoma
- gastrointestinal disorders, including alcoholic hepatitis, inflammatory bowel disease (IBD), and liver abscess
- inflammation associated with indwelling catheters, intravenous lines, and nasogastric tubes
- neuroleptic malignant syndrome, which is a rare and potentially fatal reaction to certain antipsychotic medications

Fever patterns

Fevers may be classified as intermittent (the patient's temperature falls to normal at some point during the day); sustained (the temperature remains high); or relapsing (periods of fever are followed by several days of normal temperatures). The fever pattern may be helpful in the differential diagnosis; for example, fevers related to medication reactions are more often sustained than intermittent. A relapsing pattern suggests **malaria**.

The degree of temperature elevation in a fever does not necessarily correspond to the seriousness of the illness. In general, children with fevers run higher temperatures than adults, while elderly persons and newborns may have less marked fevers.

Diagnosis

The differential diagnosis of fever is complicated by the variety of possible causes. In most cases, the patient's history—including a medication history and history of exposure to infectious diseases—vital signs, a **complete blood count**, and blood cultures will help to narrow the number of possible causes. In fevers of unknown origin (FUOs), however, the physician may need to schedule a chest x-ray or ultrasound and CT imaging.

Fevers of unknown origin (FUOs)

The origin of some fevers is difficult to determine. The term “fever of unknown origin” (FUO) has been applied to cases of fever in which the patient's temperature remains over 101°F (38.3°C) for three weeks and in which the diagnosis is not apparent after seven or more days of studies. The most common cause of FUOs is an infectious disease of some kind, although many cancers present initially as FUOs. About 15% of FUOs never receive a definite diagnosis.

Temperature measurement

A variety of different devices are available to register body temperature, including the traditional glass thermometers used for oral or rectal temperature readings. More recently, sophisticated electronic devices have been introduced that register body temperature as a digital readout. For younger children and infants, there are forehead meter strips and pacifiers with temperature-sensitive readouts.

Treatment

Routine measures

Most fevers are caused by common infections, are short-lived, and do not require symptomatic treatment. The patient's comfort, however, may be improved by measures to remove body heat, antipyretic medications, and fluid replacement. Measures to remove body heat include alcohol or cold sponges; ice bags; and ice baths. The most common antipyretic medications are aspirin or acetaminophen, 350–650 mg every four hours. Children or adolescents with influenza-like symptoms should not be given aspirin without consulting a physician because of the possibility of developing Reye's syndrome, a rare disorder characterized by vomiting and liver dysfunction.

Fluid replacement is an important part of fever treatment. Extra fluid is required to prevent electrolyte imbalance as well as to replace fluid lost through perspiration.

Emergency treatment

Body temperature over 105.8°F (41°C) in an adult is a medical emergency and requires immediate treatment.

The following indications in specific patient groups may require emergency treatment:

- newborns (three months or younger) with fever of 100.5°F (38°C) or higher
- infants or children with fever of 103°F (39.4°C) or higher
- adults with fever of 101°F or higher lasting longer than three days; or a temperature of 100.5°F lasting longer than three weeks without other symptoms

A very high fever in a small child can trigger febrile seizures, and therefore requires immediate treatment. A fever accompanied by a stiff neck, severe headache, throat swelling, and changes in mental status may indicate the presence of **meningitis** or another serious infection, and should be brought to the immediate attention of a physician. High fever does not always produce sweating or diaphoretic symptoms, which indicates weakness in the body's defenses against severe disease.

Prognosis

Most fevers caused by infection end as soon as the immune system rids the body of the pathogen and do not produce any lasting effects. Exceptions include fevers associated with meningitis, typhoid, or scarlet fever. High fevers can produce major disturbances of the body's metabolism and alter the body's responses to medications. In addition, a high fever during the first trimester of pregnancy increases the risk of such birth defects as anencephaly (absence of a portion of the **skull** and brain).

The prognosis for fevers associated with such chronic conditions as autoimmune disorders depends on the stage of the disease and its management.

Health care team roles

Nurses assess and record the fever patient's signs and symptoms. Nurses as well as physicians can obtain relevant information from the patient's medical history. Home health care and visiting nurses may also help to educate patients about at-home treatment of fevers. In some cases, **home care** nurses may counsel patients and caregivers over the phone, advising when the condition warrants in-person medical attention.

Prevention

Since most fevers are caused by infectious agents, careful attention to proper methods of food handling, hand washing, and similar **public health** measures is an important form of prevention. Fevers related to medication reactions can sometimes be prevented by substitution of drugs that are less likely to produce such reactions. Fevers related to indwelling catheters and similar devices may be avoided by removing them as soon as they are no longer required.

Hyperthermia related to environmental conditions may be prevented by proper attention to climatic conditions, adequate fluid and electrolyte intake, and acclimatization to hot environments. Educating the public about the early signs of **heat disorders** is another important preventive measure.

Resources

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KEY TERMS

Antipyretic—A drug that lowers body temperature, such as aspirin or acetaminophen.

Autoimmune disease—A disorder in which the immune system attacks the body's own cells.

Febrile seizure—Convulsions brought on by high body temperature and inflammation of the brain or brain covering.

Hyperthermia—Abnormally high body temperature that occurs when the body's metabolic heat production or environmental heat load exceeds the normal heat loss capacity (or when heat loss is impaired). Heat stroke is an example of hyperthermia.

Hypothalamus—A region in the posterior section of the forebrain that regulates body temperature, sleep cycles, and the activity of the pituitary gland.

Intermittent—A fever pattern marked by the patient's temperature returning to normal at some point during the day.

Macrophage—A type of large white blood cell that helps the body fight off pathogenic microorganisms by ingesting them.

Malignant hyperthermia—A rare inherited condition in which a person develops a very high fever when given general anesthetics or muscle relaxants in preparation for surgery.

Pyrogen—A substance that produces a rise in body temperature. Bacterial toxins are one type of pyrogen.

Relapsing—A fever pattern in which periods of fever alternate with several days of normal temperatures.

Reye's syndrome—A rare disorder that occurs primarily in children recovering from a viral illness and associated with aspirin usage. It is characterized by vomiting, swelling of the brain, and liver dysfunction.

Vasoconstriction—Narrowing of the blood vessels, which serves to conserve body heat and maintain or raise blood pressure.

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Lisette Hilton

Fever blister see **Cold sore**

Fiber-modified diet see **Diet therapy**

Fibrin degradation products test

Definition

When injury occurs to a **blood** vessel wall, thrombin (a coagulation enzyme) is formed in the first stage of a complicated series of steps called the coagulation cascade. In the second phase, fibrinogen, a coagulation protein made by the **liver**, is converted to fibrin, which results in the formation of a gel-like meshwork at the site. This fibrin mesh is altered by the action of factor XIIIa which cross-links fibrin polypeptides, forming a stable clot. As the site heals, the clot is broken down by the enzyme plasmin. This process, called fibrinolysis, is initiated by a protein called tissue plasminogen activator that is released from blood vessel cells adjacent to the injured site. Plasminogen activator converts plasminogen to an enzyme called plasmin. The plasmin splits polypeptides from the fibrin clot. These fragments are known as fibrin degradation products (FDP).

Fibrin degradation products are fragments (polypeptides) produced when either fibrin or fibrinogen is broken down by the enzyme plasmin. There are four principal fibrin degradation products called X, Y, D, and E that are liberated in various combinations. When a fibrin clot is broken down by plasmin, the last fragment to be degraded is one consisting of two D and one E subunits. This is split, releasing the E fragment and two D fragments that are covalently linked together. This fragment is called D-dimer, and it is produced from fibrin but not from fibrinogen degradation.

Purpose

A test for FDP may be requested by a physician when excessive bleeding occurs and thrombosis or other serious disorder in the coagulation mechanism is suspected. The FDP assay measures amounts of the fibrin and fibrinogen split products in the blood and directly indicates the level

of activity of the fibrinolytic system. High levels of FDP will indicate increased fibrinolysis. Excessive fibrin degradation products are released into the plasma in three main conditions: disseminated intravascular coagulation (DIC), thromboembolytic therapy, and primary fibrinogenolysis. Fragments X, Y, E, and D are released whenever either fibrin or fibrinogen is broken down by plasmin. This degradation occurs in all three situations.

Normal blood plasma does not have significant amounts of D-dimer. It is present in the blood in detectable amounts in several conditions, most notably in disseminated intravascular coagulation (DIC), a rare disruption in normal coagulation in which rapid intramicrovascular (within the **blood vessels**) coagulation occurs at the same time as fibrinolysis (clot dissolution mechanism). The D-dimer test is used to diagnose DIC. It is also frequently used to help diagnose deep-vein thrombosis (clots in veins); pulmonary embolism (clots in the **lungs**); the thrombosis of malignancy; and sickle cell anemia (a form of anemia characterized by bleeding episodes); and to monitor the effects of thrombolytic drugs. Thrombolytic drugs that may increase D-dimer levels are barbiturates, heparin, streptokinase, and urokinase. Levels of D-dimer will be elevated in these conditions.

Description

When functioning normally, coagulation and fibrinolysis maintain hemostasis (the normal fluid state of blood in the circulatory system) by regulating clot formation and dissolution. When bleeding occurs, coagulation results in production of a clot at the site of injury, and subsequent fibrinolysis dissolves the clot as the vessel wall heals. The fibrinolytic system is highly complex. A deficiency of plasminogen will result in increased risk of thrombosis. Plasmin is inactivated by several proteases, which are enzymes that catalyze the breakdown of polypeptides. A deficiency of one of these can result in spontaneous bleeding. FDPs themselves can neutralize the activity of some coagulation factors and interfere with normal clot formation. In three conditions, disseminated intravascular coagulation, thromboembolytic therapy, and primary fibrinogenolysis the fibrinolytic activity of the plasma is increased. When this occurs, depletion of coagulation factors, including fibrinogen, results in uncontrolled bleeding. Measurement of FDP and D-dimer are used to identify these causes of hemorrhage.

DIC results in the formation of circulating small fibrin clots formed by a condition that triggers the coagulation cascade. Coagulation factors become depleted and hemorrhage results. DIC is a rapidly progressing condition caused by an underlying disease or trauma, such as the clinical conditions shown below.

- complications of **pregnancy**, such as toxemia, abortion, cesarean section, **placenta previa**, and other conditions
- tissue trauma, such as major surgery, severe trauma and **burns**, rejection of transplant, and heatstroke
- hemolytic processes (destruction of red blood cells), such as transfusion of mismatched blood, drowning, complications of **infection**, and certain types of poisoning
- malignancies, such as solid tumors, leukemia, and other forms of cancer
- infections, such as bacterial infections, septicemia, Rocky Mountain spotted **fever**, some viral infections, and parasitic infections
- miscellaneous clinical conditions, such as diseases of the liver and **pancreas**, uremia, **shock**, stroke, severe **heart failure**, and aortic aneurysm (rupture of the aorta)

Coronary artery disease can result in the formation of a blood clot at the site of blockage in the **heart** vessels. One alternative form of treatment is the administration of a thrombolytic agent such as streptokinase or tissue plasminogen activator. These drugs act by stimulating fibrinolysis, and consequently they may cause both the fibrin clot and fibrinogen to break down. Fibrinogen depletion and accumulation of FDP can interfere with coagulation, causing spontaneous hemorrhage.

Primary fibrinogenolysis is a condition in which fibrinogen is broken down to fibrin in the absence of a clot. Unlike DIC, the formation of intravascular thrombi does not occur. However, if severe, hemorrhage can result because the body's supply of fibrinogen becomes depleted. Causes include shock, hypoxia, heat stroke, hemorrhage, surgery, and liver disease.

FDP tests will yield abnormal results in all three conditions described above because the fragments detected are produced when either fibrin or fibrinogen is split by plasmin. Therefore, the FDP test is not specific for thrombotic diseases such as DIC or deep vein thrombosis. The FDP test uses latex particles coated with anti-D and anti-E. When mixed with plasma, these antibodies react with D and E fragments of both fibrin and fibrinogen, forming a clump.

The D-dimer test measures only the D fragments of fibrin that are covalently bound together. When a fibrin clot is stabilized by factor XIIIa, the D domains of adjacent molecules become linked together. The action of plasmin causes these to be released from the clot as a dimer, which is a molecule composed of two identical simpler molecules. Therefore, the D-dimer test will be positive only when fibrin degradation has occurred. This happens in DIC, after thromboembolytic therapy, and in such throm-

bolic conditions as deep vein thrombosis and pulmonary embolism, but does not occur in primary fibrinogenolysis.

D-dimer is detected by a latex agglutination test. Latex particles coated with anti-D that bind only to D-dimer are used. These particles will clump when mixed with serum that has an increased level of D-dimer. Since D-dimer levels parallel the amount of fibrinolytic activity in DIC, a quantitative test is often used to evaluate the severity of the disease. The test used is a two-site double antibody sandwich immunoassay.

Precautions

Blood for FDP testing is collected by venipuncture into tubes containing EDTA, citrate, or heparin anticoagulant. The nurse or phlebotomist performing this procedure should follow **universal precautions** for the prevention of transmission of bloodborne pathogens. Performing a venipuncture to obtain a blood sample for the D-dimer test may be contraindicated if the patient is exhibiting prolonged bleeding from other sites. In this case the nurse or phlebotomist should consult the testing physician, who will determine an alternate means of obtaining a blood sample (such as placement of a catheter). There are no other notable precautions associated with performing the D-dimer test.

Preparation

There is no special preparation for the D-dimer test. No fasting is required.

Aftercare

Following venipuncture to obtain blood samples for the D-dimer test, the laboratory technologist, nurse, or phlebotomist drawing the sample should apply pressure to the site to stop any residual bleeding. The venipuncture site should then be carefully inspected to make sure that the wound has closed and no bleeding is present. If bleeding continues even after pressure is applied, this event should be reported to the testing physician.

Complications

DIC often involves a rapidly changing hemostatic condition. Patients with DIC or thrombosis may be in serious condition and will likely not be ambulatory; more typically, patients with suspected DIC or thrombosis will be hospitalized. Nurses should be alert to any change in the patient's condition. Noticeable changes in the patient's condition at the time of venipuncture should be reported to the patient's physician. The venipuncture site should be examined for bleeding and any prolonged

KEY TERMS

D-dimer—A fibrin degradation fragment or product that is produced by the action of plasmin on fibrin in the clot dissolution process.

Disseminated intravascular coagulation (DIC)—A disruption in hemostasis in response to an underlying disease or trauma. It is associated with the release of a tissue factor that triggers coagulation and activates rapid thrombin formation and fibrinolysis throughout the vascular system.

Fibrin—A protein formed in the blood as an important component of the coagulation process.

Fibrin degradation products—Known also as fibrin split products, fibrin degradation products are formed when the fibrinolytic system is activated in response to the formation of clots in the vascular system. Fibrin degradation products, including D-dimer, will be present in fibrinolysis or thrombosis.

Fibrinolysis—The dissolution of clots by an activated fibrinolytic system. When clot formation occurs, the fibrinolytic system activates factors that lead to the formation of plasmin, which degenerates the fibrin in the clot.

Hemostasis—A regulating process that maintains blood in a fluid state and prevents the loss of blood through clot formation when the vascular system is compromised.

Plasmin—Plasmin is an enzyme formed in the activation of the fibrinolytic system to dissolve clots. Plasmin breaks down the fibrin in a clot into the fragments that are known as fibrin degradation products.

Thrombolytic drugs—Anticoagulants used to inhibit clotting. Thrombolytic therapy is used when increased fibrin degradation products are present, such as in patients who have had a heart attack or who have a compromised coagulation mechanism or a history of thrombosis.

Thrombosis—The presence of a clot or clots in the vascular system.

bleeding that cannot be stopped by applying pressure should be reported to the physician immediately.

Results

Reference ranges for FDP tests will vary according to the test method used and the laboratory performing the

test. Qualitative results may be reported only as positive or negative. Typical FDP results are listed below.

- Undiluted plasma is negative (no clumping): FDP is reported as less than 2 micrograms/mL.

A clumping reaction is reported as positive. If plasma is diluted, reporting is as follows:

- If the undiluted plasma only is positive: equal to or greater than 2 mcg/mL but less than 10 mcg/mL.
- If a 1:5 dilution of plasma is positive: equal to or greater than 10 mcg/mL but less than 80 mcg/mL.
- If a 1:20 dilution is positive: equal to or greater than 80 mcg/mL.

D-dimer results are reported as follows.

- Qualitative negative: less than 250 nanograms/mL.
- Qualitative positive: equal to or greater than 250 ng/mL.
- Quantitative: normally less than 250 ng/mL or less than 250 micrograms/L.

Health care team roles

A physician orders the FDP tests and interprets them. The testing physician must obtain an accurate patient history, especially to determine if the patient is taking any drugs that can affect the test results and to learn about any recent illness, trauma, or symptoms that could be related to DIC or thrombosis. The procedure should be explained to the patient by the unit nurse, who should be aware of the degree of seriousness of the patient's condition. FDP tests are performed by clinical laboratory scientists/medical technologists or by clinical laboratory technicians/medical laboratory technicians.

Training

Laboratory technologists performing D-dimer tests will have studied hematology and coagulation, enabling them to understand coagulation and the fibrinolytic system. Hands-on clinical laboratory training will prepare technologists to perform agglutination tests or monoclonal antibody tests for D-dimer. Nursing personnel responsible for patients undergoing D-dimer testing will understand the patient's condition and will be trained to observe changes that may signal a critical hemostatic event.

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ORGANIZATIONS

American Nurses Association. 600 Maryland Ave. SW, Ste. 100 West, Washington, DC 20024. (800)274-4ANA.
<<http://www.nursingworld.org>>.

American Society of Clinical Pathologists. 2100 West Harrison St., Chicago, IL 60612 (312) 738-1336.
<<http://www.ascp.org>>.

L. Lee Culvert

Fibrinogen test *see* **Coagulation tests**

Fibromyalgia

Definition

Fibromyalgia (formerly known as fibrositis) is an inflammation of the fibrous or connective tissue (muscles, joints, ligaments, and tendons) of the body. Widespread **pain**, fatigue, and multiple tender points characterize this condition. Other symptoms may include sleep disturbance, headache, and bowel disturbances.

Description

Fibromyalgia is more common than previously thought, with as many as 3–6% of the population affected by the disorder. Fibromyalgia is more prevalent in adults than children, with more women affected than men—particularly women aged 35 to 55. Fibromyalgia symptoms have often been characterized as psychosomatic in origin. Recent research has proved that belief false, and fibromyalgia is now regarded as a disorder that can be diagnosed and treated effectively with ongoing care and follow-up.

Causes and symptoms

The exact cause of fibromyalgia is not known. There are events that can precipitate the symptoms of fibromyalgia, including **sports injuries**, car accidents, **falls**, or other trauma to the body. Sometimes it occurs in several members of a family, suggesting that there may be an inherited tendency for the disorder. People with fibromyalgia are most likely to complain of three pri-

mary symptoms: pain in muscles, joints, and ligaments; stiffness; and excessive fatigue. Widespread, ongoing pain is characteristic of fibromyalgia. A careful history and **physical examination** may uncover additional areas of pain when the chief complaint lies in only one area of the body. The most significant area of pain may shift over time, and the pain can be intermittent.

Pain is the major symptom of fibromyalgia, with aches, tenderness, and stiffness of multiple muscles, joints, and soft tissues. The pain may also tend to move from one part of the body to another. It is most common in the neck, shoulders, chest, arms, legs, hips, and back. Although the pain is present most of the time and may last for years, the severity of the pain is variable and dependent on individual patient perception.

Symptoms of sleeplessness and overall fatigue may result from the individual’s chronic pain, coupled with **anxiety** about the problem and how to find relief. The body’s inflammatory response also produces chemicals in the **brain** that are known to contribute to fatigue. Other common symptoms are tension headaches, difficulty swallowing, recurrent abdominal pain, **diarrhea** (irritable bowel syndrome), and numbness or tingling of the extremities. **Stress**, anxiety, depression, lack of dietary control, or lack of sleep can increase symptoms. Intensity of symptoms varies. Some patients gradually improve, while others have recurrent episodes of their symptoms.

Diagnosis

Diagnosis is difficult, and the disease may be overlooked because symptoms of fibromyalgia are vague and general. In addition, fibromyalgia may mimic symptoms of other diseases and conditions. Support staff should question the patient regarding sleep and **exercise** patterns, diet, and emotional conditions. Coexisting nerve and muscle disorders, such as rheumatoid arthritis, spinal arthritis, or Lyme disease, may further complicate the diagnostic process. Presently, there are no tests available to specifically diagnose fibromyalgia. The final diagnosis is frequently made after a period of time in which the physician observes the patient and rules out other medical conditions with similar symptoms.

Because of the emotional distress experienced by people with this condition and the influence of stress on the symptoms themselves, fibromyalgia has often been labeled a psychosomatic condition. Recognition of the underlying inflammatory process involved in fibromyalgia has helped promote the validity of this disease. Nurses, nurse practitioners or physician’s assistants should inquire into the emotional state of the patient, and be prepared to note it in the chart. Mental health consultation may be necessary due to depression or anxiety, and

emphasis on the importance of a support group for fibromyalgia patients should be given.

In 1990, the American College of Rheumatology developed standards for fibromyalgia that health care practitioners can use to diagnose this condition. According to these standards, a person is thought to have fibromyalgia if he or she has widespread pain in combination with tenderness for at least three months in at least 11 of the 18 sites known as trigger points. Trigger point sites include the neck, spine, hip, elbow, knee, and shoulder.

Treatment

There is no known cure for fibromyalgia. Therefore, the goal of treatment is successful symptom management. Treatment usually requires a combination of therapies, including exercise, proper rest, and diet, and pharmacologic treatment. **Patient education** by the health care team is imperative so that the patient has a clear understanding of his or her role in the recovery process and the successful management of this condition.

Physical regimens found to be helpful include a regular stretching program and low-impact aerobic activities that increase the **heart** rate. Exercise programs should be approved by a physician or physical therapist, and include both warm-up and cool-down sessions, with special attention given to avoiding exercises that cause joint pain. Adequate rest is essential in the treatment of fibromyalgia.

Nutrition is an important component in the management of this condition. The patient's diet should include a wide variety of fruits and vegetables to provide the body with trace elements and **minerals** that are necessary for healthy muscles. Avoidance of stimulating drinks (such as coffee, tea, or any drink containing **caffeine**), avoidance of alcohol (may lead to sleeplessness) and such medications as decongestants prior to bedtime is advised. If diet, exercise, and adequate rest do not relieve the symptoms of fibromyalgia, medication may be prescribed.

Medications that have been found to have some benefit include **antidepressant drugs**, **muscle relaxants**, and **nonsteroidal anti-inflammatory drugs** (NSAIDs).

People with fibromyalgia often need a rheumatology consultation (a meeting with a doctor who specializes in disorders of the joints, muscles, and soft tissue) to decide the cause of various rheumatic symptoms, to be educated about fibromyalgia and its treatment, and to exclude other rheumatic diseases. A physician must recommend a treatment program that is individualized to meet the patient's needs.

Alternative treatment

Massage therapy can be helpful, especially when a family member is instructed on specific massage techniques to manage episodes of increased symptoms. Specific attention to mental health, including behavior modification and psychological consultation, may also be important because depression and anxiety may precede or accompany an incident of fibromyalgia. Other alternative therapies, including homeopathic medicine, Chinese traditional medicine (both acupuncture and herbs), polarity therapy, and Western botanical medicine, can assist the person with fibromyalgia in day-to-day functioning and contribute to alleviation of symptoms.

Prognosis

Fibromyalgia is a chronic condition, but causes no body damage or deformity. It does not cause damage to internal organs, as opposed to conditions such as rheumatoid arthritis, which leads to joint deformity. Treatment is based on the relief of symptoms, so a cure is not a realistic goal. Management of the condition may allow patients to return to a higher level of function at work, play, and home.

Health care team roles

Fibromyalgia can be a stressful and frustrating condition for a majority of patients. Successful treatment often requires a period of trial and error to pinpoint which agents and activities work best for the individual patient. Patience while waiting for diagnosis and treatment should be stressed by support staff, along with reassurance that the physician is working to find a treatment regimen that will provide relief. However, there is no set treatment that works for every patient. Even the process of diagnosing fibromyalgia can take time, which also leads to patient frustration. Therefore, support from the health care team and coordination of care through follow-up calls to outside health care providers is needed to avoid actually worsening the patient's condition due to undue stress. Nursing parameters are **pain management**, improved sleep management, introduction of **relaxation** techniques (including massage and biofeedback if needed), and monitoring alternative treatments and medication. There could be a wide variety of health care providers on a patient's health care team: nurses, physicians, a rheumatologist or other subspecialist, nutritionist, physical therapist, alternative medicine caregiver, or mental health care providers. This requires that the health care providers who most frequently see the patient coordinate and record in the patient's medical chart all treatments being undertaken at any given time. Coordination

of care increases patient compliance, and may boost the patient's perception of his or her level of function. Patient education is an integral part of the treatment and management of fibromyalgia and its symptoms. Patients should be supported both physically and emotionally. Chronic pain may make it more difficult to communicate with a patient in a manner that promotes professionalism and optimal care. Constant cognizance of the treatment goals (to control pain and increase level of function) is needed as well as positive reinforcement of compliance with treatment suggestions and monitoring of patient milestones.

Prevention

There is currently no way to specifically prevent fibromyalgia. However, adequate sleep and nutrition, stress management, safe levels of exercise, and annual check-ups are important in the avoidance of this condition.

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Fibrosarcoma see **Sarcomas**

Filling materials see **Restorative dental materials**

Filmless imaging see **Computed radiography**

Fine motor skills

Definition

Fine motor skills encompass the abilities required to control the smaller muscles of the body for writing, playing an instrument, artistic expression, and craft work.

The muscles required to perform fine motor skills are generally found in the hands, feet, and head.

Description

Fine motor skill involves deliberate and controlled movements requiring both muscle development and maturation of the **central nervous system**. Although newborn infants can move their hands and arms, these motions are **reflexes** that a baby cannot consciously start or stop. The development of fine motor skills is crucial to an infant's ability to experience and learn about the world and thus plays a central role in the development of intelligence. Like **gross motor skills**, fine motor skills develop in an orderly progression, but at an uneven pace characterized by both rapid spurts and, at times, frustrating but harmless delays. In most cases, difficulty with acquiring certain fine motor skills is temporary and does not indicate a serious problem. However, medical help should be sought for children who are significantly behind their peers in multiple aspects of fine motor development; or if they regress, losing previously acquired skills.

Function

Fine motor skills develop over a long period of time, primarily during childhood. However, athletes, musicians, jewelry makers, physicians, machinists, and others who engage in activities requiring high degrees of manual dexterity and control may spend decades improving their level of muscle coordination and fine motor skills.

Infancy

The hands of newborn infants are closed most of the time and, like the rest of their bodies, are not well controlled. If its palm is touched, an infant will make a very tight fist, but this is an unconscious action called the Darwinian reflex, and it disappears within two to three months. Similarly, an infant will grasp at an object placed in the hand, but without any conscious awareness of the act. At some point, hand muscles will relax, and an infant will drop an object, equally unaware that it has fallen. Babies may begin flailing at objects that interest them by two weeks of age but cannot grasp them. By eight weeks, they begin to discover and play with their hands, at first solely by touch, and then, at about three months, by sight as well. At this age, however, the deliberate grasp remains largely undeveloped.

Hand-eye coordination begins to develop between the ages of two and four months, inaugurating a period of trial-and-error practice at sighting objects and grabbing at them. At four or five months, most infants can grasp an



A six-month-old baby demonstrates fine motor skills.
(Photo Researchers, Inc. Reproduced by permission.)

object that is within reach, looking only at the object and not at their hands. Referred to as “top-level reaching,” this achievement is considered an important milestone in fine motor development. At the age of six months, infants can typically hold on to a small block for a brief period, and many have started banging objects. Although their grasp is still clumsy, they have acquired a fascination with grabbing small objects and trying to put them in their mouths. At first, babies will indiscriminately try to grasp things that cannot be grasped, such as pictures in a book, as well as those that can, such as a rattle or ball. During the latter half of the first year, they begin exploring and testing objects before grabbing, touching them with an entire hand and eventually poking them with an index finger.

One of the most significant fine motor accomplishments is the pincer grip, which typically appears between the ages of 12 and 15 months. Initially, an infant can only hold an object, such as a rattle, in the palm, wrapping fingers (including the thumb) around it from one side—an

awkward position called the palmar grasp, which makes it difficult to hold on to and manipulate the object. By the age of eight to ten months, a finger grasp begins, but objects can only be gripped with all four fingers pushing against the thumb, which still makes it awkward to grab small objects. The development of the pincer grip, the ability to hold objects between the thumb and index finger, gives infants a more sophisticated ability to grasp and manipulate objects, and also to drop them deliberately. By about the age of one, an infant can drop an object into a receptacle, compare objects held in both hands, stack objects, and nest them within each other.

Toddler period

Toddlers develop the ability to manipulate objects with increasing sophistication, including using their fingers to twist dials, pull strings, push levers, turn book pages, and use crayons to produce crude scribbles. Dominance of either the right or left hand usually emerges during this period as well. Toddlers also add a new dimension to touching and manipulating objects by simultaneously being able to name them. Instead of only random scribbles, their drawings include such patterns as circles. Their play with blocks is more elaborate and purposeful than that of infants, and they can stack as many as six blocks. They are also able to fold a sheet of paper in half (with supervision), string large beads, manipulate snap toys, play with clay, unwrap small objects, and pound pegs.

Preschool

The more delicate tasks facing preschool children, such as handling silverware or tying shoelaces, represent more of a challenge than most of the gross motor activities learned during this period of development. The central nervous system is still in the process of maturing sufficiently for complex messages from the **brain** to get to a child’s fingers. In addition, small muscles tire more easily than large ones, and the short, stubby fingers of preschoolers make delicate or complicated tasks more difficult. Finally, gross motor skills call for energy, which is boundless in preschoolers, while fine motor skills require patience, which is in shorter supply. Thus, there is considerable variation in fine motor development among children of this age group.

By the age of three, many children have good control of a pencil. Three-year-olds can often draw a circle, although their attempts at drawing people are still very primitive. It is common for four-year-olds to be able to use scissors, copy geometric shapes and letters, button large buttons, and form clay shapes with two or three parts. Some can print their own names in capital letters.

A human figure drawn by a four-year-old is typically a head atop two legs with one arm radiating from each leg.

School age

By the age of five, most children have clearly advanced beyond the fine motor skill development of the preschool age. They can draw recognizably human figures with facial features and legs connected to a distinct trunk. Besides drawing, five-year-olds can also cut, paste, and trace shapes. They can fasten visible buttons (as opposed to those at the back of clothing), and many can tie bows, including shoelace bows. Their right- or left-handedness is well established, and they use the preferred hand for writing and drawing.

Role in human health

Nurturing the development of fine motor skills is considerably more complicated than developing gross motor skills. Helping a child succeed in fine motor tasks requires planning, time, and a variety of play materials. Fine motor development can be encouraged by activities that youngsters enjoy, including crafts, puzzles, and playing with building blocks. Helping parents with everyday domestic activities, such as baking, can be fun for a child in addition to developing fine motor skills. For example, stirring batter provides a good workout for hand and arm muscles, and cutting and spooning out cookie dough requires hand-eye coordination. Even a computer keyboard and mouse can provide practice in finger, hand, and hand-eye coordination. Because the development of fine motor skills plays a crucial role in school readiness and cognitive development, it is considered an important part of a preschool curriculum. Montessori schools in particular were early leaders in emphasizing the significance of fine motor tasks and the use of learning aids such as pegboards and puzzles in early childhood education. The development of fine motor skills in children of low-income parents, who often lack the time or knowledge required to foster these abilities, is a key ingredient in the success of such programs as Head Start.

Common diseases and disorders

There are a range of diseases that decrease one's ability to perform tasks that require fine motor skills. Among young persons, such developmental problems as genetic disorders, **muscular dystrophy**, **cerebral palsy** and some neurological conditions adversely impact fine motor skill development. Among older persons, arthritis is a common condition. Arthritis affects the joints of the hands and feet, thus impairing the ability of muscles to perform fine movements. Stroke can impair fine motor

KEY TERMS

Darwinian reflex—An unconscious action in infants in which if a palm is touched, the infant makes a very tight fist. This instinct disappears within two to three months.

Gross motor skills—The abilities required to control the large muscles of the body for walking, running, sitting, crawling, and other activities. The muscles required to perform gross motor skills are generally found in the arms, legs, back, abdomen and torso.

Locomotion—Such movements as walking.

Motor—A term referring to muscles and movement.

Palmar grasp—A young infant's primitive ability to hold an object in the palm by wrapping fingers and thumb around it from one side.

Pincer grip—The ability to hold objects between thumb and index finger, which typically develops in infants between 12 and 15 months of age.

Top-level reaching—The ability of an infant to grasp an object that is within reach, looking only at the object and not at their hands. Typically develops between four and five months of age.

coordination. **Parkinson's disease** affects fine motor movements. **Alcoholism** and drug use or withdrawal all cause fine motor problems.

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American Academy of Pediatrics. 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. (847) 434-8000. <<http://www.aap.org/default.htm>>. kidsdoc@aap.org.

American Academy of Physical Medicine and Rehabilitation. One IBM Plaza, Suite 2500, Chicago, IL 60611-3604. (312) 464-9700. (312) 464-0227. <<http://www.aapmr.org/consumers/public/amputations.htm>>. info@aapmr.org.

Coping.org, 6319 Chauncy Street, Tampa, FL 33647. (813) 631-5176. Fax: (813) 631-1119. <<http://www.coping.org>>. jjmess@tampabay.rr.com

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First aid

Definition

First aid is the initial basic treatment of an injured or ill person. First aid requires an observer first to evaluate the injured or ill person and then to intervene, using a small amount of supplies.

Purpose

First aid is provided to a person immediately following an accident or onset of illness to decrease complications and to offer psychological (emotional) and physical comfort. It is performed to decrease the individual's **pain** and suffering until **emergency medical technicians** (EMTs) or other health care givers arrive on the scene.

Precautions

The provision of first aid should never postpone the initial contact with the emergency medical system. The bystander should wear disposable latex gloves if available, in case of contact with **blood** or body fluids. If gloves are not available, plastic bags or wrap can be used as a protective barrier.

Description

First aid is a universal term that encompasses many general concepts for rapid assessment of health crises and intervention. The following sections present the most common injuries and illnesses requiring first aid, and the interventions appropriate in these situations.

Changes in mental status

ASSESSMENT. With any sudden changes in a person's **brain** functioning, first aid should start immediately. Assess the person for:

- unconsciousness
- lightheadedness
- weakness on one side of body
- aggressiveness
- confused state

- changes in orientation
- headache
- blurred or double vision
- unsteady balance

INTERVENTION. Initiate **cardiopulmonary resuscitation (CPR)** if the person is not breathing. Secure the area around the person by removing any potential hazards, and maintain a favorable environment by providing an adequate area ventilation and room temperature. The person should be placed in a side-lying position.

Bleeding (hemorrhage)

ASSESSMENT. Assessing an injured person for bleeding must be done promptly, with first aid started immediately if there is active bleeding. All blood and body fluids must be regarded as potentially infectious, and protective barriers used.

INTERVENTION. Direct pressure should be applied to the hemorrhaging (bleeding) area by placing a clean pad or bandage over the site and pressing down with the palm of the hand. If bleeding persists, increase the amount of pressure to the area. If the person is awake and no latex gloves or other protective barriers are available, have him or her apply direct steady pressure to the hemorrhaging area. If the bleeding occurs on an arm or leg, elevate the bleeding part higher than the person's **heart**; this position will help decrease the amount of blood flow to the injured area. When a person is losing blood, body temperature tends to decrease. Maintaining body temperature is an essential first-aid intervention.

Poisoning: inhalation, ingestion, or exposure

ASSESSMENT. Initial evaluation of a poison victim is done after the threat of exposure to the rescuer is determined. If noxious gas or fumes remain in the environment, the rescuer must first protect him- or herself and others. The rescuer must move the person to a secure environment as promptly as possible to start first aid.

INTERVENTION. The first and most important intervention is to call a poison control center and get instructions on how to proceed. Having information on the type of poison ingested, if possible, as well as reading the label over the phone or spelling out the active ingredients on the bottle, will help the poison control center in determining the appropriate interventions. The rescuer must never induce vomiting or give any substance unless directed by the poison control center.

Burns

ASSESSMENT. **Burns** are categorized by the extent of damage to the skin or underlying tissue. First-degree burns are the least critical; they cause reddening of the skin without blistering. Second-degree burns cause damage to the superficial (outer) and the internal (inner) layers of skin, creating bubble-like sores (blisters) that contain clear, watery liquid. Third-degree burns are the most severe and most damaging of all burns; the destruction of all layers of skin occurs and the burnt area is left open and charred. When applying first-aid concepts to burns, the rescuer must quickly assess the extent of damage to the person's skin. The rescuer needs to determine through assessment what to do next.

INTERVENTION. First-degree burns can usually be treated at home with a sterile burn gel, and complete healing should take place within one week. A person with a second-degree burn greater than the size of his or her palm should seek medical treatment, or if the burn is in a sensitive area like the groin. Third-degree burns need medical attention immediately. Ice application is not recommended for severe burns because ice can cause trauma to the area. Cool to lukewarm water is recommended. The burn victim must be covered, preferably with clean blankets, in order to maintain a normal body temperature.

Head/neck injuries

ASSESSMENT. It is vital for the rescuer to determine the nature of the head/neck injury, as well as if the person has had any loss of consciousness. This information should be conveyed to the emergency medical responders to help determine the need for further testing.

INTERVENTION. It is important to limit the movement of the victim of a head or neck injury, because it could result in more damage. Do not move the head or neck unless absolutely necessary—for example, if vomiting starts. In such a situation, the rescuer must carefully turn the person to the side in order to prevent inhalation of vomit into the **lungs**.

Seizure

ASSESSMENT. A seizure occurs when the brain emits irregular electrical signals. The person having a seizure usually falls to the ground and shakes. The person may lose urinary or bowel functioning.

INTERVENTION. It is important to clear a safe area for a seizure victim. Protecting the **skull** with a cushion or blanket will help decrease injuries to the head and neck. The rescuer should never restrain the victim or put anything in the mouth. When the seizure stops, place the

KEY TERMS

Emergency medical technician (EMT)—A person who is trained and certified to provide basic life support.

Hemorrhage—To be actively bleeding.

Superficial—A term meaning outermost or not deep.

victim in a side-lying position to avoid the breathing in of mucus and other secretions.

Muscle/bone injuries

ASSESSMENT. When there have been muscle or bone injuries, the person initiating first aid should assume that the arm or the leg is broken.

INTERVENTION. If the arm or leg appears misshapen, the rescuer should not try to align it. The rescuer wants to stabilize the injured body part in order to protect it from further injury. Ice application can reduce swelling and pain. Heat should not be used, because it increases circulation to the injured site.

Preparation

A first-aid kit can have a variety of equipment in it. The basic items should include:

- ace bandages in a variety of sizes
- antibiotic ointment
- latex gloves
- a protective barrier/shield for use in CPR
- sterile gauze pads and wraps in a variety of sizes
- sealed alcohol packets
- scissors
- tape
- tweezers

Aftercare

The care needed after first aid varies widely, depending on the type of injury or illness sustained. Health care professionals are excellent resources to consult about appropriate individualized aftercare.

Complications

Many unexpected complications can happen while providing first aid. The most severe complication is if the patient stops breathing or the heart stops beating. In such a situation, the rescuer should immediately start CPR.

Results

The results of first aid vary with the case. Successful first aid results in the improved health and recovery of the patient.

Health care team roles

All health care professionals have a professional obligation to know the basics of first aid. Accidental injuries account for 2.6 million hospital admissions annually. Unplanned injury is the fifth-leading cause of fatalities in the United States.

Patient education

Health care professionals are in a position that allows them to provide education about first aid to patients. Emphasis on the importance of having a first-aid kit available and well stocked is valuable information to pass on to patients. Information about local areas that offer first-aid training should be offered.

Training

Extensive training is not needed for first aid. The Occupational Safety and Health Administration (OSHA) advises that retraining in first aid should occur every three years.

Good Samaritan Law

Legally, health care professionals coming to a person's aid in an emergency situation are covered under the federal Good Samaritan Law. Protection under this law requires that the situation is deemed an emergency, that no monetary compensation for the treatment is provided, and that the care provided is done "in good faith." In most U.S. states, health care professionals have no mandatory obligation to help in an emergency situation, but the Good Samaritan Law is in place to protect from liability those who do offer assistance.

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First aid kit

Definition

The **first aid** kit is a portable container of medicines, supplies, and information. It is kept for situations in which quick medical attention is needed for minor injuries.

Purpose

A first aid kit is used to treat minor illnesses and injuries in or outside the home, thereby reducing the risk of complications from minor injuries.

Description

The American College of Emergency Physicians recommends that every home have a first aid kit to respond to common medical emergencies. The contents of a well-stocked kit should include the following items:

- thermometers for infants, children, and adults
- rubbing alcohol to clean tweezers, needles, and thermometers
- tweezers and needles to remove slivers and ticks
- adhesive bandages in assorted sizes
- sterile gauze pads (2x2, 4x4, and 5x9 inches)
- non-adherent dressings, as **burns** or abrasions need a non-stick dressing

KEY TERMS

Cardiopulmonary resuscitation (CPR)—A series of steps to establish normal breathing following cardiac or respiratory arrest.

- triangular bandage to make a sling or use as a tourniquet
- elastic bandage to support a sprain
- safety pins to fasten bandages
- medical tape to affix a gauze pad to a large wound
- plastic resealable bag
- scissors
- **CPR** shield
- butterfly closures to pull the edges of small **wounds** together
- latex gloves
- medicine dropper to administer medicine to children
- medicine spoon
- petroleum jelly to lubricate rectal thermometers for infants under one year old
- heating pad/hot water bottle
- tongue depressors
- antiseptic wipes to cleanse hands or wounds
- cotton-tipped swabs for cleaning wounds
- iodine swabs for cleaning around a wound
- topical calamine lotion or antihistamine cream for **allergies**, insect bites, and rashes
- acetaminophen in appropriate doses for infants, children, and adults
- cough suppressant to relieve coughing in appropriate doses for infants, children, and adults
- antibacterial cream
- oral rehydration fluid for the treatment of diarrhea
- sunscreen
- insect repellent
- first aid manual
- an emergency information list

Operation

The items in the kit can be stored in a box or a tote bag where adult members of a family or other group



A well-stocked first aid kit is essential for every home and workplace. (Custom Medical Stock Photo. Reproduced by permission.)

know where it is located. The kit should be stored out of reach of children, and products should have child safety caps. Follow the manufacturer's guidelines for the correct use of medications and supplies.

The kit should be compact enough to be transported in a car, suitcase, or rucksack if traveling.

Maintenance

The kit should be inspected monthly to ensure that the contents are not damaged or out of date.

Health care team roles

All members should have knowledge of the appropriate use of all equipment and medication, and the ability to recognize situations in which immediate medical attention is required. The emergency information list should include the following:

- telephone numbers of family physicians and pediatricians
- the regional Poison Control Center number
- numbers of local police, fire, and ambulance services

In addition, a list should be compiled of any allergies that a family or team member has, and the treatment required.

Training

Adults with access to the first aid kit should have an understanding of the first aid manual and the correct use of all medications and equipment. Attendance at a course in basic first aid will enable them to respond quickly and appropriately to any emergency, equipping them with a knowledge of life-threatening situations and the first aid treatment to be given. At least one person in every large group should be trained in first aid and **cardiopulmonary resuscitation (CPR)**.

Resources

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Schmitt, B.D. "First Aid Kit." *Clinical Reference Systems Annual*. 2000, p670.

ORGANIZATIONS

American College of Emergency Physicians (ACEP). 1125 Executive Circle, Irving, TX 75038. (800) 798-1822.

American Red Cross. For information on first aid courses contact the Red Cross. Look in the phone book for your nearest office or email info@usa.redcross.org.

Margaret A Stockley, RGN

Fitness testing see **Endurance testing**

Flow cytometry analysis

Definition

Flow cytometry analysis is the classification of cell populations based upon the analysis of light scattering and fluorescence facilitated by a laser. Cells are counted and analyzed as they pass singly through the counting area created by a liquid sheath that flows past the laser. Cells scatter the light from the laser; forward and right-angle scatter are measured to determine size and granularity. This initial light scattergraph (dot plot) is used to select a specific cell population for testing using specific antibodies covalently bound to fluorescent dyes. The laser excites the fluorochrome causing it to emit visible light, so that the cells bound to the dye can be detected.

Purpose

Principles of flow cytometry are incorporated into some automated hematology analyzers to determine the reticulocyte (stage preceding a mature red cell) count and the percentage of each type of white **blood** cell (automated differential count). Flow cytometers are specialized instruments that can measure specific cell subpopulations in blood, bone marrow aspirates, body fluids and tissues. Flow cytometry has many applications including:

- Counting of lymphocyte subpopulations to evaluate immunological function and **immunodeficiency** states. The number of B, T and NK lymphocytes can be counted by flow cytometry to evaluate a person's cellular immune status. T helper and suppressor cells can be counted to assist in the diagnosis and staging of persons with HIV disease.
- Counting of immature white blood cells (blasts) to determine the cell lineage. Cell lineage must be defined to properly classify acute and **chronic leukemias** and non-Hodgkins lymphomas. Flow cytometry tests for surface markers on early white blood cells to determine the cell lineage (lymphoid vs myeloid), and to determine the stage of cell maturation.
- Determining the DNA content of cells. Malignant cells often possess an abnormally high DNA content.

Determination of DNA content, called ploidy analysis, is used to investigate tumor cell populations. Cells from solid tissues (for example, breast tissue) can be made into a suspension and analyzed.

- Physically sorting cell subpopulations by applying an electrostatic charge to the cells and using a fluid collecting device to harvest them from droplets passing through the flow chamber.
- Evaluation of autoimmune thrombocytopenia, transplant rejection, and autoimmune diseases.

Precautions

Universal precautions for the prevention of transmission of bloodborne pathogens is observed when collecting and processing blood, bone marrow, body fluids and tissues for flow cytometry analysis. Blood or bone marrow aspirate specimens may be submitted in sodium heparin (green top tube), EDTA (lavender top tube), or ACD (yellow top tube). Of these, the preferred anticoagulant is sodium heparin. Lithium heparin and other anticoagulants are not used.

Lymph node or other tissue specimens are not placed in fixative. They should be submitted fresh, in isotonic saline or transport medium. Specimens should be kept at room temperature if the analysis is done within 24 hours. Otherwise the specimen should be refrigerated, but not frozen.

Description

A flow cytometer consists of a laser light source, flow measurement chamber, and an optical system consisting of lenses, filters, and light detectors. Two photomultiplier tubes (light detectors), one at 180 degrees and one at 90 degrees to the laser, are used to measure forward and right-angle scatter, respectively. Three fluorescence detectors, each consisting of a filter and photomultiplier tube, are used to detect fluorescence. The three detectors sense green, orange, and red fluorescence. Cells are identified by sort logic applied to all five of the detector signals using a computer.

A typical analysis of blood is performed by first measuring the right-angle and forward light scatter of the cells. The resulting scattergraph is used to identify the counting gate, a set of parameters used to select a subpopulation of cells for further study. The gated area of the scattergraph is the portion in which the cells of interest are found. The gate parameters are selected so that only this cell subpopulation is reported in subsequent fluorescence studies.

Portions of the specimen are treated with two monoclonal antibodies, each specific for a cell surface antigen. Each monoclonal antibody is covalently bound to a dif-

KEY TERMS

Aneuploidy—An abnormal number of chromosomes within a cell.

Antigen—A molecule, usually a protein, that elicits the production of a specific antibody. In flow cytometry studies, an antigen is a cell surface marker that is recognized by a specific antibody and referred to by its cluster of differentiation (CD) number.

CD marker—A monoclonal antibody for a specific CD antigen.

Gating—The selection of cells that fit a specific set of parameters for further analysis. Only those cells belonging to the gated cell subpopulation are measured.

Immunophenotyping—Identification of antigens on the surface of cells using fluorescent-labeled antibodies. The phenotype profile is used to classify the cell.

Immune system—The body's system of defenses against infectious diseases, which includes both cellular and humoral (antibody) responses.

ferent fluorescent dye. There are approximately two dozen fluorochromes in use with flow cytometry, but the most commonly used labels are fluorescein isothiocyanate (FITC) which produces apple-green light and phycoerythrin (PE) which produces orange-red light when excited by the laser. For DNA analysis of cells the label most often used is propidium iodide (PI), which binds to DNA of nuclei and emits orange-red light when excited. The specific surface antigen to which an antibody binds is defined by the cluster of differentiation (CD) number. Each CD number represents a specific antibody combining site on the white cell surface. When the white cell surface marker is recognized by a fluorescent-labeled monoclonal antibody, the antibody binds to the cell membrane. When the cell passes through the flow chamber, the laser will excite the fluorochrome and it will emit light stimulating one of the detectors. This process is interpreted by the computer as an event. An event is a cell that meets a set of criteria required to register a dot on the scattergraph.

The process of determining the specific cell type from a panel of antibody-conjugated fluorescent stains is called immunophenotyping. For example, CD45 is a marker common to all white blood cells. CD2, CD3, CD5, and CD7 are markers for T lymphocytes. CD4 is

the site that defines a T-helper lymphocyte and CD8 is the marker or surface antigen that defines a suppressor or cytotoxic T lymphocyte. Therefore, a cell subpopulation that tests positive (i.e., produces a significant number of events) with antibodies to CD45, CD2, CD3, CD5, CD7 and CD4 is defined as a T-helper cell. Normally, a panel of antibodies is selected for use depending upon the characteristics of the gated population. For example, if the gated (selected) population is located in the region of the scattergraph where lymphocytes normally are seen, then lymphocyte markers are used. Two fluorescent-labeled antibodies are mixed with a small portion of the sample and measured simultaneously. One will be labeled with FITC and the other with PE. The events are shown as a plot of colored dots. The most commonly used plot consists of a square divided into four quadrants. The position of a dot (event) on the plot depends upon whether the cell is positive for one marker, both, or neither. For example, a positive staining reaction with FITC but not PE causes a dot in the lower right quadrant of the square. The percentage of events that fall into each quadrant is reported by the computer, and this report correlates with the density of the dots in the respective quadrant. A typical immunophenotyping for lymphocytes consists of the markers mentioned above and CD19 and CD20, which recognize B cells; HLA-DR, which recognizes B cells, T cells, monocytes and precursor cells; and anti-lambda and anti-kappa, which recognize the light chains of surface immunoglobulin molecules. The corresponding profile of positive results will identify the type of lymphocyte and its stage of maturation.

Preparation

If possible, a person should avoid eating a heavy meal within hours of the test or engaging in strenuous **exercise** for the 24 hours preceding the blood test.

Aftercare

The puncture site or biopsy site should be observed for excessive bleeding or **infection**.

Complications

In rare cases, the puncture site or biopsy site may show excessive bleeding or become infected.

Results

Interpretation of immunophenotyping requires the careful evaluation of known control cells to insure that the signals measured are not the result of background or nonspecific fluorescence. When performing the test to

determine the lineage of a cell line as in leukemia, the percentage of cells that are positive for each marker is reported. These results are evaluated along with the morphology of the cells in blood and bone marrow, and the use of cytochemical stains to determine the type of precursor cell (lymphocytic, monocytic, granulocytic) and its maturation stage.

When performing immunophenotyping of lymphocytes for the evaluation of immunological function, such as the staging of HIV disease, the percentage of cells positive for the defining marker is multiplied by the absolute lymphocyte count (i.e., number of lymphocytes per microliter). The absolute lymphocyte count is measured by the automated hematology analyzer used for the **complete blood count**. For example, to quantify the number of T-helper cells, the percentage of CD4-positive gated cells is multiplied by the lymphocyte count.

DNA content is measured by comparing the cells in the G0/G1 phase (resting or presynthesis of DNA) of the cell cycle to the G0/G1 phase of a normal diploid control. The ratio of G0/G1 DNA peaks is called the DNA index (DI), and is normally 1.00. Values greater than 1.00 indicate that an increased amount of DNA is present in the sample. A DI of 2.0 indicates that the cells are tetraploid (i.e., have twofold the normal number of chromosomes). Benign tissues do not display aneuploidy (an abnormal number of chromosomes), so the finding of aneuploidy points to a malignant state. Some malignant cells do not display aneuploidy, so a normal finding cannot rule out malignancy. In general DNA aneuploidy is not well correlated with prognosis, since the course of malignant disease is dependent upon the stage (progression), histological type of the tumor, and the tissue of origin. However, in some malignancies, the **cancer** is associated with a greater chance of recurrence or decreased survival when aneuploidy is present

Health care team roles

The physician will order the specific type of flow cytometry study, and if a biopsy is needed, will obtain a sample of the tissue. If blood is needed, the nurse or phlebotomist will draw the blood and transport the specimen to the laboratory. A clinical laboratory scientist/medical technologist with special training in flow cytometry will perform the analysis. Results are interpreted by a clinical pathologist who issues an interpretive report of the cell subpopulation(s) studied.

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Mark A. Best

Flu *see* **Influenza**

Fluency disorder *see* **Stuttering**

Fluid balance

Definition

When water intake equals water loss, the body is in fluid balance. When water loss is greater than intake, or vice versa, a fluid imbalance may result.

Description

Total body water content averages 60% of body weight in young normal-weight men and is slightly lower in women at approximately 55%. Total body water can be significantly lower in obese individuals and the elderly. Approximately two-thirds of the body water is located inside the cells (intracellular) while the remaining is outside the cells (extracellular). About three-quarters of the extracellular fluid is present in the interstitial space and connective tissues surrounding cells, while the remainder is intravascular. Approximately 8% of body water is in the bloodstream. This fairly small volume of water in the bloodstream must be kept relatively constant because it is critical for proper body function.

KEY TERMS

Antidiuretic hormone—A hormone that encourages the kidneys to retain water when body stores are low.

Dehydration—A deficit of body water that results when the output of water exceeds intake.

Diuretic—An agent or drug that eliminates excessive water in the body by increasing the flow of urine.

Electrolyte—A substance that dissociates into electrically charged atoms (ions) when dissolved in water.

Homeostasis—An organism's regulation of body processes to maintain internal equilibrium in temperature and fluid content.

Overhydration—An excess of body water that results when water intake exceeds output.

Function

The kidney is responsible for maintaining fluid balance through the elimination of waste products and excess water. Water is primarily absorbed through the gastrointestinal tract and excreted by the **kidneys** as urine. Water intake can vary widely on a daily basis, influenced by such factors as access to water, thirst, habit, and cultural factors. The variation in water volume ingested is dependent on the ability of kidneys to dilute and concentrate the urine as needed. There is a reservoir of water outside of the bloodstream that can replace or absorb excess water in the **blood** when necessary.

The body also works to maintain water balance through mechanisms such as the thirst sensation. When the body requires more water, nerve centers in the hypothalamus of the **brain** are stimulated to encourage a person to drink in order to replenish the water stores. The **pituitary gland** in the brain is also involved in maintaining fluid balance through secretion of antidiuretic hormone (ADH) into the blood. This hormone encourages the kidney to retain water when body stores are low. During water conservation by the kidneys, water is transferred from a large reservoir in the cells into the blood in order to maintain **blood pressure** and blood volume until water intake is increased. The thirst mechanism is suppressed when the body has excess water, small amounts of ADH are secreted, and through function of the kidneys, excess water is excreted in the urine.

Role in human health

For a normal adult, a daily intake between 0.74-0.84 US quarts (700-800 ml) is required to meet water losses and maintain fluid balance. To protect against **dehydration** and developing **kidney stones**, a greater water consumption between 1.5-2 US quarts/day (1.4-2 L/day) is advised. Water losses occur through evaporation in expired air and through the skin. Sweat losses are usually minimal but can be significant in warmer climates or with accompanying **fever**.

The body can accommodate extreme changes in water intake when the brain and kidneys are functioning normally. It is usually possible for a person to consume enough water to maintain blood volume and **electrolyte balance** in the blood. However, if a person is unable to consume enough water to equal excessive water loss, dehydration may result.

Common diseases and disorders

Dehydration

Dehydration is a deficit of body water that results when the output of water exceeds intake. Dehydration stimulates the thirst mechanism, instigating water consumption. Sweating and the output of urine both decrease. If water intake continues to fall short of water loss, dehydration worsens.

Causes of dehydration may include:

- vomiting
- **diarrhea**
- diuretics
- excessive heat
- excessive sweating
- fever
- decreased water intake

Dehydration induces water to move from the reservoir inside cells into the blood. If dehydration progresses, body tissues begin to dry out and the cells start to shrivel and malfunction. The most susceptible cells to dehydration are the brain cells. Mental confusion, one of the most common signs of severe dehydration, may result and can lead to **coma**. Dehydration can occur when excessive water is lost with such diseases as **diabetes mellitus**, diabetes insipidus, and Addison's disease.

Dehydration is often accompanied by a deficiency of electrolytes, sodium and potassium in particular. Water does not move as rapidly from the reservoir inside of the cells into the blood when electrolyte concentration is decreased. Blood pressure can decline due to a lower

volume of water circulating in the bloodstream. A drop in blood pressure can cause lightheadedness, or a feeling of impending blackout, especially upon standing (orthostatic hypotension). Continued fluid and electrolyte imbalance may further reduce blood pressure, causing **shock** and damage to many internal organs including the brain, kidneys, and **liver**.

TREATMENT OF DEHYDRATION. Consumption of plain water is usually sufficient for mild dehydration, although when both water and electrolyte losses have occurred after vigorous **exercise**, electrolytes must be replaced; sodium and potassium in particular. Adding a little salt to drinking water or consuming such drinks as Gatorade during or following exercise can replace lost fluids. Individuals with **heart** or kidney problems should consult a physician regarding the replacement of fluids after exercise.

Sodium chloride may be administered intravenously by medical personnel if blood pressure decreases enough to induce shock or risk of shock. The underlying cause of dehydration must be addressed along with treatment to replace fluids. For example, if the cause of dehydration is due to diarrhea, then drugs may be given to alleviate diarrhea as well. Following treatment of the cause, individuals may be monitored to ensure that oral fluid intake is adequate to maintain fluid hydration.

Overhydration

Overhydration is an excess of body water that results when water intake exceeds output. Drinking large amounts of water does not typically lead to overhydration if the kidneys, heart, and pituitary gland are functioning properly. An adult would have to drink more than 2 US gallons per day (7.6 L per day) to exceed the body's ability to excrete water. Excessive body water causes electrolytes in the blood, including sodium, to become overly diluted. Overhydration occurs in individuals whose kidneys do not function normally, primarily in kidney, heart, or liver disease. People with these conditions may have to limit their water and dietary salt intake. Similar to dehydration, the brain is the most sensitive organ to overhydration. The brain cells can adapt to increased fluid volume when overhydration increases slowly; however, when it occurs rapidly, mental confusion, seizures, and coma can result.

Overhydration can occur alone or in conjunction with excess blood volume. Distinguishing between the two conditions may be quite complicated. Overhydration induces water accumulation within and around the cells but does not typically show symptoms of fluid accumulation. On the other hand, with excess blood volume, there is an accumulation of sodium and the body cannot

transfer water into the reservoir within cells. Conditions such as **heart failure** and liver cirrhosis may induce volume overload, whereby fluid accumulates around cells in the abdomen, chest, and lower legs.

TREATMENT OF OVERHYDRATION. Treatment of overhydration depends somewhat upon the cause, although whatever the underlying condition, fluids must be limited. Drinking less than about 1 US quart (1 L) of fluid a day usually improves overhydration over several days. Fluids should only be limited at a physician's request. A diuretic may be prescribed to increase water output by the kidneys. Diuretics are particularly beneficial for treatment of excess blood volume where overhydration is accompanied by excess blood volume.

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Fluorescence in situ hybridization test see
Genetic testing

Fluoride therapy

Definition

Fluoride therapy is the use of fluoride products topically (applied to the tooth surface) or systemically

(ingested in supplements or water) to prevent or reduce the incidence of **dental caries** (tooth decay).

Purpose

Fluoride therapy may be initiated systemically before a child's teeth emerge during tooth development in order to strengthen tooth enamel (the hard outer surface of a tooth) and prevent dental caries. Fluoride may also be applied in the form of gels, foams, and varnishes to the tooth surface, which provides temporary protection. Topical methods are effective for adults and children. The use of fluoridated toothpaste and mouth rinses is another means of delivering fluoride therapy.

Precautions

Fluoride therapy is contraindicated for children who are drinking fluoridated water and/or who are also receiving the optimal fluoride dosage (about 1.0 ppm) from foods and bottled beverages. Fluoride in dentifrices (toothpastes) and mouth rinses also has the potential of being ingested. Overexposure to fluoride while a child's teeth are forming under the gums results in **fluorosis**, an abnormal condition that affects the appearance of tooth enamel and can be very mild (a few white spots on a tooth) to severe (etching, pitting, and brown discoloration on many teeth).

Pediatricians, oral care professionals, and dental hygienists assess the amount of fluoride in a child's natural environment and caries risk before prescribing fluoride supplements or topical fluoride therapy. Usually, if a child lives in an area where fluoride has been added to the drinking water, supplements are not necessary. A pediatrician or oral care professional may recommend supplements if the child exhibits moderate-to-high risk for dental caries. However, supplementation should be done with caution, weighing the risks of fluoride overexposure against slightly more added protection.

Description

Fluoride therapy can be administered through fluoride supplements, fluoridated water, and some bottled beverages containing fluoride. Carbonated drinks, juices, and bottled waters can contain fluoride in varying amounts. Often, the fluoride in these products is not printed on the labels. Some other foods and beverages are high in fluoride, including fish with bones, tea, poultry products, cereals, or infant formula made with fluoridated water. Food cooked in Teflon-coated pans also provides fluoride.

Breast-fed infants usually do not need supplements until after they are six months old. By that time, they may be drinking water from a cup or eating some foods that contain fluoride, so supplements still may not be necessary.

Fluoride supplements are dispensed in the United States and Canada as lozenges, oral solutions, tablets, and chewable tablets. Fluoride can also be prescribed in combination with a vitamin supplement as chewable tablets or in an oral solution. In the United States, common brand names for fluoride supplements are Fluoritab, Fluorodex, Flura, Flura-Drops, Flura-Loz, Karidium, Luride, Luirde Lozi-Tabs, Pediaflor, Pharmaflur, and Phos-Flur. The vitamin/fluoride combination is sold as Adeflor, Cari-Tab, Mulvidren-F, Poly-Vi-Flor, Tri-Vi-Flor, and Vi-Daylin/F. These supplements are available only by prescription from a pediatrician or a oral care professional.

Dosing of fluoride supplements is different for every child. When determining the amount to prescribe, pediatricians and oral care professionals should consider all fluoride exposure in the child's environment and prescribe supplements with fluoride limits in mind. Recommended total daily fluoride intake has been set at 0.1 to 1.5 mg for the infant and child to three years of age, 1–2.5 mg for the four-to-six-year old, 1.5–1.5 mg for the seven-to-ten year old, and 1.5–4 mg for an adolescent and an adult.

Calcium supplements, or any products with aluminum hydroxide, should not be taken along with fluoride supplements. Each dose should be spaced at least two hours apart to achieve the maximum benefit of each.

Overexposure to fluoride is a concern to pediatricians and oral care professionals because it can result in fluorosis. Fluorosis, which is caused by exposure to excessive amounts of fluoride while the enamel is being formed, can affect both the primary (baby) teeth and permanent teeth. It does not affect the permanent teeth once they have fully developed. Most often, the fluorosis appears on the front incisors (front teeth) and less frequently on the molars. This characteristic poses a high cosmetic problem because the front teeth are most exposed when children speak or smile. There is no cure for fluorosis except cosmetic restoration, which can be costly.

Fluoride gels and foams are the most common form of topical fluoride application at the oral care professional's office. A flavored gel containing a concentration of fluoride is offered in a tray to the patient. There is one tray for the upper teeth and one for the lower teeth. The patient should sink his or her teeth into the tray and let the teeth bathe in the fluoride for a specific amount of

time. The mouth should be emptied but not rinsed; then, the patient is instructed not to eat or drink for 30 minutes.

Fluoride varnishes that are being used in Europe have been found to be easier to apply and more durable for the patient; however, varnishes have not been approved for use as a fluoride treatment in the United States. With the varnishes used in Europe, the patient may also eat or drink soon after application. The residue is removed only when the patient's teeth are brushed.

Finally, the use of fluoride toothpaste and fluoridated mouth rinses may also be recommended for adults and children. According to the American Dental Association, young children under six often use too much fluoride toothpaste, and consistently swallow it. This has contributed significantly to excess fluoride ingestion. Careful monitoring of toothpaste amounts by parents and encouragement to spit, instead of swallowing the toothpaste, can drastically decrease the amount of fluoride a child ingests from dentifrices.

Composite resins and adhesives with fluoride are used by oral care professionals when filling cavities and cementing crowns into place. Sufficient amounts of topical fluoride are applied to protect adjacent teeth that normally are at risk for further wear and decay due to the location of the cavity (e.g., deep pits in molars) or the stress due to bridge and crown fittings.

Dental and medical insurance usually cover fluoride therapy as "routine care."

Preparation

The oral care professional should thoroughly dry the patient's teeth before applying fluoride gels or foams. The varnishes, however, can be applied to damp teeth and still produce the desired effect. Fluoride dentifrices and mouth rinses require no special preparation.

Aftercare

When varnishes are used, the patient can generally eat before 30 minutes, the time he or she is required to wait after a fluoride treatment. This detail can be extremely important for patients with diabetes, who must eat frequently.

Results

Fluoride treatments provide temporary protection against dental caries. They are not as effective as systemic intake of fluoridated water, but they can be extremely helpful to children who are at moderate-to-high risk for dental caries. Furthermore, they can also

KEY TERMS

Dental caries—Tooth decay.

Dentifrices—Toothpastes.

Enamel—The hard outer surface of a tooth.

Fluoride—A fluorine ion used to treat water or apply directly to tooth surfaces to prevent dental caries.

Incisors—Front teeth used for biting. Includes central and lateral incisors.

Primary teeth—The teeth a child has before permanent ones; primary teeth; baby teeth.

Systemic—Ingested as tablets or drops and circulates throughout the human body.

Topical—On the surface of a tooth.

help in patients who need extra protection against root caries due to gum recession and xerostomia (dry mouth).

Health care team roles

The pediatrician has an important role in a child's oral health. The first person to be consulted about a child's dental needs, the pediatrician can monitor a child's **oral hygiene**, determine when to make referrals, and regulate fluoride therapy.

Oral care professionals and dental hygienists provide fluoride therapy, monitor oral hygiene, and also assess the amount of fluoride in a person's environment. The oral care professional also makes detailed repairs and suggests therapeutic plans for the child's dental health.

The pediatrician plays an important role in the education of parents regarding fluoride excess and safety issues about fluoride toothpastes and mouth rinses. Nurses and teachers also participate in parent education about fluoride usage and good dental habits. They can teach children about proper tooth brushing, especially the amount of toothpaste to use. These are lessons all adults need to learn as well. The educators can also encourage periodic testing of the water for fluoride levels in the community or at home, especially if water filters are used.

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Janie F. Franz

Fluorine toxicity *see* **Fluorosis**

Fluoroscope

Definition

A fluoroscope is an x-ray device that allows live images to be projected onto a viewing monitor during diagnostic and interventional procedures.

Purpose

A fluoroscope is used for real-time imaging of various anatomical areas during a diagnostic or interventional procedure. Fluoroscopy produces a live image of the area of interest, and can be used to view such motion as **blood** flow and catheter insertion. In contrast, radiography, or x-ray imaging, produces a still image on film.

Specific procedures that use fluoroscopy include aneurysm repair, hip and knee replacement, **arthroscopy**, catheter placement, needle biopsy, location of **foreign bodies**, swallowing studies, fracture reduction, discography, **lithotripsy**, brachytherapy, pacemaker insertion, endoscopic retrograde cholangiopancreatography (ERCP), and gastrointestinal evaluation (e.g., bowel studies). Fluoroscopy may also be used to detect bone **cancer** or digestive cancers, and digestive ulcers; however, computed tomography (CT) imaging is now routinely used to detect these conditions.

Description

The term fluoroscope generally refers to a mobile radiographic/fluoroscopic unit, also called a mobile C-arm because of its shape. A mobile C-arm system consists of two wheeled units: one carries the imaging arm, x-ray generator, and control console, and the other carries the image display monitors and image processing and recording devices. The imaging arm, which is shaped like the letter C, has an x-ray tube mounted on one end and an image intensifier mounted on the other end. The x-ray generator supplies the power to the x-ray tube, which emits x rays that pass through the patient and are absorbed by the image intensifier. The image intensifier is a phosphor screen that converts the x rays into light, which is then scanned and transmitted by a charge-coupled device (CCD) camera to a display monitor.

Fluoroscopy is also performed using larger stationary radiographic/fluoroscopic systems that include a patient table, an x-ray generator, an x-ray tube, an image intensifier, and an image display system configured in a shielded room. The term fluoroscope may be used to refer to the components of this stationary system that perform fluoroscopy, but it is most commonly used in reference to a mobile system.

Fluoroscopy is performed in surgical, orthopedic, critical care, emergency care, and diagnostic radiology settings. In addition, mobile fluoroscopes are used to image patients on stretchers, beds, or examination/procedure tables when they cannot be transported to the radiology department.

Scaled-down compact fluoroscopes that can be handheld are also available and are designed for fast, continuous imaging of the extremities at various angles. Mini C-arms may be used in the emergency department, during surgery, in a physician's office, in sports medicine and **physical therapy**, and in the field such as an accident site.

In 2000, a fluoroscope with a navigational or surgical guidance computer was introduced to improve instru-

ment placement and imaging during minimally invasive surgical procedures, particularly those involving the spine.

Operation

The fluoroscope is maneuvered in such a way that the patient, and the anatomical area of interest, is positioned between the x-ray tube and the image intensifier. The operator uses the control console to set imaging parameters. The intensity of the x rays is controlled with the milliamperage (mA) setting, and the energy and intensity of the x rays are controlled with the peak kilovoltage (kVp) setting. A typical fluoroscopy image setting is 70 kVp at 2 mA. Most mobile C-arms have capabilities for magnified views, automatic brightness stabilization to maintain a constant brightness during the exam, and last-image hold to freeze the last acquired image on the monitor.

During fluoroscopic imaging, the patient is exposed to radiation; continuous fluoroscopy for long periods (e.g., during a surgical procedure) can deliver a significant radiation dose. Therefore, most systems have a pulsed fluoroscopy mode, which allows the x-ray output to be pulsed for periods ranging from 10 milliseconds to 30 times per second, and displays the image acquired with each pulse. Although the image on the monitor may be jumpy, radiation exposure to the patient can be reduced by as much as 75% with this mode. Dose reduction is especially important in pediatric patients and young adult patients of reproductive age. Clinical staff are also exposed to radiation, and portable radiation shields, lead aprons, and radiation badges should be worn by all staff present during fluoroscopy.

All images displayed on the monitor can be saved to a disk, video disk, compact disk, or tape. Some systems have digital capabilities that allow storage in digital **memory** or on a computer network. A videocassette recorder or digital recorder can be used to record several minutes of real-time fluoroscopy. Snapshot images can also be printed as hard copy using video printers, thermal printers, or a multi-format camera (a camera that records and prints multiple images; for example, four images on one film).

Maintenance

A fluoroscope is usually maintained either through a service contract with the manufacturer, a third-party service company, or by the hospital **biomedical engineering** department. The x-ray technologist operating the fluoroscope may perform periodic performance testing to check image quality, radiation dose, and other imaging parameters. A quality control program should be imple-

KEY TERMS

Brachytherapy—A radiation therapy treatment in which a radioactive source material is inserted, injected, or implanted into the cancerous area; fluoroscopy is frequently used to guide placement of brachytherapy sources.

Discography—A radiographic/fluoroscopic imaging procedure that involves injecting contrast material into an intervertebral disk.

Endoscopic retrograde cholangiopancreatography (ERCP)—A procedure that involves inserting an endoscope through the mouth, esophagus, stomach, and into the first part of the small intestine (the duodenum) to examine the pancreas, pancreatic ducts, and bile ducts. A catheter is threaded through the endoscope to inject dye, and x-ray and fluoroscopic imaging are performed.

Lithotripsy—A procedure that uses fluoroscopic guidance to locate and break up stones in the urinary tract and gallbladder.

Myelography—A fluoroscopic imaging procedure that examines the spinal cord and is used for diagnosing such conditions as spinal abscesses, tumors, and dislocated intervertebral disks.

mented to ensure optimal image quality and minimal radiation doses.

Health care team roles

Fluoroscopic imaging may be performed by x-ray technologists, radiologists, surgeons, cardiologists, and other health care professionals. For such diagnostic procedures as an upper gastrointestinal (GI) series, the fluoroscopic examination is performed by a radiologist and an x-ray technologist in a hospital radiology department or an outpatient imaging center. For such orthopedic procedures as arthroscopy, an orthopedic surgeon and x-ray technologist perform the fluoroscopic examination. For interventional diagnostic and therapeutic procedures, an interventional radiologist, cardiovascular specialist, and x-ray technologist are involved in the fluoroscopic procedure. Nursing staff may be present to assist during fluoroscopic procedures, depending on the condition of the patient and whether medication administration is necessary. Mini-C-arms have clinical applications outside the hospital, and thus may be used in medical emergencies at

sporting events, and in sports medicine and physical therapy facilities.

Training

Use of a fluoroscope requires training in radiographic and fluoroscopic principles and techniques. X-ray technologists should have completed appropriate educational programs (registered technologist programs). Any staff using fluoroscopic equipment should participate in clinical training provided by the equipment manufacturer.

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American Registry of Radiologic Technologists. 1255 Northland Drive, St. Paul, MN 55120-1155. (651) 687-0048. <<http://www.arrt.org>>.

American Society of Radiologic Technologists (ASRT). 15000 Central Avenue SE, Albuquerque, NM 87123-2778. (800) 444-2778. <<http://www.asrt.org>>.

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Fluorosis

Definition

Fluorosis is an abnormal condition of the tooth enamel caused by excessive exposure to fluoride (a nutrient used to prevent tooth decay) while a child's teeth are forming under the gums. Excessive fluoride affects the formation of tooth enamel (the hard outer surface of a

Classification and descriptive criteria for dental fluorosis

Classification	Descriptive criteria
Normal	Enamel shows no evidence of fluorosis. The surface of the tooth is smooth, glossy, and typically has a pale, creamy white color.
Very mild	Evidence of fluorosis in the enamel is shown by areas with parchment-white color that total up to 25% of the tooth surface. This includes fluorosis seen only on the incisal edges of anterior teeth and cusp tips of bicuspids or molars ("snowcapping").
Mild	Parchment-white fluorosis can be seen on more than 25% but less than 50% of the tooth surface.
Moderate	Light to very dark brown staining occurs on the enamel, along with the parchment-white coloration of fluorosis.
Severe	All enamel surfaces are affected, and the anatomy of the tooth may be altered. Discrete or confluent pitting of the enamel surface exists. Dark-brown stain is usually present and may be widespread, presenting a corroded appearance of the teeth.

tooth). Fluorosis can be very mild, as a few white spots on a tooth; or severe, showing etching, pitting, and brown discoloration on many teeth.

Description

Fluoridated community water systems and toothpaste with fluoride have significantly contributed to the prevention and mitigation of **dental caries** (tooth decay) in developed countries, reducing the number of cavities by 70%. Even at the safe level of 1 ppm of fluoride in drinking water, 22% of the people drinking that water have reported some form of fluorosis. In some areas, the rate of incidence is 50%.

Though fluorosis is mainly a cosmetic problem, it has become a marker for overexposure to fluoride in a child's environment.

Causes and symptoms

Fluorosis does not affect the permanent teeth once they have fully appeared. Fluorosis may occur in primary (baby) teeth as well as permanent teeth. Most often, the condition appears on the front incisors (front teeth) and less frequently on the molars. This characteristic poses a high cosmetic problem because the front teeth are most exposed when children speak or smile.

Symptoms can range from mild to severe. Very mild fluorosis is seen as tiny white spots on 25% of a tooth surface. Mild fluorosis covers 26% to 50% of a tooth surface. Moderate fluorosis compromises all of a tooth's surface and is most characterized by brown discoloration

of the tooth. Severe fluorosis involves pitting of the enamel and more serious brown staining. Approximately 94% of dental fluorosis is very mild to mild.

Excess fluoride exposure is often accidental. Naturally occurring fluoride in well water can sometimes be much higher than water from artificially fluoridated, community or municipal systems that are kept at strict levels. Drought conditions can also concentrate fluoride levels.

According to the ADA, young children under six often use too much toothpaste that contains fluoride, and they consistently swallow it. This alone has been the biggest cause of excess fluoride ingestion.

Some children drink fluoridated water and also drink large amounts of bottled beverages that have fluoride in them. Carbonated drinks and juices have fluoride in varying amounts. Often, the fluoride in these products is not printed on the labels. Still other children are offered foods high in fluoride (fish with bones, tea, poultry products, cereals, or infant formula made with fluoridated water) in addition to fluoridated water.

Finally, fluorosis may be caused by some pediatricians who prescribe fluoride supplements without determining the amount of fluoride exposure the child has in his or her environment.

Topical applications of fluoride gels applied by dentists to the surfaces of a child's teeth and fluoride mouth rinses available through dentists or over the counter (OTC) are other ways that a child can add to her fluoride quota. These methods are extremely helpful for older children and adults, but they often add to the cumulative fluoride exposure a young child can have, especially if she swallows fluoride residues.

Diagnosis

Fluorosis can be identified through examination by a dentist or dental hygienist. Very mild fluorosis sometimes can be detected only through x rays. Often the dentist uses the Fluorosis Index to classify the severity of the condition from very mild to severe. (See Causes & Symptoms for details of each classification.)

Treatment

There is no treatment for fluorosis except cosmetic restoration.

Prognosis

There are many more ways to deliver fluoride than through drinking water and toothpaste. These methods,

KEY TERMS

Deciduous teeth—The teeth a child has before permanent ones; baby teeth.

Dental caries—Tooth decay.

Enamel—The hard outer surface of a tooth.

Fluoride—A fluorine compound used to treat water or apply directly to tooth surfaces to prevent dental caries.

Incisors—Front teeth used for biting.

however, remain the most effective ways to discourage dental caries (tooth decay). With more awareness of the amount of fluoride in a child's environment, pediatricians and dentists are becoming more accurate in prescribing fluoride supplements to infants and young children. Parents are becoming educated about the risks of their children swallowing fluoride toothpaste and fluoride mouth rinses.

Health care team roles

The pediatrician has an important role in a child's oral health because the pediatrician is usually the first health-care professional a child sees about his or her dental needs. The pediatrician can monitor a child's **oral hygiene**, determine when to make referrals, and regulate **fluoride therapy** in relation to a child's specific fluoride needs. The pediatrician can also educate parents about fluoride excess and safety issues.

The dentist regulates the amount and frequency of fluoride therapy, monitors a child's oral hygiene, and also assesses the amount of fluoride in a child's environment. The dentist also suggests and implements therapeutic plans for the child's dental health. Parent education is also a part of the dentist's role.

Dental hygienists, nurses, and teachers participate in parent education about fluoride usage and good dental habits, teach children about proper tooth brushing—especially the amount of toothpaste to use—and encourage periodic testing of the water for fluoride levels in the community or at a child's home, where filters that may lower fluoride concentrations in tap water may be used.

Prevention

Fluorosis can be prevented by monitoring the amount of fluoride children are exposed to before the age of six. Professionals can educate parents about diet,

fluoridated water, proper tooth brushing, and safe amounts of toothpaste to use. Children under six should be monitored during tooth brushing, shown to use only a pea-sized drop of toothpaste, and encouraged to not swallow toothpaste. Children under six should also not use fluoridated mouth rinses. Parents should limit the amount of fluoride in bottled beverages, and substitute milk for between-meal snacks. Pediatricians and dentists should adhere to the new guidelines for fluoride supplements. These supplements are not recommended for children who are exposed to adequate amounts of fluoridated water.

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American Dental Association. 211 East Chicago Ave., Chicago, IL 60611. (800)947-4746, (312)440-2500. <<http://www.ada.org>>.

National Association of Pediatric Nurse Associates & Practitioners. 1101 Kings Highway, N., Suite 206, Cherry Hill, NJ 08034-1912. <<http://www.napnap.org>>.

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Folate see **Folic acid**

Folic acid

Description

Folic acid is a water-soluble vitamin belonging to the B-complex group of **vitamins**. These vitamins help the body break down complex **carbohydrates** into simple sugars to be used for energy. Excess B vitamins are excreted

from the body rather than stored for later use. This is why sufficient daily intake of folic acid is necessary.

Folic acid is also known as folate or folacin. It is one of the nutrients most often lacking in the Western diet, and there is evidence that deficiency is a problem on a worldwide scale. Folic acid is found in leafy green vegetables, beans, peas and lentils, **liver**, beets, brussels sprouts, poultry, nutritional yeast, tuna, wheat germ, mushrooms, oranges, asparagus, broccoli, spinach, bananas, strawberries, and cantaloupes. In 1998, the U.S. Food and Drug Administration (FDA) required food manufacturers to add folic acid to enriched bread and grain products to boost intake and to help prevent neural tube defects (NTD).

General use

Folic acid works together with **vitamin B₁₂** and **vitamin C** to metabolize protein in the body. It is important for the formation of red and white **blood** cells. It is necessary for the proper differentiation and growth of cells and for the development of the fetus. It is also used to form the nucleic acid of DNA and RNA. It increases the appetite and stimulates the production of **stomach** acid for digestion and it aids in maintaining a healthy liver. A deficiency of folic acid may lead to anemia, in which there is decreased production of red blood cells. Anemia reduces the amounts of oxygen and nutrients that are able to get to the tissues. Symptoms may include fatigue, reduced secretion of digestive acids, confusion, and forgetfulness. During **pregnancy**, a folic acid deficiency may lead to preeclampsia, premature birth, and increased bleeding after birth.

People who are at high risk of strokes and **heart** disease may greatly benefit by taking folic acid supplements. An elevated blood level of the amino acid homocysteine has been identified as a risk factor for some of these diseases. High levels of homocysteine have also been found to contribute to problems with **osteoporosis**. Folic acid, together with vitamins B₆ and B₁₂, helps break down homocysteine, and may help reverse the problems associated with elevated levels.

Pregnant women have an increased need for folic acid, both for themselves and their child. Folic acid is necessary for the proper growth and development of the fetus. Adequate intake of folic acid is vital for the prevention of several types of birth defects, particularly NTDs. The neural tube of the embryo develops into the **brain, spinal cord**, spinal column, and the **skull**. If this tube forms incompletely during the first few months of pregnancy a serious, and often fatal, defect results in spina bifida or anencephaly. Folic acid, taken from one year to one month before conception through the first

four months of pregnancy, can reduce the risk of NTDs by 50-70%. It also helps prevent a cleft lip and palate.

Research shows that folic acid can be used to successfully treat cervical dysplasia, a condition diagnosed by a Pap smear, of having abnormal cells in the cervix. This condition is considered to be a possible precursor to cervical **cancer**, and is diagnosed as an abnormal Pap smear. Daily consumption of 1,000 mcg of folic acid for three or more months has resulted in improved cervical cells upon repeat Pap smears.

Studies suggest that long-term use of folic acid supplements may also help prevent lung and colon cancer. Researchers have found that alcoholics who have low folic acid levels face a greatly increased possibility of developing colon cancer.

Preparations

To correct a folic acid deficiency, supplements are taken in addition to food. Since the functioning of the B vitamins is interrelated, it is generally recommended that the appropriate dose of B-complex vitamins be taken in place of single B vitamin supplements. The Recommended Dietary Allowance (RDA) for folate is 400 mcg per day for adults, 600 mcg per day for pregnant women, and 500 mcg for nursing women. Medicinal dosages of up to 1,000-2,000 mcg per day may be prescribed.

Precautions

Folic acid is not stable. It is easily destroyed by exposure to light, air, water, and cooking. Therefore, the supplement should be stored in a dark container in a cold, dry place, such as a refrigerator. Many medications interfere with the body's absorption and use of folic acid. This includes sulfa drugs, sleeping pills, estrogen, anti-conulsants, birth control pills, **antacids**, quinine, and some **antibiotics**. Using large amounts of folic acid (e.g., over 5,000 mcg per day) can mask a vitamin B₁₂ deficiency and thereby risk irreversible nerve damage.

Side effects

At levels of 5,000 mcg or less, folic acid is generally safe for use. Side effects are uncommon. However, large doses may cause nausea, decreased appetite, bloating, gas, decreased ability to concentrate, and insomnia. Large doses may also decrease the effects of phenytoin (Dilantin), a seizure medication.

KEY TERMS

Homocysteine—An amino acid involved in the breakdown and absorption of protein in the body.

Preeclampsia—A serious disorder of late pregnancy in which the blood pressure rises, there is a large amount of retained fluids, and the kidneys become less effective and excrete proteins directly into the urine.

Raynaud's disease—A symptom of various underlying conditions affecting blood circulation in the fingers and toes and causing them to be sensitive to cold.

Recommended Daily Allowance (RDA)—Guidelines for the amounts of vitamins and minerals necessary for proper health and nutrition established by the National Academy of Sciences in 1989.

Water-soluble vitamins—Vitamins that are not stored in the body and are easily excreted. They must, therefore, be consumed regularly as foods or supplements to maintain health.

Interactions

As with all B-complex vitamins, it is best to take folic acid with the other B vitamins. Vitamin C is important to the absorption and functioning of folic acid in the body.

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Patience Paradox

Folic acid test see **Vitamin tests**

Follicle-stimulating hormone test see **Pituitary hormone tests**

Food poisoning

Definition

Food **poisoning** is a general term for health problems arising from eating contaminated food. Food may be contaminated by **bacteria**, **viruses**, environmental toxins, or toxins present within the food itself, such as the poisons in some mushrooms. Symptoms of food poisoning usually involve the prompt onset of vomiting and **diarrhea**. Some toxins also affect the nervous system.

Description

Every year millions of people suffer from bouts of vomiting and diarrhea that they blame on “something I ate.” These people are generally correct. The Centers for Disease Control and Prevention (CDC) estimates that there are from six to 33 million cases of food poisoning in the United States each year. Many cases are mild and pass so rapidly that they are never diagnosed. Occasionally a severe outbreak creates a newsworthy **public health hazard**.

Classical food poisoning, sometimes incorrectly called ptomaine poisoning, is caused by a variety of dif-

ferent bacteria. The most common are *Salmonella*, *Staphylococcus aureus*, *Escherichia coli* O157:H7, *Shigella*, and *Clostridium botulinum*. Each has a slightly different incubation period and duration, but all except *C. botulinum* cause inflammation of the intestines and diarrhea. Sometimes food poisoning is called bacterial gastroenteritis or infectious diarrhea. Food and water can also be contaminated by viruses (cholera, rotavirus), environmental toxins (heavy metals), and poisons produced within the food itself (mushroom poisoning or fish and shellfish poisoning).

Careless food handling creates conditions for the growth of bacteria that make people sick. Food can become contaminated at many different points during its trip from farm to table. Vegetables that are eaten raw, such as lettuce, may be contaminated by bacteria in soil, water, and dust during washing and packing. Home canned and commercially canned food may be improperly processed at too low a temperature or for too short a time to kill the bacteria.

Raw meats carry many foodborne bacterial diseases. The United States Food and Drug Administration (FDA) estimates that 90% or more of raw poultry sold at retail carries some disease-causing bacteria. Other raw meat products and eggs are contaminated to a lesser degree. Thorough cooking kills the bacteria and makes the food harmless. However, properly cooked food can become recontaminated if it comes in contact with plates, cutting boards, counter tops, or utensils that were used with raw meat and not cleaned and sanitized.

Cooked foods can also be contaminated after cooking by bacteria carried by food handlers or from bacteria in the environment. It is estimated that 50% of healthy people have the bacterium *Staphylococcus aureus* in their nasal passages and throat, as well as on their skin and hair. Rubbing a runny nose, then touching food can introduce the bacteria into cooked food. Bacteria flourish at room temperature and will rapidly grow into quantities capable of making people sick. To prevent this growth, food must be kept hot or cold, but never just warm.

Although the food supply in the United States is probably the safest in the world, anyone can get food poisoning. Serious outbreaks are rare. When they occur, the very young, the very old, and those with **immune system** weaknesses have the most severe and life-threatening cases. For example, this group is 20 times more likely to become infected with the *Salmonella* bacterium than the general population.

Travel outside the United States to countries where less attention is paid to sanitation, water purification, and good food handling practices increases the chances that a person will get food poisoning. People living in institu-

tions such as **nursing homes** are also more likely to get food poisoning.

Rotavirus is the most common cause of severe diarrhea in children and accounts for the hospitalization of an estimated 55,000 children in the United States and over 600,000 deaths of children worldwide per year.

Other less common but serious food-borne illnesses may arise from consuming animals infected with *Bovine spongiform encephalopathy*. Bovine spongiform encephalopathy (BSE) is a degenerative disorder affecting the **central nervous system** in cattle. It is also commonly referred to as “mad cow disease.” BSE results from an “unconventional transmissible agent” which is yet to be determined precisely but is thought to be a pathogenic protein. Cell death leads to holes in the **brain**, creating a “sponge-like” consistency, which results in the animal’s death. As of November 2000, there have been more than 177,500 cases of BSE confirmed in the United Kingdom (UK). However, no cases have been reported in the United States, where the food supply has been monitored closely. Imports of ruminants (suborder of mammals that includes sheep) and ruminant products have been restricted to some degree from countries where BSE was reported and has extended to all European countries. BSE is believed to be linked to a new variation of **Creutzfeldt-Jakob disease** (CJD) in humans, which is a progressive neurological disorder that can lead to death.

Causes and symptoms

The symptoms of food poisoning occur because foodborne bacteria release toxins or poisons as a byproduct of their growth in the body. These toxins (except those from *C. botulinum*) cause inflammation and swelling of the **stomach, small intestine** and/or **large intestine**. The result is abdominal muscle cramping, vomiting, diarrhea, **fever**, and the chance of **dehydration**. The severity of symptoms depends on the type of bacteria, the amount consumed, and the individual’s general health and sensitivity to the bacterial toxin.

Salmonella

According to the CDC, approximately 1.4 million cases of *Salmonella* contamination occur annually in the US, with about 40,000 being culture-confirmed cases reported to the CDC. *Salmonella* is found in egg yolks from infected chickens, in raw and undercooked poultry and in other meats, dairy products, fish, shrimp, and many more foods. The CDC estimates that one out of every 50 consumers is exposed to a contaminated egg yolk each year. However, thorough cooking kills the bacteria and makes the food harmless. *Salmonella* is also found in the feces of such pet reptiles as turtles, lizards, and snakes.

About one out of every 1,000 people get food poisoning from *Salmonella*. Of these, two-thirds are under age 20, with the majority under age nine. Most cases occur in the warm months between July and October. *Salmonella* poisoning manifests itself as *salmonellosis*, mostly caused by *Salmonella enteritidis* and *Salmonella typhimurium*. The incidence of salmonellosis has increased dramatically during the last two decades, due in part to the growing popularity of pet iguanas.

Symptoms of food poisoning begin 12–72 hours after eating food, water, or contact with animals contaminated with *Salmonella*. These include the traditional food poisoning symptoms of abdominal **pain**, diarrhea, vomiting, and fever. The symptoms generally last two to five days. Dehydration can be a complication in severe cases. People generally recover without antibiotic treatment, although they may feel tired for a week after the active symptoms subside. The CDC estimates that there are over 500 fatalities per year in the US, with 2% of the cases complicated by chronic arthritis.

Staphylococcus aureus

Staphylococcus aureus is found in dust, air, and sewage. The bacteria are spread primarily by food handlers using poor sanitary practices. Almost any food can be contaminated, but salad dressings, milk products, cream pastries, and any food kept at room temperature, rather than hot or cold, are likely candidates.

It is difficult to estimate the number of cases of food poisoning from *Staphylococcus aureus* that occur each year, because its symptoms are so similar to those caused by other foodborne bacteria. Many cases are mild and the victim never sees a doctor.

Symptoms appear rapidly, usually two to eight hours after the contaminated food is eaten. The acute symptoms of vomiting, diarrhea, and severe abdominal cramps usually last only three to six hours and rarely more than 24 hours. Most people recover without medical assistance. Deaths are rare.

Escherichia coli (*E. coli*)

There are many strains of *E. coli*, and not all of them are harmful. The strain that causes most severe food poisoning is *E. coli* O157:H7. Food poisoning by *E. coli* occurs in three out of every 10,000 people. Foodborne *E. coli* is found mainly in food derived from cows such as dairy products and beef, especially ground beef.

Symptoms of food poisoning from *E. coli* are slower to appear than those caused by some of the other foodborne bacteria. *E. coli* produces toxins in the large intestine rather than higher up in the **digestive system**. This

factor accounts for the delay in symptoms and the fact that vomiting rarely occurs in *E. coli* food poisoning.

One to three days after eating contaminated food, the victim with *E. coli* O157:H7 begins to have severe abdominal cramps and watery diarrhea that usually becomes bloody within 24 hours. There is little or no fever, and rarely does the victim vomit. The bloody, watery diarrhea lasts from one to eight days in uncomplicated cases. *E. coli* is the most common cause of “travelers’ diarrhea,” affecting people travelling to many high-risk areas such as Latin America, Asia, Africa, and the Middle East. It is most often caused by water or foods contaminated with fecal matter.

Campylobacter jejuni (*C. jejuni*)

According to the FDA, *C. jejuni* is the leading cause of bacterial diarrhea in the United States. It is responsible for more cases of bacterial diarrhea than *Shigella* and *Salmonella* combined. Anyone can get food poisoning from *C. jejuni*, but children under five and young adults between the ages of 15 and 29 are more frequently infected.

C. jejuni is carried by healthy cattle, chickens, birds, and flies. It is not carried by healthy people in the United States or Europe. The bacterium is also found in ponds and stream water. The ingestion of only a few hundred *C. jejuni* bacteria can make a person sick.

Symptoms of food poisoning begin two to five days after eating food contaminated with *C. jejuni*. These symptoms include fever, abdominal pain, nausea, headache, muscle pain, and diarrhea. The diarrhea can be watery or sticky and may contain **blood**. Symptoms last from seven to 10 days, and relapses occur in about one quarter of people who are infected. Dehydration is a common complication. Other complications such as arthritis-like joint pain and hemolytic-uremic syndrome (HUS) are rare.

Shigella

Shigella is a common cause of diarrhea in travelers to developing countries. It is associated with contaminated food and water, crowded living conditions, and poor sanitation. The bacterial toxins affect the small intestine.

Symptoms of food poisoning by *Shigella* appear 36 to 72 hours after eating contaminated food. These symptoms are slightly different from those associated with most foodborne bacteria. In addition to the familiar watery diarrhea, nausea, vomiting, abdominal cramps, and fever, up to 40% of children with severe infections show neurological symptoms, including seizures caused

by fever, confusion, headache, lethargy, and a stiff neck that resembles **meningitis**.

The disease runs its course in two to three days. Dehydration is a common complication. Most people recover on their own, although they may feel exhausted. Children who are malnourished or have weakened immune systems may die.

Clostridium botulinum (*C. botulinum*)

C. botulinum, which causes both adult botulism and infant botulism, is unlike any of the other foodborne bacteria. First, *C. botulinum* is an anaerobic bacterium that can live only in the absence of oxygen. Second, the toxins from *C. botulinum* are neurotoxins. They poison the nervous system, causing **paralysis** without the vomiting and diarrhea associated with other foodborne illnesses. Third, toxins that cause adult botulism are released when the bacteria grow in an airless environment outside the body. They can be broken down and made harmless by heat. Finally, botulism is much more likely to be fatal, even in tiny quantities.

Adult botulism outbreaks are usually associated with home canned food, although occasionally commercially canned or vacuum-packed foods are responsible for the disease. *C. botulinum* grows well in non-acidic, oxygen-free environments. If food is canned at too low heat or for too brief a time, the bacterium is not killed. It reproduces inside the can or jar, releasing its deadly neurotoxin. The toxin can be made harmless by heating the contaminated food to boiling for ten minutes. However, even a very small amount of the *C. botulinum* toxin can cause serious illness or death.

Symptoms of adult botulism appear about 18 to 36 hours after the contaminated food is eaten, although there are documented times of onset ranging from four hours to eight days. Initially a person suffering from botulism feels weakness and dizziness followed by double **vision**. Symptoms progress to difficulty speaking and swallowing. Paralysis moves down the body, and when the respiratory muscles are paralyzed, death results from asphyxiation. People who show any signs of botulism poisoning must receive immediate emergency medical care to increase their chance of survival.

Infant botulism is a form of botulism first recognized in 1976. It differs from foodborne botulism in its causes and symptoms. Infant botulism occurs when a child under the age of one year ingests the spores of *C. botulinum*. These spores are found in soil, but a more common source of spores is honey.

The *C. botulinum* spores lodge in the baby’s intestinal tract and begin to grow, producing their neurotoxin.

COMMON PATHOGENS CAUSING FOOD POISONING

<i>Pathogen</i>	<i>Common Host(s)</i>
<i>Campylobacter</i>	Poultry
<i>E.coli</i> 0157:H7	Undercooked, contaminated ground beef
<i>Listeria</i>	Found in a variety of raw foods, such as uncooked meats and vegetables, and in processed foods that become contaminated after processing
<i>Salmonella</i>	Poultry, eggs, meat, and milk
<i>Shigella</i>	This bacterium is transmitted through direct contact with an infected person or from food or water that become contaminated by an infected person
<i>Vibrio</i>	Contaminated seafood

Source: Food Safety and Inspection Service, U.S. Department of Agriculture

(Illustration by Standley Publishing. Courtesy of Gale Group.)

Onset of symptoms is gradual. Initially the baby is constipated, which is followed by poor feeding, lethargy, weakness, drooling, and a distinctive wailing cry. Eventually the baby loses the ability to control its head muscles. From there the paralysis progresses to the rest of the body.

Rotavirus

The clinical characteristics of rotavirus include vomiting and watery diarrhea for three to eight days with abdominal pain and fever also frequently occurring. The incubation period is about two days. Subsequent bouts of rotavirus tend to be less severe than the initial **infection**. Illness can occur when in contact with contaminated food, water, or surfaces. Rotavirus infections are higher in countries with temperate climates (November to April in the United States) with most infections occurring in children under two years old. Adult cases tend to be milder.

Bovine spongiform encephalopathy and Creutzfeldt-Jakob disease

It is extremely unlikely that bovine spongiform encephalopathy will become a foodborne illness in the United States, because the feeding of ruminant by-products to other animals was probably a factor that led to the outbreak in the United Kingdom. Furthermore, the FDA implemented a ban on ruminant feed in 1997 due to evidence that BSE can be transmitted to humans.

Creutzfeldt-Jakob disease has atypical clinical symptoms, including psychiatric or sensory symptoms early in its course, and neurological abnormalities and **dementia** later on. Incidence of CJD in people under 30 years is extremely rare in the US (less than 5 cases per 1 billion per year). In the UK, it primarily affects younger people, with over half of the patients who have died of CJD under 30 years old.

Diagnosis

One important aspect of diagnosing food poisoning is for doctors to determine if a number of people have eaten the same food and show the same symptoms of illness. When a cluster of cases occurs, food poisoning is strongly suspected. The diagnosis is confirmed when the suspected bacterium is found in a **stool culture** or a fecal smear from the person. Other laboratory tests are used to isolate bacteria from a sample of the contaminated food. Botulism is usually diagnosed from its distinctive neurological symptoms, since rapid treatment is essential. Many cases of food poisoning go undiagnosed, since a definite diagnosis is not necessary to effectively treat the symptoms. Because it takes time for symptoms to develop, it is not necessarily the most recent food one has eaten that causes the symptoms.

Treatment

Treatment of most food poisoning, except that caused by *C. botulinum*, focuses on preventing dehydra-

KEY TERMS

Diuretic—Medication that increases the urine output of the body.

Electrolytes—Salts and minerals that produce electrically charged particles (ions) in body fluids. Common human electrolytes are sodium chloride, potassium, calcium, and sodium bicarbonate. Electrolytes control the fluid balance of the body and are important in muscle contraction, energy generation, and almost all major biochemical reactions in the body.

Lactobacillus acidophilus—This bacterium is found in yogurt and changes the balance of the bacteria in the intestine in a beneficial way.

Platelets—Blood cells that help the blood to clot.

tion by replacing fluids and electrolytes lost through vomiting and diarrhea. Electrolytes are salts and **minerals** that form electrically charged particles (ions) in body fluids. Electrolytes are important because they control body **fluid balance** and are important for all major body reactions. Pharmacists can recommend effective, pleasant-tasting, electrolytically balanced replacement fluids that are available without a prescription. When more fluids are being lost than can be consumed, dehydration may occur. Dehydration is more likely to happen in the very young, the elderly, and people who are taking diuretics. To prevent dehydration, a doctor may give fluids intravenously.

In very serious cases of food poisoning, medications may be given to stop abdominal cramping and vomiting. Anti-diarrheal medications are not usually given. Stopping the diarrhea keeps the toxins in the body longer and may prolong the infection.

People with food poisoning should modify their diet. During the period of active vomiting and diarrhea, they should not try to eat and should drink only clear liquids frequently but in small quantities. Once active symptoms stop, they should eat bland, soft, easily digested foods for two to three days. Such foods include bananas, rice, applesauce, and toast, all of which are easy to digest. Milk products, spicy food, alcohol, and fresh fruit should be avoided for a few days, although babies should continue to breastfeed. These modifications are often all the treatment that is necessary.

Severe bacterial food poisonings are sometimes treated with **antibiotics**. Trimethoprim and sulfamethox-

azole (Septra, Bactrim), ampicillin (Amcill, Polycill) or ciprofloxacin (Ciloxan, Cipro) are most frequently used.

Botulism is treated in a different way from other bacterial food poisonings. Botulism antitoxin is given to adults but not infants if it can be administered within 72 hours after symptoms are first observed. If given later, it provides no benefit.

Both infants and adults require hospitalization, often in the intensive care unit. If the ability to breathe is impaired, patients are put on a mechanical ventilator to assist their breathing and are fed intravenously until the paralysis passes.

Alternative treatment

Alternative practitioners offer the same advice as traditional practitioners concerning diet modification. In addition, they recommend taking charcoal tablets, *Lactobacillus acidophilus*, *Lactobacillus bulgaricus*, and citrus seed extract. An electrolyte replacement fluid can be made at home by adding one teaspoon of salt and four teaspoons of sugar to one quart of water. For food poisoning other than botulism, two homeopathic remedies, either *Arsenicum album* or *Nux vomica*, are strongly recommended.

Prognosis

Most cases of food poisoning (except botulism) clear up on their own within one week without medical assistance. The patient may continue feel tired for a few days after active symptoms stop. So long as the sick person does not become dehydrated, there are few complications. Deaths are rare and usually occur in the very young, the very old, and people whose immune systems are already weakened.

Complications of *Salmonella* food poisoning include arthritis-like symptoms that occur three to four weeks after infection. Although deaths from *Salmonella* are rare, they do occur, mostly in elderly people in nursing homes.

Adults usually recover without medical intervention, but many children need to be hospitalized as the result of *E. coli* food poisoning. *E. coli* toxins may be absorbed into the blood stream where they destroy red blood cells and platelets, which are important in blood clotting. About 5% of victims develop hemolytic-uremic syndrome, which results in sudden kidney failure and makes dialysis necessary. (Dialysis is a medical procedure used to filter the body's waste product when the **kidneys** have failed.)

Botulism is the deadliest of the bacterial foodborne illnesses. With prompt medical care, the death rate is less than 10%.

Health care team roles

Definitive identification of food poisoning is made by a physician, usually with the aid of stool or blood cultures. Nurses, medical technologists, and other health care professionals often aid in taking and analyzing cultures, and in educating patients about preventive measures they can take to avoid food poisoning.

Prevention

Food poisoning is almost entirely preventable by practicing good sanitation and good food handling techniques. These include:

- Keep hot foods hot and cold foods cold.
- Cook meat to the recommended internal temperature. Use a meat thermometer to check. Cook eggs until they are no longer runny.
- Refrigerate leftovers promptly. Do not let food stand at room temperature.
- Avoid contaminating surfaces and other foods with the juices of uncooked meats.
- Wash fruits and vegetables before using.
- Purchase pasteurized dairy products and fruit juices.
- Throw away bulging or leaking cans, or any food that smells spoiled.
- Wash hands well before and during food preparation and after using the bathroom.
- Sanitize food preparation surfaces regularly.

Resources

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Centers for Disease Control and Prevention.
<<http://www.cdc.gov>>.

United States Department of Agriculture. Food Safety and Inspection Service. Washington, DC 20250. (800) 535-4555. <<http://www.fsis.usda.gov>>.

USDA/FDA Foodborne Illness Education Information Center. National Agricultural Library/USDA. Beltsville, MD 20705-2351. (301) 504-5719. Fax (301) 504-6409. E-mail: foodborne@nal.usda.gov.
<<http://www.nal.usda.gov/foodborne/index.html>>.

OTHER

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<<http://www.agnic.org>>.

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Foot care

Definition

Foot care involves all aspects of preventive and corrective care of the foot and ankle. Physicians specializing in foot care are called podiatrists.

Purpose

During an average lifetime, each person walks about 115,000 miles; and 75% of all people have foot problems at some point in their lives.

Foot problems can arise from wearing ill-fitting shoes, from general wear and tear, as a result of injury, or as a complication of disease. People with **diabetes mellitus** or circulatory diseases are 20 times more likely to have foot problems than the general public.

Podiatrists specialize in treating the foot and ankle. Other doctors who have experience with foot problems are family physicians, orthopedists, sports medicine specialists, and those who care for diabetics. Problems with the feet include foot **pain**, joint inflammation, plantar warts, such fungal infections as athlete's foot, nerve disorders, torn ligaments, broken bones, bacterial infections, and such tissue injuries as frostbite.

Precautions

People with diabetes or circulatory disorders should be alert to even the smallest of foot problems. In this patient population, a break in the skin can lead to possible **infection, gangrene**, and amputation.

Description

Daily foot care for people likely to develop foot problems includes washing the feet in tepid water with mild soap and moisturizing the feet with lanolin-based lotion. Toenails should be cut straight across above the level of the skin after soaking the feet in tepid water. Corns and calluses should not be cut. If they need removal, it should be done under the care of a doctor. If they develop in high-risk patients, athlete's foot and plantar warts should also be treated by a doctor.

Many people with diabetes or circulatory disorders suffer with the problem of cold feet. A problem with cold feet can be helped by not smoking (it constricts the **blood vessels**); not crossing the legs while sitting or sitting in one position too long; wearing warm socks; and avoiding constricting stockings. People with circulatory problems should not use heating pads or hot water bottles on their feet, as even moderate heat can damage the skin if the circulation is impaired.

The patient who is at risk for foot problems should also choose socks that are soft and cushioned. Cotton material is best at wicking moisture away from the feet. Good shoes should be worn whenever the patient is ambulating or out of bed. Flat shoes are preferred, and the fit should allow about 0.75 inch (about 2 cm) between the end of the big toe and the shoe. The patient should not walk barefoot.

A routine part of foot care includes an assessment of the feet for changes or injury. These can include blisters, cuts, redness, scratches, or other breaks in the skin.

Preparation

No special preparation is necessary other than understanding the nature of foot problems.

Aftercare

Foot care is preventative and should be ongoing throughout a person's life.

Complications

There are no complications associated with foot care. The risks are in ignoring the feet and allowing problems to develop.

Results

With regular care, such foot disorders as infections, skin ulcers, and gangrene can be prevented.

Health care team roles

The nurse plays an important role in identifying patients at risk for foot problems and in providing foot care. The patient should be instructed on appropriate foot care and the measures that can be taken to prevent complications.

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ORGANIZATIONS

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Foot orthoses

Definition

A foot orthosis is an assistive device used in occupational and **physical therapy**. It is designed to support a person's foot in a way that makes it more functional following disease or injury.

Purpose

Persons with foot and ankle disorders, such as arthritis, ulcers, diabetes, bunions, various forms of tendinitis, and other deformities, can benefit from foot orthoses. Typically, foot orthoses are inlays placed in a client's shoe. The orthosis supports, cushions, and/or pads the foot.

Description

Types of foot orthoses

Most clients with foot problems benefit from mass-produced, prefabricated orthoses. They are relatively common and may absorb shock in the foot or provide added arch under the foot, for example.

Occasionally a prefabricated orthosis is modified in some way to better accommodate a client, and this is referred to as a customized orthosis. These may be molded to better fit a client's foot or have additional padding.

However, some clients with severe foot deformities or disorders may not be able to use a prefabricated orthosis or even a customized orthosis. These clients require custom-molded orthoses that are made from the mold of the client's foot for a perfect, tight fit.

Operation

In order for a client to use a foot orthosis appropriately, he/she must go through a thorough assessment that evaluates the position and range of motion (ROM) of foot and ankle joints in all parts of the foot. Clients should be tested while walking and bearing weight as well as while standing. Clients must be tested for rigidity and flexibility in addition to assessing any foot or ankle **pain**.

Maintenance

Clients who are prescribed footwear need to maintain their orthoses with proper cleaning and repairs when necessary. As the condition of the foot may change or worsen, a previously prescribed orthosis may become ineffective or unnecessary, just as a prescription drug might. Periodic follow-up with a physician, occupational therapist, or appropriate health care professional is necessary to ensure that the foot orthosis remains as functional as possible.

Health care team roles

A variety of health care professionals can help a client determine the most appropriate foot orthosis. Occupational or physical therapy practitioners can provide assessments and evaluations of the effectiveness of foot orthoses. Orthotists and prosthetists, although typically consulted by patients who have lost limbs, also can help in choosing an appropriate orthosis. Pedorthists can evaluate a client in need of an orthosis, provide and fit the shoe, and follow-up the client. However, a prescription for a foot orthosis is necessary.

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ORGANIZATIONS

American Occupational Therapy Association. 4720 Montgomery Lane, Bethesda, MD 20824-1220. (301) 652-2682. <<http://www.aota.org>>.

American Physical Therapy Association. 1111 North Fairfax Street, Alexandria, VA 22314-1488. (703) 684-2782. <<http://www.apta.org>>.

Meghan M. Gourley

Foreign bodies

Definition

"Foreign" means "originating elsewhere" or simply "outside the body." Foreign bodies typically become lodged in the eyes, ears, nose, airways, and rectum of human beings.

Description

Both children and adults experience problems caused by foreign objects getting stuck in their bodies. Young children in particular are naturally curious and may intentionally put such shiny objects as coins or button batteries into their mouths. They are also prone to inserting objects in their ears and nostrils. Adults may accidentally swallow a non-food object or inhale a foreign body that gets stuck in the throat or **lungs**. Even if an object like a toothpick successfully passes through the esophagus and into the **stomach**, it can get stuck inside the rectum. Airborne particles can lodge in the eyes of people at any age.

Foreign bodies can be in hollow organs (like swallowed batteries) or in tissues (like bullets). They can be inert or irritating. If they irritate they will cause inflammation and scarring. They can bring **infection** with them or acquire it and protect it from the body's immune defenses. They can obstruct passageways either by their size or by the scarring they cause. Some foreign bodies can be toxic.

Causes and symptoms

Eyes

Dust, dirt, sand, or other airborne material can lodge in the eyes, causing minor irritation and redness. More serious damage can be caused by hard or sharp objects that penetrate the surface and become embedded in the cornea or conjunctivae (the mucous membranes around the inner surface of the eyelids). Swelling, redness, bleeding from the surface **blood vessels**, sensitivity to light, and sudden **vision** problems are all symptoms of foreign matter in the eyes.

Ears and nose

Children will sometimes put objects into their noses, ears, and other openings. Beans, popcorn kernels, raisins, and beads are just a few of the many items that have been found in these bodily cavities. On occasion, insects may also fly into the ears and nose. **Pain, hearing loss,** sounds or a sense of something stuck in the ear are symptoms of foreign bodies in the ears. A smelly, bloody discharge from one nostril is a symptom of a foreign body in the nose.

Airway and stomach

At a certain age children will eat anything. A very partial list of items recovered from young stomachs includes the following: coins, chicken bones, fish bones, beads, rocks, plastic toys, pins, keys, round stones, marbles, nails, rings, batteries, ball bearings, screws, staples, washers, a **heart** pendant, a clothespin spring, and a toy soldier. Some of these items will pass completely through the **digestive system** to be excreted some time later. The progress of metal objects has been successfully followed with a metal detector. Others, like sharp bones, can get stuck and cause problems. Batteries are corrosive and must be removed immediately.

Children eat things and stick things into their bodily openings of their own volition. But they inhale them unwittingly. The most commonly inhaled item is probably a peanut. A crayon and a cockroach have been found in the windpipes (tracheas) of children. These items always cause symptoms (difficulty swallowing and spitting up saliva, for instance) and may elude detection for some time while a child is being treated for **asthma** or recurring **pneumonia**.

Adults are not exempt from unorthodox inedibles. Dental devices are commonly swallowed. Adults with mental illness or subversive motives may swallow such inappropriate objects as toothbrushes.

Rectum

Sometimes a foreign object will successfully pass through the throat and stomach only to get stuck at the juncture between the rectum and the anal canal. Items may also be self-introduced to enhance sexual stimulation and then get stuck. Sudden sharp pain during elimination may signify that an object is lodged in the rectum. Other symptoms vary depending upon the size of the object, its location, how long it has been in place, and whether or not infection has set in.

Diagnosis

The symptoms of foreign bodies are as diverse as the objects and their locations. The most common manifestation of a foreign object anywhere in the body is infection. Even if an object entered in a sterile condition, **bacteria** still seem to find it and are able to hide from the body's defenses there. Blockage of passageways—breathing, digestive or excretory—is another result. Pain is common.

Treatment

Eyes

Small particles like sand may be removable without medical help, but if the object is not visible or cannot be retrieved, prompt emergency treatment is necessary. Trauma to the eyes can lead to loss of vision and should never be ignored. Before attempting any treatment, a person should move to a well-lighted area where the object can be more easily spotted. Hands should be washed, and only clean, preferably sterile, materials should make contact with the eyes. If the particle is small, it can be dislodged by blinking or pulling the upper lid over the lower lid and flushing out the speck. A clean cloth can also be used to pick out the offending particle. Afterwards, the eye should be rinsed with clean, lukewarm water or an ophthalmic wash.

If the foreign object cannot be removed at home, the eye should be lightly covered with sterile gauze to discourage rubbing. A physician will use a strong light and possibly special eyedrops to locate the object. Surgical tweezers can effectively remove many objects. An antibiotic sterile ointment and a patch may be prescribed. If the foreign body has penetrated the deeper layers of the eye, an ophthalmic surgeon will be consulted for emergency treatment.

Ears and nose

A number of ingenious extraction methods have been devised for removing foreign objects from the nose and ears. A bead in a nostril, for example, can often be popped out by blowing into the mouth while holding the other nostril closed. Skilled practitioners have removed peas from the ears by tiny improvised corkscrews. Marbles have been extracted by using cotton swabs and super glue. Tweezers often work well. Insects can be floated out of the ear by pouring warm (not hot) mineral oil, olive oil, or baby oil into the ear canal. Items that are lodged deep in the ear canal are more difficult to remove because of the possibility of damaging the ear drum. These require emergency treatment from a qualified physician.

Airways and stomach

Mechanical obstruction of an airway, which commonly occurs when food gets lodged in the throat, can be treated by applying the **Heimlich maneuver**. If the object is lodged lower in the airway, a bronchoscope (a special instrument to view the airway and remove obstructions) can be inserted. On other occasions, as when an object is blocking the entrance to the stomach, a fiberoptic **endoscope** (an illuminated instrument that views the interior of a body cavity) may be used. A physician typically administers a sedative and anesthetizes the throat. The foreign object will then either be pulled out or pushed into the stomach, depending on whether or not the physician thinks it will pass through the digestive tract on its own. Objects in the digestive tract that are not irritating, sharp or large may be followed as they continue on through. Sterile objects that are causing no symptoms may be left in place. Surgical removal of an offending object is necessary only if it causes symptoms.

Rectum

A rectal retractor can remove objects that a physician can feel during **physical examination**. Surgery may be required for objects deeply lodged within the rectum.

Prognosis

Once foreign objects are removed, persons have no further medical problems. If surgery is required (such as to remove a bullet), permanent damage may be sustained when the object initially enters the body. Once surgical incisions have healed, many persons have no further medical problems. Counseling may be needed to help persons cope with potential after-effects.

Health care team roles

First aid may be provided by trained persons. **Emergency medical technicians** may provide support while transporting people to a hospital or emergency treatment facility. Physicians remove most foreign objects. Surgeons may be needed to remove some objects from the eye (ophthalmologists), ears (otolaryngologists), gastrointestinal system (gastroenterologists), **brain** (neurosurgeons) or body tissues (general surgeons). Radiologists may document progress of an object through the body. Nurses supply supportive care and prevention education to the patient or family. Therapists may be needed to cope with such after-effects as physical impairment, mental distress or simple embarrassment.

KEY TERMS

Bronchoscope—An illuminated instrument that is inserted into the airway to inspect and retrieve objects from the bronchial tubes.

Conjunctivae—Mucous membranes around the inner surface of the eyelid.

Cornea—The rounded, transparent portion of the eye that covers the pupil and iris and lets light into the interior.

Endoscopy—The surgical use of long, thin instruments that have both viewing and operating capabilities.

Heimlich maneuver—An emergency procedure for removing a foreign object lodged in the airway that is preventing the person from breathing. To perform the Heimlich maneuver on a conscious adult, the rescuer stands behind the victim and encircles the choking person's waist. The rescuer makes a fist with one hand and places the other hand on top, positioned below the rib cage and above the waist. The rescuer then applies pressure by a series of upward and inward thrusts to force the foreign object back up the choking person's trachea.

Trachea—Windpipe. The tube that connects the pharynx with the lungs.

Prevention

Using common sense and following safety precautions are the best ways to prevent foreign objects from entering the body. For instance, parents and grandparents should toddler-proof their homes, storing batteries in a locked cabinet and properly disposing of used batteries, so they are not in a location where curious preschoolers can retrieve them from a wastebasket. To minimize the chance of youngsters inhaling food, parents should not allow children to eat while walking or playing. Adults should chew food thoroughly and not talk while chewing. Foods should not be thrown up into the air and caught in an open mouth. Many eye injuries can be prevented by wearing safety glasses while using power tools.

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American Academy of Pediatrics. 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. Fax: (847) 434-8000. <<http://www.aap.org/default.htm>> E-mail: kidsdoc@aap.org.

American College of Radiology. 1891 Preston White Drive, Reston, VA 20191. (703) 648-8900. Fax: (703) 262-9319. <<http://www.acr.org>>. info@acr.org.

American Osteopathic College of Radiology. 119 East Second St., Milan, MO 63556. (660) 265-4011. Fax: (660) 265-3494. <<http://www.aocr.org/>>. aocr@nemr.net.

OTHER

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Baylor College of Medicine. <<http://www.bcm.tmc.edu/otostuds/fb.html>>.

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University of Maryland. <<http://umm.drkoop.com/conditions/ency/article/000036.htm>>.

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Fractures

Definition

A fracture is a complete or incomplete break in a bone resulting from the application of excessive force. An injury may be classified as a fracture-dislocation when a fracture involves the bony structures of any joint with associated dislocation of the same joint.

Description

Fractures usually result from traumatic injury to a bone, causing the continuity of bone tissues or bony cartilage to be disrupted or broken. Fracture classifications include simple, compound, incomplete, and complete. Simple fractures (more recently termed closed fractures) are not obvious on the surface, as the skin has not been broken and remains intact. Compound fractures (now commonly referred to as open fractures) break the skin, exposing bone and causing additional soft tissue injury and possible **infection**. Single and multiple fractures refer to the number of breaks in the same bone. Fractures are termed complete if the break is completely through the bone, and described as incomplete or "greenstick" if the fracture occurs partly across a bone shaft. This latter type of fracture is often the result of bending or crushing forces applied to a bone.

Fractures are also named by the specific portion of the bone involved and the nature of the break. Identification of a fracture line can further classify fractures. Types include linear, oblique, transverse, longitudinal, and spiral fractures. Fractures can be further subdivided by the positions of bony fragments and are described as comminuted, non-displaced, impacted, overriding, angulated, displaced, avulsed, and segmental.

Fracture lines identification

Linear fractures have a break that runs parallel to the bone's main axis or in the direction of the bone's shaft. For example, a linear fracture of the arm bone could



An x ray can be used to diagnose a fracture, as in this x ray of a fractured humerus bone. (Bates MD/Custom Medical Stock Photo. Reproduced by permission.)

extend the entire length of the bone. Oblique and transverse fractures differ in that an oblique fracture crosses a bone at approximately a 45° angle to the bone's axis. In contrast, a transverse fracture crosses a bone's axis at a 90° angle. A longitudinal fracture is similar to a linear fracture. Its fracture line extends along the shaft but is more irregular in shape and does not run parallel to the bone's axis. Spiral fractures are described as crossing a bone at an oblique angle, creating a spiral pattern. This type of break usually occurs in the long bones of the body such as the upper arm bone (humerus) or the thigh bone (femur).

Bony fragment position identification

Comminuted fractures have two or more fragments broken into small pieces, in addition to the upper and lower halves of a fractured bone. Fragments of bone that maintain their normal alignment following a fracture are described as being non-displaced. An impacted fracture is characterized as a bone fragment forced into or onto another fragment, resulting from a compressive force. Overriding is a term used to describe bony fragments that

overlap and shorten the total length of a bone. Angulated fragments result in pieces of bone being at angles to each other. A displaced bony fragment occurs from disruption of normal bone alignment with deformity of these segments separate from one another. An avulsed fragment occurs when bone fragments are pulled from their normal position by forceful muscle contractions or resistance from ligaments. Segmental fragmented positioning occurs if fractures in two adjacent areas occur, leaving an isolated central segment. An example of segmental alignment occurs when the arm bone fractures in two separate places, with displacement of the middle section of bone.

Causes and symptoms

Individuals with high activity levels appear to have a greater risk for fractures. This group includes children and athletes participating in contact sports. Because of an increase in bone brittleness with aging, elderly persons are also included in this high-risk population. It has been recognized that up to the age of 50, more men suffer from fractures than women due to occupational hazards. However, after the age of 50, more women suffer frac-

tures than men. Specific diseases causing an increased risk for fractures include Paget's disease, rickets, osteogenesis imperfecta, **osteoporosis**, and prolonged disuse of a nonfunctional body part such as after a stroke.

Symptoms of fractures usually begin with **pain** and swelling at the involved site. There may also be a great deal of tenderness in the area near the fracture. The skin in the area may be pale and an obvious deformity may be present. In more severe cases, there may be a loss of pulse below the fracture site (such as in the extremities), accompanied by numbness, tingling, or **paralysis** below the fracture. An open or compound fracture is often accompanied by bleeding or bruising. If a leg is fractured, weakness will usually accompany the injury, causing difficulty with weight bearing.

Diagnosis

Diagnosis begins immediately with an individual's own observation of symptoms. A thorough medical history and physical exam completed by a physician or advanced practice nurse often provides enough information to determine if further testing is necessary. An x ray of the injured area is the most common test used to determine the presence of a bone fracture and its associated displacement. However, it is important to note that not all fractures are apparent on an initial x ray. Rib fractures are often difficult to diagnose and may require several views at different angles to see any fracture lines. If a fracture is open and occurs in conjunction with soft tissue injury, further laboratory studies are often conducted to determine if **blood** loss has occurred.

In the event of exercise-related stress fractures (micro-fractures due to excessive stress), a tuning fork can provide a simple, inexpensive test. The tuning fork is a metal instrument with a stem and two prongs that vibrate when struck. If an individual has increased pain when the tuning fork is placed on a bone, such as the lower leg bone or shinbone, the likelihood of a stress fracture is high. Bone scans are also helpful in detecting stress fractures. In this diagnostic procedure, a radioactive tracer is injected into the blood stream and images are taken of specific areas or the entire skeleton.

Treatment

Fracture treatment depends on the type of fracture, its severity, and the individual's age and general health. The first priority in treating any fracture is to address the entire medical status of an individual. If an open fracture is accompanied by serious soft tissue injury, it may be necessary to control bleeding and the **shock** that can accompany loss of blood.

First aid is the appropriate initial treatment in emergency situations. It includes proper splinting, control of blood loss, and monitoring **vital signs** such as breathing and circulation.

Immobilization

Immobilization of a fracture site can be done internally or externally. The primary goal of immobilization is to maintain the realignment of a bone long enough for healing to start and progress. Immobilization by external fixation uses splints, casts, or braces. This may be the primary and only procedure for fracture treatment. Splinting to immobilize a fracture can be done with or without traction. In emergency situations, splinting is a useful form of fracture management if the injured individual must be moved by someone other than a trained medical professional. Splinting should be done without causing additional pain and without moving the bone segments. In a clinical environment, plaster of Paris casts are used for immobilization. Braces are also useful, as they often allow movement above and below a fracture site. Treatments for stress fractures include rest and decreasing or stopping any activity that causes or increases pain.

Fracture reduction

Fracture reductions are either closed or open. Closed reduction refers to realigning bones without breaking the skin. It is accomplished using manipulation and/or traction and is commonly done with some kind of anesthetic. Open reduction primarily refers to surgery that is performed to realign bones or fragments. Fractures with little or no displacement may not require any form of reduction.

Traction is used to help reposition a broken bone. It works by applying pressure to restore proper alignment. The traction device immobilizes the area and maintains realignment as the bone heals. A fractured bone is immobilized by applying opposing forces at both ends of an injured area, using an equal amount of traction and countertraction. Weights provide the traction pull needed, or the pull is achieved by positioning the individual's body weight. Traction is a form of closed reduction and is sometimes used as an alternative to surgery. Since it restricts movement of an affected limb or body part, it may confine a person to bed rest for an extended period of time.

A person may need open reduction if there is an open, severe, or comminuted fracture. This procedure allows a physician to examine and surgically correct associated soft tissue damage while reducing the fracture and, if necessary, applying internal or external devices. Internal fixation is a surgical procedure that is required

when a fracture cannot be reduced by closed fracture methods. Internal fixation devices include plates, nails, screws, and rods. When healing is complete, the physician may or may not elect to remove these devices.

Alternative treatment

In addition to the importance of **calcium** for strong bones, many alternative treatment approaches advocate mineral supplements to help build and maintain a healthy, resilient skeleton. Some physical therapists use electrostimulation over a fractured site to promote healing. Chinese traditional medicine may be helpful by working to reconnect *chi* through the meridian lines along the line of a fracture. **Homeopathy** can enhance the body's healing process. Two particularly useful homeopathic remedies are arnica (*Arnica montana*) and symphytum (*Symphytum officinalis*). If possible, applying contrast **hydrotherapy** to an extremity (e.g., a hand or foot) of a fractured area can assist healing by enhancing circulation.

Prognosis

Fractures can normally be cured with proper first aid and appropriate aftercare. If determined necessary, the fractured site should be manipulated, realigned, and immobilized as soon as possible. Realignment has been shown to be much more difficult after six hours. Healing time varies from person to person, with the elderly generally needing more time to heal completely. A non-union fracture may result when a fracture does not heal, such as in the case of an elderly person or an individual with medical complications. Recovery is complete when there is no bone motion at the fracture site, and x rays indicate complete healing.

Health care team roles

When treating most fractures, an orthopedic surgeon is the head of the health care team. These physicians have specialized training in bones. They are responsible for reducing, realigning, and immobilizing fractured bones. In the absence of an orthopedic surgeon, a general surgeon or a family practitioner may treat simple, closed fractures. Emergency medical service providers may render immediate first aid to persons with fractures. After fracture reduction and healing have occurred, physical therapists may assist in returning injured body parts to their normal levels of function.

Prevention

Adequate calcium intake is necessary for strong bones and can help decrease the risk of fractures. People

KEY TERMS

Avulsion fracture—A fracture caused by the tearing away of a fragment of bone where a strong ligament or tendon attachment forcibly pulls the fragment away from the bone tissue.

Axis—A line that passes through the center of the body or body part.

Comminuted fracture—A fracture in which there are several breaks in a bone, creating numerous fragments.

Contrast hydrotherapy—A series of hot and cold water applications. A hot compress (as hot as an individual can tolerate) is applied for three minutes followed by an ice cold compress for 30 seconds. These applications are repeated three times each and ending with the cold compress.

Osteogenesis imperfecta—A genetic disorder involving defective development of connective tissues, characterized by brittle and fragile bones that are easily fractured by the slightest trauma.

Osteoporosis—Literally meaning “porous bones,” this condition occurs when bones lose an excessive amount of their protein and mineral content, particularly calcium. Over time, bone mass and strength are reduced leading to increased risk of fractures.

Paget's disease—A common disease of bone of unknown cause, usually affecting middle-aged and elderly people, characterized by excessive bone destruction and unorganized bone repair.

Reduction—The restoration of a body part to its original position after displacement, such as the reduction of a fractured bone by bringing ends or fragments back into original alignment. The use of local or general anesthesia usually accompanies a fracture reduction. If performed by outside manipulation only, the reduction is described as closed; if surgery is necessary, it is described as open.

Rickets—A condition caused by the deficiency of vitamin D, calcium, and usually phosphorus, seen primarily in infancy and childhood, and characterized by abnormal bone formation.

Traction—The process of placing a bone, limb, or group of muscles under tension by applying weights and pulleys. The goal is to realign or immobilize the part or to relieve pressure on that particular area to promote healing and restore function.

who do not get enough calcium in their diets can take a calcium supplement. **Exercise** can help strengthen bones by increasing bone density, thereby decreasing the risk of fractures from **falls**. A University of Southern California study reported that older people who exercised one or more hours per day had approximately half the incidence of hip fractures as those who exercised fewer than 30 minutes per day or not at all.

Fractures can be prevented if safety measures are taken seriously. These measures include using seat belts in cars and encouraging children to wear protective sports gear. Estrogen replacement for women past the age of 50 has been shown to help prevent osteoporosis and the fractures that may result from this condition. In one study, elderly women on estrogen replacement therapy demonstrated a lower risk of hip fractures when compared to similar women not on estrogen replacement therapy.

Resources

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ORGANIZATIONS

- American Academy of Orthopaedic Surgeons. 6300 North River Road, Rosemont, IL 60018-4262. (847) 823-7186 or (800) 346-2267. Fax: (847) 823-8125. <<http://orthoinfo.aaos.org/>>.
- American College of Sports Medicine. P.O. Box 1440, Indianapolis, IN 46206-1440. 401 W. Michigan St., Indianapolis, IN 46202. (317) 637-9200, Fax: (317) 634-7817.
- Children's Orthopedics of Atlanta. <<http://www.childrensortho.com/fractures.htm>>.
- Nemours Foundation. <http://kidshealth.org/kid/ill_injuries/broken_bones.html>.

OTHER

- Family Practice Notebook*. <<http://www.fpnotebook.com/FRA.htm>>.
- National Library of Medicine*. <<http://medlineplus.adam.com/ency/article/000001.htm>>.

L. Fleming Fallon, Jr., MD, PhD, DrPH

Frostbite and frostnip see **Cold injuries**

Fungal culture

Definition

Fungal (mycotic) cultures are microbiology laboratory tests to detect or rule out the presence of **fungi** (plural of fungus) in specimens taken from patients, animals, and the environment. The laboratory uses optimal conditions to grow and identify any fungus present in the specimen while attempting to eliminate or identify contaminants. The specimen is cultured by spreading a small portion of it on various agar media (inoculation). The media are then incubated in a warm, moist environment and examined regularly to detect growth of any organisms. The isolated fungus is identified primarily by its colony morphology and microscopic structures.

Mycology, the study of fungi

Fungi are simple plantlike organisms that do not have roots, stems, or leaves and that live off organic matter such as skin, hair, and vegetation. The group includes mushrooms, yeast, rusts, smuts, molds, and mildews, but only yeast and molds typically cause disease in humans. The basic structural unit of a fungus is either a single yeast cell, or multicellular filamentous hyphae, which are the tubular projections of molds. Molds grow by elongation and branching of hyphae during the vegetative (feeding) stage and produce spores during the reproductive stage. Spores are small reproductive bodies that are capable of sprouting new hyphae. Multiple, loosely intertwined hyphae strands called mycelia are the fluffy, colorful colonies seen as mold growing on rotting fruit. These mycelia are spore producing structures. Yeast primarily reproduce by budding, which is the out-pouching and eventual pinching off of part of the cell. A chain of budding yeast cells adhering together may appear to be like hyphae and are called pseudohyphae. Some fungi, capable of existing in either a yeast or filamentous mold form, depending on the environment, are called dimorphic. The term fungal elements includes any of the structures that may be seen during examination of specimens

or cultures: yeast, budding yeast, hyphae, pseudohyphae, spores, and mycelia.

Fungi differ from higher plants in that they do not contain chlorophyll and thus cannot manufacture their own **carbohydrates**. They must use preformed carbon and nitrogen compounds made by other organisms and are therefore either saprophytic (living on dead or decaying organic matter) or parasitic (living on or within other living organisms). Most fungi trace back to a soil origin. All are obligate aerobes (require oxygen to survive), and tend to thrive in a dark, moist, undisturbed atmosphere. They grow well at room temperature, but some of the pathogenic (disease causing) dimorphic fungi also grow well at body temperature.

Of the more than 50,000 species of fungi, only 100 to 150 species of yeast and molds cause disease in humans. The number routinely seen is much lower. Humans are generally resistant to fungi even when they become accidental hosts by inhaling spores or by having a cut or scrape exposed to a fungus. However, inhalation of spores of some of the dimorphic fungi produces illness ranging from mild cough and **fever** to severe disseminated disease. People with weakened immune systems (immunocompromised) are susceptible to illness from many normally harmless fungi. The characteristics of fungi that make them pathogenic to humans are:

- a small enough spore size to be able to reach the alveoli of the **lungs**
- the ability to grow at body temperature
- the ability of a dimorphic fungus to convert from a mold to a yeast form within the host
- toxin production

Purpose

The purpose of the fungal culture is to attempt to grow and identify any fungus originating from a patient's specimen when the medical staff of a hospital, clinic or doctor's office suspects fungal **infection**. Further, the goal is to determine whether the isolated fungus is clinically significant; that is, the causative agent of the patient's disease. While the physician makes the final decision regarding clinical significance, the laboratory may assist in this process by noting the presence of common contaminants, etc. Since the goal is also to provide information in a timely manner, fungal cultures will usually include smears and stains taken directly from the specimen for microscopic examination. The direct examination attempts to visually detect such fungal elements as hyphae, yeast, or spores.

Precautions

Contraindications

It should be noted that 90% of fungal infections are due to dermatophytes (fungi that infect skin, hair and nails), which do not normally need a fungal culture for diagnosis. A dermatologist can generally make the diagnosis in the office from a KOH preparation (see section on direct examination of specimens) along with the patient's symptoms and site of infection. However, a culture may be needed to prove that a skin condition is not due to nerves, psoriasis, or metabolic imbalances.

Another contraindication for fungal cultures is if the patient has already been treated with antifungal medication. Many patients who see their doctor for the first time with a possible fungal infection have already been treating themselves with such over-the-counter antifungal medication as imidazoles. A fungus may be causing an infection in the patient, yet antifungal agents present within the specimen suppress the growth of the organism in culture. All topical antifungal therapy should be stopped for at least one week prior to culture.

Safety precautions

The medical staff should observe their institution's procedures to protect both themselves and their patients from spread of infectious diseases. The use of such protective barriers as gloves, gowns, aprons, masks or protective eyewear can reduce the risk of exposure of the health care worker to potentially infective materials. All medical staff should take precautions to prevent injuries by needles, scalpels and other sharp instruments during procedures; when cleaning used instruments; and during disposal of used needles. Gloves should be changed after contact with each patient. Hands and other skin surfaces should be washed immediately after gloves are removed. When collecting **blood**, genital, tissue, cerebrospinal and other body fluid specimens universal cautions for the prevention of transmission of bloodborne pathogens should be followed.

Laboratory personnel need to take several precautions when working with fungal cultures. The cultures should never be sniffed. Fungus colonies may release airborne spores that can be inhaled. Processing of specimens and all work with exposed fungus cultures should be performed in a biological safety hood. Spattering of infectious material by careless flaming of wire needles or loops should be avoided. Cultured petri dishes should be sealed with oxygen-permeable tape. Test tubes should have screw-type caps rather than cotton plugs. All contaminated materials must be autoclaved before discarding, and the work area should be disinfected daily.

Description

The fungus culture is a microbiology laboratory test that is part of a comprehensive attempt to determine if any microorganism is causing an infection in a patient. The physician and nursing staff must first suspect the possibility of infection and order the appropriate cultures. The possibilities include testing not only for fungi, but also for aerobic and anaerobic **bacteria**; mycobacteria (also called acid-fast bacteria, AFB, a family of bacteria which includes the **tuberculosis** organism); **viruses**; or parasites. Many fungal infections are clinically similar to mycobacterial infections and so the same specimen is often cultured for both fungi and mycobacteria. Although fungal cultures are usually covered by insurance, they are costly and time-consuming. Cultures should be ordered only when the medical staff is reasonably suspicious of a fungal infection or when the patient is very ill and the culture is a critical part of assessing the illness. The test is also performed in the offices of dermatologists who frequently encounter fungal skin infections. The office staff may report the presence of dermatophytes or yeast, but a reference laboratory is usually required for specific identification.

Direct examination of specimens

The direct examination of specimens is an important first step in processing the specimen for several reasons. Since fungi take days to weeks to grow in culture on agar media, a direct examination result provides a rapid report to the physician, which may allow early treatment to begin. Sometimes easily identifiable morphological characteristics of a fungus may be seen on a direct exam, giving a clue as to the identification of the organism. This information may be helpful not only to the physician but also to the laboratory personnel who can set up additional specialized media to hasten the identification of the fungus. The information may also indicate the need to harvest specimens from other body sites and order serological tests. Direct examinations may also provide evidence of infection even when the fungus culture is negative.

KOH PREPARATION WITH CALCOFLUOR WHITE. The potassium hydroxide (KOH) preparation is used to detect fungal elements in virtually all types of clinical specimens, especially skin, nails, hair, sputum, concentrated urine, and tissue. A 10% to 20% solution of KOH is mixed with the specimen on a slide, a coverslip is placed on top of the preparation and the slide is gently heated. The preparation is then viewed under the 10x (low power) objective of a light **microscope** with fairly low illumination. KOH dissolves keratin and other cellular material but leaves the fungal structures intact and refractile. Hyphae, pseudohyphae, yeast, and spores can be seen. Calcofluor white, a fluorescent dye, may be added

to the KOH preparation to aid in visualizing the fungal elements. Calcofluor white binds to polysaccharides in the cell wall of fungi, and fluoresces either apple-green or blue-white, depending on the combination of filters used in a fluorescent microscope.

INDIA INK PREPARATION AND CRYPTOCOCCAL ANTIGEN TEST. Traditionally, India ink preparations have been used to examine cerebrospinal fluid (CSF) and other clear body fluids for the presence of the encapsulated yeast *Cryptococcus neoformans*. A drop of India ink is mixed with a drop of sediment from a centrifuged specimen and the preparation is examined under the light microscope. Budding yeast in CSF surrounded by a large clear capsule against a black background is presumptive evidence of *C. neoformans* **meningitis**. Since only 50% of these meningitis patients have at least one positive India ink preparation, many laboratories now use the latex agglutination test for cryptococcal antigen in place of the India ink examination. This test detects the capsular polysaccharide antigen of *C. neoformans* in the supernatant of centrifuged CSF and serum.

OTHER DIRECT PREPARATIONS. Stains used in other parts of the laboratory will detect fungal elements. The **gram stain**, which is performed on specimens sent for bacterial culture, will detect most fungi, if present. The acid-fast stain used for the detection of mycobacteria will also detect *Blastomyces dermatitidis*. The Papanicolaou stain, which is used to examine secretions for the presence of malignant cells, also stains fungal elements well. The Wright stain, which is used routinely on peripheral blood smears and bone marrow aspirates, will also detect *Histoplasma capsulatum* and *Cryptococcus neoformans*. Common tissue stains that are excellent for the detection of fungal elements are the periodic acid-Schiff (PAS) stain, the Gomori methenamine-silver nitrate (GMS) stain, and the Mayer mucicarmine stain. Fluorescent antibody stains can be used to detect fungi directly in tissue or fluids and stains for specific organisms are available at the national Centers for Disease Control (CDC) in Atlanta, Georgia. Molecular probes capable of detecting fungi in clinical specimens are promising but not yet commercially available.

Culturing specimens

As the direct examination of the specimen is proceeding, the specimen is set up as a culture without delay. The viability of fungi decreases with time, and contaminant overgrowth may hinder the recovery of the pathogen. When delay cannot be avoided, the specimens, with the exception of blood, CSF, and dermatological (skin, hair, nail) specimens, can be refrigerated for a short time. It is not necessary to concentrate most mycology

specimens except for body fluids over 5 milliliters, such as urine. If such respiratory secretions as sputum are highly viscous, mucolytic agents may be added to liquefy the secretions and facilitate plating on agar media. Tissue samples are ground with a mortar and pestle in a small amount of sterile saline before being inoculated onto media.

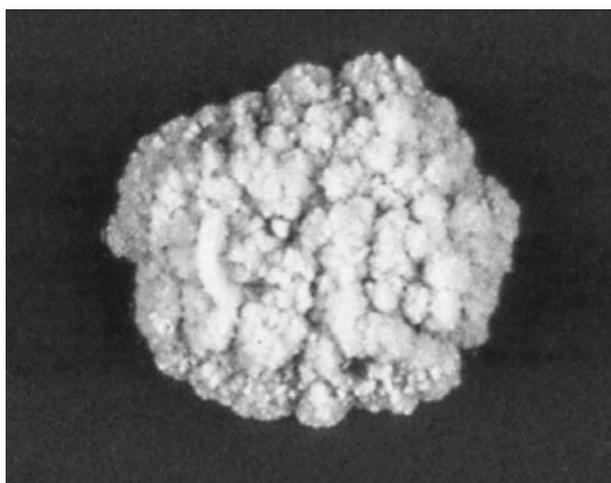
For optimal recovery of fungi, a battery of agar media should be inoculated. Common media for primary fungal isolation include Sabouraud dextrose agar and brain-heart infusion agar, either in petri dishes or screw-top tubes. The media may be enriched with 5% to 10% sheep blood to support the growth of certain fungi. Specimens that are likely to be contaminated with other microorganisms, such as urine or sputum, are set up on agar media containing antimicrobials. Chloramphenicol, streptomycin, or penicillin are incorporated into the agar to inhibit the growth of bacteria, and cycloheximide is used to inhibit the growth of contaminant fungi.

Fungus cultures are incubated at either at 30°C (86°F) or at room temperature (22-25°C or 72-77°F). A temperature of 30°C is recommended because nearly all pathogenic fungi grow better and more rapidly at this temperature. A relative humidity of 40% to 50% is desired to prevent the agar from drying out over time and can be achieved by placing an open pan of water in the incubator. Cultures should be incubated for 30 days and examined at least three times weekly before reporting as negative. Dermatophyte cultures should be incubated six weeks at room temperature.

Identification of positive cultures

The fungi grown in positive cultures are identified by noting their growth rate, colonial morphology, and microscopic structures. Rapid-growing fungi appear in one to three days, intermediate growers take five to nine days to colonize and slow growers take up to four weeks to appear. Colonial morphology traits include color, size, texture, and topography of the colony. Yeast colonies resemble bacterial colonies (moist, rounded, opaque and raised), whereas mold colonies are described variously as wrinkled, heaped, folded, etc. The pigments of both the underside and top of the colony are noted.

The examination of microscopic structures of fungi usually provides definitive identification for molds. Microscopic morphological features that are looked for are the type, size, shape and arrangement of spores and the size and color of hyphae. It is also important to note whether the hyphae have cross walls (septations). Yeast identification may require biochemical tests for fermentation and assimilation of carbohydrates.



Fungus culture topography. (Delmar Publishers, Inc. Reproduced by permission.)

Microscopic observation of molds is done by using several techniques, always prepared in a biological safety hood. Transparent tape preparations are a rapid method for observing the arrangement of spores. The tape is pressed, sticky side down, on the surface of a mold colony and then onto a slide containing a drop of dye-mounting fluid such as lactophenol cotton blue (LPCB). The preparation is then examined under low and high magnification on the microscope for spore type and arrangement. In a wet mount preparation, portions of colonies are teased apart with a dissecting needle, transferred to a drop of LPCB and observed under a coverslip on the microscope. Occasionally, a slide culture is needed to observe spore production. In this procedure, a small cube of agar media is inoculated on four sides with the fungus, placed between two coverslips and incubated five to ten days. When spores are evident, the coverslips are removed and mounted in LPCB and examined under the microscope.

Susceptibility testing

Susceptibility testing of fungal isolates to antifungal agents is generally done only after treatment failure. Testing is done by a reference microbiology laboratory using the minimal inhibitory concentration (MIC) method. Common antifungal agents include amphotericin B, griseofulvin, fluconazole, itraconazole, ketoconazole, miconazole, clotrimazole, flucytosine and nystatin.

Preparation

Specimen collection

The proper collection of appropriate specimens is critical to successful fungus cultures and diagnosis of

mycotic infections. The laboratory should be sent fresh specimens, properly obtained and labeled, of satisfactory volume, and accompanied by pertinent, critical patient information. All specimens for fungus culture should be transported to the microbiology laboratory and processed as soon as possible. Since many pathogenic fungi grow slowly, any delay in processing increases the possibility of overgrowth by rapidly growing contaminants and decreases the probability of isolating the causative agent. Although almost any tissue or body fluid can be submitted for fungal culture, the most common specimens are respiratory tract secretions, hair, skin, nails, tissue, blood, bone marrow, and CSF.

Direct microscopic examination of specimens for fungal elements should always be requested along with fungus culture. Specimens or cultures that need to be sent to a reference laboratory over a long distance should be sent by air-express service. Taped screw-top tubes must be placed in a container, then placed in a second container. The outside label must include a biohazard label.

Specimen types

Respiratory tract secretions including sputum, bronchial washings, and tracheal aspirates are the most common specimen types submitted for fungus cultures, as many fungal infections have a primary focus in the lungs. Patients ideally should provide sputum from a deep cough after rising in the morning. All respiratory specimens should be collected into sterile, leak-proof, screw-top containers.

Hair, skin, and nail scrapings submitted for dermatophyte culture are generally contaminated with bacteria and/or rapidly growing contaminant fungi. Skin and nails should be disinfected with 70% isopropanol before sampling. Skin samples are gently scraped from the outer edge of a surface lesion using a sterile scalpel. Nail specimens may be submitted as either scrapings or cuttings and occasionally as a complete nail. The best nail specimen is crumbly material from the nail bed. A sterile scalpel blade, small curette, or scissors is used to harvest the nail.

A Wood's lamp (ultraviolet radiation from a mercury-vapor source) can be used to detect infected hairs. Hairs infected with such fungi as *Microsporum* species and *Trichophyton schoenleinii* fluoresce when a Wood's lamp is shone on the scalp. Sterile forceps should be used to pluck the hair for culturing. These hair, skin, and nail specimens should be transported to the laboratory in sterile petri dishes, or screw top containers. A potassium hydroxide (KOH) wet mount should be requested. Specimens should not be refrigerated.

Blood cultures are helpful to detect disseminated fungal infections. Blood from patients that are septic (growing organisms in their blood) can harbor a wide variety of fungal pathogens as well as opportunistic saprophytes. Yeast are adequately recovered from any of several automated bacterial **blood culture** systems in use in microbiology laboratories, but filamentous fungi may require specialized techniques for isolation and fungal blood cultures should be specified. A lysis-centrifugation system may be employed which lyses red and white blood cells that may be harboring fungi. After lysis, centrifugation concentrates the organisms before culturing on fungal media.

Cerebrospinal fluid for fungal culture should ideally be of a volume of one to two milliliters or more. The specimen is transported to the lab immediately in a sterile, leak-proof tube. The second or third tubes collected in the lumbar puncture are preferred for any microbiology culture. An India-ink preparation and latex agglutination for cryptococcal antigen test should be requested along with fungal culture.

Other sterile body fluids, deep tissue samples and bone marrow aspirates should be collected by the physician in a sterile manner and transported to the lab in sterile syringes or screw-top tubes. A minimum of 0.5 milliliters of fluid is required, but any size tissue is acceptable. Bone marrow aspirates require sterile anticoagulant.

Urine to be cultured for fungus should be collected by the clean-catch, midstream (CCMS) void method into a sterile screw-top container. First-voided morning urine specimens are preferred, as they are more concentrated. Twenty-four-hour or quantitative urine samples are not acceptable for culturing.

Abscess fluids and wound drainage may be cultured for fungus. Actual tissue from the wound site will greatly increase the likelihood of recovering a fungal pathogen. Urogenital and fecal specimens may occasionally be sent for fungal culture but are generally screened only for yeast. Swabs are acceptable for these cultures, as well as for throats and **wounds**, but the medical staff should be aware that only yeast, no molds, would be isolated.

Aftercare

The care of patients after the collection of a specimen varies with the specimen type. Scrapings of skin or nails, plucking of hair, urine or stool collection and sputum production should involve little or no discomfort or subsequent care. Urogenital and throat swabs may be momentarily uncomfortable. Collection of some respiratory-type specimens such as **bronchoscopy** or bronchial

washes may result in coughing or hoarseness. The patient should be observed for hypoxia (low oxygen), bloody sputum or hemorrhage.

Following the sterile collection of blood for fungal cultures, firm pressure is applied to the draw site for a few minutes, followed by a bandage. Collection of bone marrow aspirates, deep tissue biopsies and sterile body fluids are invasive procedures performed by trained physicians observing sterile procedures. The patient should be monitored afterward to avoid hemorrhage at the site of aspiration or biopsy. Lumbar puncture for the collection of CSF requires special aftercare. The patient should lie prone for four to twelve hours to avoid headaches and the aspiration site is monitored for swelling or bleeding. Any of the invasive procedures may result in some normal aches for one to two days.

Complications

Complications for the patient whose specimen is being sent for fungus culture is dependent on the type of specimen being collected. Drawing of blood cultures can sometimes result in hematoma (bruising) at the draw site and should be done by a well-trained phlebotomist who is familiar with sterile drawing procedures. More invasive procedures such as tissue biopsy, aspiration of bone marrow and other body fluids may be complicated by hemorrhage or infection of the sampling site. Complications for lumbar puncture for CSF collection may include numbness, tingling or **pain** in the legs.

Results

Validity of results

Fungus cultures are fraught with false-positive and false-negative test results and the medical staff must interpret culture results in light of the patient's health status. Any direct microscopic examination may be falsely called negative, giving the physician and patient the early impression that no fungal infection exists. The false-negative direct examination may be due to examiner error through inexperience or lack of thoroughness. The portion of the specimen selected to be examined may have very few organisms, or the organisms may be missed amongst background debris in the smear. Likewise, a direct microscopic examination may be called falsely positive when an examiner misinterprets background artifacts as fungal elements in a preparation. This happens with the widely used KOH preparation and thorough training and experience is essential. A false-positive direct examination may cause antifungal treatment to be initiated unnecessarily.

It is important to be aware that falsely negative fungal cultures may result if the patient has already had anti-

KEY TERMS

Dermatophyte—A fungus that infects only epidermal tissues in which keratin is abundant: hair, skin and nails.

Dimorphic fungus—A fungus capable of existing in both a yeast and mold form, generally as a yeast at body temperature and mold at room temperature. Some dimorphic fungi cause disease in humans.

Fungal elements—Microscopic structures of fungi that may be observed in specimens or from positive cultures: yeast, budding yeast, hyphae, pseudohyphae, spores, mycelium.

Hyphae—Multicellular filaments or tubular projections composing the mycelium of a mold.

Mycelium—A mass of loosely intertwined hyphae extended out from a mold colony.

Mycosis—Any disease caused by a fungal infection.

Opportunistic pathogen—An organism that normally is present in the environment or as part of the normal flora of a host without causing disease, but which causes disease when the host becomes debilitated.

Pseudohyphae—chains of budding yeast that adhere together and appear to look like hyphae during microscopic examination.

Spore—A small, reproductive body of a fungus that is capable of sprouting new hyphae.

Yeast—A single-celled, rounded fungi that usually reproduce by budding.

fungal treatment. Inhibitory agents within the patient's tissues and specimens may suppress the growth of organisms in culture.

False positive cultures result when a fungus contaminates a culture. Certain species of fungi are known to routinely be contaminants of fungal cultures; thus a positive culture report should lead to a discussion between the patient's doctor and the microbiology laboratory or infectious disease specialists, if necessary. Repeating the culture is sometimes indicated.

Mycoses

The fungal diseases, or mycoses, have been categorized as superficial or cutaneous, subcutaneous, and sys-

temic, depending on the tissue or organs involved. The superficial or cutaneous mycoses involve the keratinized tissues of hair, skin, and nails without invasion of deeper tissue. The superficial types are mild, chronic infections of hair and the most superficial layer of the skin. In general they are of little medical consequence except for their cosmetic effect. Included in this group are conditions known as tinea and piedra. The cutaneous mycoses are sometimes referred to as the dermatomycoses, as they are caused by a group of fungi called dermatophytes. These fungi penetrate into epidermal tissue and include the agents of athlete's foot and ringworm. Dermatophytes belong to three genera: *Epidermophyton*, *Microsporum*, and *Trichophyton*.

The subcutaneous mycoses include a diverse group of infections that are characterized by the formation of a lesion at the inoculation site, often the result of injury. Generally, the fungus grows slowly in the subcutaneous tissues at the site, causing gradual spreading of the lesion, but does not disseminate to distant parts of the body. Examples of subcutaneous mycoses include chromoblastomycosis, mycetoma, and sporotrichosis.

The systemic mycoses are those fungal diseases involving the internal organs, often spreading from an initial lung infection. They may become widely disseminated and involve any organ system where they can produce abscesses and granulomas (inflammatory nodules). Prior to effective antifungal therapy, these disseminated mycoses were almost invariably fatal. Traditionally, this group included dimorphic fungi from the genera *Blastomyces*, *Histoplasma*, *Coccidioides* and *Paracoccidioides*, as well as the yeast *Cryptococcus*. Recently, *Penicillium marneffeii* has been added to this group.

Opportunistic pathogens comprise another category of mycosis, which is becoming increasingly common. Opportunistic infections are caused by organisms normally found in the environment, or as part of the normal body flora, which do not cause illness unless the host becomes debilitated. Opportunists cause infection in patients that are immunocompromised, either by underlying disease or such immunosuppressive agents as steroids or cytotoxic drugs. Examples of such opportunists are *Aspergillus* species, which are among the most ubiquitous molds in the human environment. These fungi may inadvertently cause infection in a hospital setting through such portals as dialysis bags, air conditioning ducts and airborne particles associated with construction. Another frequent opportunist is *Candida albicans*, a yeast commonly carried in the mouth, vagina and intestinal tracts of healthy humans. *C. albicans* is the causative agent of oral thrush, vaginal yeast infections and occasionally systemic disease.

In the last two decades there has been a striking increase in the incidence of opportunistic infections, not only because the number of immunocompromised patients, such as **AIDS** patients, is increasing, but also because some modern treatments permit the proliferation and invasion of vital organs by opportunistic molds and yeast. Such things as prolonged use of indwelling catheters, prosthetic **heart** valves, and immunosuppressive drugs for organ transplants have contributed to the increase.

Health care team roles

Members of the health care team play essential roles in the diagnosis of a fungal infection. Doctors and nurses must be aware of when to suspect an infection in general and fungal infections in particular. Signs of any infection include fever, chills, headache, loss of appetite, bad odor, persistent cough, localized pain, burning or bloody urination, **diarrhea**, pus or discharge from a wound or lesion, and elevated white blood cell count. The very young patient (less than one year), the very old, and the debilitated or immunocompromised patient are more susceptible to infection.

Predisposing factors for fungal infection include patients who have received broad-spectrum **antibiotics**, which eradicate the normal bacterial flora and allow fungi to overgrow. Steroid treatment decreases the body's normal protective inflammatory response to invading fungi. Cytotoxic drugs used during **cancer chemotherapy** suppress the **immune system** and make the patient more susceptible to fungi in their environment. Patients who have very low white blood cell counts (less than 1,000 cells per cubic millimeter), or such underlying disorders as **AIDS**, **pneumonia**, diarrhea, leukemia, hepatitis, or transplanted organs are more prone to fungal infections.

Skin conditions that may indicate fungal infection include scaling of skin, blisters of hands or feet, scaling of scalp with broken-off hairs, and discolored toenails or fingernails. Fungus infections of the cornea are more common in farm workers, contact lens wearers, topical steroid users, and those who have corneal injury due to such organic material as a tree branch.

Certain fungal infections are more common in particular areas of the world and the medical staff needs to be aware of what fungi are endemic (constantly present) in their area and also inquire about a patient's travel history. For example, *Histoplasma capsulatum*, the cause of histoplasmosis, is endemic in the Ohio and Mississippi River valleys of the United States.

The medical staff also has a critical role in selecting the appropriate specimen for fungus culture and should be knowledgeable about their institution's requirements

for collecting the specimen properly. See the Preparation section for proper specimen collection.

The mycology section of the microbiology laboratory has the important role of notifying the medical staff promptly of positive direct examination results as well as positive culture results. The cytology and surgical pathology laboratories must work closely with the microbiology laboratory as these former laboratories may detect fungal elements with their tissue stains.

The experienced microbiology technologist's knowledge of common fungal contaminants is invaluable to the doctor. A discussion between the doctor and the lab is often helpful in distinguishing between a contaminant and an opportunistic infection. Fungi that would have once been disregarded as contaminants on a culture are now known to be responsible for serious disease in debilitated hosts.

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Fungi

Definition

Fungi are eukaryotic organisms (each containing a membrane-bound nucleus) that develop from reproductive bodies called spores. Fungi may be the cause of any

number of diseases in humans, animals, and plants; fungal infections are called mycoses (singular, mycosis).

Description

Mycology is the branch of science that studies organisms of the kingdom Fungi. Scientists estimate that over 200,000 species of fungus exist in nature. These species include yeasts, moulds, mildews, mushrooms, lichens, and smuts.

There are a number of characteristics that fungi share: they are eukaryotic (containing a nucleus that is bound by a nuclear membrane); they develop from reproductive bodies called spores; their cell walls are composed mostly of chitin, a nitrogen-containing carbohydrate; and they are heterotrophic (they cannot synthesize their own food and therefore absorb food from an external source through their cell walls).

Most fungi obtain their nutrients from dead organic matter and are called saprophytes. Saprophytes play an important ecological role in the decomposition of dead plants, animals, and other organic matter: they release large amounts of carbon dioxide into the atmosphere and recycle nitrogen and other important nutrients for use by plants and other organisms. Other fungi are parasites (obtaining their nutrients from a living host organism in a relationship that usually harms the host) or mutualists (involved in a mutually beneficial relationship with another organism).

Another important characteristic of fungi is that they do not contain chlorophyll. Chlorophyll is a green pigment that enables plants and such other photosynthetic organisms as algae and cyanobacteria to absorb energy from sunlight and use it to synthesize **carbohydrates** (photosynthesis). Because fungi are not reliant on sunlight as an energy source, they can grow in dark or low-light environments and in directions not normally observed in plants.

Morphology

Most fungi may be classified according to two major growth forms: yeasts or molds. Yeasts are round, unicellular (single-celled) organisms that form a vegetative body called a thallus. The thallus may consist of cells in groups or in branched chains called pseudo-hyphae. Examples of yeasts include *Saccharomyces cerevisiae*, used in making bread and alcoholic beverages; and *Candida albicans*, the causative agent of yeast infections.

Molds, on the other hand, are composed of long filaments called hyphae (singular, hypha). Hyphae may be further classified as septate (containing cross walls) or aseptate. A mass of hyphae is called a mycelium.



Oral candidiasis (thrush) in an infant, showing a white coating over the tongue. This infection is caused by a yeast-like fungus, usually *Candida albicans*. (Photograph by Dr. P. Marazzi. Science Source/Photo Researchers. Reproduced by permission.)

Whereas yeast cells each contain a single nucleus, cells in septate hyphae may be uninucleate (containing one nucleus), binucleate (containing two nuclei), or multinucleate (containing many nuclei). An example of a mold is *Penicillium roqueforti*, used to make blue cheese.

Some fungi are dimorphic: they may exist in either yeast or mold form. What form a fungus assumes depends on such environmental factors as the temperature or nutrients present. Some examples of dimorphic fungi include *Histoplasma capsulatum* and *Coccidioides immitis*.

Reproduction

All fungi can reproduce asexually by the production of single-celled structures called spores. The number of chromosomes (structures in the nucleus containing genetic material) remains unchanged when cells duplicate their genetic material and then divide. This is not the ideal state for a fungus and is thus called the imperfect state. (It is often observed in the laboratory when fungi that are normally pathogenic to humans are allowed to reproduce.)

Sexual reproduction can also occur in most fungi and is called the perfect state. In this process, one cell divides to become two haploid cells (each containing a single set of unpaired chromosomes). Two cells can then fuse together to become a diploid cell (containing a full set of chromosomes); that cell can then divide.

Role in human health

Some fungi have been found to be directly or indirectly beneficial to humans, while others are pathogenic

(disease-causing). Still others are pathogenic to plants and animals important in the food chain.

Food manufacturing

Different yeasts in the genus *Saccharomyces* are employed by bakers, brewers, and vintners to make their bread, beer, or wine. For instance, *S. cerevisiae* is commonly used as baker's yeast and in the production of ales. *Candida milleri* is a yeast used in conjunction with an acid-producing **bacteria** to yield sourdough bread.

Various species of mushrooms are cultivated specifically for human consumption. These include *Agaricus bisporus* (accounting for 38% of the world's cultivated mushroom supply), *Lentinus edodes* (shiitake mushrooms), *Volvariella volvacea* (the paddy straw mushroom), and the *Pleurotus* family (oyster mushrooms). Other edible fungi include truffles (fungi of the family *Tuber* that grow in a special subterranean (mycorrhizal) association with certain trees), morels (of the *Morchella* family), and the blue-green mold of the *Penicillium* family that is essential in the production of certain cheeses.

Medicinal and recreational drugs

Discovered in 1929, a metabolite of the fungus *Penicillium notatum* (later to be called penicillin) became the first antibiotic (a substance produced by a microorganism that can selectively treat an infectious disease). Other fungi that are the source of clinically important **antibiotics** include those in the family *Streptomyces*: *S. nodosus* (amphotericin B), *S. erythreus* (erythromycin), *S. fradiae* (neomycin), *S. griseus* (streptomycin), *S. orientalis* (vancomycin), and *S. rimosus* (tetracycline).

Some species of fungi are known as hallucinogens (substances inducing false sensations in the absence of true stimuli) and have been used by many cultures during religious ceremonies (for example, *Amanita muscaria*). *Claviceps purpurea* (the ergot fungus) and fungi of the *Psilocybe* family are also known for their hallucinogenic effects.

Biomedical research

Phycomyces blakesleeanus is a fungus that grows on animal feces in nature. The sporangiophores (the stalks on which spores are produced) of *Phycomyces* have been shown to respond to a variety of stimuli, including light, gravity, wind, and nearby objects. One important finding was that the light sensitivity of the sporangiophore is about the same as the eyes of humans. Furthermore, like humans, the sporangiophore can adapt to a one-billion-fold change in ambient light intensity.

Biologists have recently shown that *Neurospora crassa*, also known as red bread mold, can produce spores at approximately 24-hour intervals (known as a circadian rhythm) when in a constant environment. The fungus is therefore being used as a model organism for investigating circadian rhythms, which occur in many different organisms including humans.

Common disease and disorders

Human mycoses can be classified as superficial, cutaneous, subcutaneous, systemic, or opportunistic.

Superficial and cutaneous mycoses

These fungal infections do not invade underlying muscle or bone and are mostly restricted to the outer layers of the skin, nails, and/or hair. Superficial mycoses involve only the outermost layers of skin and result in a change in hair or skin pigment. For example, tinea nigra, caused by *Exophiala werneckii*, results in black lesions on the skin. *Piedraia hortai*, the causative agent of black piedra, creates hard dark-colored nodules on scalp hair, eyebrows, and/or eyelashes.

Cutaneous mycoses are generally caused by **infection** with a dermatophyte (a skin-infecting fungus). Common families of dermatophytes are *Epidermophyton*, *Microsporum*, and *Trichophyton*. Some of the more commonly seen cutaneous infections include:

- tinea corporis (body, “ringworm”)
- tinea capitis (scalp, eyebrows, eyelashes)
- tinea barbae (beard, “barber’s itch”)
- tinea cruris (groin, “jock itch”)
- tinea inguim (nails)
- tinea pedis (feet, “athlete’s foot”)

Subcutaneous mycoses

In the case of subcutaneous fungal infection, muscle, bone, connective tissue, and/or overlying skin may be involved. Subcutaneous mycoses may begin at the site of a laceration or even a seemingly innocuous scratch or puncture wound; fungi are introduced from soil or plant material. These mycoses, however, typically remain localized rather than spread from the site of infection. Sporotrichosis (caused by *Sporothrix schenckii*) and mycetoma (caused by *Madurella grisea*, among others) are two noted exceptions; sporotrichosis may spread along the **lymphatic system**, and mycetoma to deeper muscle and bone.

KEY TERMS

Cyanobacteria—Photosynthetic bacteria, commonly known as blue-green algae.

Dermatophyte—A fungus that can cause a skin infection.

Hypa—Cellular unit of the fungi; typically a branched and tubular filament.

Lichen—A fungus that grows a symbiotic relationship with algae.

Meningitis—Inflammation of the meninges, the membranes surrounding the brain and spinal cord.

Metabolite—A substance produced by way of a metabolic process.

Morphology—The study of the shape and structure of an organism.

Mutualism—Close relationship of two or more organisms, which typically involves exchange of food or other resources.

Mycorrhiza—Subterranean symbiotic relationship between a fungus and a plant root.

Septum—Wall that separates the cells of a fungal hypha into segments.

Systemic mycoses

Systemic fungal infections usually involve more than one type of body tissue. The **lungs** are often a site of primary infection when airborne spores are inhaled. Often the primary infection is asymptomatic (shows no signs of infection) or resolves quickly. If the fungus spreads to the bloodstream, however, it may disseminate to other organs or systems. The following are the most commonly seen systemic mycoses:

- Blastomycosis, caused by *Blastomyces dermatitidis*; begins as a pulmonary infection but may disseminate to bone and/or skin.
- Coccidioidomycosis, caused by *Coccidioides immitis*; begins as a pulmonary infection (although 60% of infections are asymptomatic) but may disseminate to the **central nervous system**, bone, and/or skin.
- Cryptococcosis, caused by *Cryptococcus neoformans*; begins as a pulmonary infection but may disseminate to the central nervous system to cause meningitis.

- Histoplasmosis, caused by *Histoplasma capsulatum*; begins as a pulmonary infection but may disseminate to the lymph nodes, spleen, and/or **liver**.
- Paracoccidioidomycosis, caused by *Paracoccidioides immitis*; begins as a pulmonary infection but may disseminate to the mucous membranes, lymph nodes, and/or skin.

Opportunistic mycoses

Opportunistic fungi do not normally cause disease in healthy humans, but can cause infection in individuals who are immunocompromised, such as those with acquired immune deficiency syndrome [AIDS] or those who have undergone organ transplantation. Some important opportunistic mycoses include:

- Aspergillosis, a mycosis caused by members of the *Aspergillus* family. Common mechanisms of infection include hypersensitivity (an allergic reaction); local pulmonary infection; opportunistic infection (leading to **pneumonia** and the development of a characteristic “fungal ball”); and systemic infection (leading to abscesses in the **brain**, liver, **kidneys**, skin, or bone).
- Candidiasis. *Candida albicans* is a yeast that causes oropharyngeal candidiasis, also known as thrush. Thrush is an often-seen opportunistic infection in patients with acquired immune deficiency syndrome

(AIDS). *Candida albicans* is also the cause of the majority of cases of vulvovaginitis (yeast infection).

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Stéphanie Islane Dionne

Furunculosis see **Boils**

G

Gait and balance assessment

Definition

Gait or walking is a coordinated action of the neuromuscular and musculoskeletal systems. The coordination of **muscle contraction**, joint movement, and sensory perception allows the human body to move in the environment. Individuals with neuromuscular and/or musculoskeletal involvement may have abnormal or inappropriate muscle activation, joint motion, or sensory perception. The result may be decreased mobility and function, and altered gait. Gait assessment is important to help identify areas of impairment. Once a reason for gait impairment is determined, a treatment plan can be developed. The goals of therapy are to minimize functional loss, restore mobility, and promote safety.

Balance is the ability to sit, stand, or walk safely without postural deviation, falling, or reaching for external items for support. Balance, like gait, is a coordinated response of the neuromuscular and musculoskeletal systems, as well as **vision** and sensory perception. Vestibular and cortico-cerebellar levels in the **brain** are also involved in maintaining stability. Balance assessment is used to evaluate the patient's ability to maintain appropriate posture during functional activities. It is usually evaluated statically and dynamically.

Purpose

The goal of gait assessment is to evaluate walking in an effort to isolate dysfunction. Areas of impairment may include muscle weakness, loss of joint range, incoordination, or poor postural control.

During balance assessment, a patient's stability during activities is evaluated to identify areas of impairment, the reason for impairment, and the effect on function.

Both gait and balance evaluations are useful in identifying areas of impairment so that safe and proficient function and mobility can be restored.

Precautions

During gait and balance assessment, individuals with impairment are at risk for further injury, especially from **falls**. Clinicians who evaluate patients with suspected gait and balance deficits must provide close supervision and ensure that the testing areas are safe.

Description

Gait can be analyzed with a variety of techniques, involving a range of difficulty. One basic method is simply watching the patient walk and interact in the environment, noting any deviations or instability. More advanced techniques use motion analysis, force platform data, and **electromyography** in an effort to gain a global representation of joint motions, joint forces, and electrical activity of muscles during walking.

Balance is very complex and requires many systems to work at optimum levels. A problem or injury affecting strength, joint motion, vision, sensory perception, or vestibular apparatus may lead to functional impairment. Balance needs to be evaluated both statically and dynamically, and if a deficit is present, further testing is indicated.

Preparation

In a simple gait analysis, the patient is observed during standing (static testing) and walking (dynamic testing). Initially, the patient is examined in the standing position to evaluate posture as well as bone and soft tissue symmetry. The clinician evaluates the foot and ankle during standing to assess any deviation in the rear foot and forefoot. The patient is then asked to walk across the floor while the clinician evaluates the gait cycle. The clinician assesses joint range of motion, speed, and quality

KEY TERMS

Berg balance scale—An assessment tool used to evaluate stability during functional activities. The patient is scored on 14 different tasks.

Cortico-cerebellar—Pertaining to the cerebellum and the cerebral cortex of the brain.

Dynamic—Movement such as walking that is due to muscles contracting.

Electromyography—An evaluation tool that detects electrical activity of muscles.

Force platform—A large plate, usually mounted in the floor, that records forces when an individual stands or walks on it.

Forefoot—The front portion of the foot from the ankle.

Functional reach test—A test that evaluates stability when reaching out beyond an individual's base of support. In this test the patient stands and tries to reach out with one hand as far as possible without losing balance. The reach is recorded in inches.

Get-up-and-go test—Evaluates balance during a functional activity. The test is scored based on the patient's ability to get up from a chair, walk forward about 10 feet (3 m), return to the chair and sit down. The test may be timed to monitor progress.

Motion analysis—Use of an instrumented system to record whole body and joint movement for later analysis.

Musculoskeletal system—Pertaining to the muscle and skeletal systems.

Neuromuscular—Pertaining to the nervous and muscle systems.

Normative—A group that is free from dysfunction compared to a group that has dysfunction. For example, in groups with and without knee osteoarthritis, the group without the osteoarthritis is the normative group.

Proprioception—The ability to sense movement and position of the body.

Rear foot—The back portion of the foot that includes the ankle and heel.

Sensory perception—The ability to perceive touch, pressure, pain, and joint position in the limbs and trunk.

Static—Without movement, i.e. standing still, with or without muscle contraction.

Tinetti balance test—A battery of tests to assess balance and identify individuals at risk for falling.

Vestibular—Pertaining to the apparatus in the inner ear that senses orientation and movement of the body in space.

of gait, and synchrony of all upper and lower extremity joints. The patient should be evaluated walking barefoot as well as while wearing normal walking shoes. The clinician should observe walking from the back, front, and side. In more complex gait assessments, videography is used to record patient movement and joint motion, and force plates and electromyography provide additional information. Unfortunately, the equipment used in complex analyses is expensive and thus cost-prohibitive to the average clinician. However, there are gait laboratories that have equipment specializing in instrumented gait analysis.

Various tests are used for balance assessment. Certain tests are specific to visual, cerebellar, muscular, or proprioceptive areas. Sensory integration tests and the Romberg test are used to try to isolate involvement of vision, sensation, and cerebellar integrity. Other tests commonly used are the Berg balance scale, the get-up-

and-go test, the functional reach test, and the Tinetti balance tests. These tests provide quantitative data that allow the clinician to compare individual results with a normative group and document progress over time.

Aftercare

The treatment of an individual with a gait abnormality may include stretching, strengthening, joint mobilization, splinting or bracing, education, or a change in footwear. The treatment of an individual with a balance deficit may include stretching, strengthening, postural awareness exercises, various weight-shifting exercises, and increasing environmental stimuli in an effort to retrain proprioception. Treatment is individualized according to a patient's problem. For example, strengthening exercises are recommended for an identified muscle weakness.

Complications

A major concern is safety during a gait or balance assessment. If impaired balance or gait abnormalities increase the likelihood of falling, appropriate measures need to be taken, such as clear and safe pathways, adequate lighting, and good guarding techniques by staff members.

Results

Gait or balance assessments are usually recommended for a decline in function, self-reported loss of balance, or unexplained falls. The patient may be fearful of falling, and restoring confidence often needs to be addressed. Ideally, areas of impairment are identified during the assessment so that appropriate treatments can be directed at the problem.

Health care team roles

Nursing and other allied health professionals in hospitals, outpatient clinics, diagnostic centers, skilled nursing facilities, and assisted living facilities need to be aware of their patients' gait, posture, and general mobility. When a patient is using an assistive device inappropriately, or gait and balance appear to have changed, it is the health care provider's role to address the problem to minimize the risk of falls. A request for further evaluation, such as a gait or balance assessment, may be an appropriate next step.

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one's center of gravity (COG) over the base of support (BOS) in static or dynamic tasks and environments.

Description

Any number of factors may contribute to gait and balance problems. Postural control, the task that involves controlling one's position in space, involves maintaining a relationship among the body, the task at hand, and the given environment. Difficulty in maintaining an appropriate relationship may occur due to:

- impaired sensory processes (visual, vestibular, somatosensory)
- inadequate neuromuscular responses (signaling of **brain** to/from muscle)
- musculoskeletal problems (impaired range of motion, strength, flexibility)
- decreased cognition (inability to anticipate or adapt to postural needs)

Due to the wide variety of factors, many individuals can be affected with gait and balance problems at some point in their lives. Inability of peripheral sensory receptors to gain information about the environment results in the inability to use that information for postural control. This type of loss may occur in people who have visual, vestibular, or somatosensory deficits not based in the **central nervous system** (CNS). Examples include, but are not limited to, diabetic retinopathy, **cataracts**, **glaucoma**, temporal bone fracture, acoustic neuroma, Ménière's disease, **spinal cord injury**, peripheral neuropathy, and amputation.

The CNS is responsible for integrating the environmental information that is supplied through peripheral sensory receptors; this is called sensory processing. Motor planning, on the other hand, is an individual's ability to plan movement to accomplish a task. Individuals who have experienced injury to the CNS in the form of a stroke, brain trauma, or disease process like **multiple sclerosis**, Parkinson's or cerebellar ataxia, may exhibit gait and balance problems due to difficulty with sensory processing and/or motor planning.

Musculoskeletal problems, whether orthopedic or neurologic in origin, can contribute to balance and gait difficulties because certain levels of mobility and strength are required to execute movements within functional parameters. Automatic postural strategies, such as an ankle or hip strategy, operate to keep the body over the center of gravity when a disturbance to balance is presented. The larger the disturbance is, the more intense the response. If there is inadequate range of motion at the

Gait and balance problems

Definition

Gait and balance problems exist when a disease process, trauma, or aging result in the inability to control



A balance machine is used in the assessment of balance problems. (Photograph by Will & Deni McIntyre. *Science Source/Photo Researchers. Reproduced by permission.*)

ankle, or weakness in hip musculature, these strategies cannot be adequately used.

Impaired cognition is an important contributor to balance and gait problems. Poor attention, decreased judgment and slow processing can increase risk of loss of balance. Without awareness of environmental hazards and necessary safety precautions, patients who have had a stroke or brain trauma have an increased propensity to fall.

Causes and symptoms

Cerebellar lesions

Cerebellar lesions are one cause of disturbed balance. Depending upon the area affected, the disturbance may be slight or severe. The cerebellum also contains proprioceptive feedback loops, in addition to receiving input from the **spinal cord**. When these areas are affected, the postural changes that take place affect balance. It

is very common to find gait problems in conjunction with cerebellar lesions; in one study, 60% of patients with cerebellar problems displayed ataxic gait, which resembles intoxicated gait.

Basal ganglia dysfunction

The basal ganglia are three nuclei at the base of the cerebral cortex. It appears that the basal ganglia play a large role in preparing an individual for motion. This may include preparing the cortex, setting postural **reflexes**, and organizing sensory input. When there is dysfunction in this area, such as in Parkinson's or Huntington's disease, disturbances in central sensory processing, along with rigidity and akinesia (inability to move), contribute to postural instability and gait difficulties.

Hemiplegia

Hemiplegia (**paralysis** of one side of the body) as a result of a **cerebrovascular accident**, or stroke, is also a common cause of balance and gait difficulties. Loss of trunk control results in the inability to maintain weight evenly over the pelvis. In the early stages of recovery, along with upper extremity dysfunction, lower extremity positioning in standing may be marked by pelvic depression, hip and knee flexion (decreasing the angle of the joints), and ankle plantarflexion on the affected side. Later, extensor patterns (increasing the angle of the joints) become more available, and the pelvis may be elevated, with the knee hyperextended and ankle plantarflexed. Sensory loss may manifest itself in many ways, from loss of discrimination and localization to complete neglect of the affected side. All of these factors contribute to balance and gait problems due to inadequate sensory processing, musculoskeletal tightness or weakness, and/or cognitive deficits.

Vestibular hypofunction

While problems with central processing of vestibular input can create balance and gait difficulties in individuals with CNS problems, peripheral vestibular hypofunction (the under-functioning of inner ear structures associated with balance) also is a common contributor to balance deficits. Peripheral vestibular hypofunction may result from temporal bone fracture, acoustic neuroma, ototoxicity (damage to the eighth cranial nerve due to aminoglycoside **antibiotics**), or unknown causes. One or both sides may be damaged, resulting in dizziness and vertigo that lead to decreased balance.

Although these are some of the main pathologies that are known to cause balance and gait problems, any disease process or trauma resulting in impairments of sensory processing, neuromuscular response, muscu-

loskeletal function, or cognition can result in balance and gait disturbances. Due to changes that take place in the proprioceptive (self-awareness of movement) and vestibular systems, even normal aging has an effect on balance and gait.

Diagnosis

The pathologies that underlie gait and balance problems are diagnosed by physicians using a variety of methods, including signs and symptoms, diagnosis of exclusion, imaging, etc. Discussion of specific diagnostic criteria for each disease process that could contribute to a balance disorder is beyond the scope of this entry.

A **physical therapy** diagnosis of decreased balance or abnormal gait is made based on a thorough examination that includes a patient history and systems review. In addition, tests and measures may be used to assess any or all of the following possible contributors to balance and gait disturbances: aerobic endurance, cognitive status, cranial and peripheral nerve integrity, assistive devices, muscle strength, range of motion, posture, reflexes, sensory integrity, and functional abilities. Balance, gait, and locomotion may be tested in a variety of ways, which usually include observation or video analysis of quiet standing, active standing, or functional activities. In some clinical tests such as the Clinical Test for Sensory Interaction on Balance, the physical therapist will purposefully manipulate the environment to change one component of sensory feedback (e.g., the patient stands on foam to challenge the somatosensory system). In some cases, the physical therapist manipulates the individual (e.g., the Hallpike-Dix maneuver). Other tests include a variety of functional skills that must be completed. A large number of balance tests exist; the key is choosing the right one. It is important to understand the purpose of a test before using it and to match that purpose with the impairments and goals of the patient or client being tested. For example, a test that measures stability in quiet standing may be appropriate for a patient who is recovering from a stroke, but not so appropriate for an athlete training to return to professional sports.

Treatment

Medical and surgical management of pathologies underlying balance and gait disturbances includes, but is not limited to, the following:

- levo-dihydroxy-phenylalanine (L-dopa) and/or amantadine for Parkinson's disease
- surgery to alter connectivity in the basal ganglia in Parkinson's
- dopamine antagonists in Huntington's chorea

- anti-spasticity medication (diazepam, baclofen, dantrolene) for patients who have had a stroke, **head injury** or other neurological insult
- particle repositioning maneuvers for benign paroxysmal positional vertigo (dizziness)
- surgery for Ménière's disease or acoustic neuroma (a tumor in the auditory canal)

These interventions can help to decrease the contributors to balance and gait disorders such as dyskinesia (impaired ability to move voluntarily), rigidity, hypertonicity (diminished muscle tone), or vertigo. Balance and gait, however, often must be retrained using physical therapy. Successful treatment intervention based on theories of motor learning addresses the interactions of the individual, task and environment. In the individual, it is important to recognize what impairments contribute to difficulties, and whether or not they can be realistically corrected or if compensation will be necessary. The patient must be evaluated for cognitive ability to relearn balance skills, and for the level he or she is at in learning a skill (acquisition, refinement, or retention/transfer). In evaluating a task, the clinician must determine what is predominantly required—mobility, stability or both—and the timing, force and duration needed. The environment also must be analyzed and manipulated to best aid the patient in preparing for function in the real world.

Treatments may involve the manipulation of sensory input while performing a task. This may be done for any of the three systems responsible for providing sensory feedback. For example, to encourage use of vestibular input, visual and somatosensory information may be challenged. Visual input is challenged by taking it away (e.g., eyes closed) or by destabilization (e.g., involving head and eye movements in the task). Unstable surfaces (e.g., rocker board or rough terrain) or compliant surfaces (e.g., foam) help to challenge somatosensory input. Vestibular input may be manipulated by changing the position of the vestibular organ (e.g., neck extension or repeated head movements).

Other physical therapy treatment for balance and gait focuses on the patient's ability to control his or her COG over the BOS. Exercises related to functional activities are performed and progressed according to patient ability. Initially, treatment may begin with practicing the ability to establish static balance in a position with a wide BOS, such as sitting and using hands for support. Eventually, the BOS is narrowed and/or destabilized to train automatic, anticipatory and voluntary postural responses. This type of progression can take place in sitting, standing, walking, etc., with or without the addition of such concurrent tasks as putting on a shoe while sitting or reading signs on a wall while walking. Specific bal-

KEY TERMS

Ankle strategy—An automatic posture response in which the body moves as a unit over the feet to control postural sway.

Base of support—The location on a body or object where most of the weight is supported.

Center of gravity—The center of weight in a body or object.

Hip strategy—An automatic posture response in which control comes from the pelvis and trunk.

Posturography—The study of posture and its effects on health.

Somatosensory system—The components of the central and peripheral nervous systems that process information about the muscles, pain, temperature, pressure and joint position.

Vestibular system—Interaction among the inner ear structures associated with balance and position sense, and the central nervous system.

Visual system—Components that transmit information from the retina to the brain.

ance training on a force plate designed to provide visual feedback about a patient's COG has not been shown to be convincingly more effective than conventional physical therapy in adults with hemiplegia. This may be due to the fact that weight shifting on a force plate may not carry over to such higher-level tasks as walking.

Prognosis

Prognosis depends on the cause of pathology, level of impairment, and such other factors as comorbidity. The basal ganglia disorders are progressive; therefore, while medical and physical therapy management may be effective in slowing the decline of function and training compensatory strategies, the overall prognosis is fair at best. Cerebellar lesions or cerebral stroke may allow for slight to significant return to function, depending upon the extent of the damage to the brain tissues. In a study on gait recovery following stroke, prognostic indicators included the ability to weight shift immediately post-stroke; and later in recovery, affected knee extension strength. In true orthopedic cases with no neurological involvement, recovery may be less complicated if it depends purely on restoration of range of motion or strength to a musculoskeletal structure.

Health care team roles

Upon diagnosis of pathology by a physician and referral of an individual to physical therapy, the physical therapist is responsible for examination, evaluation, diagnosis, prognosis, and intervention.

Examination

The examination includes a patient history and systems review of cardiovascular, pulmonary, integumentary, musculoskeletal, neuromuscular and/or cognitive status. Physical therapists also use a wide variety of tests and measures to determine extent of impairment and functional limitations. Some of the more common balance tests used include: Romberg, Functional Reach, Clinical Test for Sensory Interaction on Balance, Berg Balance Scale, Get Up and Go, Tinetti Performance Oriented Assessments of Balance and Gait, Fugl-Meyer Sensorimotor Assessment of Balance Performance, Functional Obstacle Course, and posturography. These tests assess tasks ranging from quiet and active standing to the ability to maneuver an obstacle course of different floor surfaces, obstacles and stairs.

Evaluation, diagnosis and prognosis

The therapist must use his or her clinical judgment and expertise to establish a physical therapy diagnosis and prognosis, including the plan of care. The diagnosis indicates the primary dysfunction(s) toward which intervention will be directed. The prognosis and plan of care must encompass many factors such as current level of function, comorbidity, familial and social considerations and overall health.

Intervention

Intervention includes treatment of any impairments that hinder function, as described in the treatment section above. In addition, **patient education** is of utmost importance. Education may include information regarding: the prognosis and plan of care, specific exercises to perform outside of therapy sessions, fall and injury prevention, compensatory strategies, assistive or adaptive device recommendations and usage, and social/community resources.

Prevention

Gait and balance problems, as discussed earlier, are usually impairments resulting from a pathological process. In some cases, such as in Parkinson's or multiple sclerosis, intentional prevention of pathology is difficult because its causes are not completely understood. Some causes, however, may be modified. For example,

high cholesterol levels contribute to risk of thrombi. Some medications may cause peripheral vestibular damage or dizziness. Reduced range of motion, decreased strength, and inactivity in the elderly can lead to balance and gait problems. Safety education, environmental adaptations, strengthening, flexibility and balance exercises, **gait training**, good shoes, orthotics, and assistive devices are all key factors in prevention of **falls** due to balance and gait problems.

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Peggy Campbell Torpey, MPT

Gait training

Definition

Gait training refers to helping a patient relearn to walk safely and efficiently. Gait training is usually done by rehabilitation specialists who evaluate the abnormalities in the person's gait and employ such treatments as strengthening and balance training to improve stability and body perception as these pertain to the patient's environment. Gait training often incorporates the use of such assistive devices as parallel bars, walkers or canes to promote safe and proficient ambulation. In order to walk again without assistance, the patient will need mental attentiveness and adequate sensation, coordinated with adequate musculoskeletal functioning and motor control.

Purpose

A person's gait is a pattern of stepping or walking that is specific to that individual. Gait training is needed to help a specific patient gain proficient and safe ambulation within and outside the home with or without an assistive device. Patients usually require gait training if there is some lower trunk or lower limb dysfunction. This dysfunction is often associated with neurological or orthopedic impairment. Complications that may require gait training include:

- muscle weakness
- deformity
- spasticity (the presence of abnormal involuntary muscular contractions)
- loss of sensation due to injury or disease that results in inaccurate sensory information and unsafe or inefficient motion
- **pain** in the weight-bearing joints of the lower extremities, which causes distortion of normal gait

These complications may result from injury to or amputation of the lower extremities; surgery; **osteoarthritis** or other disorders of the weight-bearing joints; **muscular dystrophy**; muscle atrophy due to long periods of inactivity or bed rest; lesions of the **brain** or **spinal cord**; or changes in perception and other body functions that are part of the aging process.

Normal gait

In order to understand gait training, the reader may find a descriptive outline of normal human gait helpful. Human gait is measured from heel strike to heel strike, also known as the gait cycle or "one stride." The gait cycle has two phases, the stance (about 60% of the cycle)

KEY TERMS

Ataxia—Loss of muscular coordination.

Cadence—The rhythm of a person's walk.

Double stance—The point in the gait cycle at which both feet are touching the ground. It is also sometimes called double support time.

Gait—A person's habitual pattern of walking or stepping.

Gait cycle—A unit of measurement used in evaluation of gait abnormalities. The gait cycle consists of two phases, stance and swing, and is measured from heel strike to heel strike (the length of one stride).

Gait velocity—The speed of a person's walk.

Muscular dystrophy—An inherited disease characterized by progressive wasting of the muscles.

Osteoarthritis—A degenerative joint disease that causes inflammation and pain in the peripheral and spinal joints.

Spasticity—A condition marked by sudden abnormal involuntary muscle contractions, with associated hyperactivity of deep tendon reflexes. It may be associated with rigidity.

and the swing (about 40%). The point at which the body's weight is transferred from one foot to the other, when both feet are touching the ground, is called double stance or double support time. The speed of a person's walk is called the gait velocity, and the rhythm of their walk is called the cadence. Cadence is usually related to the length of the person's leg and their overall height; short people typically take smaller steps at a more rapid cadence while taller people take larger steps at a slower cadence.

Deviations in gait

Deviations from normal gait can occur in any portion of the lower extremity. Common abnormalities include:

- Ankle/foot. Deviations of stance include foot slap and foot flat. Deviations of swing include toe drag (foot drop).
- Knee. Abnormalities of stance include hyperextension of the knee. Abnormalities of swing include limited flexion of the knee.

- Hip. Deviations of swing include circumduction and "hip hiking."
- Trunk. Deviations of stance include lateral lean (Trendelenberg gait), backward lean (gluteus maximus gait), and forward lean.
- Other. Ataxia (loss of muscular coordination) and antalgia (limping from pain).

Deviations can occur together as a group of compensations for one impairment. For example, a patient's gait may show foot drop as well as hip hiking.

Precautions

Before gait training the clinician must review all **medical records** and examine any pathologies or impairments that may affect the patient's ability to walk. Furthermore, through the rehabilitation evaluation, the clinician should have an understanding of the patient's present abilities and prior level of function. Once gait training begins, the clinician must choose the appropriate assistive device that will provide optimal stability and still allow the patient mobility.

The therapist should use a gait belt or similar device to help support the patient if he or she loses balance. Gait training should be done in a safe environment with few visual distractions, and with the patient wearing appropriate footwear. Some rehabilitation specialists have designed mechanical gait trainers with parachute harness systems that allow patients to practice their gait without overstraining the therapist.

Preparation

Patient assessment

In determining the patient's readiness for gait training, the therapist will evaluate the patient's physical abilities (weight-bearing, strength, stability, coordination and balance) and his or her mental and emotional readiness for gait training. Routine evaluation of elderly patients who are beginning to develop gait problems may be done by a primary care physician, but assessment of complex disorders usually requires a gait specialist. A simple evaluation of a patient's gait can be performed in a straight hallway without pictures or other objects that may distract the eye. The examiner will need a stopwatch for timing and a T-square to measure the length of the patient's stride. Advanced evaluation of gait kinetics, however, requires a laboratory with computer and video technology.

Assistive devices

Patients with gait problems caused by pain in the lower extremities; decreased ability to bear weight; or

loss of strength, balance, endurance, or coordination may use a range of assistive devices as part of their gait training. The physical therapist will take into account the patient's prognosis, home or institutional environment, capacity for standing, and the demands of the device itself in selecting an appropriate assistive device.

The most stable assistive device is a set of parallel bars, followed in descending order of stability by walkers, crutches, single crutches, bilateral canes, and single canes. In terms of the demands that assistive devices place on the patient's coordination, parallel bars are the least demanding, followed in ascending order by walkers, single canes, bilateral canes, axillary (under the armpit) crutches, and forearm crutches.

Choosing a device and gait pattern

The therapist must consider not only the type of assistive device most appropriate to the patient's needs, but also the gait pattern (pattern of the patient's movement) that will be most helpful. For example, a walker can be used with either a swinging or a stepping-through-and-rolling motion. Crutches can be used with either a reciprocating (uses both lower extremities) or nonreciprocating (favors the weight-bearing lower extremity). A so-called four-point gait will be used with a cane or single crutch. In this pattern the crutch or cane advances forward first, followed by the opposite lower extremity, then the other limb, all in a reciprocal pattern. In a three-point gait, one lower extremity is full weight-bearing and the other is non-weight-bearing. An example of a three-point gait would be a patient with bilateral crutches, with one limb lifted and one in contact with the ground. A two-point gait is a pattern in which the patient's assistive device is a cane or single crutch that moves simultaneously with the opposite lower limb. The progression of various gait patterns from use of assistive devices to full independence depends on the type of impairment as well as the patient's mental and physical abilities; it also depends to some extent on the experience of the clinician.

Once selected, the assistive device is fitted to accommodate the patient's height and weight. The cost varies: while a standard cane costs about \$25 and a quad cane about \$50, crutches cost between \$65 and \$110, with walkers costing between \$80 and \$150. Most health insurance policies, however, cover assistive devices.

Patient education

After the assistive device has been selected and fitted to the patient, the therapist demonstrates the appropriate gait pattern, including weight-bearing; shows the patient how to check the assistive device for safety and points of wear; teaches the patient how to move from a

sitting to a standing position; helps the patient practice the gait pattern; and shows the patient how to move from a standing to a sitting position.

The next stage in training involves learning the gait pattern on different types of surface. The patient must know how to use the assistive device on uneven surfaces, curbs, and stairs as well as level surfaces. In stair gait training, the patient is taught a basic rule regarding the affected and unaffected sides of his or her body: "Up with the good, down with the bad; the device stays below."

Aftercare

Aftercare for gait training includes helping patients cope with the various disadvantages of assistive devices. Crutches and walkers, for example, are difficult to use in small or crowded areas. In addition, walkers offer little or no protection from backward **falls**. The use of axillary crutches may place too much pressure on the patient's underarm area. Quad canes are hard to use on stairs and may be unstable on some surfaces, since the patient must have all four cane legs down on the floor or pavement with hand pressure centered over the legs.

Results

The results of gait training vary according to the cause of the patient's gait abnormalities, his or her overall health and mental attitude, and the prognosis. Some patients may be able to walk again without assistive devices, while others may make only limited progress. The importance of encouraging physical activity, however, cannot be overemphasized. Even modest amounts of **exercise** help to prevent muscle atrophy, benefit the **cardiovascular system**, and may lessen the pain of osteoarthritis. In addition, most gait training patients find that a greater degree of physical independence is good for their spirits as well as their bodies.

Health care team roles

In addition to the roles of physicians and rehabilitation specialists in patient assessment and gait training, nurses and other allied health professionals should monitor the walking patterns of their patients and any use or misuse of assistive devices. Gerontologists should routinely assess elderly patients for changes in gait velocity, cadence, step length, or other indications of fears of falling. Furthermore, nurses and other allied health professionals should monitor all patients for changes in ambulation in an effort to maximize their safety.

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Gallbladder

Definition

The gallbladder, an organ of the gastrointestinal system involved in the storage and concentration of bile, is shaped like a deflated balloon or pear, and lies on the surface of the right lobe of the **liver**.

Description

The gallbladder is pear-shaped and generally about 3–4 in (7.6–10.2 cm) in length. It consists of three parts. The fundus is the closed, bottom portion of the gallbladder that borders the liver. The body is the largest section of the gallbladder. In adults, the gallbladder can hold between 0.67 and 1.69 fl oz (20–50 ml) of bile. The neck of the gallbladder is much narrower than the body and empties into the cystic duct.



A close-up view of an inflamed gallbladder. (Custom Medical Stock Photo. Reproduced by permission.)

Function

The gallbladder acts like a storage tank for bile (a bitter, greenish yellow liquid composed in part of cholesterol, bile salts, and bile pigment). Bile is made in the liver and travels through the hepatic duct to be stored and concentrated in the gallbladder until the body needs it to help break down ingested **fats**. When the gallbladder receives a signal from cholecystokinin (a hormone) in the **small intestine**, it contracts and releases bile into the common bile duct, where it travels to the small intestine to help digest fats.

Role in human health

While the body can function normally without a gallbladder, this accessory organ of digestion is important to the proper digestion of fats.

Common diseases and disorders

One of the most common disorders of the gallbladder occurs when cholesterol mixes with bile and **calcium**, forming gallstones. Gallstones occur most frequently in middle-aged women, but they can also occur in people suffering from **obesity**, diabetes, hyperthyroidism, or any other disease that results in increased levels of cholesterol. When the stones stay in the body of the gallbladder they generally cause no **pain** or other symptoms. However, if a stone travels out into the neck of the gallbladder or into one of the bile ducts, nausea, vomiting, and severe pain follow. The patient may also become jaundiced. Gallstones usually have to be removed surgically. In severe cases, the entire gallbladder must be removed.

Other diseases can also cause obstruction of the neck of the gallbladder, causing symptoms like those of gall-

KEY TERMS

Adenocarcinoma—Any one of a large group of cancerous, epithelial cell tumors of the glands.

Biliary tree—Also referred to as biliary tract, it includes all of the parts associated with the passage of bile, beginning at the liver and ending at the opening of the bile duct into the small intestine.

Cholecystitis—Acute or chronic inflammation of the gallbladder.

Cholecystokinin—The hormone manufactured in the lining of the small intestine that signals the gallbladder to release bile.

Cystic duct—The duct that allows passage of bile from the gallbladder to the common bile duct.

stones. **Crohn's disease**, **pancreatitis** (inflammation of the **pancreas**), echinococcosis (infestation of the **digestive system** by tapeworms), and ascariasis (infestation of the digestive system by parasitic nematode worms) can all produce swellings that obstruct the gallbladder's neck.

Cholecystitis, or inflammation of the gallbladder, causes sharp, severe pain in the upper right portion of the abdomen. Cholecystitis causes **fever**, nausea, and vomiting; and, if left untreated, can be life-threatening.

Cancer that invades any portion of the biliary tree can interrupt or prevent the normal flow of bile and result in multiple complications. Two of the most common malignancies that occur in the biliary tract involve adenocarcinoma of the gallbladder itself or of the bile ducts that carry bile from the gallbladder.

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Susan Joanne Cadwallader

Gallbladder ultrasound *see* **Abdominal ultrasound**

Gallbladder x rays

Definition

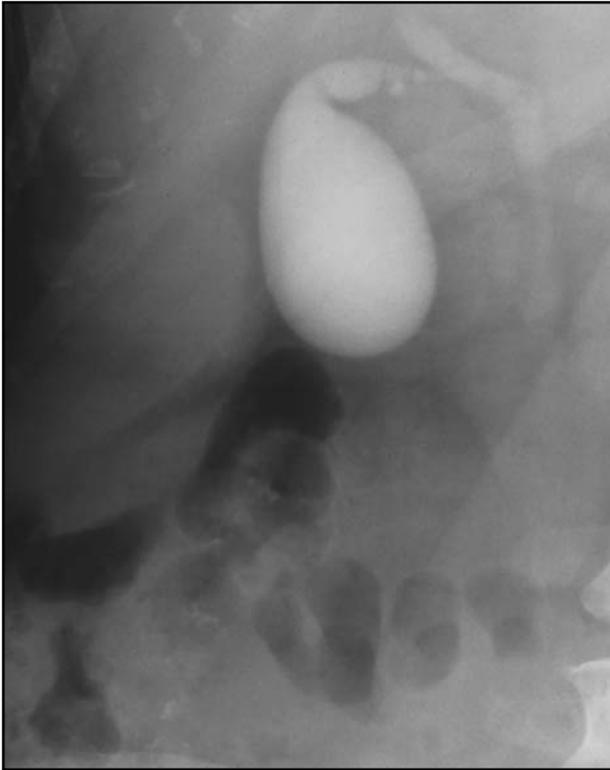
Gallbladder x rays are diagnostic studies of the gallbladder (GB), a small pear-shaped sac that stores bile and is located under the **liver**. The study involves taking tablets containing iodine compounds a day before the x ray. The tablets are absorbed by the intestine, excreted by the liver and then concentrated in the gallbladder. In some clinics and hospitals the tablets are taken over a two day period, in hope of a better visualization of the gallbladder. This is known as a double-dose oral cholecystogram. This test was once the standard for diagnosing diseases of the GB; however, in recent years it is not often requested due to the advances in diagnostic ultrasound.

Purpose

This test, also known as an oral cholecystogram or OCG, is usually ordered to help physicians diagnose disorders of the gallbladder, such as gallstones, inflammation, and tumors. The test is usually ordered when a gallbladder ultrasound has proved non-diagnostic. It is used in the investigation of patients complaining of upper abdominal **pain** after eating a fatty meal. Obese women over forty with a diet high in fat and low in fiber are at risk for gallstones. This test also measures gallbladder function, since the failure of the organ to visualize can signify a non-functioning or diseased gallbladder. The gallbladder may also not visualize if the bilirubin level is over four, and the study should not be performed under these circumstances. A CT scan, MRI (**magnetic resonance imaging**), or an ERCP (endoscopic retrograde cholangio-pancreatography) would be done instead.

Precautions

The physician must be notified if the patient is pregnant or allergic to iodine. Patients with a history of severe



An x-ray image showing a healthy gallbladder outlined as a sac-like opaque mass. (Science Source/Photo Researchers. Reproduced by permission.)

kidney damage have an increased risk of side effects from this procedure. Ultrasound is commonly used instead of the x-ray examination when gallstones are suspected. Some people experience side effects from the contrast material (iodine tablets), especially **diarrhea**. During preparation for the test, patients should not use any **laxatives**. Diabetics should discuss the need for any adjustment in medication with their physician.

Description

The exam is performed in the radiology department. The iodine tablets are purchased at a pharmacy or supplied by the hospital. The night before the test, patients swallow six tablets (one at a time) with plenty of water. If a double-dose OCG is requested, this will be done over a two day period.

The patient will be asked to put on a hospital gown. The x-ray technologist will take a preliminary or scout film to see if the gallbladder is well visualized. The patient is placed prone with the right side slightly raised to prevent superimposition of the spine. The first film should show all of the right side of the abdomen, from the lateral side of the spine down to the iliac crest (top of

the pelvis). Tall thin patients will need to be turned more since the gallbladder tends to lie lower and closer to the spine than in shorter, heavier patients. If the gallbladder is well seen on the first film, the x-ray technologist or radiologist will take another film coned-down and centered directly on the gallbladder. At least one more film in an upright or a lateral decubitus position will be done, since gallstones tend to sink downward or float in the gallbladder, as compared to a tumor or polyp, which remains in the same position. The gallbladder can displace to a considerably lower position when the patient is upright, so the radiography technologist must take into account the bodily habitus (size and shape) of each individual patient.

The radiologist will review the x-rays and then take a series of coned-down (spot) films of the gallbladder with a **fluoroscope** (a special apparatus that projects the image onto a video monitor to be seen immediately). The radiologist may ask for another film to be taken 30 minutes after a fatty meal. The patient will be given a glass of egg nog or in some instances buttered toast and coffee or tea with cream. This meal will cause the gallbladder to contract and release bile, so the gallbladder should diminish in size on the post-fatty meal film (PFM). Delayed films may be taken if this doesn't occur. The exam usually takes one hour to complete and may be done in a hospital or a clinic that is certified to take x rays.

Preparation

The day before the test, patients are instructed to eat a normal breakfast and lunch and a light fat-free dinner (no fried or fatty foods, cream, milk, or butter). The night before, six Telepaque pills (iodine tablets) are taken one at a time, five minutes apart, with a large glass of water. Only water or juice is permitted until midnight. After midnight no food or liquids are allowed until after the exam. In some instances the clinic or hospital may prefer that a double-dose OCG be routinely done. This involves taking the Telepaque tablets over a two-day period. The pills may be taken two at a time with each fat-free meal or all at once, depending on the routine requested by the radiology department.

Aftercare

No special care is required after the study.

Complications

There is a small chance of an allergic reaction to the contrast material. In addition, there is a low level of radiation exposure. X rays are monitored and regulated to provide the minimum amount of radiation exposure

needed to produce the image. Most experts feel that the risk is low compared with the benefits. Pregnant women and children are more sensitive to the risks of x rays, and the risk versus the benefits should be discussed with the treating physician. In some cases diarrhea or vomiting may occur. The x-ray technologist should be informed, since the gallbladder might not be well visualized.

Results

A normal OCG will show a normal gallbladder. The gallbladder should visualize, and be free of any solid structures, such as stones, polyps, or tumors. It should empty freely with no obstruction after the PFM (post-fatty meal).

Abnormal results may show gallstones, tumors, or cholesterol polyps (a tumor growing from the lining that is usually non-cancerous). Typically stones will “float” or move around as the patient changes position, whereas tumors will stay in the same place.

Health care team roles

The radiography technologist works closely with the nurses (if the patient is hospitalized) to make sure the patient is given the Telepaque tablets and follows a fat-free diet. Any diarrhea or vomiting must be noted and the radiology department advised. The x-ray technologist must also be aware of the bilirubin level, which could indicate liver disease and a non-functioning gallbladder. In the case of a high bilirubin level the exam would not be done. All x-ray technologists must be certified and registered with the American Society of Radiologic Technologists or an equivalent association, depending on where the exam is being done.

Patient education

Patients must understand the importance of taking the contrast tablets and following a fat-free diet. All women of child-bearing age should be aware of the dangers of x rays to a fetus, and will be protected as much as possible without obstructing the image of the gallbladder.

Resources

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KEY TERMS

Bile—A yellow-green liquid produced by the liver, which is released through the bile ducts into the small intestines to help digest fat.

Bilirubin—A reddish-yellow pigment formed from the destruction of red blood cells, and metabolized by the liver. Levels of bilirubin in the blood increase in patients with liver disease or blockage of the bile ducts.

Body habitus—The size and shape of a person’s body.

ERCP—An endoscopic retrograde cholangio-pancreatography. A flexible telescope is placed through the nose or mouth into the stomach, upper intestine and then the common bile duct to visualize the GB and pancreas. This is done when there is poor visualization of the gallbladder on an ultrasound examination, CT scan or OCG.

Ultrasound—A noninvasive procedure based on changes in sound waves of a frequency that cannot be heard, but respond to changes in tissue composition. Patients must be fasting for at least six hours but no contrast material is given. There is no radiation used in an ultrasound exam, so it is the exam of choice for the diagnosis of stones in the gallbladder, but is less accurate in diagnosing stones in the bile ducts. Gallstones as small as 2 mm can be identified.

OTHER

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Lorraine K. Ehresman

Gallium scan of the body

Definition

A gallium scan of the body is a diagnostic imaging test that utilizes a radionuclide, Ga67, to detect areas of **infection** and inflammation, or to detect certain types of tumors.

Purpose

In cases where patients have a suspected infection or inflammation, a gallium scan is useful to establish the site of origin, particularly with bone or orthopedic infections, and with such diseases as sarcoidosis. Patients with a chronic infection accompanied with a **fever** of unknown origin are also candidates for a gallium scan. Gallium is also used to localize primary tumors and locate metastases; to diagnose Hodgkin's and other lymphomas; and to determine the stage of a lymphoma. Gallium scans are also performed to follow up patients who have received therapeutic treatment, to demonstrate the regression, progression, or recurrence of disease.

Precautions

Ga67 is radioactive; therefore, patients who are pregnant are cautioned against having this test unless the benefits outweigh the risks. Women who are breastfeeding will need to stop breastfeeding for a specified period of time, usually for several weeks, depending on the dose.

Description

The patient is required to come to the testing facility, usually a hospital nuclear medicine department or outpatient radiology facility, to receive an intravenous injection of the Ga67. After the injection, the patient must return anywhere from six hours to ten days later for the images, depending on the disease or condition being evaluated. The study itself takes approximately one hour, unless a more detailed SPECT (single photon emission computed tomography) is performed, which requires more time. The patient lies on an imaging table while a gamma camera obtains the necessary data to produce an image. In most cases, the camera is moved across the patient's body, or, in the case of a SPECT study, the camera will circle around the body. The camera does not give off radiation, but instead detects the radiation from any areas where the gallium has accumulated. Images are obtained, posteriorly, anteriorly, and sometimes laterally. The camera may occasionally touch the patient but will not cause any discomfort.

KEY TERMS

Gallium—An element whose radioactive form, Ga 67, is used for gallium scans.

Sarcoidosis—A chronic, progressive disease of unknown etiology that can affect almost any organ or tissue.

Preparation

No special preparation is necessary, although some patients may be required to have light or clear meals within a day or less of the procedure. Some patients may need to take **laxatives** or an enema prior to the scan, to eliminate any residual gallium from the bowel.

Aftercare

There is no particular aftercare required.

Complications

There are no complications. There is a minimal risk of exposure to radiation from the Ga67, but the exposure from one gallium scan is generally less than exposure from many common x-ray procedures.

Results

It is normal for the gallium to accumulate in the **liver**, spleen, bones, and large bowel. An abnormal concentration of gallium in areas other than those where it normally concentrates may indicate the presence of disease. Abnormal concentrations may be due to inflammation, infection, or presence of a tumor. Further investigation with ultrasound or CT is usually necessary to confirm the suspicions of abnormal findings, or to distinguish between a malignant and a benign tumor.

Health care team roles

The injection and scan are performed by a nuclear medicine technologist, who is specially trained to handle radioactive materials and to operate the equipment used for this study. The technologist will obtain any pertinent medical history and explain the test to the patient. The technologist processes the data obtained during the scan. A doctor who is a radiologist or nuclear medicine specialist interprets the images and may make recommendations for follow-up tests or for further diagnostic procedures. If the patient is hospitalized during the time in

which the gallium scan is performed, the nursing staff may be needed to administer the enema and, if indicated, to oversee that the patient received a specified diet. The patient receives the results of this test from their personal physician or the doctor who ordered the test.

Resources

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Christine Miner Minderovic, B.S., R.T., R.D.M.S.

Gallstone analysis see **Stone analysis**

Gamete intrafallopian transfer see **Fertility treatments**

Gangrene

Definition

Gangrene is the death of tissue caused by the lack of **blood** supply.

Description

The severity of gangrene is wide-ranging. It can affect a minuscule skin area or a finger or toe, or even an entire limb such as an arm, a foot, or a leg. Gangrene is usually classified into two categories, dry gangrene and wet gangrene.

Dry gangrene

Dry gangrene occurs when a portion of bodily tissue dies because its blood supply has been decreased or completely cut off. This type of gangrene will not spread to other healthy tissue, and **infection** is not present. It is usually a slow process, with the affected area gradually becoming cold, discolored, and eventually totally black. Shrinkage and withering away of the affected tissue occurs as the tissue dies.

Wet gangrene

Dry and wet gangrene are two terms often applied to different phases of the same death of tissue. Wet gangrene (also called moist gangrene) occurs when dry gangrene becomes infected, often due to injury, and the infection causes the tissue to die.

In the United States, approximately 50% of moist gangrene cases are the result of a severe traumatic injury; 40% occur following surgery. Car and industrial accidents, crush injuries, and gunshot **wounds** are the most common traumatic causes. Because of prompt surgical management of wounds with the removal of dead tissue, the incidence of gangrene from trauma has significantly diminished. Surgeries involving the bile ducts or intestine are the most frequent procedures causing gangrene. Approximately two-thirds of cases affect the extremities, and the remaining one-third involve the abdominal wall.

One particularly dangerous type of wet gangrene is termed gas gangrene, or myonecrosis. This particular type is caused by the infection of injured tissue or surgical wounds from the *Clostridium* species of **bacteria**, an especially virulent pathogen. In anaerobic conditions, that is, conditions in which oxygen levels are low, *Clostridium* can rapidly produce poisonous substances called toxins that cause tissue to die. Four of the *Clostridium* toxins, Alpha, Beta, Epsilon, and Iota, are capable of causing death.

Gas gangrene differs from other wet gangrenes because it is more involved with muscle than skin tissue. Not only do the toxins manufactured by *Clostridium* cause the death of tissue, but they also destroy blood cells, constrict **blood vessels**, thus decreasing circulation, and damage blood vessels so that they leak. Fortunately, in peacetime, and with improvements in medical care, gas gangrene is not a frequently occurring phenomenon. (It occurs in only between one and three thousand people in the United States each year.) However, in the past, in wartime, gas gangrene has killed literally millions.

Causes and symptoms

Dry gangrene

Some of the most common causes of dry gangrene include:

- arterial obstruction, or occlusion of an artery, caused by arteriosclerosis, **diabetes mellitus**, **AIDS** or blood clot
- severe blunt trauma to a part of the body causing damage and therefore obstruction of an artery



A close-up of gangrene in the toes of a diabetic patient.

(Photo Researchers, Inc. Reproduced by permission.)

- frostbite, which occurs when tissue becomes so cold that it is literally deprived of blood and therefore oxygen, and dies
- diseases that affect the blood vessels, and especially the arteries, such as Buerger's disease or Raynaud's disease
- traumatic occurrences such as crushing injuries, **fractures**, **burns**, and even injections given into skin or muscle

Wet gangrene

Causative organisms for wet gangrene infection include:

- *Streptococcus*
- *Staphylococcus*

A serious but rare form of infection with Group A *Streptococcus* can impede blood flow and, if untreated, can progress to gangrene caused by chemical reaction. This type of gangrene is more commonly called necrotizing fasciitis, or infection of the skin and tissues directly beneath the skin.

Gas gangrene, the most serious form of wet gangrene, often is caused by *Clostridium* bacteria, which are normal inhabitants of the gastrointestinal, respiratory, and female genital tracts. They often infect thigh amputation wounds, especially in those individuals who have lost control of their bowel function (incontinence). Gangrene, incontinence, and debility are often combined in patients with diabetes, and it is in the amputation stumps of diabetic patients that gas gangrene often occurs.

Areas of either dry or moist gangrene are initially characterized by a red line on the skin that marks the border of the affected tissues. The onset of dry gangrene is normally characterized by dull, aching **pain** at the site. The skin usually develops an abnormal, unhealthy-

appearing pallor and is cold to the touch. As tissues begin to die, dry gangrene may continue to cause some pain; but it may go unnoticed, especially in the elderly or in those individuals with diminished sensation to the affected area. As more tissue dies, its color changes to brown, and finally purplish-black. This dead tissue will gradually separate from the healthy tissue and fall off.

Gas gangrene has a dramatically sudden, rapid onset. It is frequently first noticed as a marked swelling and either a pallid or brownish-red colored area surrounding the wound site. The borders of the infected site can expand literally within minutes. Symptoms of gas gangrene include:

- edema, or swelling, at the injury site that expands quickly
- pain in the area surrounding the skin injury
- *crepitus*, a bubbly, crackling sound often heard upon palpation
- pallor at the injury site, then increasingly dusky discoloration
- low-grade to moderate temperature elevation
- tachycardia, or increased **heart** rate
- diaphoresis, or clammy, sweaty skin
- formation of blisters filled with rust-colored fluid
- wound drainage, foul-smelling and rusty or bloody in appearance
- in severe cases, **shock** (Symptoms of shock include generalized pallor, hypotension, rapid pulse, and cold hands and feet.)

Diagnosis

A diagnosis of gangrene is based on a combination of the patient history, a **physical examination**, and the results of blood and other laboratory tests. A physician will look for a history of recent trauma, surgery, **cancer**, or chronic disease. Blood tests will be used to determine whether infection is present and determine the extent to which an infection has spread.

A sample of drainage from a wound, possibly obtained through surgical exploration, may be cultured with oxygen (aerobic) and without oxygen (anaerobic) to identify the microorganism causing the infection and to aid in determining which antibiotic will be most effective. A gangrenous sample will contain few if any white blood cells and, when stained (with **Gram stain**) and examined under the **microscope**, will show the presence of purple (Gram-positive) rod-shaped bacteria.

X ray studies and more sophisticated imaging techniques, such as computed tomography scans (CT) or **magnetic resonance imaging** (MRI), may be helpful in making a diagnosis, since gas accumulation and muscle death (myonecrosis) may be visible. These techniques, however, are not sufficient alone to provide an accurate diagnosis of gangrene.

Precise diagnosis of gas gangrene often requires surgical exploration of the wound. During such a procedure, the exposed muscle may appear pale, beefy-red, or in the most advanced stages, black. If infected, the muscle will fail to contract with stimulation, and the cut surface will not bleed.

Treatment

Gas gangrene is a potentially lethal condition requiring immediate action. It is recommended that anyone having any or all of the symptoms of gas gangrene contact a health provider immediately. Generally, once a diagnosis of gas gangrene is made, infected, gangrenous tissue must be removed surgically. To assure its complete removal, it is often necessary to remove all tissue surrounding the infection or even to amputate a portion of the body. Aggressive use of **antibiotics**, usually intravenously to start, is also begun as soon as possible. Pain medication will also usually be necessary.

Areas of dry gangrene that remain free from infection (aseptic) in the extremities are most often left to wither and fall off. Treatments applied to the wound externally (topically) are generally not effective without adequate blood supply to support wound healing. Assessment by a vascular surgeon, along with x rays to determine blood supply and circulation to the effected area, can help determine whether surgical intervention would be beneficial.

Once the causative organism has been identified, moist gangrene requires the prompt initiation of intravenous, intramuscular, and/or topical broad-spectrum antibiotic therapy. In addition, the infected tissue must be removed surgically (debridement), and amputation of the affected extremity may be necessary. Pain medications (**analgesics**) are prescribed to control discomfort. Intravenous fluids and, occasionally, blood transfusions are indicated to counteract shock and replenish red blood cells and electrolytes. Adequate hydration and **nutrition** are vital to wound healing.

Although still controversial, some cases of gangrene are treated by administering oxygen under pressure greater than that of the atmosphere (hyperbaric) to the patient in a specially designed chamber. The theory behind using hyperbaric oxygen is that more oxygen will

dissolve in the patient's bloodstream, and therefore more oxygen will be delivered to the gangrenous areas. By providing optimal oxygenation, the body's ability to fight off the bacterial infection is believed to be improved, and there is a direct toxic effect on the bacteria that thrive in an oxygen-free environment. Some studies have shown that the use of hyperbaric oxygen produces marked pain relief, reduces the number of amputations required, and reduces the extent of surgical debridement required. Patients receiving hyperbaric oxygen treatments must be monitored closely for evidence of oxygen toxicity. Symptoms of this toxicity include slow heart rate; profuse sweating; ringing in the ears; shortness of breath; nausea and vomiting; twitching of the lips, cheeks, eyelids, nose; and convulsions.

The emotional needs of the patient suffering from gangrene are also a large component of treatment. The individual with gangrene should be offered moral support, along with an opportunity to share questions and concerns about changes in body image. In addition, particularly in cases where amputation is required, physical, vocational, and rehabilitation therapy will also be required.

Prognosis

Except in cases where the infection has been allowed to spread through the blood stream, as in the case of severe gas gangrene, prognosis for survival is generally favorable. Anaerobic wound infection can progress quickly from initial injury to gas gangrene and the spread of the infection to the blood stream within one to two days. Between 20 and 25% of gas gangrene victims do not survive. If recognized and treated early, however, approximately 80% of patients survive, and only 15 to 20% require any form of amputation. Unfortunately, the individual with dry gangrene most often has multiple other health problems that complicate recovery, and it is usually these health problems that can prove fatal.

Health care team roles

- In most cases, gangrene is discovered while the patient is still in a healthcare facility following trauma, surgery, or treatment of serious medical conditions. A diagnosis of gangrene is generally made by a primary care physician or surgeon.
- Both registered nurses (RNs) and licensed practical nurses (LPNs) must complete a prescribed course in nursing and pass a state examination. RNs typically have a degree in nursing. Both RNs and LPNs care for patients afflicted by gangrene both in general hospitals,

KEY TERMS

Aerobic—A type of organism that grows and thrives only in environments containing oxygen.

Anaerobic—A type of organism that grows and thrives in an oxygen-free environment.

Arteriosclerosis—Build-up of fatty plaques within the arteries that can lead to the obstruction of blood flow.

Aseptic—Without contamination with bacteria or other microorganisms.

Crepitus—A crackling sound.

Gram stain—A staining procedure used to visualize and classify bacteria. The Gram stain procedure allows the identification of purple (Gram-positive) organisms and red (Gram-negative) organisms.

Hyperbaric oxygen—Medical treatment in which oxygen is administered in specially designed chambers under pressures greater than that of the atmosphere in order to treat specific medical conditions.

Incontinence—A condition characterized by the inability to control urination or bowel functions.

Myonecrosis—The destruction or death of muscle tissue.

Sepsis—The spreading of an infection in the bloodstream.

Thrombosis—The formation of a blood clot in a vein or artery that may obstruct local blood flow; or may dislodge, travel downstream, and obstruct blood flow at a remote location.

homes, or other healthcare facilities. Good nursing care and observation are primary requirements. These will include taking **vital signs**, monitoring surgical wounds or injuries for signs and symptoms of infection, providing aseptic (germ-free) treatment to wounds and injuries, collecting specimens of wound drainage to be tested, and making all efforts necessary to keep the patient as comfortable as possible. Education about the underlying cause of the gangrene (diabetes, infection, etc.) is an important aspect of caring for these patients.

- Clinical laboratory scientists have specialized training and must pass a state examination. They do the necessary tests on wound drainage specimens to determine the organism involved in the infection.

- Radiologic technologists have specialized training and must pass a state examination. They take X rays and other tests to visualize and monitor the course of the gangrene.
- Physical therapists must complete a prescribed course and pass a state examination in order to be licensed. Typically they have a degree. Physical therapists work with patients that have sustained an amputation because of gangrene to maintain and maximize mobility in walking, wheelchair use, and transferring (from wheelchair to toilet or from standing to sitting, for example). The physical therapist advises on such mobility aids as wheelchairs, braces, and canes.
- Social workers have a degree in social work. A social worker may help coordinate services and ease the transition out of the hospital back into the home or extended care facility, if necessary. Social workers may help counsel the patient and the family during the difficult rehabilitation period.
- Occupational therapists must complete a prescribed course and pass a state examination in order to be licensed. Typically they have a degree. They help people disabled after an amputation or loss of function caused by gangrene to relearn necessary functions needed to carry out normal activities of daily living such as bathing, dressing, and preparing meals.

All healthcare team members need to be aware that the person with gangrene, and possibly an amputation, and the family members who may care at home for the person will need to learn an entirely new set of skills and adaptations. Both the patient and family often experience **stress, anxiety**, and depression. Both may need teaching regarding both physical and mental symptoms that often follow gangrene or amputation, and the family may need to be taught how to deliver necessary care. For the patient with gangrene, finding other individuals or a support group composed of people that have had similar illness or injury can be one of the most important steps in the rehabilitation process.

Prevention

Patients with diabetes or severe arteriosclerosis need to take particular care of their hands and feet because of the risk of infection associated with even a minor injury. Education about proper **foot care** is vital. Diminished blood flow as a result of narrowed vessels will not lessen the body's defenses against invading bacteria. Measures taken towards the reestablishment of circulation are recommended whenever possible. Any abrasion, break in the skin, or infected tissue should be cared for immedi-

ately. Any dying or infected skin must be removed promptly to prevent the spread of bacteria.

Penetrating abdominal wounds should be surgically explored and drained, any tears in the intestinal walls closed, and antibiotic treatment begun early. Patients undergoing elective intestinal surgery should receive preventive antibiotic therapy. Use of antibiotics prior to and directly following surgery has been shown to significantly reduce the rate of infection from 20-30% to between 4 and 8%.

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Joan M. Schonbeck

Gas embolism

Definition

Gas embolism, also called air embolism or arterial gas embolism, is the presence of gas bubbles in the bloodstream that obstruct circulation.

Description

Gas embolism may occur with decompression from increased pressure. It typically occurs in ascending divers who have been breathing compressed air. If a diver does not fully exhale upon ascent, the air in the **lungs** expands as the pressure decreases, overinflating the lungs and forcing bubbles of gas (emboli) into the bloodstream. When gas emboli reach the arteries to the **brain**, the **blood** blockage causes unconsciousness. Gas embolism is second only to drowning as a cause of death among divers.

In rare cases, gas embolism may also result from trauma or medical procedures, such as catheterization

and open **heart** surgery, that allow air into the circulatory system.

Sometimes, the term "the bends" is used to describe any manifestation of **decompression sickness**, including gas embolism. Specifically, the bends refers to a condition caused by dissolved nitrogen leaving the tissues too quickly on ascent during a dive. It is manifested by **pain**, often in the limbs and joints.

Causes and symptoms

Gas embolism occurs independently of diving depth. It may occur in as little as 6 ft (2 m) of water if the swimmer has access to a source of air and takes even one breath underwater. Gas embolism is frequently caused when divers hold their breath during ascent. It may also result from an airway obstruction or other condition that prevents a diver from fully exhaling.

The primary sign of gas embolism is immediate loss of consciousness, which may or may not be accompanied by convulsions.

Diagnosis

Any unconscious diver should be assumed to be the victim of gas embolism, regardless of whether consciousness was lost during or promptly after ascent. A doctor may also find pockets of air in the victim's chest around the lungs and, occasionally, a collapsed lung from overinflation and rupture. Coughing up blood or a bloody froth around the mouth are visible signs of lung injury.

Treatment

Prompt recompression treatment in a hyperbaric (high-pressure) chamber is necessary to deflate the gas bubbles in the bloodstream, dissolve the gases into the blood, and restore adequate oxygenated blood flow to the brain and other organs. Transport to a suitable recompression chamber should take precedence over nonessential procedures.

Recompression by returning the diver to deeper water will not work, and should not be attempted. The patient should be kept lying down and given oxygen while being transported for recompression treatment.

Before the diver receives recompression treatment, other lifesaving efforts may be necessary. If the diver is not breathing, artificial respiration (also called mouth-to-mouth resuscitation or rescue breathing) should be administered. In the absence of a pulse, **cardiopulmonary resuscitation (CPR)** must be performed.

KEY TERMS

Compressed air—Air that is held under pressure in a tank to be breathed underwater by divers.

Compression—An increase in pressure from the surrounding water that occurs with increasing diving depth.

Decompression—A decrease in pressure from the surrounding water that occurs with decreasing diving depth.

Emboli—Plural of embolus. An embolus is an object that blocks the blood flow in a blood vessel, as in a gas bubble, a blood clot, a fat globule, a mass of bacteria, or other foreign body.

Hyperbaric chamber—A sealed compartment in which patients are exposed to controlled pressures up to three times normal atmospheric pressure. Hyperbaric treatment may be used to regulate blood gases, reduce gas emboli, and provide higher levels of oxygen more quickly in cases of severe gas poisoning.

Recompression—Restoring the elevated pressure of the diving environment to treat gas embolism by decreasing bubble size.

Prognosis

The prognosis is dependent upon the promptness of recompression treatment and the extent of the damage caused by oxygen deprivation. Gas embolism may cause a stroke.

Health care team roles

A gas embolism is an emergency situation. Any unconscious diver should be assumed to be the victim of gas embolism. Maintaining air supply is the most crucial step, and artificial respiration or CPR should be administered as needed. Fluids should be administered, either orally if the patient is conscious, or intravenously.

Prevention

All divers should receive adequate training in the use of compressed air and a complete evaluation of fitness for diving. People with a medical history of lung cysts or spontaneous collapsed lung (pneumothorax), and those with active **asthma** or other lung disease, must not dive, for they would be at extreme risk for gas embolism. Patients with such conditions as **alcoholism** and drug

abuse are also discouraged from diving. Individuals with certain other medical conditions, such as diabetes, may be able to dive safely with careful training and supervision.

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ORGANIZATIONS

American College of Hyperbaric Medicine. P.O. Box 25914-130, Houston, TX 77265. (713) 528-0657. <<http://www.hyperbaricmedicine.org>>.

Divers Alert Network. The Peter B. Bennett Center, 6 West Colony Place, Durham, NC 27705. (919) 684-8111. (919) 684-4326 (diving emergencies). (919) 684-2948 (general information). <<http://www.diversalertnetwork.org>>.

Undersea and Hyperbaric Medical Society. 10531 Metropolitan Avenue, Kensington, MD 20895. (301) 942-2980. <<http://www.uhms.org>>.

Jennifer F. Wilson

Gas exchange

Definition

Gas exchange is the process by which oxygen is transferred from the atmosphere to bodily tissues for use in **metabolism**; and the gas produced by metabolism, carbon dioxide, is transferred from tissues to the atmosphere.

Description and function

Overview of gas exchange

The process of gas exchange has several steps. The following is a summary of the steps:

- ventilation (breathing)
- interchange of CO₂ and O₂ between air in the lungs' alveoli and **blood** in lung capillaries by diffusion
- transport of CO₂ and O₂ through the bloodstream

- interchange of CO₂ and O₂ between blood in lung capillaries and alveolar air by diffusion
- use of O₂ and production of CO₂ by cells through metabolism

Ventilation

The transfer of oxygen from the atmosphere to the tissues starts with the inspiration of air into the **lungs**. The lungs consist mainly of tiny air-containing alveolar sacs. The alveoli are small hollow sacs connecting to the larger terminal bronchioles of the airways. The air adjacent to the surfaces of the alveolar wall are lined by a single cell layer of flat epithelial cells called type I alveolar cells. In between these type I cells are thicker and more rounded type II alveolar cells, which produce a detergent-like fluid. In the alveolar walls, the fluid and connective tissue fills the interstitial space and is interspersed with capillaries. In some places the interstitial space is nonexistent, and the epithelial **cell membranes** are in direct contact with the capillaries. The blood in the capillaries is separated from the air molecules by a single layer of flat epithelial cells. The surface area in a single alveolus, because of the undulating terrain of type I and II epithelial cells, is roughly the size of a medium-sized room. There are around 300 million alveoli in the adult male. Therefore, there is a large amount of surface area placing air and the blood stream in close proximity. This trait is needed for gas exchange to easily occur. The **respiratory system** also needs a continual supply of fresh air. This air is supplied to the lungs through the nose and mouth, trachea, and bronchi. Ventilation is the interchange of air between the atmosphere and the alveoli by bulk flow. Bulk flow is the movement of air from a region of high pressure to one of low pressure.

The physics of gas exchange

In order to understand why oxygen and carbon dioxide are able to diffuse from their respective areas of high concentration, Dalton's Law must first be presented. It states that in a mixture of gases, the pressure exerted by each gas is independent of the pressure exerted by the others. It is why carbon dioxide can move out of the bloodstream while oxygen is diffusing into the blood stream. The concentration of oxygen (O₂) will not affect the activity of carbon dioxide (CO₂).

Henry's law explains why CO₂ can move from the blood stream into the airspace of the lung, and O₂ can move from that airspace into the bloodstream. It states that the amount of gas dissolved will be directly proportional to the partial pressure of the gas with which the liquid is in equilibrium. At equilibrium, the partial pressures of the gas molecules in liquid and gaseous phases must be identical. Elemental gas can move from air into or out of a liquid where there is a pressure difference.

Interchange

During inspiration, the partial pressure of oxygen (PO₂) in the lung (105 mmHg) is higher than that in the arteries of the alveoli (40 mmHg). This pressure difference allows O₂ to transfer into the blood stream. The partial pressure of carbon dioxide (PCO₂) in the lung (40 mmHg) is less than the arterial partial pressure of the alveoli (46 mmHg). This pressure difference allows carbon dioxide to diffuse into the lung and eventually into the atmosphere. The ventilation of the lungs allows for the continual renewal of imbalance and need for breathing and metabolism to continue.

Transport

The circulatory system continually supplies blood in need of oxygenation and the ventilation of CO₂ to the lungs. It arrives in the lungs with a PO₂ of 40 mmHg and a CO₂ of 46 mmHg and leaves the lungs with a PO₂ of 100 mmHg and a CO₂ of 40 mmHg. From the lungs, the oxygenated blood travels through the pulmonary veins to the left side of the **heart** and into the systemic arteries. The blood eventually flows to the tissue capillaries where another pressure difference occurs.

Use and transport

At the capillaries the PO₂ is 100 mmHg and the PCO₂ is 40 mmHg. In the tissues the PO₂ is less than 40 mmHg and the PCO₂ is greater than 46 mmHg. The O₂ in the capillaries diffuses into the tissue and the CO₂ produced by metabolism comes into the capillaries. Deoxygenated blood travels from the tissues to the right side of the heart via the systemic veins and then returns to the lungs for more O₂ through the pulmonary arteries, where the process begins again.

Hemoglobin

Each liter of oxygenated blood normally contains 200 ml of pure gaseous O₂ at atmospheric pressure (760 mmHg). It exists in the blood stream dissolved in the plasma and erythrocyte water or combined with hemoglobin molecules in the erythrocytes.

Oxygen is relatively insoluble in water and only 3 ml will be dissolved in one liter of blood at the arterial partial pressure of 100 mmHg. It is consistent with Henry's law because the amount of O₂ dissolved in the blood is directly proportional to the partial pressure of the blood. This leaves another 197 ml of O₂ in need of a way to be dissolved in the blood stream.

The hemoglobin molecule is a protein with four subunits. Each subunit is made up of a heme (a molecular group) with a polypeptide attached. Heme contains one

KEY TERMS

Chemoreceptor—A type of cell activated by a change in its chemical balance that results in a nerve impulse.

Metabolism—The sum of physical and chemical changes in the tissue including anabolism, catabolism, energy production and synthesis of molecules.

Ventilation—Movement of gases into and out of the lungs; tidal exchange between the lungs and the atmosphere.

atom of **Iron** (Fe) to which one O₂ molecule can bind. This means that every hemoglobin molecule can bind four O₂ molecules. The four polypeptides in hemoglobin are called globin. With O₂ attached to the molecule, it is known as oxyhemoglobin (HbO₂) and without it is known as deoxyhemoglobin (Hb). The bonding of O₂ to hemoglobin allows a full 200 ml of O₂ to dissolve completely in the blood. In reference to Dalton's law it allows for a greater difference in the concentration of O₂ between the O₂ in the lung and the bloodstream, and the blood. The O₂ tied up by the hemoglobin cannot be considered when looking at concentration differences. Conversely the concentration difference between the tissues and the capillaries at the tissue level causes the O₂ to dissociate from the hemoglobin, leaving the O₂ free to diffuse into tissue and the hemoglobin free to bond to the carbon dioxide leaving the tissue. By tying up carbon dioxide with hemoglobin, even more CO₂ can be carried to the lungs by the blood.

CO₂ is far more soluble in water than O₂. Only ten percent of the carbon dioxide that enters the blood is dissolved in water. Thirty percent of the carbon dioxide bonds with hemoglobin to form carbaminohemoglobin. Sixty percent of the carbon dioxide is converted to bicarbonate.

Deoxyhemoglobin serves as a buffer in the bloodstream as well. It has an affinity for acidic hydrogen atoms left in the bloodstream by the formation of bicarbonate. This allows the blood to maintain a pH of around 7.4 and explains why even venous blood maintains this pH.

Regulation of gas exchange

The exchange of gases in the body will occur with the respective differences of partial pressure between the blood and tissues, and the lung and alveoli. Respiratory rate must be controlled in order to suit the O₂ needs of the

body and ensure a balanced supply of O₂ to the tissues. Respiratory rate is controlled by the peripheral chemoreceptors located high in the neck, where the common carotid arteries split, as well as on the arch of the aorta. They are called carotid bodies and aortic bodies respectively. These chemoreceptors are stimulated by the minor elevation of PCO₂ levels, causing an increase in ventilation. Chemoreceptor response to the PCO₂ level in the blood is the primary and most immediate indicator of gas deficiency and surplus in the blood stream. Elevated levels of PCO₂ normally cause an increase in breathing, and lower levels normally cause a decrease. This response system allows for a balance of gases available for use in metabolism.

Conversely, a decrease in arterial PO₂ levels and an increase in blood acidity do not affect a minimal increase in ventilation stimulated by chemoreceptors until PO₂ goes below 60 mmHg. Oxygen transport at the tissues will not be reduced until the blood PO₂ reaches 60 mmHg. Thus, the chemoreceptors are not triggered for lack of PO₂ in normal circumstances. If there is lung disease, or in high altitudes, these receptors can be stimulated and will affect an increase in the respiratory rate.

Role in human health

Gas exchange provides a needed fuel (O₂) for metabolism to occur and a means to expel the gaseous byproduct (CO₂) of metabolism from the body. Without gas exchange the body would not function. The hindrance of gas exchange by disease, disorder, or chemicals can slow body functions and even cause death.

Common diseases and disorders

The interference of gas exchange occurs when the function of a number of different organs and tissues is impaired. The most common form of impairment to gas exchange is hypoxia, which is the lack of oxygen in the tissues. Hypoxia can be caused by hypoventilation, diffusion impairment, shunt, and or ventilation-perfusion (the rate of ventilation relative to CO₂ production) inequality.

Hypoventilation is the reduced alveolar ventilation in comparison to the metabolic CO₂ production in which the PCO₂ levels increase above normal. It is caused by disease in the lung, abnormalities in the thoracic cage, or deficits in the respiratory control pathway from the medulla to the chemoreceptors.

Diffusion impairment occurs when there is a decrease in the surface area or thickening of the alveolar membranes. Diseases or disorders in the lung can cause this impairment.

Asthma is an intermittent disease characterized by a chronic inflammation of the airway, which causes smooth **muscle contraction** in the airway.

Chronic obstructive pulmonary disease (COPD) refers to **emphysema**, chronic bronchitis or a combination of the two. Cigarette smoking is a major cause of this and the following diseases associated to COPD. Chronic bronchitis is characterized by excessive mucus production in the bronchi and chronic inflammatory changes in the small airways. Emphysema is a major cause of hypoxia and is characterized by the destruction of the alveolar walls, and the atrophy and collapse of the lower airways. **Pneumonia** is normally caused by bacterial or viral **infection**. The alveolar spaces fill with mucus, inflammatory cells, and fibrin.

Other disorders that impact gas exchange are hyperventilation, in which ventilation is increased relative to the metabolic CO₂ production, and in which the PCO₂ drops below normal levels; and the effects of high altitude (called altitude sickness), in which the lack of O₂ in the atmosphere causes the body to compensate for that deficiency.

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Gas gangrene see **Gangrene**

Gas laws

Definition

The gas laws are mathematical formulations of the interrelationships among the four variables that describe the behavior of a gas sample: its volume (V), pressure

(P), temperature (T), and the amount (n) of gas present (see Gases, properties of).

The **properties of gases** were already being studied and described as early as the seventeenth century. Unlike solids, which have a fixed shape and volume, and liquids, which have a fixed volume but can change shape according to the container, gases assume both the shape and the volume of their container. The volume of space occupied by a sample of gas depends on the number of gas molecules present and the sample's pressure and temperature.

Simple gas laws

Boyle's law: volume is inversely proportional to pressure

Boyle's law, formulated by English scientist Robert Boyle in 1662, states that the pressure of a fixed amount of gas at a constant temperature is inversely proportional to its volume. In other words, when a sample of gas is allowed to expand to occupy a larger volume, its pressure decreases; and when it is compressed into a smaller volume, its pressure increases. Mathematically, this inverse relationship may be formulated:

$$P_1V_1 = P_2V_2$$

or

$$V = \text{constant} \div P$$

In continental Europe, this gas law is known as the law of Mariotte, after Edme Mariotte, who published the results of his studies of the properties of gases a few years later than Boyle.

The working of a syringe can be used to illustrate Boyle's law. When the plunger of a syringe is drawn back, the volume of the air inside the syringe barrel is increased and the pressure decreased relative to the exterior of the syringe, and fluid is pulled into the syringe. When the plunger is depressed, the volume is decreased, the pressure increased, and fluid is forced out.

Charles's law: volume is directly proportional to temperature

Charles's law, which was formulated by French physicist Jacques Charles in 1787, states that the volume of a sample of gas kept at constant pressure is directly proportional to the temperature; or, more simply stated, a gas sample will expand upon heating and contract when cooled. This may be formulated mathematically as:

$$V_1 \div T_1 = V_2 \div T_2$$

or

$$V = \text{constant} \times T$$



Charles's law states that the temperature and volume of a gas are directly related under constant pressure conditions. This demonstration shows the volume of air in the balloons decreasing (balloons shrinking) when they are held in a flask of liquid nitrogen (cooled), and re-expanding when the air in the balloons is allowed to warm to room temperature. (Photograph by Charles D. Winters. Science Source/Photo Researchers. Reproduced by permission.)

A hot air balloon demonstrates the principle of Charles's law. When the balloon is fired, the air is heated and expands to fill the balloon.

Gay-Lussac's law: pressure is directly proportional to temperature

This gas law, published in 1802 by Frenchman Joseph Louis Gay-Lussac, describes the relationship between the gas's pressure and temperature. At constant volume, the pressure of a gas sample is directly proportional to its temperature. In other words, a sample of gas exerts more pressure on its surrounding container when hot than when cold. The mathematical formulation of this law is

$$P_1 \div T_1 = P_2 \div T_2$$

or

$$P = \text{constant} \times T$$

Avogadro's law: volume is directly proportional to amount

In the early nineteenth century, the Italian Count Amadeo Avogadro hypothesized that different gases of

equal volume at a given temperature and pressure contain equal numbers of gas molecules. Alternatively, samples of two different gases containing the same number of molecules will occupy equal volumes. Avogadro's law mathematically formulated is:

$$V_1 \div n_1 = V_2 \div T_2$$

or

$$V = \text{constant} \times n.$$

At standard temperature and pressure (STP), one mole of any gas occupies 22.4 L.

As an example of the law of Avogadro, consider that, during respiration, the amount of air in the **lungs** is alternately increased and decreased by the movement of the diaphragm that causes the volume of the lungs to be alternately increased and decreased.

It should be noted that all gaseous substances behave alike according to these laws. Also, in each of the formulations above, the proportionality constant has a different meaning and is expressed in different units. Moreover, in calculations, temperature must be expressed in terms of the Kelvin, or absolute, temperature scale.

Ideal gas law

The ideal gas law, first derived in 1834 by Emil Clapeyron, compiles the simple gas laws into a single expression with a single constant, called the ideal gas law:

$$PV = nRT$$

The single constant R is called the universal gas constant. The value of the constant depends on the units used to express pressure and volume. The standard units for measuring volume, pressure, amount, and temperature are, respectively, the liter (L), the atmosphere (atm), the mole (mol), and Kelvin (K), giving rise to the value $R = 0.082$ liter atm mol⁻¹ K⁻¹.

All of the relationships established by the simple gas laws are preserved in the expression of the ideal gas law:

- The volume of a gas is inversely proportional to its pressure.
- The volume of a gas is directly proportional to its temperature.
- The pressure of a gas is directly proportional to its temperature.
- The volume of a gas is directly proportional to the amount of gas present.

An ideal, or perfect, gas is a hypothetical gas that obeys the gas laws in terms of its pressure, volume, and temperature behavior. Such a gas would have to be composed of molecules that do not interact with one another.

Real gases are not always accurately described by the ideal gas equation. Under ordinary conditions, however, the observed behavior of a real gas is only negligibly different from that predicted for an ideal gas.

Dalton's law of partial pressures

The simple and ideal gas laws describe the behavior of pure gaseous substances. Mixtures of gases also behave like ideal gases, provided the different components do not undergo a reaction, or interact in some other way. This concept—that each individual gas in a mixture expands to exert its partial pressure as if the other gas components were not present—was developed by John Dalton in 1801 and is known as Dalton's law of partial pressures.

Given that the pressure of a gas is directly related to the number of moles of gas present, and that all gases behave alike, it follows that the total pressure exerted by a mixture of gases is equal to the sum of the pressures of each of the components of the gas mixture. The pressure exerted by a component gas in a mixture is referred to as the partial pressure of that gas. Thus, for a mixture of gases, A, B,...,

$$P_{\text{tot}} = P_A + P_B + \dots$$

Each component gas experiences the same temperature and volume conditions as all other components. Application of the ideal gas equation to each pressure term allows formulation of a useful term known as the mole fraction (X) of a gas. The mole fraction is defined as the ratio of the number of moles of one component to the total number of moles of gas in the mixture, which is equal to the ratio of the partial pressure to the total pressure ($X_A = n_A \div n_{\text{tot}} = P_A \div P_{\text{tot}}$).

$$V = n_A RT$$

Gay-Lussac's law of combining volumes

In 1808, Gay-Lussac, in collaboration with Alexander von Humbolt, studied the reactions of gases. They determined that, at a given temperature and pressure for the reactions involving gaseous substances, the volumes of the reactant and product gases are in ratios of small whole numbers. For example, two volumes of hydrogen gas react with one volume of oxygen gas to form two volumes of water vapor.

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Celsius (centigrade) and Kelvin temperature scales—On the Celsius scale, the temperature at which water freezes is defined as zero degrees and the temperature at which water boils is defined as 100°. The Kelvin scale is the official temperature scale of the International System of Units (SI), the units preferred by most international scientific agencies. The Kelvin scale is based on the Celsius scale, with zero defined as the temperature at which molecular motion ceases, equal to -273.15°C .

Gas—One of the three physical states in which matter can exist; gaseous matter conforms to the shape and volume of its container.

Mole—An amount of substance containing a number of atoms or molecules equal to Avogadro's constant, 6.022×10^{23} .

Pressure—The force or weight per unit area exerted by matter on its surroundings. For calculations involving gas properties, pressure is usually measured in atmospheres (atm); other units of pressure include lb/in.², bar, torr, and mm mercury.

Standard conditions of temperature and pressure (STP)—For gases, standard conditions are 0°C and 1 atm.

Volume—The three dimensional space occupied by a substance, measured in liters (l).

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Gases, properties of

Definition

The fundamental physical properties of a gas are related to its temperature, pressure, and volume. These properties can be described and predicted by a set of equations known as the **gas laws**. While these laws were originally based on mathematical interpretations for an ideal or perfect gas, modern atomic and kinetic theory of gases has led to a modified expression that more accurately reflects the properties of real gases.

Description

Current understanding of gas properties came as a result of study of the interaction between volume, pressure, and temperature. Robert Boyle was the first to describe the relationship between the volume and pressure of a gas. In 1660 he learned that if an enclosed amount of a gas is compressed to half its original volume while the temperature is kept constant, the pressure will double. He expressed this mathematically as $PV = \text{constant}$, where P stands for pressure, V stands for volume, and the value of the constant depends on the temperature and the amount of gas present. This expression is known as Boyle's law.

The second fundamental property of gases was defined by Jacques Charles in 1787. He found that the temperature and volume of a gas are directly related. Charles observed that a number of gases expanded equally as heat was applied and the pressure was kept constant.

Charles's ideas were expanded upon in research by others in the field, most notably Joseph Gay-Lussac, who also studied the thermal expansion of gases. The volume/temperature relationship is known as Charles's law.

The third property of gases was described by Gay-Lussac who, in addition to his work with volume and temperature, researched the connection between pressure and temperature. In 1802, he formulated an additional law. These three laws can be combined into one generalized equation that expresses the interrelation between pressure, temperature and volume. This equation, called the ideal gas law, is written as $PV = nRT$.

While the ideal gas law works very well in predicting gas properties at normal conditions, it does not accurately represent what happens under extreme conditions. Neither does it account for the fact that real gases can undergo phase change to a liquid form. Modern atomic theory helps explain these discrepancies. It describes molecules as having a certain freedom of motion in space. Molecules in a solid material are arranged in a reg-

ular lattice such that their freedom is restricted to small vibrations about lattice sites. Gas molecules, on the other hand, have no macroscopic spatial order, and they can move about their containers at random. The motion of these particles can be described by the branch of physics known as classical mechanics. The study of this particulate motion is known as the kinetic theory of gases. It states that the volume of a gas is defined by the position distribution of its molecules. In other words, the volume represents the available amount of space in which a molecule can move. The temperature of the gas is proportional to the average kinetic energy of the molecules, or to the square of the average velocity of the molecules. The pressure of a gas, which can be measured with gauges placed on the container walls, is a function of the particle momentum, which is the product of the mass of the particles and their speed.

Function

The human body requires certain gases to function. Oxygen and carbon dioxide are respiratory gases that move between the **blood** and air through the **lungs**. Respiratory gases are exchanged between the body and the environment through the mechanisms of convection and diffusion.

Convection is also called mass flow. Convection moves the air from the air in the environment into the lungs. Convection also moves the blood between the body tissues and the lungs. Diffusion moves the oxygen and carbon dioxide across membranes and transports gases between air and blood in the lungs and between blood and respiratory tissues in the body.

Role in human health

The gases in the human body that are most significant are oxygen and carbon dioxide. If the gases are not exchanged in the proper quantities and adequately transported through the body, then both minor and major health problems can result.

Common diseases and disorders

Many common diseases or disorders can affect the adequate exchange of gases throughout the human body. These diseases or ailments can range from severe respiratory diseases, such as **emphysema**, to the **common cold**. Both lung disease and **heart** disease can lead to abnormalities in the composition of **blood gases**. Following is a list of just a few of the diseases or disorders that can cause abnormalities in the exchange of gases in the human body.

KEY TERMS

Ideal gas law—The mathematical expression that predicts the behavior of a “perfect” gas.

Kinetic theory of gases—The physical principles that describe how gas molecules interact.

- emphysema
- chronic obstructive pulmonary disease
- congestive heart failure
- pneumonia

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Gastric analysis

Definition

Gastric analysis consists of a series of tests used to analyze the contents of the **stomach**. The complete series involves:

- collecting residual gastric fluid from a fasting patient
- collecting basal secretions every 15 minutes for four hours
- intramuscular administration of a drug that stimulates gastric acid output
- collecting stomach secretions every 15 minutes for 90 minutes

The appearance, **blood**, bile, pH, volume, millimoles of H⁺ per liter, millimoles of H⁺ per volume, and

millimoles of H⁺ per hour of each specimen is then evaluated.

Purpose

A gastric analysis is performed to evaluate gastric function by measuring the contents of a fasting patient’s stomach for acidity, appearance, and volume. The basal gastric secretion test is indicated for patients with obscure gastric **pain**, loss of appetite, and weight loss. It is also utilized for suspected peptic ulcer, severe **gastritis**, and Zollinger-Ellison (Z-E) syndrome.

The gastric acid stimulation test is indicated when abnormalities are found during the basal secretion test. These abnormalities can be caused by a number of disorders, including duodenal ulcer, pernicious anemia, and gastric **cancer**. While this test will detect abnormalities, x rays and other studies are necessary to obtain a definitive diagnosis.

Precautions

Because both the basal acid output test and the gastric acid stimulation test require gastric intubation through the mouth or nasal passage, neither test is recommended for patients with esophageal problems, aortic aneurysm, severe gastric hemorrhage, or congestive **heart failure**. The gastric acid output test is also not recommended in patients who are sensitive to pentagastrin (the drug used to stimulate gastric acid output).

Description

This test, whether performed for basal gastric acid secretion, gastric acid stimulation, or both, requires gastric intubation by mouth or through the nasal passage.

Basal gastric acid secretion

The patient should be fasting overnight (12 hours) prior to intubation. After allowing approximately 10 to 15 minutes for the patient to adjust to the presence of the tube, and with the patient in a sitting position, specimens are obtained every 15 minutes for a period of 90 minutes. The first two specimens are examined visibly for blood and volume but are discarded to eliminate gastric contents that might be affected by the stress of the intubation process. The patient is allowed no liquids during the test, and saliva must be ejected to avoid diluting the stomach contents.

The final four specimens collected during the test constitute the *basal acid output*. Each sample is titrated to pH 3.5 using 0.1 N sodium hydroxide. The millimoles of hydrogen ion in each sample are calculated from the

KEY TERMS

Achlorhydria—An abnormal condition in which hydrochloric acid is absent from the secretions of the gastric glands in the stomach.

Intubation—Insertion of a tube into a body canal or hollow organ, as into the stomach.

Pernicious anemia—One of the main types of anemia, caused by inadequate absorption of vitamin B₁₂. Symptoms include tingling in the hands, legs, and feet, spastic movements, weight loss, confusion, depression, and decreased intellectual function.

Subcutaneously—Under the skin.

Zollinger-Ellison syndrome—A rare condition characterized by severe and recurrent peptic ulcers in the stomach, duodenum, and upper small intestine, caused by a tumor or tumors, usually found in the pancreas. The tumor secretes the hormone gastrin, which stimulates the stomach and duodenum to produce large quantities of acid, leading to ulceration. Most often cancerous, the tumor must be removed surgically; otherwise total surgical removal of the stomach is necessary.

amount of base used to neutralize the stomach acid of each. The results of the closest three samples are averaged and multiplied by four to give the millimoles of free hydrogen ions per hour. If analysis suggests abnormally low gastric secretion, the maximum acid output test is performed immediately afterward.

Gastric acid stimulation test

After the basal samples have been collected, the tube remains in place for the gastric acid stimulation test. Pentagastrin, or a similar drug that stimulates gastric acid output, is injected subcutaneously. After 15 minutes, a specimen is collected every 15 minutes for one hour. These specimens are called the post-stimulation specimens. As is the case with the basal gastric secretion test, the patient can have no liquids during this test, and their saliva must be ejected to avoid diluting the stomach contents. The maximal acid output (MAO) is determined by titrating each of the four specimens and averaging the results. The average is used to determine the millimoles of hydrogen ion produced per hour. Alternatively, the peak acid output (PAO) is determined by titrating each specimen and using the average hydrogen ion concentra-

tion of the highest two to calculate the acid produced in millimoles per hour.

Analyses and calculations

The appearance, blood, bile, pH, volume, millimoles of H⁺ per liter, millimoles of H⁺ per volume, and millimoles of free H⁺ per hour of each specimen are then evaluated. In addition, the basal acid output (BAO) is computed, as is the maximal acid output (MOA) or peak acid output (PAO). BAO is calculated by averaging the output of the three closest samples. MAO is calculated as the average of the four specimens. PAO is calculated by taking the mean of the two highest post-stimulation values.

Preparation

The patient should be fasting (nothing to eat or drink after the evening meal) on the day prior to the test, but may have water up to one hour before the test. **Antacids**, anticholinergics, cholinergics, alcohol, H₂-receptor antagonists (Tagamet, Pepcid, Acid, Zantac), reserpine, adrenergic blockers, and adrenocorticosteroids should be withheld for one to three days before the test, as the physician requests. If pentagastrin is to be administered for the gastric acid secretion test, medical supervision should be maintained, as possible side effects may occur.

Additionally, because such external factors as the sight or odor of food, as well as psychological stress, can stimulate gastric secretion, accurate testing requires that the patient be relaxed and isolated from all sources of sensory stimulation.

Aftercare

Such complications as nausea, vomiting, and abdominal distention or pain are possible following removal of the gastric tube. If the patient has a **sore throat**, soothing lozenges may be given. The patient may also resume the usual diet and any medications that were withheld for the test(s).

Complications

There is a slight risk that the gastric tube may be inserted improperly, entering the trachea instead of the esophagus. If this happens, the patient may experience difficulty breathing or a coughing spell until the tube is properly inserted. Also, because the tube can be difficult to swallow, if a patient has an overactive gag reflex, there may be a transient rise in **blood pressure** due to **anxiety**. Other complications may include bleeding, dysrhyth-

mias, esophageal perforation, laryngospasm and decreased mean pO₂ (a measure of blood oxygen levels).

Results

Reference values for the basal acid output test and gastric acid stimulation test vary by laboratory, but are usually within the following ranges:

- Fasting volume: 20-100 mL.
- Fasting pH: less than 2.0.
- BAO for men: 0 to 5 mmol/hour.
- BAO for women: 0 to 4 mmol/hour.
- MAO for men: 5 to 26 mmol/hour.
- MAO for women: 7 to 15 mmol/hour.

An abnormal basal acid output is considered non-specific and must be evaluated in conjunction with the results of a gastric acid stimulation test. However, elevated secretion may suggest different types of ulcers; and markedly elevated results may be suggestive of Zollinger-Ellison syndrome. Depressed secretion may indicate a gastric cancer, while complete absence of secretion (achlorhydria) may suggest pernicious anemia.

Elevated gastric secretion levels in the gastric acid stimulation test may be indicative of duodenal ulcer; highest levels of secretion suggest Zollinger-Ellison syndrome, a gastrin-secreting tumor.

Measurement of plasma gastrin by radioimmunoassay is often performed when the gastric acid level is abnormal. Frankly elevated serum gastrin levels occur in pernicious anemia and atrophic gastritis, which are both associated with low gastric acid output; and in Zollinger-Ellison syndrome, which is associated with high gastric acid output. Gastrin levels are not elevated in persons with duodenal ulcers and are normal or slightly increased in persons with gastric ulcers.

Health care team roles

A physician orders the gastric analysis and interprets the results. The testing physician must obtain an accurate patient history, especially to determine if the patient is taking any drugs that can affect the test result and to learn about any recent illness, trauma, or symptoms that could be related to gastric function. The procedure should be explained to the patient by the unit nurse, who should be aware of the degree of seriousness of the patient's condition. Gastric analysis is performed by clinical laboratory scientists/medical technologists or by clinical laboratory technicians/medical laboratory technicians.

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Gastrin test see **Gastric analysis**

Gastritis

Definition

Gastritis commonly refers to inflammation of the lining of the **stomach**, but the term is often used to encompass a variety of symptoms resulting from stomach lining inflammation, as well as symptoms of burning or discomfort. True gastritis comes in several forms and is diagnosed using a combination of tests. In the 1990s scientists discovered that the main cause of true gastritis is **infection** from a bacterium called *Helicobacter pylori* (*H. pylori*).

Description

Gastritis should not be confused with common symptoms of upper abdominal discomfort. Gastritis has been associated with resulting ulcers, particularly peptic ulcers. In some cases, chronic gastritis can lead to more serious complications.

Nonerosive Helicobacter pylori (H. pylori) gastritis

The main cause of true gastritis is *H. pylori* infection. *H. pylori* is indicated in an average of 90% of persons with chronic gastritis. This form of nonerosive gastritis is the result of infection with the *H. pylori* bacterium, a microorganism whose outer layer is resistant to the normal effects of stomach acid in breaking down **bacteria**. This resistance means that the bacterium may rest in the stomach for long periods of times, even years, and eventually cause

symptoms of gastritis or ulcers when other factors are introduced, such as the ingestion of nonsteroidal antiinflammatory drugs (NSAIDs). It also seems to be activated in people with a genetic predisposition. Study of the role of *H. pylori* in development of gastritis and peptic ulcers has disproved the former belief that **stress** led to most stomach and duodenal ulcers. This understanding has resulted in improved treatment and reduction of stomach ulcers. *H. pylori* is most likely transmitted between humans, although the specific routes of transmission were still under study in 2001. Studies are also underway to determine the role of *H. pylori* and resulting chronic gastritis in the development of gastric **cancer**.

Erosive and hemorrhagic gastritis

After *H. pylori*, the second most common cause of chronic gastritis is the use of NSAIDs. These commonly used **pain** killers, including aspirin, fenoprofen, ibuprofen, and naproxen—among others—can lead to gastritis and peptic ulcers. Other forms of erosive gastritis are those due to ingestion of alcohol and corrosive agents, or due to such trauma as ingestion of **foreign bodies**.

Other forms of gastritis

Clinicians differ on the classification of the less common and specific forms of gastritis, particularly since there is so much overlap with *H. pylori* in development of chronic gastritis and complications of gastritis. Other types of gastritis that may be diagnosed include:

- Acute stress gastritis. This is the most serious form of gastritis and usually occurs in persons who are critically ill, such as those in intensive care. Stress erosions may develop suddenly as a result of severe trauma or stress to the stomach lining.
- Atrophic gastritis. This is the result of chronic gastritis that is leading to atrophy (a decrease in size and wasting away) of the gastric lining. Gastric atrophy is the final stage of chronic gastritis and may be a precursor of gastric cancer.
- Superficial gastritis. This is a term often used to describe the initial stages of chronic gastritis.
- Uncommon forms of gastritis. These are nonspecific forms of gastritis that include granulomatous, eosinophilic, and lymphocytic gastritis.

Causes and symptoms

Nonerosive H. pylori gastritis

H. pylori gastritis is caused by infection from the *H. pylori* bacterium. It is believed that most infection occurs in childhood. The route of its transmission was still under

study in 2001 and clinicians assume there may be more than one route for the bacterium to enter a body. Its prevalence and distribution differ in nations around the world. The presence of *H. pylori* has been detected in between 86% and 99% of persons with chronic superficial gastritis. However, physicians are still learning about the link between *H. pylori* and chronic gastritis and peptic ulcers, since many persons with *H. pylori* infection do not develop symptoms of gastritis or peptic ulcers. *H. pylori* is also seen in approximately 90% to 100% of people with duodenal ulcers.

Symptoms of *H. pylori* gastritis include abdominal pain and reduced acid secretion in the stomach. However, the majority of people with *H. pylori* infection suffer no symptoms, even though the infection may lead to ulcers and resulting problems. Ulcer symptoms include dull, gnawing pain, often two to three hours after meals, and pain in the middle of the night when the stomach is empty.

Erosive and hemorrhagic gastritis

The most common cause of this form of gastritis is use of NSAIDs. Other causes may be **alcoholism**, or stress from surgery or critical illness. The role of NSAIDs in development of gastritis and peptic ulcers depends upon the dosage level. Although even low doses of aspirin or other NSAIDs may cause some gastric upset, such low doses generally will not lead to gastritis. However, as many as 10%–30% of persons on higher and more frequent doses of NSAIDs, such as those with chronic arthritis, may develop gastric ulcers. As of 2001, studies were underway to determine the role of *H. pylori* in gastritis and ulcers among persons using NSAIDs.

Individuals with erosive gastritis may also experience no symptoms. When symptoms do occur, they may include anorexia nervosa, gastric pain, nausea, and vomiting.

Other forms of gastritis

Less common forms of gastritis may result from a number of generalized diseases, or from complications of chronic gastritis. Any number of mechanisms may cause various less common forms of gastritis that may differ slightly in their presentation, symptoms, and clinical signs. However, they all have in common inflammation of the gastric mucosa.

Diagnosis

Nonerosive H. pylorigastritis

H. pylori gastritis is easily diagnosed through the use of the urea breath test. This test detects the active pres-

ence of *H. pylori* infection. Other serological tests, which may be readily available in a physician's office, may be used to detect *H. pylori* infection. Newly developed versions offer rapid diagnosis. The choice of test will depend upon cost, availability, and the physician's experience, since nearly all of the available tests have an accuracy rate of 90% or better. Endoscopy, or the examination of the stomach area using a hollow tube inserted through the mouth, may be ordered to confirm diagnosis. A biopsy of the gastric lining may also be ordered.

Erosive or hemorrhagic gastritis

The patient's clinical history may be particularly important in the diagnosis of this type of gastritis, since its cause is most often the result of chronic use of NSAIDs, alcohol, or other erosive substances.

Other forms of gastritis

Gastritis that has developed to the stage of duodenal or gastric ulcers usually requires endoscopy for diagnosis. The endoscopy allows a physician to perform a biopsy for possible malignancy and for *H. pylori*. Sometimes, an upper gastrointestinal x-ray study with barium is ordered. Some diseases, such as Zollinger-Ellison syndrome, an ulcerative disease of the upper gastrointestinal tract, may show large mucosal folds in the stomach and duodenum on radiographs or in endoscopy. Other tests check for changes in gastric function.

Treatment

H. pylori gastritis

The discovery of *H. pylori*'s role in development of gastritis and ulcers has led to improved treatment of chronic gastritis. In particular, relapse rates for duodenal and gastric ulcers have been reduced with successful treatment of *H. pylori* infections. Since the infection can be treated with **antibiotics**, the bacterium can be completely eliminated up to 90% of the time.

Although *H. pylori* can be successfully treated, the treatment can be inconvenient, and relies heavily on the patient's compliance. As of 2001 studies were underway to identify the best treatment method based on simplicity, personal cooperation, and results. No single antibiotic had been found at that time that would eliminate *H. pylori*, so a combination of antibiotics is prescribed to treat the infection.

DUAL THERAPY. Dual therapy involves the use of an antibiotic and a proton pump inhibitor. Proton pump inhibitors are medications that help reduce stomach acid by halting the mechanism that pumps acid into the stomach. This combination also helps promote healing of

ulcers or inflammation. Dual therapy has not been proven to be as effective as triple therapy, but may be ordered for some people who are unable to consistently comply with the use of a larger number of medications, and who will therefore more likely follow the two-week course of therapy.

TRIPLE THERAPY. As of 2001, triple therapy was the preferred treatment for persons with *H. pylori* gastritis. It is estimated that triple therapy successfully treats between 80% and 95% of *H. pylori* cases. This treatment regimen usually involves a two-week course of three drugs. An antibiotic such as amoxicillin or tetracycline, and a second antibiotic such as clarithromycin or metronidazole, are used in combination with bismuth subsalicylate, a substance found in the over-the-counter medication Pepto-Bismol, that helps protect the lining of the stomach from acid. Physicians are experimenting with various combinations of drugs and times of treatment to balance side effects with effectiveness. Side effects of triple therapy are not serious, but may cause enough discomfort that people are not inclined to follow the treatment regimen.

OTHER TREATMENT THERAPIES. Scientists have experimented with quadruple therapy, which adds an antisecretory drug—one that suppresses gastric secretion—to the standard triple therapy protocol. One study showed this therapy to be effective with only a one-week course of treatment in more than 90% of patients. Short-course therapy was attempted with triple therapy involving antibiotics and a proton pump inhibitor, and seemed effective in eliminating *H. pylori* in one week for more than 90% of patients. The goal is to develop the most effective therapy combination that can work in a treatment period of one week or less.

MEASURING *H. PYLORI* TREATMENT EFFECTIVENESS. In order to ensure that *H. pylori* has been eradicated from the gastrointestinal tract, physicians will test persons following treatment. The breath test is, once again, the preferred method.

Treatment of erosive gastritis

Since few people with this form of gastritis show symptoms, treatment may depend upon severity of symptoms. When symptoms do occur, patients may be treated with therapy similar to that for *H. pylori*, especially since some studies have demonstrated a link between *H. pylori* and NSAIDs in causing gastric ulcers. Avoidance of NSAIDs will most likely be prescribed.

Other forms of gastritis

Specific treatment will depend upon the cause and type of gastritis. These may include prednisone or antibi-

KEY TERMS

Duodenal—Refers to the duodenum, or the first part of the small intestine.

Gastric—Relating to the stomach.

Mucosa—The mucous membrane, or the thin layer of tissue that lines many body cavities and passages.

Ulcer—A break in the skin or mucous membrane. It can fester and create exudate like a sore.

otics. Critically ill persons at high risk for bleeding may be treated with preventive drugs to reduce risk of acute stress gastritis. If stress gastritis does occur, the patient is treated with a constant infusion of a drug to stop bleeding. Sometimes surgery is recommended, but must be weighed against the possibility of surgical complications or death. Once torrential bleeding occurs in acute stress gastritis, mortality rates can exceed 60%.

Alternative treatment

Alternative forms of treatment for gastritis and ulcers should be used cautiously and in conjunction with conventional medical care, particularly now that scientists have confirmed the role of *H. pylori* in gastritis and ulcers. Such alternative treatments as diet, nutritional supplements, herbal medicine, and Ayurvedic medicine can help address gastritis symptoms. It is believed that **zinc**, **vitamin A**, and beta-carotene aid in the stomach lining's ability to repair and regenerate itself. Herbs thought to stimulate the **immune system** and reduce inflammation include echinacea (*Echinacea* spp.) and goldenseal (*Hydrastis canadensis*). Ayurvedic medicine involves **meditation**. There are also certain herbs and nutritional supplements aimed at helping to treat ulcers.

Prognosis

The discovery of *H. pylori* has improved the prognosis for persons with gastritis and ulcers. Since treatment exists with the potential to eradicate the infection, recurrence is much less common. As of 2001, people requiring treatment for *H. pylori* were those at high risk because of such factors as NSAIDs use, or those with ulcers and other complicating factors or symptoms. Research will continue into the most effective treatment of *H. pylori*, especially in light of the bacterium's resistance to certain antibiotics. Regular treatment of persons with gastric and duodenal ulcers has been recommended, since *H. pylori* plays such a consistently high role in development of ulcers. It is believed that *H. pylori* also

plays a role in the eventual development of serious gastritis complications and cancer. Detection and treatment of *H. pylori* infection may help reduce occurrence of these diseases. The prognosis for persons with acute stress gastritis is less encouraging, with a 60% or higher mortality rate among those experiencing heavy bleeding.

Health care team roles

A family physician or internist usually makes a diagnosis of gastritis, prescribes treatment, and provides follow-up testing to ascertain the effectiveness of the prescribed treatment regimen. Surgeons occasionally remove a portion of stomach when gastritis is caused by factors other than *H. pylori* or by cancer. Nurses play an important role in **patient education**, particularly in relation to medication, diet, prevention, compliance with treatment, and treatment side effects.

Prevention

The widespread detection and treatment of *H. pylori* as a preventive measure in gastritis has been discussed but not resolved. Until more is known about the routes by which *H. pylori* is spread, specific prevention recommendations cannot be made. Erosive gastritis from NSAIDs can be prevented by discontinuing the use of these drugs. In 1998 an education campaign was launched to educate people, particularly an aging population of arthritis sufferers, about the risk of ulcers from NSAIDs and alternative drugs. As of 2001 the success of this campaign had not been evaluated.

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- OTHER**
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Gastroesophageal reflux scan

Definition

Gastroesophageal reflux disease (GERD) is one of the most common gastrointestinal problems among children or adults. It is defined as the movement of solid or liquid contents from the **stomach** into the esophagus. Gastrointestinal reflux imaging encompasses methods used to visualize and diagnose GERD.

Purpose

The purpose of gastroesophageal reflux scanning is to visualize the interior of the upper stomach and lower esophagus. Such inspections assist in making an accurate diagnosis and in planning appropriate treatment.

Precautions

For all tests used to evaluate GERD, persons must not have other medical complications such as high **blood pressure**, **asthma**, or esophageal varices. They should not be experiencing other acute medical conditions.

Description

A brief description of gastroesophageal reflux disease assists in understanding the scanning methods used. Gastroesophageal reflux disease is the term used to describe the symptoms and damage caused by the back-flow (reflux) of the contents of the stomach into the esophagus. Stomach contents are usually acidic. Because of their acidity, they have the potential to cause chemical **burns** in unprotected tissues such as those lining the esophagus.

Gastrointestinal reflux is common in the American population. Approximately one adult in three reports experiencing some occasional reflux, commonly referred to as heartburn. Approximately 10% of these persons experience reflux on a daily basis. Most persons have very mild disease. Occasionally, persons experience

burning as a result of reflux. This is described as reflux esophagitis when it occurs in the esophagus.

There are several causes of gastroesophageal reflux. These include the following:

- **Incompetent lower esophageal sphincter.** When the muscular sphincter that is the boundary of the esophagus and stomach relaxes, reflux can occur. This is the most common cause for gastroesophageal reflux. Reflux usually occurs when persons bend, lift a weight, or strain. Persons with esophageal strictures or Barrett's esophagus are more likely to experience gastroesophageal reflux than are others.
- **Acidic irritation.** Gastric contents are acidic, with a pH less than 3.9. Such acid is very caustic to the lining of the esophagus. Repeated exposure to acidic gastric contents leads to scarring. If the exposure is sufficiently severe or prolonged, strictures can develop. Occasionally, pancreatic enzymes or bile reflux into the stomach and lower esophagus. These contents are extremely acidic (with a pH less than 2.0).
- **Abnormal esophageal clearance.** Acid reflux is washed away by saliva that is swallowed over the course of a day. During the night, swallowing is decreased. This results in a longer contact time between acidic stomach contents and the esophagus. The net result is a chemical injury. Sjögren's syndrome, radiation to the oral cavity, and some medications (anticholinergics) also decrease the flow of saliva and can result in chemical injury. Saliva also contains bicarbonate, which neutralizes some acid content. This, too, is diminished at night, contributing to nocturnal exposure and irritation over a period of time. Other medical conditions such as Raynaud's disease and scleroderma are often associated with abnormal esophageal clearance. Hiatal hernia is present in more than 90% of persons with erosive disease.
- **Delayed gastric emptying.** When gastric outflow is obstructed or gastric motility is impaired, gastric contents do not leave the stomach in a timely manner. This enhances the opportunity for gastric reflux.

Heartburn associated with gastroesophageal reflux occurs 30 to 60 minutes after eating. It also occurs when a person reclines. Most persons who experience gastroesophageal reflux can obtain relief with baking soda (Alka-Seltzer) or antacid tablets. This pattern is often sufficient for diagnostic purposes. Under these conditions, **physical examination** and laboratory findings are usually within normal limits.

Persons with complicated GERD, or those who do not respond to the usual remedies (baking soda or antacid tablets), require special examinations. There are several

imaging methods used in the diagnosis of GERD. Details concerning each of the procedures follow.

Upper endoscopy

Upper endoscopy is the standard procedure for diagnosis, determination of the degree of tissue damage, and documentation of GERD. Between half and three-quarters of all persons with GERD will display abnormalities in their esophageal mucosa. The abnormalities include erosion, tissue fragility, and erythema. Upper endoscopy is also used to document esophageal strictures and Barrett's esophagus. Approximately half of all persons who undergo endoscopy have normal findings. Endoscopy is indicated for persons who have such symptoms as hematemesis, **iron deficiency anemia**, guaiac-positive stools, or **dysphagia**.

An **endoscope** is passed through the oral cavity into the esophagus. The mucosal lining of the esophagus, the gastroesophageal junction, and the lining of the upper portion of the stomach are visualized directly. Biopsy specimens can be obtained at the same time.

Ambulatory esophageal pH monitoring

This test provides information concerning the frequency and duration of acid reflux. It can also provide information related to the timing of episodes of reflux. It is the standard procedure for documenting abnormal acid reflux. However, it is not needed for most persons with GERD as they can be adequately diagnosed on the basis of history or by using upper endoscopy.

In this test, a tiny catheter (about 2 millimeters) with two electrodes is passed through the nose and throat. One electrode is positioned about 5 cm above the esophageal sphincter. The other electrode is positioned just below the esophageal sphincter. Data on pH are obtained every four seconds for 24 hours. Persons tested are instructed to keep a diary recording symptoms. Special emphasis is placed on coughing episodes, meal times, time of lying down for sleep, and time of rising in the morning. The electrodes are removed after 24 hours. The patients' diaries are reviewed.

Barium esophagography

A water solution containing barium is slowly swallowed. X-rays are taken during swallowing and are analyzed for signs of reflux, inflammation, dysmotility, strictures, and other abnormalities. This test can diagnose, or provide important information about, a number of disorders involving esophageal function, including craniopharyngeal achalasia (a swallowing disorder of the throat); decreased or reverse peristalsis; and hiatal hernia.

Esophageal manometry

When surgery is anticipated, esophageal manometry is useful. It provides data about esophageal peristalsis and minimum esophageal sphincter closing pressure.

Esophageal manometry measures the pressure within the esophagus. It can be used to evaluate the action of muscle waves in the main portion of the esophagus, as well as the muscular sphincter at the end of the esophagus. A thin soft tube is passed through the nose, or occasionally the mouth. Upon swallowing, the tip of the tube enters the esophagus and is positioned at the desired location. The patient then swallows air or water while a technician records the pressure at the tip of the tube.

Preparation

Upper endoscopy

Prior to the test, persons are instructed not to eat or drink for six hours. A mild sedative is usually given to calm persons who are about to be tested.

Ambulatory esophageal pH monitoring

No special preparations are needed. A short-acting anesthetic spray is sometimes used to relieve any discomfort associated with placing the electrodes.

Barium esophagography

Prior to the test, persons are instructed not to eat or drink for six hours.

Esophageal manometry

Persons are asked not to eat or drink for the eight hours prior to the test. Prior to the test, persons are instructed not to eat or drink for six hours. An anesthetic spray is often used to reduce the irritation experienced when the manometry tube is passed through the nose and oral cavity.

Aftercare

Upper endoscopy

After the test, persons must be driven home due to lingering effects of the sedative.

Ambulatory esophageal pH monitoring

There are no special steps to be taken after the electrodes have been removed.

Barium esophagography

There are no special instructions after the test.

KEY TERMS

Barrett's esophagus—An abnormal condition of the (usually) lower esophagus in which normal mucous cells are replaced by changed cells. The condition is often a prelude to cancer.

Dysphagia—Difficulty in swallowing.

Erythema—Redness.

Esophageal varices—Varicose veins at the lower-most portion of the esophagus. These are easily injured. Bleeding from esophageal varices is often difficult to stop.

Esophagus—The tube that connects the mouth to the stomach.

Hematemesis—Vomit that contains blood, usually seen as black specks in the vomitus.

pH—A measure of acidity; technically, a measure of hydrogen ion concentration.

Raynaud's disease—A disease of the arteries in hands or feet.

Reflux—Backflow, also called regurgitation.

Sjögren's syndrome—An autoimmune disorder characterized by dryness of the eyes, nose, mouth, and other areas covered by mucous membranes.

Sphincter—A physiologic valve comprised of muscle.

Esophageal manometry

There are no special instructions after the test.

Complications

Upper endoscopy

Patients may feel as if they are choking as the endoscope proceeds down the throat. Actual choking is uncommon due to sedation.

Ambulatory esophageal pH monitoring

There are no common complications.

Barium esophagography

Constipation after the test is an infrequent complication. This is routinely treated by administration of a laxative.

Esophageal manometry

Complications are very rare.

Results

Upper endoscopy

Endoscopy documents the condition of mucosa in the lower esophagus and upper stomach, evaluating the extent of GERD progression.

Ambulatory esophageal pH monitoring

Measurements of pH are used to evaluate the degree of GERD.

Barium esophagography

Barium esophagography can detect many abnormalities, including reflux.

Esophageal manometry

This documents the ability of the esophageal sphincter to close and keep stomach contents from refluxing.

Health care team roles

A family physician, pediatrician, internist, or cardiologist usually makes the initial diagnosis of GERD. A gastroenterologist usually performs the tests required for diagnosis. A radiology technologist performs the barium esophagography and a radiologist interprets it.

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American College of Gastroenterology, 4900 B South 31st Street, Arlington, VA, 22206. (703) 820-7400. <<http://www.acg.gi.org>>.

American College of Radiology. 1891 Preston White Drive, Reston, VA, 20191. (703) 648-8900. <<http://www.acr.org>>.

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OTHER

American Academy of Family Physicians. <<http://www.aafp.org/afp/990301ap/1161.html>>.

American College of Gastroenterology. <<http://www.acg.gi.org/phyforum/gifocus/2evi.html>>.

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National Library of Medicine. <<http://www.nlm.nih.gov/medlineplus/gastroesophagealrefluxhiatalhernia.html> and <<http://www.nlm.nih.gov/medlineplus/ency/article/000265.htm>>>.

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Gene therapy

Definition

Gene therapy is a rapidly growing field of medicine in which genes are introduced into the body to treat diseases. Genomics is the DNA which is found in an organism's total set of genes and is passed on to the offspring as information necessary for survival. Genetics is the study of the patterns of inheritance of specific traits. Genes control heredity and provide the basic biological code for determining a cell's specific functions. Gene therapy seeks to provide genes that correct or supplant the disease-controlling functions of cells that are not performing in a normal manner.

Somatic gene therapy introduces therapeutic genes at the tissue or cellular level to treat a specific individual. Germ-line gene therapy inserts genes into reproductive cells or possibly into embryos to correct genetic abnormalities that could be passed on to future generations. Initially conceived as an approach for treating inherited diseases such as **cystic fibrosis** and Huntington's disease, the scope of potential gene therapies has grown to include treatments for **cancer**, arthritis, and infectious diseases.

Description

The history of gene therapy

In the early 1970s, scientists proposed "gene surgery" for treating inherited diseases caused by abnormally functioning genes. The idea was to take out the disease-causing gene and surgically implant a gene that functioned correctly. Although sound in theory, and after some advances in science, this technique has not yet been successful.

However, in 1983, a group of scientists from Baylor College of Medicine in Houston, Texas, proposed that gene therapy could one day be a viable approach for treating Lesch-Nyhan disease, a rare neurological disorder. The scientists conducted experiments in which an enzyme-producing gene (a specific type of protein) for correcting the disease was injected into a group of cells for replication. The scientists theorized the cells could then be injected into people with Lesch-Nyhan disease, thus correcting the genetic abnormality that caused the disease.

As the science of genetics advanced throughout the 1980s, gene therapy grew in the estimation of medical scientists as a promising approach to treatments for specific diseases. One of the major reasons for the growth of gene therapy was the increasing body of knowledge

available to assist in identifying the specific genetic malfunctions that caused inherited diseases. Interest grew as further studies of DNA and chromosomes (where genes reside) showed that specific genetic abnormalities in one or more genes occurred in successive generations of certain family members who experienced diseases like intestinal cancer, manic-depression (**bipolar disorder**), **Alzheimer's disease**, **heart** disease, diabetes, and many more. Although genes may not be the only cause of the disease in all cases, they may make certain individuals more susceptible to developing a particular condition due to such environmental influences as smoking, pollution, and **stress**. In fact, some scientists theorize that all diseases may have a genetic component.

The biological basis of gene therapy

Gene therapy has grown out of the science of genetics or how heredity functions. Scientists know that life begins in a cell, the basic building block of all multicellular organisms. Humans, for instance, are made up of trillions of cells, each performing a specific function. Within each cell's nucleus (the center part of a cell that regulates its chemical functions) are pairs of chromosomes. These threadlike structures are made up of deoxyribonucleic acid (DNA), which carries the blueprint of life in the form of codes, or genes, that determine dominant or recessive inherited characteristics.

A DNA molecule looks like two ladders with one of the sides taken off both and then twisted around each other—a formation known as the double helix. The rungs of these ladders meet (resulting in a spiral staircase-like structure) and are called base pairs. Base pairs are made up of nitrogen-containing molecules and arranged in specific sequences. Millions of these base pairs, or sequences, constitute a single gene, specifically defined as a segment of the chromosome and DNA that contains certain hereditary information. The gene, or combination of genes formed by these base pairs, ultimately directs an organism's growth and characteristics through the production of certain chemicals—primarily **proteins** that carry out most of the body's chemical functions and biological reactions.

Scientists have long known that alterations in the genes present within cells may cause such inherited diseases as cystic fibrosis, sickle-cell disease, and **hemophilia**. Similarly, errors in entire chromosomes may cause such conditions as **Down syndrome** or Turner syndrome. As the study of genetics advanced, however, scientists learned that altered genetic sequences may also make people more susceptible to such diseases as atherosclerosis, cancer, and **schizophrenia**. These diseases have a genetic component, but are also influenced by

such environmental factors as diet and lifestyle. The objective of gene therapy is to treat diseases by introducing functional genes into the body to alter the cells involved in the disease process, either by replacing missing genes or by providing copies of functioning genes to replace nonfunctioning ones. The inserted genes may be naturally occurring genes that produce the desired effect or may be engineered (or altered) genes.

Scientists have known how to manipulate a gene's structure in the laboratory since the early 1970s through a process called gene splicing. The process involves removing a fragment of DNA containing a specific desired genetic sequence and then inserting it into the DNA of another gene. The resultant product is called recombinant DNA, and the process is called **genetic engineering**. This technique is used in preparing some new therapies (monoclonal antibodies, **blood** component replacements for hemophilia, antiinflammatory therapy for collagen diseases).

There are two types of gene therapy. Germ-line gene therapy introduces genes into reproductive cells (sperm and eggs) to participate in germination. Some scientists hope that it may eventually be possible to insert genes into embryos in hopes of correcting genetic abnormalities that can then be passed on to future generations. Most of the current work in applied gene therapy, however, has been in the realm of somatic therapy. In this type of gene therapy, therapeutic genes are inserted into tissue or cells to produce a naturally occurring protein or substance that is lacking or not functioning correctly in an individual.

Viral vectors

In both types of therapy, scientists need a mechanism to transport either an entire gene or a recombinant DNA to a cell's nucleus, where the chromosomes and DNA reside. In essence, vectors are molecular delivery trucks. One of the first and most widely used vectors to be developed were **viruses**, because they invade cells as part of their natural **infection** process. Viruses have the potential to be excellent vectors because they have a specific relationship with a host in that they colonize certain cell types and tissues in specific organs. As a result, vectors are chosen according to their attraction to certain cells and areas of the body.

One of the first classes of vectors used were retroviruses. Because these viruses are easily cloned (artificially reproduced) in the laboratory, scientists have studied them extensively and learned a great deal about their biologic action. They have also learned how to remove the genetic information that governs viral replication, thus reducing the chances of infection from the host vector.

Retroviruses work best in actively dividing cells, but most cells in a human body are relatively stable and do not often divide. As a result, these cells are used primarily for *ex vivo* (outside the body) manipulation. First, the cells are removed from a person's body, and the vector, or virus carrying the gene, is inserted into them. Next, the cells are placed into a nutrient culture where they grow and replicate. Once enough cells are gathered, they are returned to the body, usually by injection into the blood stream. Theoretically, as long as these cells survive, they will provide the desired therapy.

Another class of viruses, called adenoviruses, may also prove to be good gene vectors. These viruses effectively infect non-dividing cells in the body, where the desired gene product is then expressed naturally. In addition to being a more efficient approach to the problem of gene transportation, these viruses, which are known to cause respiratory infections, are more easily purified and stabilized than are retroviruses. The result is less likelihood of unintended viral infection. However, these viruses live for several days in the body, and there is some concern about the possibility of infecting other people with the viruses through sneezing or coughing. Other viral vectors include **influenza** viruses, Sindbis virus, and a herpesvirus that infects nerve cells.

Scientists have also studied nonviral vectors. These vectors rely on the natural biologic process in which cells take up (or gather) macromolecules. One approach is to use liposomes, globules of fat produced by the body and taken up by cells. Scientists are also investigating the introduction of raw recombinant DNA by injecting it into the bloodstream or placing it on microscopic beads of gold injected into the skin using air pressure. Another possible vector under development is based on dendrimer molecules. A class of polymers (naturally occurring or artificial substances that have a high molecular weight and are formed by smaller molecules of the same or similar substances) is constructed in a laboratory by combining these smaller molecules. They have been used in manufacturing styrofoam, polyethylene cartons, and Plexiglas. In the laboratory, dendrimers have shown the ability to transport genetic material into human cells. They can also be designed to form an affinity for particular **cell membranes** by attaching to certain sugars and protein groups. Much additional research must be conducted before dendrimers can be used on a routine basis.

Viewpoints

On September 14, 1990, a four-year old girl who had a genetic disorder that prevented her body from producing a crucial enzyme became the first person to undergo gene therapy in the United States. Because her body

could not produce adenosine deaminase (ADA), she had a weakened **immune system**, making her extremely susceptible to severe, life-threatening infections. W. French Anderson and colleagues at the National Institutes of Health's Clinical Center in Bethesda, Maryland, took white blood cells (which are crucial to proper immune system functioning) from the girl, inserted ADA-producing genes into them, and then transfused the cells back into the girl. Although the young girl continued to show an increased ability to produce ADA, debate arose as to whether the improvement resulted from the gene therapy or from an additional drug treatment she received.

Although gene therapy testing in humans has advanced rapidly, many questions surround its use. For example, some scientists are concerned that the therapeutic genes themselves may cause disease. Others fear that germ-line gene therapy may be used to control human development in ways not connected with disease, such as intelligence or physical appearance.

Nevertheless, a new era of gene therapy began as more and more scientists sought to conduct clinical trial (testing in humans) research in this area. In that same year, gene therapy was tested on persons with melanoma (skin cancer). The goal was to help them produce antibodies (disease fighting substances in the immune system) to battle the cancer.

The relative success of these experiments prompted a growing number of attempts at gene therapies designed to perform a variety of functions in the body. For example, a gene therapy for cystic fibrosis aims to supply a gene that alters cells, enabling people with cystic fibrosis to produce a specific protein to battle the disease. Another approach was used for people with **brain** cancer, in which the inserted gene was designed to make the cancer cells more likely to respond to drug treatment. A third gene therapeutic approach for people experiencing artery blockage, which can lead to strokes, induces the growth of new **blood vessels** (collateral circulation) near clogged arteries, thus ensuring relatively normal blood circulation.

As of 2001, there are a host of new gene-therapy agents in clinical trials. In the United States, both nucleic acid-based (*in vivo*) treatments and cell-based (*ex vivo*) treatments are being investigated. Nucleic acid-based gene therapy uses vectors (such as viruses) to deliver modified genes to target cells. Cell-based gene therapy requires removal of cells from a person, genetically altering the cells and then reintroducing them into the body of the person being treated. Presently, gene therapies for the following diseases are being studied: cystic fibrosis (using adenoviral vector), HIV infection (cell-based), **malignant melanoma** (cell-based), Duchenne **muscular**

dystrophy (cell-based), hemophilia B (cell-based), kidney cancer (cell-based), Gaucher disease (retroviral vector), **breast cancer** (retroviral vector), and **lung cancer** (retroviral vector). When a cell or individual is treated using gene therapy and successful incorporation of engineered genes has occurred, the cell or individual is said to be transgenic.

The medical establishment's contribution to transgenic research has been supported by increased government funding. In 1991, the U.S. government provided \$58 million for gene therapy research, with increases in funding of \$15-40 million dollars a year over the following four years. With fierce competition over the promise of societal benefits in addition to huge profits, large pharmaceutical corporations have moved to the forefront of transgenic research. In an effort to be first in developing new therapies, and armed with billions of dollars of research funds, such corporations are making impressive progress toward making gene therapy a viable reality in the treatment of once elusive diseases.

The Human Genome Project

Although great strides have been made in gene therapy in a relatively short time, its potential usefulness has been limited by lack of scientific data concerning the multitude of functions that genes control in the human body. For instance, it is now known that much genetic material is contained in non-coding regions. That is, they merely store information that may be used at different times in a cell's life cycle. Some of these large portions of the genome are involved in control and regulation of gene expression. Each individual cell in the body carries thousands of genes that have coding for proteins. Some experts estimate this number to be 150,000 genes. For gene therapy to advance to its full potential, scientists must discover the biologic role for each of these individual genes and identify the location on the DNA helix for each of the base pairs that comprise them.

To address this issue, the National Institutes of Health initiated the Human Genome Project in 1990. Led by Dr. James Watson (one of the co-discoverers of the chemical makeup of DNA) the project's 15-year goal is to map the entire human genome (a combination of the words gene and chromosome). A genome map would clearly identify the location of all genes as well as the more than three billion base pairs that comprise them. With a precise knowledge of gene locations and functions, scientists may one day be able to conquer or control diseases that have plagued humanity for centuries.

Scientists participating in the Human Genome Project have identified an average of one new gene a day, but many expect this rate of discovery to increase. In

February of 2001, scientists published a rough draft of the complete human genome. With fewer than the anticipated number of genes found, between 30,000 and 40,000, the consequences of this announcement are potentially profound. Scientists caution, however, that the initial publication is only a draft of the human genome, and much more work is still ahead for the completion of the project. By the year 2005, their goal is to determine the exact location of all the genes on human DNA and the exact sequence of the base pairs that make them up. Some of the genes identified through this project include a gene that predisposes people to **obesity**; one associated with programmed cell death (apoptosis); a gene that guides HIV viral reproduction; and the genes of inherited disorders like Huntington's disease, amyotrophic lateral sclerosis (Lou Gehrig's disease), and some colon and breast cancers. As the human genome is completed, more information will be available for gene therapy research and implementation.

Professional implications

Diseases targeted for treatment by gene therapy

The potential scope of gene therapy is enormous. More than 4,200 diseases have been identified as resulting directly from non-functioning or abnormal genes, and countless others that may be partially influenced by a person's genetic makeup. Initial research has concentrated on developing gene therapies for diseases whose genetic origins have been established and for other diseases that can be cured or ameliorated by substances genes produce.

The following are examples of potential gene therapies. People with cystic fibrosis lack a gene needed to produce a salt-regulating protein. This protein regulates the flow of chloride into epithelial cells, (the cells that line the inner and outer skin layers) that cover the air passages of the nose and **lungs**. Without this regulation, people with cystic fibrosis have a buildup of thick mucus in their lungs. In turn, this mucus makes these patients prone to lung infections and respiratory problems, and usually leads to death within the first 29 years of life. A gene therapy technique to correct this abnormality might employ an adenovirus to transfer a normal copy of what scientists call the cystic fibrosis transmembrane conductance regulator (CTRF) gene. The gene is introduced into a person by spraying it into the nose or lungs.

Familial hypercholesterolemia (FH) is also an inherited disease, resulting in the inability to process cholesterol properly, which leads to high levels of artery-clogging fat in the bloodstream of even the youngest family members. Persons with FH often suffer heart attacks and strokes because of blocked arteries. A gene therapy

approach used to address FH is much more intricate than most gene therapies because it involves partial surgical removal of persons' livers (*ex vivo* transgene therapy). Corrected copies of a gene that acts to reduce cholesterol build-up are inserted into the **liver** sections, which are then transplanted back into the people.

Gene therapy has also been tested on persons with acquired immune deficiency syndrome (**AIDS**). AIDS is caused by the human **immunodeficiency** virus (HIV), which weakens the body's immune system to the point that people with the condition are unable to fight off such diseases as **pneumonia** and cancer. In one approach, genes that produce specific HIV proteins have been altered to stimulate immune system functioning without causing the negative effects that a complete HIV molecule has on the immune system. These genes are then injected in a person's blood stream. Another approach to treating AIDS is to insert, via white blood cells, genes that have been genetically engineered to produce a receptor that would attract HIV and reduce its chances of replicating. As of 2001, these approaches are experimental and have not been approved for treatment.

Several cancers also have the potential to be treated with gene therapy. A therapy tested for melanoma, a progressive, aggressive skin cancer, would introduce a gene with an anticancer protein called tumor necrosis factor (TNF) into test tube samples of a person's own cancer cells, which are then reintroduced into the person's body. In brain cancer, the approach is to insert a specific gene that increases the cancer cells' susceptibility to a common drug used in fighting the disease.

Gaucher disease is an inherited disease caused by a mutant gene that inhibits the production of an enzyme called glucocerebrosidase. Persons with Gaucher disease have enlarged livers (hepatomegaly) and spleens (splenomegaly). Clinical gene therapy trials will focus on inserting the gene for producing the missing enzyme.

Gene therapy is also being considered as an approach to solving a problem associated with a surgical procedure known as balloon **angioplasty**. In this procedure, a stent (a piece of tubular material resembling a straw) is used to open the clogged artery. However, in a "fail-safe" response to the trauma of the stent insertion, the body initiates a natural healing process that produces too many cells in the artery and results in restenosis or reclosing of the artery. The gene therapy approach to preventing this unwanted side effect is to cover the outside surfaces of an inserted stent with a soluble gel containing vectors for genes that may reduce an overactive healing response.

The future of gene therapy

Gene therapy seems elegantly simple in its concept: supply the human body with a gene that can correct a biologic malfunction causing a disease. However, there are many obstacles and some distinct questions concerning the viability of gene therapy. For example, viral vectors must be carefully controlled lest they infect a person with a viral disease. Some vectors, like retroviruses, can also enter normally functioning cells and interfere with natural biologic processes, possibly leading to other diseases. Other viral vectors, such as adenoviruses, are often recognized and destroyed by the immune system so their therapeutic effects are short-lived. Maintaining gene expression so that it performs its role properly after vector delivery is difficult. As a result, some therapies need to be repeated often to provide long-lasting benefits.

One of the most pressing issues, however, is gene regulation. Genes work in concert to regulate their functioning. In other words, several genes may play a part in turning other genes on and off. For example, certain genes work together to stimulate **cell division** and growth; but if these are not regulated, the inserted genes could cause tumor formation and cancer. Another difficulty is learning how to make the gene go into action only when needed. For the best and safest therapeutic effort, a specific gene should turn on, for example, when certain levels of a protein or enzyme are low and must be replaced. But the gene should also remain dormant when not needed to ensure that it does not oversupply a substance and disturb the body's delicate chemical balance.

One approach to gene regulation is to attach other genes that detect certain biologic activities and then react as a type of automatic off-and-on switch, regulating the activity of other genes according to biologic cues. Although still in the rudimentary stages, researchers are making progress in inhibiting some gene functioning by using a synthetic DNA to block gene transcriptions (the copying of genetic information). This approach may have applications for gene therapy.

The ethics of gene therapy

While gene therapy holds promise as a revolutionary approach for treating disease, ethical concerns over its use and ramifications have been expressed by scientists and lay people alike. For example, since much needs to be learned about how these genes actually work and their long-term effects, is it ethical to test these therapies on humans, in whom they could have a disastrous result? As with most clinical trials concerning new therapies, including many drugs, the people participating in these studies have usually not responded to more established

KEY TERMS

Cells—The smallest living units of the body that carry a full complement of the DNA, and which group together to form tissues and help the body perform specific functions.

Chromosome—Threadlike structures in a cell that carry most of the genetic material in the form of DNA and genes.

Clinical trial—The testing of a drug or some other type of therapy in a specific human population.

Clone—A cell or organism derived through asexual (without sex) reproduction, and which contains the identical genetic information of the parent cell or organism.

DNA (deoxyribonucleic acid)—The specific molecules that comprise chromosomes and genes.

Embryo—The earliest stage of development of the zygote before the human or animal is considered a fetus (which is usually the point at which the embryo takes on the basic physical form of its species). Embryos are formed *in vivo* (*in utero*) or *in vitro* (in a laboratory) in preparation for implantation.

Enzyme—A type of molecule made by cells that, when released, facilitates chemical reactions in the body.

Eugenics—A social movement in which the population of a society, country, or the world is to be improved by selective mating, controlling the passage of hereditary information.

Gene—A specific biologic component found in the cell nucleus that carries the instructions for the formation of an organism and its specific traits, such as eye or hair color.

Gene transcription—The process by which genetic information is copied from DNA to RNA, resulting in a specific protein formation.

Genetic engineering—The manipulation of genetic material to produce specific results in an organism.

Genetics—The study of hereditary traits passed on through genes.

Genome—The total set of genes carried by an individual or cell.

Genomics—The DNA which is found in the organism's total set of genes carried by an individual or cell and is passed on to offspring as information necessary for survival.

Germ-line gene therapy—The introduction of genes (natural or engineered) into reproductive cells or embryos to correct inherited genetic abnormalities that can cause disease by replication.

Liposome—Fat organelle made up of layers of lipids.

Macromolecule—A large molecule composed of thousands of atoms.

Nitrogen—An element that is a component of the base pairs in DNA.

Nucleus—The central part of a cell that contains most of its genetic material, including chromosomes and DNA.

Protein—Macromolecule made up of long sequences of amino acids. Proteins comprise the dry weight of most cells and are involved in structures, hormones, and enzymes in muscle contraction, immunological response, and many other functions essential to life.

Somatic gene therapy—The introduction of genes into tissue or cells to treat a genetic-related disease in an individual.

Vector—Something used to transport genetic information to a cell.

therapies and are often so ill that the novel therapy is their only hope for long-term survival.

Another questionable outgrowth of gene therapy is that scientists could potentially manipulate genes to control traits in human offspring that are not related to health. For example, perhaps a gene could be inserted to ensure that a child would not be bald, a seemingly harmless goal. However, what if genetic manipulation were

used to alter skin color, prevent homosexuality, or ensure good looks? If a gene is found that can enhance intelligence of children who are not yet born, will all members of society have access to the technology, or will it be so expensive that only the elite can afford it?

The Human Genome Project, which plays such an integral role for the future of gene therapy, also has social repercussions. If individual genetic codes can be deter-

mined, will such information be used against people? For example, will someone more susceptible to a disease have to pay higher insurance premiums or be denied health insurance altogether? Will employers discriminate between two potential employees, one with a healthy genome and the other with genetic abnormalities?

Some of these concerns can be traced back to the eugenics movement that was popular in the first half of the twentieth century. This genetic philosophy was a societal movement that encouraged people with so-called positive traits to reproduce while those with less desirable traits were sanctioned from having children. Eugenics was used to pass strict immigration laws in the United States, barring less suitable people from entering the country lest they reduce the quality of the country's collective gene pool. Probably the most notorious example of eugenics in action was the rise of Nazism in Germany, which fostered the Eugenic Sterilization Law of 1933. The law required sterilization for those with certain disabilities and even for some persons who were simply deemed to be unattractive. To ensure that this novel science is not abused, many governments have established organizations specifically for overseeing the development of gene therapy. In the United States, the Food and Drug Administration and the National Institutes of Health require scientists to take a precise series of steps and meet stringent requirements before approving clinical trials.

In fact, gene therapy has been immersed in more controversy and is surrounded by more scrutiny from both the health care and ethics communities than most other technologies (except, perhaps, for cloning) that have the potential to substantially change society. Despite the health and ethical questions surrounding gene therapy, the field will continue to grow and is likely to change medicine more quickly than any previous medical advancement.

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ORGANIZATIONS

- American Academy of Family Physicians. 11400 Tomahawk Creek Parkway, Leawood, KS 66211-2672, (913) 906-6000, <<http://www.aafp.org>>.
- American Society of Gene Therapy. 611 East Wells Street, Milwaukee, WI 53202, (414) 278-1341, (414) 276-3349. <<http://www.asgt.org>>.
- World Health Organization. 20 Avenue Appia, 1211 Geneva 27, Switzerland, +41 (22) 791 4140, +41 (22) 791 4268. <<http://www.who.int/gtb>>.

OTHER

- American Civil Liberties Union. <<http://www.aclu.org/issues/aids/docket98.html>>.
- Association of American Medical Colleges. <<http://www.aamc.org/newsroom/reporter/june2000/view.htm>>.
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General anesthetic *see* **Anesthesia, general**

Genetic counseling

Definition

Genetic counseling is a communication process by which personal genetic risk information is translated into practical information for families. Genetic counselors are health care professionals with specialized training and experience in the areas of medical genetics and counseling. Genetic counselors are able to assist individuals and families by:

- Helping people to understand information about birth defects or genetic disorders. This includes explaining patterns of inheritance, recurrence risks, natural history of diseases, and **genetic testing** options.
- Providing nondirective supportive counseling regarding emotional issues related to a diagnosis or testing options.
- Helping individuals and families make decisions with which they are comfortable, based on their personal ethical and religious standards.
- Connecting individuals and families with appropriate resources, such as support groups or specific types of medical clinics, locally and nationally.

Purpose

There are several purposes or aspects to be addressed within the scope of genetic counseling. These include obtaining a pedigree; tracing ethnicity; exploring issues of consanguinity; and documenting exposures to toxins, diseases, or environmental agents during **pregnancy**.

Pedigree

In all types of genetic counseling, an important aspect of the counseling process is information gathering about family and medical history. Information gathering is performed by drawing a chart called a pedigree. A pedigree is made of symbols and lines that represent a family history. To accurately assess the risk of inherited diseases, information about three generations of the fam-

ily, including health status and cause of death, is usually needed. If a family history is complicated, information from more distant relatives may be helpful, and **medical records** may be requested for any family members who have had a genetic disorder. Thorough examination of a family history may enable a counselor to calculate the probability of occurrence of genetic disorders in the future.

Ethnicity

In obtaining a family history, a genetic counselor asks about a person's ethnicity or ancestral origin. There are some ethnic groups that have a higher chance of being carriers of some genetic diseases or abnormalities. For instance, the chance that an African American is a carrier of a gene for **sickle cell disease** is one in 10. People of Jewish or central European ancestry are likely to be carriers of several conditions, including Tay-Sachs disease, Canavan's disease and **cystic fibrosis**. People of Mediterranean ancestry are likely to be carriers of a type of anemia called thalassemia. Genetic counselors discuss inheritance patterns of these diseases, carrier risks, and genetic screening or testing options.

Consanguinity

Another question a genetic counselor asks in obtaining a family history is whether the couple are related to one another by **blood**. The practice of marrying or having children with relatives is infrequent in the United States, but is more common in some countries. When two people are related by blood, there is an increased chance for their children to be affected with conditions that are inherited in a recessive pattern. In recessive inheritance, each parent of a child affected with a disease carries a single gene for a disease. The child gets two copies, one from each parent, and is affected. People who have a common ancestor are more likely than unrelated people to be carriers of genes for the same recessively inherited disorders. Depending on family history and ethnic background, blood tests can be offered to couples to get more information about the chance of these conditions occurring.

Exposures during pregnancy

During prenatal genetic counseling, the counselor will ask about pregnancy history. If a woman has taken medications or has had exposure to a potentially harmful substance from the environment such as a chemical, toxin, or radiation, the genetic counselor can discuss the possibility of adverse effects. Ultrasound is often a useful tool to look for some effects of exposure.

Precautions

There are no physical precautions that are needed before genetic counseling. However, persons who will receive the results of genetic tests should be prepared mentally and emotionally for the possibility of unpleasant information. This includes discussing if they want to know the results of genetic testing and what choices they may have to make based on the information supplied.

Description

Types of genetic counseling

Genetic counselors work with people concerned about the risk of an inherited disease or condition. These people represent several different populations. Prenatal genetic counseling is provided to couples that have an increased risk of birth defects or inherited conditions, and are expecting a child or planning a pregnancy. Pediatric genetic counseling is provided to families with children suspected of having a genetic disorder or with children previously diagnosed with a genetic disorder. Adult genetic counseling is provided to adults with clinical features of an inherited disease or a family history of an inherited disease. **Cancer** genetic counseling is provided to those with a strong family history of certain types of cancer. Ethics are an important component of genetic counseling.

Prenatal genetic counseling

There are several different reasons a person or couple may seek prenatal genetic counseling. If a woman is age 35 or older and pregnant, there is an increased chance that her fetus may have a change in the number of chromosomes present. Changes in chromosome number may lead to mental retardation and birth defects. **Down syndrome** is the most common change in chromosome number that occurs proportionally more often in the fetuses of older women. Couples may seek prenatal genetic counseling because of abnormal results of screening tests performed during pregnancy. A blood test called the alpha fetal protein (AFP) test is offered to all pregnant women. This blood test screens for Down syndrome, open spine defects (spina bifida), and another type of mental retardation caused by a change in chromosome number called trisomy 18. When this test is abnormal, further tests are offered to get more information about the chance of these conditions actually occurring in the fetus. Another reason that people seek prenatal genetic counseling is a family history of birth defects or inherited diseases. In some cases, blood tests of the parents may be available to indicate if their children would be at risk of being affected. Genetic counselors assess risk in each case, help persons

to understand their risks, and explore how they feel about or will cope with these risks.

Prenatal tests that are offered during genetic counseling include level II ultrasounds, maternal serum AFP screening, **chorionic villus sampling (CVS)**, and **amniocentesis**. Level II ultrasound is a detailed ultrasound surveying fetal anatomy for birth defects. Ultrasound is limited to detection of structural changes in anatomy and cannot detect changes in chromosome number. The maternal serum AFP screening is used to indicate if a pregnant woman has a higher or lower chance of having a child with certain birth defects. This test can only provide information concerning the probability of a birth defect. The screening cannot diagnose an actual birth defect. CVS is a way of learning how many chromosomes are present in a fetus. A small piece of placental tissue is obtained for these studies during the tenth to twelfth weeks of pregnancy. Amniocentesis is also a way of learning how many chromosomes are present in a fetus. Amniotic fluid is obtained for these studies, usually between 15 and 20 weeks of pregnancy. There is a small risk of **miscarriage** associated with both of these tests. Genetic counseling regarding these procedures involves the careful explanation of benefits and limitations of each testing option. A genetic counselor also tries to explore how persons feel about prenatal testing and the impact of such testing on the pregnancy. Genetic counselors are supportive of any decision a person makes about whether or not to have prenatal tests performed.

Pediatric genetic counseling

Families or pediatricians seek genetic counseling when a child has features of an inherited condition. Any child who is born with more than one birth defect; mental retardation; or dysmorphic features has an increased chance of having a genetic syndrome. A common type of mental retardation in males for which genetic testing is available is Fragile X syndrome. Genetic testing is also available for many other childhood illnesses such as **hemophilia** and **muscular dystrophy**. Genetic counselors work with medical geneticists to determine if a genetic syndrome is present. This process includes a careful examination of family history, medical history of the child, review of pertinent medical records in the family, a **physical examination** of the child, and sometimes blood work or other diagnostic tests. If a diagnosis is made, then a medical geneticist and genetic counselor review what is known about the inheritance of the condition, the natural history of the condition, treatment options, further examinations that may be needed for health problems common in the diagnosed syndrome, and resources for helping the family. The genetic counselor also helps the family adjust to the diagnosis by pro-

viding emotional support and counseling. Many families are devastated by receiving a diagnosis, learning of the likely outcome for the child and by the loss of the hoped for healthy child. There would also be a discussion about recurrence risks in the family and who else in the family may be at risk.

Adult genetic counseling

Adults may seek genetic counseling when a person in the family decides to be tested for the presence of a known genetic condition; when an adult begins exhibiting symptoms of an inherited condition; or when there is a new diagnosis of someone with an adult-onset disorder in the family. In addition, the birth of a child with obvious features of a genetic disease leads to diagnosis of a parent who is more mildly affected. Genetic counseling for adults may lead to the consideration of presymptomatic genetic testing. Testing a person to determine the likelihood for a condition existing before any symptoms occur is an area of controversy. Huntington's disease is an example of a genetic disease for which presymptomatic testing is available. This is a neurological disease resulting in **dementia**. Onset of the condition is between 30 and 50 years of age. Huntington's disease is inherited in an autosomal dominant pattern. If a person has a parent with the disease, the risk of being affected is 50%. Would presymptomatic testing relieve or create **anxiety**? Would a person benefit from removal of doubt about being affected? Would knowing about the condition help a person with life planning? Genetic counselors help people sort through their feelings about such testing and whether or not the results would be helpful to them.

Cancer genetic counseling

A family history of early onset breast, ovarian, or colon cancer in multiple generations of a family is a common reason a person would seek a genetic counselor who works with people who have cancer. While most cancer is not inherited, there are some families in which a dominant gene is present and causing the disease. A genetic counselor is able to discuss the chances that the cancer in the family is related to a dominantly inherited gene. The counselor can also discuss the option of testing for the breast and ovarian cancer genes, BRCA1 and BRCA2. In some cases the persons seeking testing have already had cancer but others have not. Therefore, presymptomatic testing is also an issue in cancer genetics. Emotional support is important for these people, as they have often lost close relatives from cancer and are fearful of their own risks. For families in which a dominant form of cancer is detected through genetic testing, a plan can be made for increased surveillance of disease symptoms.

Ethical issues in genetic counseling

Prenatal diagnosis of anomalies or chromosomal abnormalities may lead to a decision about whether or not a couple wishes to continue a pregnancy. Some couples choose to continue a pregnancy. Prenatal diagnosis gives them additional time to emotionally prepare for the birth of the child and to gather resources. Others choose not to continue a pregnancy in which problems have been diagnosed. These couples have unique emotional needs. Often the child is a very much desired addition to the family and parents are devastated that the child is not healthy. Presymptomatic testing for adult-onset disorders and cancer raises difficult issues regarding the need to know and the reality of dealing with abnormal results before symptoms occur. The National Society of Genetic Counselors has created a Code of Ethics to guide genetic counselors in caring for people. The Code of Ethics consists of four ethical principles:

- **Beneficence** is the promotion of personal well-being in others. The genetic counselor is an advocate for the person being counseled.
- **Non-maleficence** is the concept of doing no harm to a person.
- **Autonomy** is recognizing the value of an individual, the person's abilities and point of view. Important aspects of autonomy are truthfulness with persons, respecting confidentiality, and practicing **informed consent**.
- **Justice** is providing equal care for all, freedom of choice, and providing a high quality of care.

The main ethical principle of genetic counseling is the attempt to provide nondirective counseling. This principle again points to an individual-centered approach to care by focusing on the thoughts and feelings of each person. Five percent of the Human Genome Project budget is designated for research involving the best way to deal with ethical issues that arise as new genetic tests become available. Genetic counselors can help people navigate through the unfamiliar territory of genetic testing.

Preparation

Persons should be apprised of possible outcomes and given the opportunity to discuss their feelings prior to undergoing genetic tests. There is a burden associated with knowing the probability of a future outcome. Difficult decisions may be required as a result of learning genetic information through testing. The process of adequately preparing an individual for genetic counseling is called informed consent. Ethical genetic counselors always obtain informed consent prior to undertaking any genetic tests.

Aftercare

Persons must be provided access to competent counselors and therapists. Such professionals can assist in processing the feelings and reactions that may emerge as a result of receiving the findings of genetic tests.

Complications

The complications that arise from the process of genetic counseling are most commonly mental and emotional. Individuals and couples who have received genetic counseling often experience mental changes such as depression and anguish when they receive unfavorable results about tests. Complications include the need to make difficult decisions regarding themselves, their families, or their unborn children. This is also referred to as a burden of knowing, meaning that likely but unwanted outcomes may become known before they occur. Depending on the condition, personal preferences and situation, persons may elect to continue with a pregnancy that is likely to result in a child with one or more abnormalities, terminate a pregnancy, select a different partner, or decide not to have children. These are all difficult situations that may require the assistance and intervention of a trained mental health counselor or therapist.

Results

The results given to a person during genetic counseling are highly individualized and depend on the nature of tests being performed and the issues of importance to the person being counseled.

The results of the process of genetic counseling vary. Genetic counseling offers information to people, thereby allowing them to make informed choices. Some of the options may not be easy or pleasant to contemplate. However, they are based on hard data rather than on wishes, hopes, or some other non-scientific basis. Genetic counselors have an ethical duty to obtain informed consent from individuals prior to beginning genetic counseling, provide unbiased information and the ability to interact in a non-judgmental or coercive manner.

Health care team roles

Genetic counselors are specially trained members of a health care team who have a master's degree in genetic counseling. They receive referrals from obstetricians, pediatricians, family physicians, and other doctors. They interpret the results of tests from laboratory personnel, medical geneticists, and pathologists. They refer people to therapists and counselors for assistance in resolving issues that arise from the process of genetic counseling.

KEY TERMS

Canavan disease—A serious genetic disease more common among the Eastern European Jewish population that causes mental retardation and early death. Canavan disease is caused by the lack of an enzyme called aspartoacylase.

Cystic fibrosis—A respiratory disease characterized by chronic lung disease, pancreatic insufficiency, and an average age of survival of 29 years. Cystic fibrosis is caused by mutations in a gene on chromosome seven that encode a transmembrane receptor.

Dysmorphic feature—A subtle change in appearance such as low set ears or a flattened nasal bridge that suggests a genetic syndrome may be present.

Fragile X syndrome—The most common inherited cause of mental retardation in males. People with Fragile X syndrome often have large ears, a long face, hyperextensible finger joints, hyperactivity or autism. Fragile X syndrome is caused by an expansion in a gene on the X chromosome. Some females are also affected.

Human Genome Project—An international collaborative project among scientists to map the genetic sequence of all the chromosomes. This project is funded by the National Institute of Health in the United States.

Informed consent—Provision of complete information to a competent individual regarding a treatment or test. Part of informed consent is to ensure a person's understanding of the advantages and disadvantages of a procedure and to obtain voluntary authorization to perform the procedure.

Sickle-cell anemia—A chronic, inherited blood disorder characterized by crescent-shaped red blood cells. It occurs primarily in people of African descent, and produces symptoms including episodic pain in the joints, fever, leg ulcers, and jaundice.

Tay-Sachs disease—A genetic disease affecting young children of eastern European Jewish descent. This disease is caused by the lack of an enzyme called hexosaminidase A. This deficiency results in mental retardation, convulsions, blindness and, finally, death.

Thalassemia—An inherited group of anemias occurring primarily among people of Mediterranean descent. It is caused by abnormal formation of part of the hemoglobin molecule.

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- American Board of Genetic Counseling, 9650 Rockville Pike, Bethesda, MD 20814-3998. (301) 571-1825. Fax: (301) 571-1895. <<http://www.faseb.org/genetics/abgc/abgcmenu.htm>>.
- American Infertility Association, 666 Fifth Avenue, Suite 278, New York, NY 10103. (718) 621-5083.

<<http://www.americaninfertility.org>>. info@americaninfertility.org.

- American Public Health Association, 800 I Street, NW, Washington, DC 20001-3710. (202) 777-2742. Fax: (202) 777-2534. <<http://www.apha.org>>. comments@apha.org.
- American Society for Reproductive Medicine, 1209 Montgomery Highway, Birmingham, AL 35216-2809. (205) 978-5000. <<http://www.asrm.com>>.

OTHER

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L. Fleming Fallon, Jr., MD, DrPH

Genetic engineering

Definition

Genetic engineering involves altering the genetic structure of embryonic cells or vectors to provide them with desired traits or to eliminate undesirable traits.

Description

For thousands of years, humans have engaged in primitive forms of genetic engineering. They have chosen plants or animals with survival strength and desirable characteristics for further breeding, and have combined different strains of a species in attempts to retain and emphasize desirable characteristics of both. But in the 1970s, the field of genetic engineering took a quantum technologic leap when researchers developed a technique known as recombinant DNA, or gene splicing, enabling them to directly alter the genetic code and sequence of cells. This development transformed genetic engineering

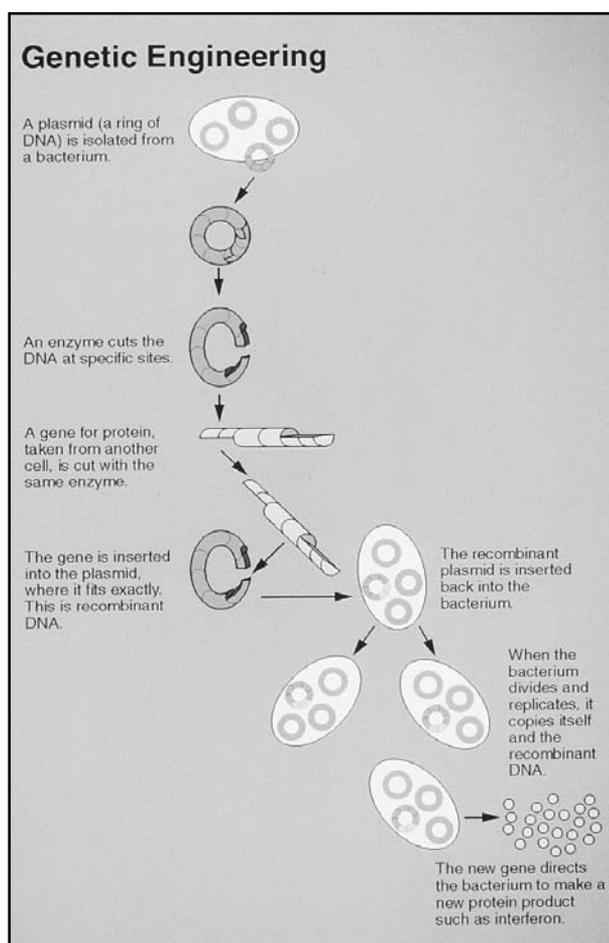
in medicine, food production, and industry. Engineered **bacteria** are even being used to take the place of standard microchip circuitry for computers.

Genes, which are composed of molecules of DNA, determine the physical characteristics that make organisms unique. Gene splicing, which involves introducing new genes into an organism in order to produce new characteristics, is performed in a number of ways. Sometimes a DNA “gun” is used to shoot genes directly into cells such as plant cells. When a gene cannot be directly “cut and pasted” from one organism to another, it may be placed in a harmless bacterium that duplicates repeatedly, acting as a “gene factory.” The bacteria are then used to ferry the genes into cells.

A sheep named Dolly, born in 1997, was produced using a genetic engineering technique known as cloning. Here, scientists replaced the genetic material from one ewe’s egg with genetic material from another ewe, producing an animal genetically unrelated to its surrogate mother. Hundreds of animals have been cloned, including bulls, cows, mice, monkeys, and pigs. Even clones of clones have been produced. Cloning is used to produce laboratory test animals with specific disease-related characteristics. Areas of cloning research range from cloning cows and sheep to produce medicines in their milk, to using cloning to preserve endangered species such as the Indian cheetah and the Asian guar.

Genetic engineering techniques are used to produce several widely used drugs. In addition to the hormone insulin, used to treat some forms of diabetes, these techniques are now used to produce the following: interferon, an antiviral and anticancer drug; tissue plasminogen activator (tPA), which dissolves **blood** clots; erythropoetin, which stimulates red blood-cell production; a hepatitis B vaccine; and others. In food production, genetic engineering can produce tomatoes with a longer shelf life; as well as crops with insect, herbicide, frost, and virus resistance. It is used to increase milk production in dairy cows, and to increase the size and infection-resistance of farmed fish like salmon. In addition, genetically altered bacteria have been used to decompose garbage and petroleum products.

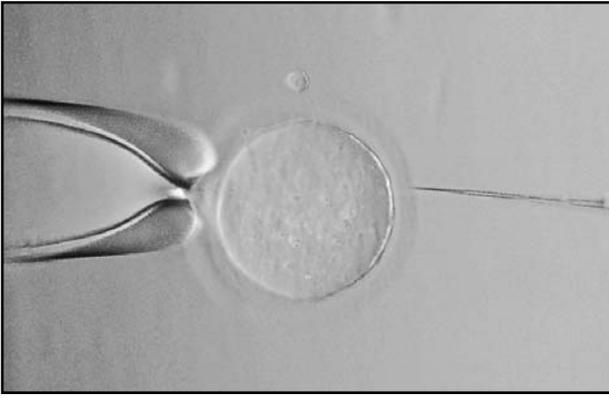
Despite all its advances, the field of genetic engineering is still in its infancy. Now that researchers have mapped much of the human genome (or DNA blueprint), and some of the genes and their mutations responsible for genetic disorders like **cystic fibrosis** have been found, the next challenge is to understand **proteins**. These are the most complex of all known molecules. Each of the body’s genes carries the code to create many different proteins (peptides), which are essentially the workers that carry out the DNA instructions. Understanding how mes-



Many steps are required to make recombinant DNA and final products such as interferon. (National Institutes of Health. Reproduced by permission.)

senger proteins work is essential to preventing or curing disease. This will be a major focus of research over the next decade.

Promising areas of genetic engineering include human **gene therapy** and stem-cell research. Gene therapy involves repairing or replacing mutated genes in order to correct the malfunctions in protein production that can lead to disease. The use of gene therapy is being researched for diseases such as **cancer, muscular dystrophy, hemophilia B**, heart disease, and severe combined immune deficiency disease (known as “bubble boy disease”), among others. Stem cells are the undifferentiated cells from which specialized embryonic cells develop. They are considered one of science’s best hopes for curing disease. Modified stem cells may one day be used to replace diseased cells affecting function throughout the body’s systems. These cells also play an important role in tissue engineering, which involves the manufacture of blood products; artificial skin products; and bio-



Animal cell being microinjected with foreign genetic material. (Photograph by M.Baret/RAPHU. National Audubon Society Collection/Photo Researchers, Inc. Reproduced by permission.)

genetic replacement of organs, **blood vessels**, and cartilage. Other examples of genetic engineering research range from the manufacture of bananas engineered to contain vaccines (to eliminate the challenge of cold vaccine storage in developing countries) to coffee plants that have been altered to “switch off” **caffeine** before the beans even start growing.

Viewpoints

Genetic engineering is controversial and has led to many protests regarding the potential of short- and long-term health and environmental risks. Stem-cell research is particularly controversial. Stem cells have traditionally been culled from aborted fetuses or from embryos left behind after successful **fertility treatments**, or they are produced using cloning technology. Many fear that using stem-cell research to cure genetic disorders or produce body tissues will eventually lead to the process being used to enhance or improve humans, a practice known as positive eugenics, termed by opponents as the “search for the master race.” It is feared that altering human genomes may have unknown consequences for future generations that inherit the changes. Some individuals, including James Watson, co-discoverer of DNA’s double-helix structure, are not opposed to altering DNA to make human “improvements.”

The primary concerns with genetic engineering in plants are that a transferred gene could migrate unintentionally via pollen scattering from a transgenic plant to a related species and alter the ecosystem, or that a plant designed to kill a particular pest could end up killing beneficial insects like bees and butterflies. Transgenic plants could also interbreed with weeds, producing weeds resistant to herbicides. Allergens from one food

KEY TERMS

Cloning—The production of an organism that is genetically identical to its parent.

Deoxyribonucleic acid (DNA)—The genetic material of all cellular organisms and most viruses. DNA carries the information needed to direct proteins. Each molecule of DNA consists of two twisted strands, called a double helix.

Eugenics—A practice involving use of genetic principles to “improve” humankind.

Gene—The basic unit of hereditary traits found in the cells of all living organisms, from bacteria to humans. Genes determine the physical characteristics that an organism inherits, such as hair and eye color.

Human Genome Project—An international scientific collaboration that seeks to identify and clarify the entire human genetic blueprint.

Protein—A molecule made of a sequence of amino acids. Proteins are the most common organic molecules in living organisms and among the most complex.

Recombinant DNA—DNA that has been altered by joining genetic material from two different sources. It usually involves putting a gene from one organism into the genome of a different organism.

Stem cells—The undifferentiated cells from which specialized embryonic cells develop.

crop, such as peanuts, can be transferred to another through genetic engineering. Animal-rights groups have argued that genetically engineered fish may cause problems if they interbreed with unaltered fish, which may change the characteristics of wild fish. The use of bovine growth hormone to increase dairy-cow milk production is also controversial, with critics questioning its safety for both cows and the humans who consume the milk.

Professional implications

The advances in genetic engineering require health care practitioners to consider their responsibilities in handling genetic information. As genetics advances are incorporated into tools for primary health care delivery, the use of genetic assessment testing will expand in medical practice. Health care practitioners, including nurses and allied-health professionals, will need a functional

understanding of the potential ethical, legal, and social issues involved with such tests; special attention must be paid to disclosures for **informed consent**, and medical-record confidentiality. A statement on the Scope and Standards of Genetics Clinical Nursing Practice has been published by the American Nurses Association to guide nurses in their practice of genetic-based health care.

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Ann Quigley

Genetic studies see **Genetic testing**

Genetic testing

Definition

A genetic test examines the genetic information contained inside a person's cells, called DNA, to determine if that person has or will develop a certain disease or could transmit a disease to a child. Genetic tests also determine whether or not couples are at a higher risk than the general population for having a child affected with a genetic disorder.

Purpose

Some families or ethnic groups have a higher incidence of a certain disease than do the population as a whole. For example, individuals of Eastern European, Ashkenazi Jewish descent are at higher risk for carrying genes for rare conditions such as Tay-Sachs disease (a lipid storage disease) that occur much less frequently in populations from other parts of the world. Before having a child, a couple from such a family or ethnic group may want to know if their child would be at risk of having that disease. Genetic testing for this type of purpose is called genetic screening.

During **pregnancy**, a baby's cells can be studied for certain genetic disorders or chromosomal problems such as **Down syndrome**. Chromosome testing is most commonly offered when a mother is 35 years or older at the time of delivery. When there is a family medical history of a genetic disease or there are individuals in a family affected with developmental and physical delays, genetic testing may also be offered during pregnancy. Genetic testing during pregnancy is called prenatal diagnosis.

Prior to becoming pregnant, couples who are having difficulty conceiving a child or who have had multiple miscarriages may be tested to see if a genetic cause can be identified.

A genetic disease may be diagnosed at birth by performing a physical evaluation of the baby and observing characteristics of the disorder. Genetic testing can help to confirm the diagnosis made by a physical evaluation. In addition, biochemical tests (e.g., **blood** phenylalanine measurement) are performed routinely on all newborns to screen for certain genetic diseases that can affect a newborn baby's health shortly after birth.

There are several genetic diseases and conditions in which the symptoms do not occur until adulthood. One such example is Huntington's disease. This is a serious disorder affecting the way in which individuals walk, talk and function on a daily basis. Genetic testing may be able to determine if someone at risk for the disease will in fact develop the disease.

Some genetic abnormalities may make a person more susceptible to certain types of **cancer**. Testing for these abnormalities can help predict a person's risk. Other types of genetic tests help diagnose, predict, and monitor the course of certain kinds of cancer, particularly leukemia, lymphoma, and **breast cancer**.

Precautions

Genetic tests are performed on cells derived from blood, bone marrow, amniotic fluid, or tissues. The

health care worker collecting the specimen should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. Because genetic testing is not always accurate and because there are many concerns surrounding insurance and employment discrimination for an individual receiving a genetic test, **genetic counseling** should always be performed prior to genetic testing. A genetic counselor is an individual with a master's degree in genetic counseling. A medical geneticist is a physician specializing and board certified in genetics.

A genetic counselor reviews a person's family history and **medical records** and the reason for the test. The counselor explains the likelihood that the test will detect all possible causes of the disease in question (known as the sensitivity of the test), and the likelihood that the disease will develop if the test is positive (known as the positive predictive value of the test).

Learning about the disease in question, the benefits and risks of both a positive and a negative result, and what treatment choices are available if the result is positive, will help prepare a person undergoing testing. During the genetic counseling session, an individual interested in genetic testing will be asked to consider how the test results may affect his or her life, family, and future decisions.

After this discussion, persons should have the opportunity to indicate, in writing, that they gave **informed consent** to have the test performed, verifying that the counselor provided complete and understandable information.

Description

Genes and chromosomes

Deoxyribonucleic acid (DNA) is a long molecule made up of two strands of genetic material coiled around each other in a unique double helix structure. Francis Crick and James Watson discovered this structure in 1953. Each strand of DNA consists of a backbone of deoxyribose sugars linked together by phosphate groups. Each sugar is bound (with a covalent bond) to one of four bases, adenine, guanine, thymine or cytosine. The two strands are held together by hydrogen bonds between the bases. Adenine pairs with thymine and guanine pairs with cytosine.

Most of the DNA is found in the nucleus of the cell. Each person's DNA is a unique blueprint, giving instructions for that person's physical traits, such as eye color, hair texture, height, and susceptibility to disease. DNA is organized into structures called chromosomes.

The instructions are contained as a code spelled out by the order of the four bases in each of the strands of DNA. When a base pair is out of order, or is missing, then cells may not produce an important protein or may produce an abnormal protein resulting in a genetic disorder. While genes are found in every nucleated cell of the human body, not every gene is functioning all of the time. Some genes are turned on during critical points in development and then remain silent for the rest of a cell's life. Other genes remain active throughout life so that cells can produce important **proteins** that help humans digest food properly or fight off the **common cold**.

In the human genome there are 3.1 billion bases and approximately 100,000 genes. Approximately 95% of DNA consists of non-coding regions called introns. The remaining 5% consists of coding regions called exons, which are the structural units that form genes. Within the exon, the specific order of the base pairs on a strand of DNA dictates the order of amino acids that comprise the protein made when the gene is transcribed and translated. A grouping of three sequential base pairs within the exon is called a codon. Each codon, or triplet, codes for an amino acid. These are added in tandem to form a protein. A string of many codons together can be thought of as a series of words all coming together to make a sentence. This sentence provides the instructions for cells to make a protein that is needed in order for the body to function properly.

Human DNA strands containing a hundred to several thousand genes are found on structures called chromosomes. Each cell typically has 46 chromosomes arranged into 23 pairs. Each parent contributes one chromosome to each pair. The first 22 pairs are called autosomal chromosomes, or non-sex chromosomes and are assigned a number from one to 22. The last pair are the sex chromosomes and include the X and the Y chromosomes. If a child receives an X chromosome from each parent, the child is female. If a child receives an X from the mother, and a Y from the father, the child is male.

Just as each parent contributes one chromosome to each pair, so each parent contributes one gene from each chromosome. The pair of genes produces a specific trait in the child. In autosomal dominant conditions, it takes only one copy of a gene to influence a specific trait. The stronger gene is called dominant; the weaker gene is said to be recessive. Two copies of a recessive gene are needed to express a trait while only one copy of a dominant gene is needed. Some genes, (for example, those coding for blood groups) exhibit codominant expression. In this case, both genes are active and produce traits. Human sex chromosomes, the X and the Y also contain important genes. Some genetic diseases are caused by missing or altered genes on one of the sex chromosomes. Males are

most often affected by sex chromosome diseases when they inherit an X chromosome with missing or mutated genes from their mothers.

Types of genetic mutations

Genetic disease results from a change, or mutation, in a chromosome or in one of several base pairs on a gene. Some people inherit such mutations from their parents. These are called hereditary or germline mutations. Other mutations can occur spontaneously, or for the first time in an affected child. For many of the adult on-set diseases, genetic mutations can occur over the lifetime of an individual. These are called acquired or somatic mutations and occur while cells are making copies of themselves or dividing in two. Environmental effects, such as radiation or other chemicals, can also contribute to these types of mutations.

There are a variety of different types of mutations that can occur in the genetic code to cause disease. For each genetic disease, there may be more than one type of mutation to cause the disease. For some genetic diseases, the same mutation occurs in every individual affected with the disease. For example, the most common form of dwarfism, called achondroplasia, is caused by a single base pair substitution. This same mutation occurs in all individuals affected with the disease. Other genetic diseases are caused by different types of genetic mutations that may occur anywhere along the length of a gene. For example, **cystic fibrosis**, the most common genetic disease in the Caucasian population, is caused by any of several hundred different gene mutations. Individual families may carry the same mutation as each other, but not as the rest of the population affected with the same genetic disease.

Some genetic diseases occur as a result of a larger mutation that can occur when a chromosome itself is either rearranged or altered or when a baby is born with more than the expected number of chromosomes. There are only a few types of chromosome rearrangements that are possibly hereditary, or passed on from the mother or the father. The majority of chromosome alterations, where a baby is born with too many chromosomes or missing a chromosome, occur sporadically or for the first time with a new baby.

The type of mutation that causes a genetic disease will determine the type of genetic test to be performed. In some situations, more than one type of genetic test will be performed to arrive at a diagnosis. The cost of genetic tests vary. Chromosome studies can cost hundreds of dollars and some gene studies, thousands. Insurance coverage also varies among companies and the policies. It may take several days or several weeks to complete a

test. Research testing, when the exact location of a gene has not yet been identified, can require several months to years for results.

Types of genetic testing

DIRECT DNA MUTATION ANALYSIS. Direct DNA sequencing examines the base pair sequence of a gene for specific mutations. Some genes contain more than 100,000 bases and a mutation of any one base can make the gene nonfunctional and cause disease. As the number of possible mutations increases, the less likely a test is able to detect all of them. DNA sequencing is a research tool that is used to identify the order of bases in cloned genes. Base sequencing identifies the specific mutation. Once this is known a DNA probe can be made that recognizes the mutation. DNA probes typically contain 20-60 bases to insure that they bind only to the specific mutation site. DNA testing for disease genes is usually performed on white blood cells but can also be performed on other tissues.

There are several different lab techniques used to test for a direct mutation. One early approach begins by using chemicals to separate DNA from the rest of the cell. Special enzymes (called restriction enzymes) are added to the DNA. The enzymes then function like scissors and cut the strands in specific places. Next, the DNA fragments are separated by size using a process called electrophoresis. The fragments are treated chemically to separate them into single stranded fragments and transferred to a nylon filter, a process called Southern blotting. The DNA probe is added to the fragments. The probe is designed to bind to the specific mutated portion of the gene. The probe is labeled with a radioactive isotope. When the probe hybridizes with the target sequence containing the mutation, it will render this piece of DNA on the filter radioactive. The radioactivity will expose a piece of x-ray film layered over the nylon filter, and the mutation will appear as a band in the expected location.

When only small quantities of DNA are available, as in prenatal diagnosis, the target DNA from the fetal cells must first be amplified. This is accomplished by a method known as the polymerase chain reaction. This procedure can copy a specific sequence of DNA that frames the gene to be tested. Up to one million copies can be made in as little as two hours.

INDIRECT DNA TESTING. Family linkage studies are performed to study a disease when the exact type and location of the genetic alteration is not known but the general location on the chromosome has been identified. These studies are possible when a chromosome marker has been found to be associated with a disease. Chromosomes contain certain regions that vary in appearance between individuals. These regions are called



A scientist examines a DNA sequencing autoradiogram on a light box. Each group of four strips represents the nucleotide sequence of ACGT (Adenine-Guanine-Cytosine-Thymine) in the DNA of the nematode worm, *Onchocerca volvulus*, a human parasite responsible for river blindness in tropical countries. (Photo Researchers, Inc. Reproduced by permission.)

polymorphisms and do not cause a genetic disease to occur. If a polymorphism is always present in family members with the same genetic disease, and absent in family members without the disease, it is likely that the gene responsible for the disease is near that polymorphism. The gene mutation can be indirectly detected in family members by looking for the polymorphism.

To look for the polymorphism, DNA is isolated from cells in the same way it is for direct DNA mutation analysis. A restriction enzyme known to cut the DNA at the site where the polymorphism occurs is added. If the polymorphism is present, the restriction enzyme will not recognize the site and will not cut the DNA there. This results in a larger size fragment of DNA. If sufficient DNA is present, the fragments can be separated by electrophoresis, and the DNA bands are stained with ethidium bromide to visualize the position of the bands. If the amount of DNA is small, the double stranded fragments can be separated and a DNA probe can be used to determine whether the polymorphism is present. The pattern of banding of a person being tested for the disease is compared to the pattern from a family member affected by the disease.

Linkage studies have disadvantages not found in direct DNA mutation analysis. These studies require multiple family members to participate in the testing. If key family members choose not to participate, the incomplete family history may make testing other members useless. The indirect method of detecting a mutated gene also causes more opportunity for error, and many disease genes are not associated with polymorphisms.

CHROMOSOME ANALYSIS. Various genetic syndromes are caused by structural chromosome abnormali-

ties. To analyze a person's chromosomes, cells are allowed to grow and multiply in the laboratory until they reach a certain stage of growth. The length of growing time varies with the type of cells. Cells from blood and bone marrow take one to two days, fetal cells from amniotic fluid require seven to 10 days.

When the cells are ready, they are placed on a **microscope** slide using a technique to make them swell, allowing easier visualization of chromosomes. The slides are stained. The stain creates a banding pattern unique to each chromosome. Under a microscope, the chromosomes are counted, identified, and analyzed based on their size, shape, and stained appearance.

A karyotype is the final step in the chromosome analysis. After the chromosomes are counted, a photograph is taken of the chromosomes from one or more cells as seen through a microscope. Then the chromosomes are cut out and arranged side-by-side with their partner in ascending numerical order, from largest to smallest. The karyotype is done either manually or using a computer attached to the microscope. Chromosome analysis is also called cytogenetics.

Applications for genetic testing

NEWBORN SCREENING. Genetic testing is used most often for newborn screening. Every year, millions of newborn babies have their blood samples tested for potentially serious genetic diseases. Phenylketonuria is the genetic disease test most commonly performed.

CARRIER TESTING. An individual who has a gene associated with a disease but never exhibits any symptoms of the disease is called a carrier. A carrier is a person who is not affected by a possessed mutated gene, but can pass the gene to an offspring. Genetic tests have been developed that tell prospective parents whether or not they are carriers of certain diseases. If one or both parents are carriers, the risk of passing the disease to a child can be predicted.

To predict the risk, it is necessary to know if the gene in question is autosomal or sex-linked. If the gene is carried on any one of chromosomes one through 22, the resulting disease is called an autosomal disease. If the gene is carried on the X or Y chromosome, it is called a sex-linked disease.

Sex-linked diseases, such as the bleeding condition **hemophilia**, are usually carried on the X chromosome. A woman who carries a disease-associated mutated gene on one of her X chromosomes has a 50% chance of passing that gene to her son. A son who inherits that gene will develop the disease because he does not have another normal copy of the gene on a second X chromosome to

compensate for the abnormal copy. A daughter who inherits the disease associated gene from her mother, on one of her X chromosomes will become a carrier and be at risk for having a son affected with the disease.

The risk of passing an autosomal disease to a child depends on whether the gene is dominant or recessive. A prospective parent carrying a dominant gene, has a 50% chance of passing the gene to a child. A child needs to receive only one copy of the mutated gene to be affected by the disease.

If the gene is recessive, a child needs to receive two copies of the mutated gene, one from each parent, to be affected by the disease. When both prospective parents are carriers, their child has a 25% chance of inheriting two copies of the mutated gene and being affected by the disease; a 50% chance of inheriting one copy of the mutated gene and being a carrier of the disease but not affected; and a 25% chance of inheriting two normal genes. When only one prospective parent is a carrier, a child has a 50% chance of inheriting one mutated gene and being an unaffected carrier of the disease, and a 50% chance of inheriting two normal genes.

Cystic fibrosis is a disease that affects the **lungs** and **pancreas** and is discovered in early childhood. It is the most common autosomal recessive genetic disease found in the Caucasian population: one in 25 people of Northern European ancestry are carriers of a mutated cystic fibrosis gene. The gene, located on chromosome seven, was identified in 1989.

The gene mutation for cystic fibrosis is detected by a direct DNA test. Over 600 mutations of the cystic fibrosis gene have been identified. Each of these mutations cause the same disease. Tests are available for the most common mutations. Tests that check for the 86 most common mutations in the Caucasian population will detect 90% of carriers for cystic fibrosis. The percentage of mutations detected varies according to an individual's ethnic background. When persons test negative, it is likely, but not guaranteed that they do not have the gene. Both prospective parents must be carriers of the gene to conceive a child with cystic fibrosis.

Tay-Sachs disease, also autosomal recessive, affects children primarily of Ashkenazi Jewish descent. Children with this disease die between the ages of two and five. This disease was previously detected by looking for a missing enzyme. The mutated gene has now been identified and can be detected using direct DNA mutation analysis.

PRESYMPTOMATIC TESTING. Not all genetic diseases show their effect immediately at birth or early in childhood. Although the gene mutation is present at birth, some diseases do not appear until adulthood. If a specif-

ic mutated gene responsible for a late-onset disease has been identified, a person from an affected family can be tested before symptoms appear.

Huntington's disease is one example of a late-onset autosomal dominant disease. Its symptoms of mental confusion and abnormal body movements do not appear until middle to late adulthood. The chromosome location of the gene responsible for Huntington's chorea was located in 1983 after studying the DNA from a large Venezuelan family affected by the disease. Ten years later, the gene was identified. A test is now available to detect the presence of the expanded base pair sequence responsible for causing the disease. The presence of this expanded sequence means a person will develop the disease.

Another late onset condition, **Alzheimer's disease**, is not as well understood as Huntington's disease. The specific genetic cause of Alzheimer's disease is not as clear. Although many cases appear to be inherited in an autosomal dominant pattern, many cases exist as single incidents in a family. Like Huntington's disease, symptoms of mental deterioration first appear in adulthood. Genetic research has found an association between this disease and genes on four different chromosomes. The validity of looking for these genes in a person without symptoms or without family history of the disease is still being studied.

CANCER SUSCEPTIBILITY TESTING. Cancer can result from an inherited (germline) mutated gene or a gene that mutated sometime during a person's lifetime (acquired mutation). Some genes, called tumor suppressor genes, produce proteins that protect the body from cancer. If one of these genes develops a mutation, it is unable to produce the protective protein. If the second copy of the gene is normal, its action may be sufficient to continue production, but if that gene later develops a mutation, the person is vulnerable to cancer. Other genes, called oncogenes, are involved in the normal growth of cells. A mutation in an oncogene can cause too much growth, the beginning of cancer.

Direct DNA tests are currently available to look for gene mutations identified and linked to several kinds of cancer. People with a family history of these cancers are those most likely to be tested. If one of these mutated genes is found, the person is more susceptible to developing the cancer. The likelihood that the person will develop the cancer, even with the mutated gene, is not always known because other genetic and environmental factors are also involved in the development of cancer.

Cancer susceptibility tests are most useful when a positive test result can be followed with clear treatment options. In families with familial polyposis of the colon, testing a child for a mutated APC gene can reveal

whether or not the child needs frequent monitoring for the disease. In families with potentially fatal familial medullary thyroid cancer or multiple endocrine neoplasia type two, finding a mutated RET gene in a child provides the opportunity for that child to have preventive removal of the **thyroid gland**. In the same way, MSH1 and MSH2 mutations can reveal which members in an affected family are vulnerable to familiar **colorectal cancer** and would benefit from aggressive monitoring.

In 1994, a mutation linked to early-onset familial breast and ovarian cancer was identified. BRCA1 is located on chromosome 17. Women with a mutated form of this gene have an increased risk of developing breast and ovarian cancer. A second related gene, BRCA2, was later discovered. Located on chromosome 13, it also carries increased risk of breast and ovarian cancer. Although both genes are rare in the general population, they are slightly more common in women of Ashkenazi Jewish descent.

When a woman is found to have a mutation of one of these genes, the likelihood that she will get breast or ovarian cancer increases, but not to 100%. Other genetic and environmental factors may also influence the outcome.

Testing for these genes is most valuable in families where a mutation has already been found. BRCA1 and BRCA2 are large genes; BRCA1 includes 100,000 bases. More than 120 mutations to this gene have been discovered, but a mutation could occur in any one of the bases. Studies show tests for these genes may miss 30% of existing mutations. The rate of missed mutations, the unknown disease likelihood in spite of a positive result, and the lack of a clear preventive response to a positive result, make the value of this test for the general population uncertain.

PRENATAL AND POSTNATAL CHROMOSOME ANALYSIS. Chromosome analysis is usually performed on fetal cells when a mother will be age 35 or older at the time of delivery, has experienced multiple miscarriages, or reports a family history of a genetic abnormality. Prenatal testing is done on the fetal cells from a **chorionic villus sampling** (from the baby's developing placenta) at nine to 12 weeks of gestation or from the amniotic fluid (the fluid surrounding the baby) at 15-18 weeks of pregnancy. Cells from amniotic fluid usually must grow for seven to 10 days before they are ready to be analyzed. Chorionic villi cells have the potential to grow faster and can be analyzed sooner.

Chromosome analysis using blood cells is performed for a child who is born with or later develops signs of mental retardation or physical malformation. In an older child, chromosome analysis may be requested to investigate developmental delays.

Extra or missing chromosomes cause mental and physical abnormalities. A child born with an extra chromosome 21 (trisomy 21) has Down syndrome. An extra chromosome 13 or 18 also produces well known syndromes. A missing X chromosome causes Turner syndrome and an extra X in a male causes Klinefelter syndrome. Other abnormalities are caused by extra or missing pieces of chromosomes. Fragile X syndrome is a sex-linked disease, causing mental retardation in males.

Chromosome material may also be rearranged, such as the end of chromosome 1 moved to the end of chromosome 3. This is called a chromosomal translocation. If no material is added or deleted in the exchange, a person may not be affected. Such an exchange, however, can cause **infertility** or abnormalities if passed to children.

Evaluation of a couple's infertility or repeated miscarriages will include blood studies of both to check for a chromosome translocation. Many chromosome abnormalities are incompatible with life. Fetuses with these abnormalities often spontaneously abort during the first trimester. Cells from a fetus that died before birth can be studied to look for chromosome abnormalities that may have caused the death.

CANCER DIAGNOSIS AND PROGNOSIS. Certain cancers, particularly leukemia and lymphoma, are associated with changes in chromosomes: extra or missing complete chromosomes, extra or missing portions of chromosomes, or exchanges of material (translocations) between chromosomes. Studies show that the locations of the chromosome breaks are at locations of tumor suppressor genes or oncogenes.

Chromosome analysis on cells from blood, bone marrow, or a solid tumor help to diagnose certain kinds of leukemia and lymphoma and often help predict how well a person will respond to treatment. After treatment has begun, periodic monitoring of these chromosome changes in the blood and bone marrow gives a physician information as to the effectiveness of the treatment.

A well-known chromosome rearrangement is found in chronic myelogenous leukemia. This leukemia is associated with an exchange of material between chromosomes 9 and 22. The resulting smaller chromosome 22 is called the Philadelphia chromosome.

Preparation

Most tests for genetic diseases of children and adults are done using blood. To collect the 5-10 mL of blood needed, a health care worker draws blood from a vein in the inner elbow region. Collection of the sample takes only a few minutes.

Prenatal testing is done either on amniotic fluid or a chorionic villus sampling. To collect amniotic fluid, a physician performs a procedure called **amniocentesis**. An ultrasound is done to find the baby's position and an area filled with amniotic fluid. The physician inserts a needle through the woman's skin and the wall of her uterus and withdraws 5-10 mL of amniotic fluid. Placental tissue for a chorionic villus sampling is taken through the cervix. Each procedure takes approximately 30 minutes.

Bone marrow is used for chromosome analysis in a person with leukemia or lymphoma. The person is given **local anesthesia**. Then the physician inserts a needle through the skin and into the bone (usually the hip bone). A sample (0.5 to 2.0 mL) of bone marrow is withdrawn. This procedure takes approximately 30 minutes.

Aftercare

After blood collection, a person may feel discomfort or bruising at the puncture site or may become dizzy or faint. Pressure to the puncture site until the bleeding stops reduces bruising. Warm packs to the puncture site relieve discomfort.

The chorionic villi sampling, amniocentesis and bone marrow procedures are all done under a physician's supervision. A person to be tested is asked to rest after the procedure and is watched for weakness and signs of bleeding.

Complications

Collection of amniotic fluid and chorionic villi share the risks of **miscarriage**, **infection**, and bleeding. The risks are higher for the chorionic villi sampling. Because of the potential risks for miscarriage, 0.5% following the amniocentesis and 1% following chorionic villi sampling procedure, both of these prenatal tests are offered to couples, but are not required. A woman should tell her physician immediately if she has cramping, bleeding, fluid loss, an increased temperature, or a change in the baby's movement following either of these procedures.

After bone marrow collection, the puncture site may become tender and a person's temperature may rise. These are signs of a possible infection.

Genetic testing involves other nonphysical risks. Many people fear the possible loss of privacy about personal health information. Results of genetic tests may be reported to insurance companies and affect a person's insurability. Some people pay out-of-pocket for genetic tests to avoid this possibility. Laws have been proposed to deal with this problem. Other family members may be affected by the results of a person's genetic test. Privacy of the person test-

KEY TERMS

Autosomal disease—A disease caused by a gene located on chromosomes 1 through 22.

Carrier—A person who has a disease-causing gene but does not show symptoms of that disease.

Chromosome—Structures made up of DNA, on which genes are located.

DNA (Deoxyribonucleic acid)—A long molecule made up of two strands of material coiled around each other in a unique double helix. DNA contains the blueprint for all of a person's traits.

Dominant gene—A gene, whose presence as a single copy, controls the expression of a trait.

Enzyme—A protein produced in a cell.

Gene—A grouping of base pairs that give instruction for a specific trait.

Karyotype—Visual comparison of chromosomes arranged side-by-side with their partner in ascending numerical order, from largest to smallest.

Mutation—Any change in the sequence of DNA.

Positive predictive value (PPV)—The probability that a person with a positive test result has, or will develop a disease or condition.

Recessive gene—A gene that must be present in both copies of the gene pair to allow the expression of a trait.

Sensitivity—The likelihood that a negative test means a person will not have the disease or a mutation.

Sex-linked disorder—A disorder caused by a gene located on a sex chromosome, usually the X chromosome.

ed and the family members affected is a consideration when deciding to have a test and to share the results.

A positive result carries a psychological burden, especially if the test indicates a person will develop a disease, such as Huntington's chorea. The news that a person may be susceptible to a specific kind of cancer, while it may encourage positive preventive measures, may also negatively shadow many future decisions and activities.

A genetic test result may also be inconclusive, meaning no definitive result can be given to the individual or family. This may cause an individual to feel more anxious and frustrated and experience psychological difficulties.

Prior to undergoing genetic testing, genetic counselors should inform individuals to be tested about the likelihood that the test could miss a mutation or abnormality.

Results

Normal results

A normal result for chromosome analysis is 46, XX or 46, XY. This means there are 46 chromosomes (including two X chromosomes for a female or one X and one Y for a male) with no structural abnormalities. A normal result for a direct DNA mutation analysis or linkage study is the absence of gene mutations.

There can be some benefits from genetic testing when an individual tested is not found to carry a genetic mutation. Those who learn with great certainty they are no longer at risk for a genetic disease may choose not to undergo prophylactic therapies and may feel less anxious and relieved.

Abnormal results

An abnormal chromosome analysis report will include the total number of chromosomes and will identify the abnormality found. Tests for gene mutations will report the mutations found.

There are many ethical issues to consider with an abnormal prenatal test result. Many of the diseases tested for during a pregnancy cannot be treated or cured. In addition, some diseases tested for during pregnancy may have a late-onset of symptoms or have minimal effects on an affected individual.

Before making decisions based on an abnormal test result, a person should meet again with a genetic counselor to fully understand the meaning of the results, learn what options are available based on the test result, and what are the risks and benefits of each of those options.

Health care team roles

A family physician or obstetrician often makes an initial recommendation for genetic counseling. A physician specially training in the technique will perform bone marrow aspiration, amniocentesis, or chorionic villus sampling. A nurse or phlebotomist usually collects blood samples. A cytogenetic technologist or clinical laboratory scientist/medical technologist will perform the DNA test depending upon the type of testing requested. A pathologist or geneticist processes and interprets findings of tests. Genetic counselors interpret test results and discuss options. Members of the clergy often assist people who have been tested to make decisions based on test results.

Resources

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ORGANIZATIONS

- American Board of Genetic Counseling, 9650 Rockville Pike, Bethesda, MD 20814-3998. (301) 571-1825. Fax: (301) 571-1895. <<http://www.faseb.org/genetics/abgc/abgcmenu.htm>>.
- American College of Obstetricians and Gynecologists, 409 12th St., S.W., PO Box 96920, Washington, D.C. 20090-6920. <<http://www.acog.org/>>.
- American Infertility Association, 666 Fifth Avenue, Suite 278, New York, NY 10103. (718) 621-5083. <<http://www.americaninfertility.org/>>. info@americaninfertility.org.
- American Public Health Association, 800 I Street, NW, Washington, DC 20001-3710. (202) 777-2742. Fax: (202) 777-2534. <<http://www.apha.org/>>. comments@apha.org.

American Society for Reproductive Medicine. 1209 Montgomery Highway, Birmingham, AL 35216-2809. (205) 978-5000. <<http://www.asrm.com>>.

OTHER

- American College of Physicians. <<http://www.acponline.org/journals/annals/15jun97/currgene.htm>>.
- Lawrence Livermore Laboratory. <<http://www.lbl.gov/Education/ELSI/Frames/genetic-testing-f.html>>.
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Genital culture

Definition

Genital culture is the use of enrichment and selective media to isolate and identify organisms that cause genital infections such as urethritis, cervicitis, and salpingitis (pelvic inflammatory disease). The primary reason for a genital culture is to isolate *Neisseria gonorrhoeae*, the causative agent of gonorrhea. Other organisms that cause genital infections and can be cultured are *Gardnerella vaginalis*, *Candida albicans*, *Neisseria meningitidis*, *Haemophilus ducreyi*, *Mycoplasma hominis*, and *Ureaplasma urealyticum*.

Purpose

Genital culture is performed on persons who have signs of abnormal discharge or skin lesions in the genital area, or complaints such as itching or **pain** on urination. It is performed on persons who have evidence of other sexually transmitted diseases for which culture is not routinely performed because of the high prevalence of concomitant **infection**. For example, there are approximately three million new cases of *Chlamydia trachomatis* infection in the United States each year and many infected persons also will test positive for *N. gonor-*

rhoeae. Genital culture is also performed on any person who may be a victim of a sexual assault. Genital culture may be performed as a screening test on patients who have no symptoms, but are at increased risk for infection because of sexual behavior, since many sexually transmitted diseases can be carried silently. Also, pre and postnatal genital cultures for gonococcus and group B streptococcus are performed routinely on obstetrical patients.

Although most genital infections are sexually transmitted, children or elderly persons are also at risk. In children, skin or wound infections may cause vaginal or urethral infections, especially when there has been physical injury to the genital area. Persons with deficient immune function and persons on prolonged antibiotic treatments are more susceptible to vaginal yeast infections (e.g., *Candida albicans* or *Torulopsis glabrata* infection). Abscesses may form in the pelvic area and Bartholin's gland following **pregnancy**, abortion, malignancy, obstetrical procedures, obstruction, and other conditions, and these often involve anaerobic **bacteria**.

Precautions

Some infections, particularly gonorrhea, can be difficult to culture. In males it may be necessary to culture other sites that may be infected, such as the anus and mouth, if the patient has corresponding sexual habits which put him at risk. Up to 35% of males and 50% of females who are positive for gonococcal infection will test positive for *Chlamydia trachomatis*. This organism as well as *Treponema pallidum*, the causative agent of **sypilis**, *Trichomonas vaginalis*, human **immunodeficiency** virus, cytomegalovirus, herpes simplex 2, and human papilloma virus are not generally cultured. Because of their high prevalence, tests for these organisms (i.e., immunoassays, DNA probes, tests for antibodies) may also be performed. When performing genital cultures, **universal precautions** for prevention of transmission of bloodborne pathogens must be observed.

Description

Neisseria gonorrhoeae causes approximately 650,000 genital infections in the United States each year. If untreated, gonorrhea can result in permanent damage to the reproductive organs (pelvic inflammatory disease), gonococcal arthritis, skin infection, and neonatal conjunctivitis (when transmitted via pregnancy).

The female patient will be in the dorsal lithotomy position typical for Pap testing. A speculum is moistened with warm water (no lubricant should be used) and inserted into the vagina to secure good visualization of

KEY TERMS

Group B streptococcus—A serotype of *Streptococcus*, *Streptococcus agalactiae*, which is beta hemolytic and can cause neonatal sepsis, pneumonia, or meningitis if present in the birth canal at the time of delivery especially when the delivery is difficult.

Os—The opening of the cervix, which is the mouth of the uterus.

the cervix. Any excess cervical mucous should be removed with a cotton ball (held by ring forceps). A sterile cotton swab is inserted just inside the opening of the cervix (the os) and rotated gently for 30 seconds. Genital swabs are usually placed in transport media that contains charcoal to absorb toxins that inhibit the growth of gonococcus.

Care should be taken not to touch the vaginal surfaces with the swab in order to avoid the transfer of normal vaginal flora. For culture, the sample is placed in Stuart's or Amies transport medium with charcoal added and delivered to the laboratory at room temperature. For DNA probe testing (in which organisms are not cultured, but the presence or absence of their genetic material is confirmed) the swab is broken off at the top of the sterile tube provided, and the tube is capped and sent to the laboratory. For immediate viewing, a swab sample may be placed in normal saline. One drop can then be placed between a slide and coverslip, and viewed beneath the **microscope**. This is called a "wet prep." A wet prep is useful for diagnosing yeast infection and trichomoniasis. Pelvic inflammatory disease samples and samples from genital lesions such as chancres are collected by aspiration. Plating for *H. ducreyi* should be done from the chancre aspirate and performed immediately because the organism is fastidious.

In the male patient, a smaller sterile cotton swab is used to remove cells and any discharge from the last 2 cm of the urethra, and the swab is transported for culture or DNA probe testing as described for the female patient. If visible discharge is present on the surface of the penis, this should be swabbed, and it is unnecessary to enter the urethra. If prostate infection is suspected, **urine culture** should be performed. If infection of the prostate, epididymus or testes is suspected, seminal fluid should be cultured.

All swabs or aspirates are plated on modified Thayer-Martin (MTM) agar or New York City (NYC) agar. These media are selective for the growth of *N. gonorrhoeae*.

orrhoae. MTM is chocolate agar (heated sheep **blood** agar) containing colistin to inhibit the growth of gram negative bacilli, nystatin, or anisomycin to inhibit yeast, vancomycin to inhibit growth of gram-positive bacteria, and trimethoprim to inhibit *Proteus spp.* NYC agar contains amphotericin B instead of nystatin and consists of clear proteose-peptone supplemented agar. In addition, the sample is plated on either 5% sheep blood agar or Columbia agar with 5% sheep blood and colistin and nalidixic acid (CNA) to isolate yeast and *Gardnerella vaginalis*. In addition, special selective and differential agar may be used to isolate *Mycoplasma hominis* and *Ureaplasma urealyticum*. Plates are incubated at 36°C in 5-10% carbon dioxide. MTM or NYC agar are examined for growth at 24 hours and if negative again at 48 hours. After 24 hours, any suspicious colonies are Gram-stained and tested for oxidase, which provides presumptive identification of *Neisseria* if positive. Further biochemical testing may be performed to differentiate *N. gonorrhoeae* from *N. meningitidis* which is sometimes isolated from homosexual males. Isolated colonies should also be tested for penicillin resistance. Plates may be discarded at 48 hours if no growth is seen. Other plates are observed at 24 hours, and any suspicious colonies are isolated and tested biochemically to identify the organism. No growth or negative plates are held an additional 24 hours. Anaerobic cultures are performed on abscesses and by request. Pathogens other than *N. gonorrhoeae* are also tested for antibiotic susceptibility.

Microscopic analysis should always be included with genital culture. Wet preparations can identify both yeast and *Trichomonas vaginalis*. A **Gram stain** of the swab material can identify gram-negative diplococci, which is presumptive evidence of gonococcal infection. In males, a positive finding on the Gram stain obviates the need for culture and the patient can begin antibiotic treatment. In females, the diplococci must be located intracellularly in order to make a presumptive diagnosis of gonorrhea infection, and culture must be performed to confirm the diagnosis. The presence of clue cells, epithelial cells containing gram-negative or gram-variable coccobacilli, can signal the presence of *Gardnerella vaginalis*. In homosexual males engaging in anal intercourse, microscopic examination may reveal *Giardia lamblia* or *Entamoeba histolytica* which originated in the intestinal tract.

For both male and female patients, urine tests for the DNA of *Chlamydia trachomatis* and *Neisseria gonorrhoeae* are available. These tests measure bacterial DNA that is amplified either by the ligase chain reaction (LCR) or the polymerase chain reaction (PCR). Both methods can detect the organisms within four hours, thus affording for more rapid treatment. However, the tests do not

detect any other genital tract pathogens that might be present in the patient.

Preparation

Male patients can improve the accuracy of test results by not urinating for one hour prior to testing. Females should avoid douching for at least 24 hours prior to testing. If one of the DNA tests is to be used, it may be preferable to collect the first urine sample of the day. Women should be informed that having cultures performed is no more uncomfortable than routine Pap testing. Men may experience some temporary discomfort. It is much preferable that these tests be done before any **antibiotics** are started, so that the growth of the causative agent is not suppressed.

Aftercare

Patients should be instructed to have no sexual contacts until test results are back.

Complications

The minor discomforts of genital testing are short lived, and no significant complications are common.

Results

A normal result would be no growth of pathologic organisms, or no evidence of infectious organisms on DNA probe or LCR assay. Any infection identified, or organisms seen, can be appropriately treated and the patient counseled regarding prevention, if the causative agent is transmitted sexually. Yeast infections and bacterial vaginosis do not generally represent sexually transmitted diseases (STDs), whereas gonorrhea, chlamydia, herpes, and trichomonas infections are classed as STDs.

Health care team roles

Genital cultures are ordered by a physician and collected by a physician, nurse, or physician assistant. Culture, microscopic analysis, immunoassay, and DNA testing are performed by clinical laboratory scientists/medical technologists. Wet preparations may also be performed by the physician or physician assistant or nurse practitioner with appropriate training.

Nursing staff have a very important task in educating the patient in what to expect, assisting with obtaining samples, and helping to explain test results to patients. Many patients undergoing genital testing are in need of counseling regarding the risks of careless sexual behav-

ior, and the opportunity should be used by staff for education to reduce risks in the future.

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Erika J. Norris

Genital herpes

Definition

Genital herpes (*herpes genitalis*) is a highly contagious sexually transmitted disease (STD) caused by a strain of the herpes simplex virus (HSV). Genital herpes invades the body through mucous membranes, also known as small breaks in the skin.

Description

Genital herpes is characterized by **pain**, itching, and sores (i.e., blister-like lesions) in the genital areas of the body, including the male penis or scrotum, the female labia or vagina, or the urethra, anus, upper thighs, groin, or buttocks. Herpes simplex virus appears in two recognized forms: HSV type 1 and HSV type 2. Previously, it was believed that HSV type 1 only affected the upper body and the face, especially the mouth, appearing often as cold sores. HSV type 2 was believed to be the infecting organism in genital HSV infections. By 2001, it became known that either HSV type can cause infections in either area of the body (i.e., 15% of all genital herpes infections are caused by HSV type 1, and are believed to be the result of oral-to-genital contact). It is not spread by objects (e.g., toilet seat or doorknob), swimming pools, hot tubs, or through the air.



Herpes simplex virus. (Photograph courtesy of the CDC.)

Herpes **viruses** are not new to the modern medicine. The name is derived from the Greek adjective, *herpestes*, which means “creeping,” and refers to the serpent-like pattern often formed by the water blisters (vesicles) of genital herpes. Other members of the herpes virus family share similar traits, also infecting human beings. These traits include varicella zoster virus, the source of both chicken pox and shingles. Epstein-Barr virus, another member of the herpes virus family, is the cause of mononucleosis.

As of 2000, in the United States, there are 45 million adolescents and adults infected with HSV **infection**. Genital herpes is slightly more common in women, possibly because male-to-female transmission of the virus is more effective; it attacks one out of every four women. In contrast, one out of every five men contract genital herpes, and a greater percentage of black versus white males (i.e., 45.9% vs. 17.6%, respectively) become infected with the virus. According to the web site of the Centers for Disease Control, race and ethnicity in the United States are frequently associated with poverty, access to quality health care, whether health care is sought, illicit drug use, and life in communities with high incidences of STDs. Therefore, it is not surprising that HSV 2 infections are more prevalent among African-Americans (45.9%) than European-Americans (17.6%). Among teenagers, the incidence of genital herpes infections has risen steadily, at 30%, since 1970. That increase, five times higher than it was 20 years ago, is most dramatic among white teenagers in the 12–19. Young adults between the ages of 20 and 29 are now twice as likely to have HSV 2 as they were previously.

Causes and symptoms

While anyone can be infected by the herpes virus, not everyone will have symptoms. Risk factors for geni-

tal herpes include: early age at first sexual activity, multiple sexual partners, and other STDs.

Most patients with genital herpes experience a prodrome (i.e., symptoms of oncoming disease) that includes pain, burning, itching, or tingling at the site where blisters will form. This prodromal stage may last anywhere from a few hours, to one to two days. The herpes infection prodrome can occur in both the primary infection and recurrent infections. The prodrome for recurrent infections may be intense, and cause severe burning or stabbing pain in the genital area, legs, or buttocks.

Primary genital herpes

The first symptoms of herpes usually occur within two to seven days after contact with an infected person, but may take up to two weeks. Symptoms of the primary infection are usually more severe than those of recurrent infections. For up to 70% of patients, the primary infection presents with symptoms that affect the whole body (i.e., “constitutional symptoms”), including tiredness, headache, **fever**, chills, muscle aches, and loss of appetite. There may also be painful, swollen lymph nodes in the groin. These symptoms are greatest during the first three to four days of the infection and disappear within one week.

Following the prodrome, herpes blisters form; they are similar in men and women. First, small red bumps appear. These bumps quickly become fluid-filled blisters. In dry areas, the blisters become filled with pus and take on a white-to-gray appearance, become covered with scabs, and heal within two to three weeks. In moist areas, the fluid-filled blisters burst, forming painful ulcers that drain before healing. New blisters may appear over a period of one week or more, and may join together to form very large ulcers. The pain is relieved within two weeks; the blisters and ulcers heal, without scarring, by the third to fourth week after the prodrome.

Women may experience a very severe and painful primary infection. Herpes blisters first appear on the vagina’s entrance, labia majora (i.e., outer lips), and labia minora (i.e., inner lips). Blisters often appear on the clitoris, at the urinary opening, around the anal opening, and on the buttocks and thighs. In addition, women may get herpes blisters on the lips, breasts, and fingers, and in the eyes (due to spreading from contact with the hands). The vagina and cervix are almost always involved. This causes a watery discharge. Other symptoms that occur in women with primary infections are painful or difficult urination (83%), swelling of the urinary tube (85%), **meningitis** (36%), and throat infection (13%). Most women develop painful, swollen lymph nodes (i.e., lymphadenopathy) in the groin and pelvis. About one in ten

women get a vaginal yeast infection as a complication of the primary herpes infection.

In men, the herpes blisters usually form on the penis, but can also appear on the scrotum, thighs, and buttocks. Less than half of the men with primary herpes experience the “constitutional symptoms.” A significant percentage of men (30–40%) have a discharge from the urinary tube. Some develop lymphadenopathy in the groin and pelvis. Men, although with less frequency than women, may experience painful or difficult urination (44%), swelling of the urinary tube (27%), meningitis (13%), and throat infection (7%).

Recurrent genital herpes

One or more outbreaks of genital herpes per year occur in 60–90% of those infected with the herpes virus. About 40% of persons infected with herpes simplex virus type 2 will experience six or more outbreaks each year. Genital herpes recurrences are less severe than the primary infection; however, women still experience more severe symptoms and pain than men. Constitutional symptoms are not usually present. Blisters appear at the same sites during each outbreak. Usually, there are fewer blisters, less pain, and a shorter time span from symptom onset to healing than in the primary infection. One out of every four women experience painful or difficult urination during recurrent infection. Both men and women may develop lymphadenopathy.

The **immune system** will naturally create antibodies to fight viruses; herpes viruses are no exception. Herpes viruses, however, share a survival characteristic that makes it very difficult for the immune system to actually eliminate these viruses from the body. Herpes viruses evade antibodies by traveling via nerve pathways and hiding in **neurons** (i.e., nerve cells). These small colonies of surviving viruses enter what is known as the latent, or dormant phase, and remain that way until reactivated. The mechanisms by which the herpes virus is reactivated are not completely understood. Reactivation, however, can cause further outbreaks of the infection. The latent phase of the herpes virus can last for days, months, or years.

One of the ways that viruses differ from **bacteria** is in their reproductive ability. While bacteria reproduce independently, viruses require cells from their hosts to do so. When the herpes virus reactivates, it enters cells in its primary site of infection—in this case, the genital region—and causes the cells there to make more virus. Thousands of new herpes virus cells are released into the body’s system before each cell dies. This cell death and resulting tissue damage are the actual cause of the lesions that appear during an outbreak of genital herpes.

Reactivation of herpes viruses in human beings is specific to each individual, different in both triggers and severity. Evidence, however, supports the prediction that virtually all people infected with HSV type 2 will experience some form of recurrence; this averages to approximately four times per year. HSV type 1 infections are less likely to result in further symptomatic outbreaks, with an overall average recurrence rate of once per year. Rates of recurrence tend to diminish over time.

Newborn babies who are infected with herpes virus experience a very severe, potentially fatal disease. This is called “neonatal herpes infection.” In the United States, one in every three women of childbearing age are infected with the herpes virus; only one in 2,000 newborns will be born infected. Newborns can be infected during passage through the birth canal or during the **pregnancy**, should the embryonic sac rupture early. Doctors will normally perform a cesarean section (cs) on women who go into labor with active genital herpes.

All newborn infants should be checked for symptoms of neonatal herpes. Symptoms include skin lesions, listlessness, fever, and lack of appetite. Left untreated, it can cause damage to the infant’s **brain** and central nervous system or death.

The reasons for the reactivation of herpes viruses is not yet completely understood, but research has identified some triggers that are either causative, or suspected of being causative, of recurrent outbreaks.

Among these are:

- prolonged exposure to ultraviolet light (i.e., sunburn), which often reactivates facial herpes infections
- excessive friction or injury to genital areas
- compromise of the strength of the body’s immune system, the result of herpes virus’ recurrence, and its accompanying symptoms of fatigue and illness
- **stress** (This has also been considered a prime culprit in bringing about outbreaks. Through mid-2001, however, clinical research has not proved the a causal relationship between stress and reactivation. The investigators of one clinical study have shown a connection between decreased ability to cope with stress and recurrent infections.)
- the presence of HIV (Human **Immunodeficiency Virus**) (Human Immunodeficiency Virus has demonstrated a weakening of the immune system, with a consequent increase in the strength and severity of genital herpes infections.)
- the presence of either HSV type 1 or HSV type 2, or both, that are transmitted to others through direct bodily contact (This includes any sexual interaction [i.e.,



A close-up view of a penis with a blister (center of image) caused by the herpes simplex virus. (Photograph by Dr. P. Marazzi, Custom Medical Stock Photo. Reproduced by permission.)

vaginal, anal, or oral], kissing, or skin-to-skin contact. It is passed along with or without the presence of open sores or other prodromal symptoms. Notably, HSV infections are symptom free the majority of the time. For this reason, the virus is often transmitted by people infected with HSV who are not even aware that they are infected, or believe that lack of symptoms means that they are not contagious.)

Interestingly, an August 2000 report in the *New England Journal of Medicine* stated that in a University of Washington study, the majority of people who tested positive for HSV 2 infections reported no symptoms whatsoever. Another group of researchers at the University of Washington has assembled a list of ailments about which the subjects complained; they did not know that they had genital herpes. These ailments included:

For women:

- hemorrhoids
- physical irritation from sexual contact
- heat rash
- aching or itching during menses
- allergy to condoms or spermicide
- allergy to elastic in panty hose

For men:

- jock itch
- zipper burn
- hemorrhoids
- acne
- physical irritation from wearing tight jeans
- physical irritation from sexual contact

Diagnosis

Because genital herpes is so prevalent, it is diagnosed primarily by the presentation of symptoms. A diagnosis can often be made upon **physical examination**, and taking of a complete sexual history.

Because a mild case of genital herpes may be overlooked during a routine physical examination, laboratory tests are very important. When possible, it is helpful to know the type of HSV with which a patient is infected. As noted previously, HSV type 2 is potentially life-threatening to newborn infants.

Viral culture is one of the most accurate and specific tests for identifying HSV type 1 or 2. As healing sores do not shed much virus, a sample from an open sore should be taken for viral culture. The doctor must determine the exact cause of the sores. The above-mentioned tests should be performed to confirm that the herpes virus is causing the genital sores.

Other conditions that may produce genital sores are:

- syphilis
- chancroid
- lymphogranuloma venereum
- granuloma inguinale
- herpes zoster
- erythema multiform
- inflammatory bowel disease
- contact dermatitis
- candidiasis
- impetigo

Because of this, a viral culture test should be performed to be absolutely certain that the sores are caused by the HSV.

The results of serological tests (i.e., **blood** tests [either by finger-stick or blood draw] that reveal antibodies to HSV) are available within one day. They, too, are considered very accurate tests that can be performed whether open lesions are present or not. The disadvantage of this blood test is that it must be taken no earlier than 12 days post-infection; in a first infectious outbreak,

antibodies sometimes cannot be detected for three months.

Because most newborns who are infected with herpes virus are born to mothers with no symptoms of infection, it is important to check all newborn babies for symptoms. A culture of any skin sore should be taken to determine if it is caused by HSV. Babies should be checked for sores in their mouths and for signs of herpes infection in their eyes.

Treatment

There is no cure for the herpes virus. There are, however, **antiviral drugs** available that have some effect in lessening the symptoms and decreasing the length of herpes outbreaks. There is evidence that some of these medications may also prevent future outbreaks.

The antiviral drugs work by interfering with the replication of the viruses and are most effective when taken as early in the infection process as possible. For the best results, drug treatment should begin during the prodrome stage, before blisters are visible. Depending on the length of the outbreak, drug treatment could continue for up to 10 days.

Acyclovir (Zovirax) is the drug of choice for herpes infection and can be given intravenously, taken by mouth (orally), or applied directly to sores as a topical ointment. Acyclovir has been in use for many years; only 5 out of 100 patients (5%) experience side effects. Side effects of acyclovir treatment include nausea, vomiting, itchy rash, and **hives**. Although acyclovir is the recommended drug for treating herpes infections, other drugs may be used. They include famciclovir (Famvir), valacyclovir (Valtrex), vidarabine (Vira-A), idoxuridine (Herplex Liquifilm, Stoxil), trifluorothymidine (Viroptic), and penciclovir (Denavir).

Acyclovir is effective in reducing the severity of both the primary infection and recurrent outbreaks. When taken intravenously or orally, acyclovir reduces the healing time, virus shedding period, and duration of vesicles. The drug is taken three or five times daily depending on the dose for a period of 10 days. Recurrent herpes is treated with the same doses for a period of five days. Intravenous (IV) acyclovir is given to patients who require hospitalization because of severe primary infections or herpes complications, such as aseptic meningitis or sacral ganglionitis (i.e., inflammation of nerve bundles).

Patients with frequent outbreaks (i.e., greater than six to eight per year) may benefit from long-term use of acyclovir, called “suppressive therapy.” Patients on suppressive therapy typically have longer periods between herpes outbreaks. The specific dosage used for suppres-

sion would need to be determined for each patient and should be reevaluated every few years. Alternatively, patients may use short-term suppressive therapy to lessen the chance of developing an active infection on special occasions, such as a wedding, or during holidays.

There are several things that a patient may do to lessen the pain of genital sores. Wearing loose fitting clothing and cotton underwear is helpful. Removing clothing or wearing loose pajamas while at home may reduce pain, as may soaking in a tub of warm water and using a blow dryer on the “cool” setting to dry the infected area. Application of an ice pack on the affected area for 10 minutes, followed by five minutes without the ice pack, then repeating this procedure, may relieve pain. A **zinc** sulfate ointment may also help to heal the sores. Baking soda compresses may be soothing.

Neonatal herpes

Newborn babies with herpes virus infections are treated with acyclovir IV or vidarabine for 10 days. These drugs have greatly reduced neonatal deaths and increased the number of babies who appear normal at one year of age. Infected babies may be treated with long-term suppressive therapy.

Alternative treatment

An imbalance in the amino acids lysine and arginine is thought to be one contributing factor in herpes virus outbreaks. A ratio of lysine to arginine that is in balance (i.e., more lysine than arginine) appears to optimize the function of the immune system work. Thus, a diet that is rich in lysine may help prevent recurrences of genital herpes. Foods that contain high levels of lysine include most vegetables, legumes, fish, turkey, beef, lamb, cheese, and chicken. Patients may take 500 mg of lysine daily and increase to 1,000 mg three times a day during an outbreak. Intake of the amino acid arginine should be reduced. Foods rich in arginine that should be avoided are chocolate, peanuts, almonds, and other nuts and seeds.

Since clinical experience indicates a connection between high stress and herpes outbreaks, some patients may respond well to stress-reduction and **relaxation** techniques. **Acupressure** and massage may relieve tiredness and stress. **Meditation, yoga, tai chi, and hypnotherapy** can also help relieve stress and promote relaxation.

Some herbs, including echinacea (*Echinacea* spp.) and garlic (*Allium sativum*), are believed to strengthen the body’s defenses against viral infections. Red marine algae (family *Dumontiaceae*), both taken internally and applied topically, is thought to be effective in treating HSV type 1 and 2 infections. Other topical treatments may be helpful in inhibiting the growth of the herpes

KEY TERMS

Groin—The region of the body that lies between the abdomen and the thighs.

Latent virus—A nonactive virus which is in a dormant state within a cell. Herpes virus is latent in cells of the nervous system.

Prodrome—Symptoms which warn of the beginning of disease. The herpes prodrome consists of pain, burning, tingling, or itching at a site before blisters are visible.

Recurrence—The return of an active herpes infection following a period of latency.

Lesion—A morbid, or diseased, change in tissue formation at a local site.

virus, in minimizing the damage it causes, or in helping the sores heal. Zinc sulfate ointment seems to help sores heal and to fight recurrence. Lithium succinate ointment may interfere with viral replication. An ointment made with glycyrrhizinic acid, a component of licorice (*Glycyrrhiza glabra*), seems to inactivate the virus. Topical applications of **vitamin E** or tea tree oil (*Melaleuca* spp.) help dry up herpes sores. Specific combinations of homeopathic remedies may also be helpful treatments for genital herpes.

Prognosis

Although physically and emotionally painful, genital herpes is usually not a life-threatening disease. The primary infection can be severe and may require hospitalization for treatment. Complications of the primary infection may involve the cervix, **urinary system**, anal opening, and the nervous system. Persons who have a decreased ability to produce an **immune response** to infection (called “immunocompromised”) due to disease or medication are at risk for a very severe, possibly fatal, herpes infection. Even with antiviral treatment, neonatal herpes infections can be fatal or cause permanent nervous system damage.

Prevention

The only way to prevent genital herpes is to avoid contact with infected persons. This is not an easy solution because many people aren’t aware that they are infected and can easily spread the virus to others. Avoid all sexual contact with an infected person during a herpes outbreak. Because the herpes virus can be spread at any

time, condom use is recommended to prevent the spread of virus to uninfected partners. It is also important, however, to realize that condoms cannot stop the transmission of the herpes virus from body areas other than the sexual organs. Though research continues, there is no herpes vaccine proven effective in human beings.

Health care team roles

As genital herpes infections and their consequences may dramatically vary among people, there is diverse and varied involvement of health care team members. These include:

- Primary care physicians, nurse practitioners, and alternative health care providers, all of whom will be involved in physical examinations of people complaining of symptoms. Genital herpes can be diagnosed and treated by the family doctor, dermatologist (i.e., a doctor who specialize in skin diseases), urologists (i.e., doctors who specialize in the urinary tract diseases of men and women and the genital organs of men), gynecologists (i.e., doctors who specialize in the diseases of women’s genital organs) and infectious disease specialists. Any of these may also pick up the presence of unknown genital herpes infections on routine examinations.
- Physicians or nurse practitioners routinely do viral cultures. A sterile cotton swab is wiped over open sores and the sample used to infect human cells in culture. Cells killed by the herpes virus have a certain appearance under microscopic examination. The results of this test are available within two to ten days. Though it is considered quite accurate, there are estimates that up to 20% of viral culture tests give a false negative reading. Other areas that may be sampled, depending upon the disease symptoms in a particular patient, include the urinary tract, vagina, cervix, throat, eye tissues, and cerebrospinal fluid. Direct staining and microscopic examination of the lesion sample may also be used.
- Finger-stick or blood-drawn laboratory tests are usually done by either nurses or laboratory technicians, but are sometimes carried out by physicians or nurse practitioners.
- Obstetricians (i.e., physicians who deliver newborn babies), nurse midwives (i.e., nurses who deliver newborn babies) and obstetrical nurses (i.e., nurses who assist in the delivery of newborns and the care of mothers and infants after birth) will be involved in assuring that mothers infected with active genital herpes are provided a safe delivery (usually by cesarian section), and that newborns are thoroughly checked for signs and symptoms of the disease. As noted previously, many newborns are born infected with herpes virus to moth-

ers who had no symptoms of infection. Therefore, it is important to check all newborn babies for skin sores or lesions inside the mouth, and for signs of herpes infection in their eyes.

- Physicians, nurse practitioners, and alternative health practitioners will prescribe medications or herbs and diet to alleviate the symptoms of genital herpes.
- Nurses will be involved in the day-to-day care, including the provision of comfort measures, such as the administration of analgesic medications, warm baths, and applying compresses and ointments to those seriously ill enough to require hospitalization or nursing **home care**. Many of these will be immune system-compromised people, such as those who have AIDS.

Patient education

All health care providers will be involved in providing education about genital herpes. Because STDs are such a sensitive area of health care, it will be important for the health care provider to show understanding and sensitivity for health care consumers infected with HSV. Information and education, given without suggestion of judgment, can be among the most important care provided. It should emphasize that there is currently no *cure* for genital herpes, that the disease is extremely pervasive, and that precautions must be used during sexual contact in order to avoid infecting others. An important goal of **patient education** should be to make the patient aware that condoms are an excellent means of protection from HSV and pregnancy. The patients should also learn what laboratory tests will need to be done, and what medications, or treatments, can help alleviate symptoms.

The diagnosis and treatment of this infectious disease should be covered by most insurance providers.

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Joan M. Schonbeck

Geriatric nutrition

Definition

Geriatric **nutrition** applies nutrition principles to delay effects of aging and disease, to aid in the management of the physical, psychological, and psychosocial changes commonly associated with growing old.

Purpose

The number of people over 65 years of age jumped from 4% of the U.S. population in 1900 to 13% in 1990, and is expected to reach 20% in 2030, due primarily to advances in health care. "Elderly" was once defined as being age 65 or above, but the growing number of active and healthy older people has caused that definition to expand to "young old" (65 to 75), "old old" (75 to 85), and "oldest old" (85 and beyond). The over-85 age group is the one that is growing most rapidly.

The cornerstone of geriatric nutrition is a well-balanced diet. This provides optimal nutrition to help delay the leading causes of death: **heart** disease, **cancer**, and stroke. In addition, ongoing research indicates that dietary habits, such as restricting one's calorie intake and consuming antioxidants, may increase longevity.

Precautions

Physiological changes

With age comes many physical changes. Once the body reaches physiologic maturity, the rate of degenerative change exceeds the rate of cell regeneration. However, people age at different rates, so the elderly population is not a homogeneous group; there is great variability among individuals.

The following are typical physiologic changes that can affect nutritional status:

- Body composition changes as fat replaces muscle, in a process called sarcopenia. Research shows that **exercise**, particularly weight training, slows down this process. Because of the decrease in lean body mass, basal metabolic rate (BMR) declines about 5% per decade during adulthood. Total caloric needs drop, and lowered protein reserves slow the body's ability to

respond to injury or surgery. Body water decreases along with the decline in lean body mass.

- Gastrointestinal (GI) changes include a reduction in digestion and absorption. Digestive hormones and enzymes decrease, the intestinal mucosa deteriorates, and the gastric emptying time increases. As a result, two conditions are more likely: pernicious anemia and constipation. Pernicious anemia may result because of hypochlorhydria, which decreases **vitamin B₁₂** absorption and affects approximately one third of older Americans. Constipation, despite considerable laxative use among older people, may result from slower GI motility, inadequate fluid intake, or physical inactivity.
- Musculoskeletal changes occur. A progressive drop in bone mass starts when people are in their 30s or 40s; this accelerates for women during **menopause**, making the skeleton more vulnerable to **fractures** or **osteoporosis**. Adequate intake of **calcium** and **vitamin D** helps to retain bone.
- Geriatric nutrition must take into account sensory and oral changes. Decreases in all the senses, particularly in the **taste** buds that affect perception of salty and sweet tastes, may affect appetite. Xerostomia, lack of salivation, affects more than 70% of the elderly. Also, denture wearers chew less efficiently than those with natural teeth.
- Other organ changes may occur. Insulin secretion is decreased, which can lead to carbohydrate intolerance, and renal function deteriorates in the 40s for some people.
- Cardiovascular changes may occur. Reduced sodium intakes become important, as **blood pressure** increases in women over age 80 (but, interestingly, it declines in older men). Serum cholesterol levels peak for men at age 60 but continue to rise in women until age 70.
- Immunocompetence decreases with age. The lower immune function means less ability to fight infections and malignancies. **Vitamin E**, **zinc**, and some other supplements may increase immune function.

Psychosocial changes

A number of changes may occur in the aging person's social and psychological status, potentially affecting appetite and nutrition status. These include:

- Depression, the most common cause of unexplained weight loss in older adults, occurs in approximately 15% of adults over age 65, with a much higher incidence in those living in extended-care facilities.
- Memory impairment caused by various types of **dementia**, **Alzheimer's disease**, or other neurological

diseases rises dramatically, with half of all persons over age 85 affected. Weight loss and improper nutrition are potential problems.

- Alcohol abuse is often unreported, especially since approximately one third of alcoholics age 65 years or older begin drinking later in life. Excessive alcohol intake (over 15% of total calories) increases morbidity and mortality, and leads to both physical and psychosocial problems.
- Social isolation becomes more common because of declining income, health problems, loss of spouse or friends, and assistance needs. All of these may affect appetite and possibly nutritional status.

Description

Basic energy and nutrient needs

Calorie requirements decrease with age, although individuals vary greatly depending on their activity level and health status. Diets that fall below 1,800 calories a day may be low in protein, calcium, **iron**, and **vitamins**, so should feature nutrient-dense foods.

Protein needs of healthy older adults are the same as for other adults, with 0.8 to 1 gm of protein per kg of body weight recommended. Most older people without debilitating disease eat adequate protein, but those with infections or severe disease may become protein-mal-nourished due to increased protein requirements and poor appetites. Seniors do better eating more complex **carbohydrates**, which increase fiber, vitamins, and **minerals**, and help with insulin sensitivity. Lactase-treated milk or fermented dairy products are suggested if lactose intolerance develops. Because caloric needs drop and heart disease is so prevalent, reducing total dietary fat and especially the amount of saturated **fats** is advised.

Mineral deficiencies are uncommon in older adults, and recommended amounts are the same or similar to those for younger adults. Iron-deficiency anemia related to nutrition is rare, and more likely due to **blood** loss. Of the vitamins, vitamin D intakes are often lower than recommended, especially among homebound or institutionalized people who lack sun exposure (the most accessible source of vitamin D). The antioxidant vitamins, vitamin E, carotenoids, and **vitamin C**, continue to receive attention because of their potential to improve immune function and ward off disease. Requirements for **riboflavin**, vitamins B₆ and B₁₂, and zinc are increased in the elderly. However, needs for **vitamin A** decrease.

Dysphagia

The incidence of **dysphagia**, or difficulty in swallowing, increases with age. Dysphagia results from con-

ditions such as stroke, Alzheimer's or **Parkinson's disease, multiple sclerosis**, or physiological changes such as loss of teeth or poorly fitting dentures. Inadequate dietary intake as a result of dysphagia can lead to weight loss, **dehydration**, and nutritional deficiencies. The American Dietetic Association has developed Level 1 through Level 4 dysphagia diets, which provide varying textures and liquids based on the severity of the condition.

Fluid balance

Dehydration is the most common cause of fluid and electrolyte disturbances in older adults. Reduced thirst sensation and fluid intake, medications such as diuretics and **laxatives**, and increased fluid needs during illness contribute to dehydration. Adequate water-intake guidelines are 1 ml water/kcal energy consumed (for example, 1.8 L for an 1,800-calorie intake), or 25–30 ml/kg of weight for most individuals.

Skin integrity

Skin breakdown is a common problem, particularly in bedridden or immunologically impaired people. The most common skin breakdown is the **pressure ulcer**, which occurs in 4% to 30% of hospitalized patients and 2% to 23% of residents of skilled-care **nursing homes**.

Pressure ulcers are graded or staged to classify the degree of tissue damage. Those with more serious Stage II to Stage IV ulcers have increased nutritional needs. Protein needs increase to 1–1.5 gm protein/kg, caloric needs increase to 30–35 kcal/kg, and 25–35 cc fluid/kg is recommended.

Malnutrition

While most elderly people maintain adequate nutritional status, institutionalized and hospitalized older adults are at higher risk for malnutrition than individuals who are living independently. Cancer cachexia, the weak, emaciated condition resulting from cancer, accounts for about half of malnutrition cases in institutionalized adults.

Two common forms of malnutrition are protein-calorie malnutrition, in which the person appears ill-nourished; and protein malnutrition, in which an overweight person may have depleted protein stores. Nutrition support may involve higher protein and caloric amounts, nutritional supplements such as Ensure, or enteral tube feedings that provide nutrient solutions into the GI tract.

Preparation

Assessment

The following are used to assess nutritional needs:

- A thorough medical history, **physical examination**, and dietary history can provide a general picture of the individual's nutritional status. Lab values also provide valuable information.
- Weight evaluation may be recommended. Normal weight status guidelines include a BMI of 21 to 27 (BMI = weight in pounds x 704.5/ht(in) squared) or Ideal Body Weight +/-10%. Guidelines for significant weight loss include 10% weight loss in six months, 5% in one month, or 2% in one week.
- Dehydration evaluation involves physical assessment (poor skin turgor, dark urine, flushed skin), and assessment of recent fluid and food intake. High laboratory levels of blood urea nitrogen (BUN), albumin, serum sodium, and serum osmolality can indicate dehydration.

Aftercare

Laboratory values, particularly albumin for protein status and sodium and BUN for hydration status, should continue to be assessed after treatment. Tube feedings need to be continually monitored to prevent aspiration.

Results

Normal laboratory values in the elderly

- Protein status: albumin 4 to 6 gm/dL; prealbumin: 19 to 43 mg/dL.
- Anemia status: hemoglobin: 12 to 18 gm/dL; **hematocrit** 33% to 49% (can be slightly lower in the elderly); MCV: 80 to 95 μm^3 ; MCHC: 27 to 31 pg; B_{12} : 100 to 1,300 pg/mL.
- Hydration: serum sodium: 135 to 147mEq/L; serum osmolality: 285 to 295 mOsm/kg; BUN 10 to 20 mg/dL (can be slightly higher in elderly).

Health care team roles

- Registered dietitians play the primary role in assessing and coordinating geriatric nutrition care.
- Nursing staff also assesses patients, and physicians oversee total care and ordering of lab tests.
- A speech-language therapist typically conducts a swallowing assessment and coordinates care for dysphagia.

KEY TERMS

Hypochlorhydria—A deficiency of hydrochloric acid in the gastric juice.

Osteoporosis—A loss of bone density leading to fractures because the skeleton is unable to sustain ordinary stresses.

Pressure ulcer—Any lesion caused by unrelieved pressure resulting in damage to the underlying tissue.

Sarcopenia—A deficiency of muscle or flesh that occurs in the elderly.

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Gestational diabetes

Definition

Gestational **diabetes mellitus** (GDM) is a condition that occurs during **pregnancy**. Like other forms of diabetes, GDM involves a defect in the way the body processes and uses sugars (glucose) in the diet. Gestational diabetes, however, has a number of characteristics that are different from other forms of diabetes. This form of diabetes does not include women who are diabetic before they become pregnant. Gestational diabetes usually occurs in the second and third trimesters of the pregnancy.

Description

Glucose is a form of sugar that is present in many foods, including sweets, potatoes, pasta, and breads. The body uses glucose to provide energy. It is stored in the **liver**, muscles, and fatty tissue. The **pancreas** produces a hormone (a chemical produced in one part of the body that travels to another part of the body in order to exert its effect) called insulin. Insulin is required to allow glucose to enter the liver, muscles, and fatty tissues, thus reducing the amount of glucose in the **blood**. In persons with diabetes, blood levels of glucose remain abnormally high. The inability of the pancreas to produce enough insulin is the cause of these high levels of glucose.

In gestational diabetes, the pancreas is not at fault. The problem is in the placenta. During pregnancy, the placenta provides the baby with nourishment. It also produces a number of hormones that interfere with the body's usual response to insulin. This condition is referred to as "insulin resistance." The development of insulin resistance is primarily caused by a substance called lactogen, which is produced during pregnancy, and from increased blood levels of the hormones progesterone and estrogen. The blood levels of these substances tend to peak in the second and third trimester of the pregnancy, which is when GDM is most likely to occur. Most pregnant women do not develop GDM because the pancreas works to produce extra quantities of insulin to compensate for insulin resistance. However, when a woman's pancreas cannot produce enough extra insulin, blood levels of glucose remain abnormally elevated, and the woman is considered to have GDM. It is believed that some women with borderline blood sugar problems before pregnancy are more likely to have long-term blood sugar regulation problems after developing GDM.

As of January 2001, about 200,000, or 7%, of pregnant women in the United States develop GDM every year. Women at risk for GDM include those who:

- are overweight
- have immediate family members with a history of Type II diabetes
- have previously given birth to a large (over 9 lbs [4 kg]) baby
- have previously had a baby who was stillborn, or born with a birth defect
- have an excess amount of amniotic fluid (the cushioning fluid within the uterus that surrounds the developing fetus)
- are over 25 years of age
- belong to an ethnic group proved to experience higher rates of GDM. (In the United States, these groups

include Hispanic-Americans, American Indians, and African-Americans, as well as individuals from Asia, India, and the Pacific Islands.)

- have had GDM during a previous pregnancy
- have persistent evidence of excess glucose in the urine
- have a history of chronic drug abuse involving agents such as corticosteroids

Causes and symptoms

Most women with GDM have no recognizable symptoms. However, leaving GDM undiagnosed and untreated is dangerous to the developing fetus. Left untreated, a woman with diabetes will have consistently high blood sugar. This sugar will cross the placenta and the unborn baby's pancreas will respond to this high level of sugar by constantly producing large amounts of insulin. The insulin will allow the cells of the fetus to take in glucose, where it will be converted to fat and stored. A fetus that has been exposed to consistently high levels of sugar may be abnormally large. Such a baby may grow so large that he or she cannot be born through the vagina, but will instead need to be born through a surgical procedure (cesarean section).

Furthermore, when the baby is born, the baby will still have an abnormally large amount of insulin circulating in the blood. After birth, when the mother and baby are no longer connected via the placenta and umbilical cord, the baby will no longer be receiving the mother's high level of sugar. The baby's high level of insulin, however, will very quickly use up the glucose circulating in its bloodstream, predisposing the baby to a dangerously low level of blood glucose (i.e., a condition called hypoglycemia).

Diagnosis

Since GDM most often exists with no symptoms detectable by the patient, and since its existence puts the developing baby at considerable risk, screening for the disorder is a routine part of **prenatal care**. This screening is usually done between the 24th and 28th week of pregnancy. By this point in the pregnancy, the placental hormones have reached a sufficient level to cause insulin resistance. Screening for GDM involves the pregnant woman drinking a special solution that contains exactly 50 grams of glucose. An hour later, the woman's blood is drawn and tested for its glucose level. A level less than 130-140 mg/dl is considered normal.

When the screening glucose level is over the safe level, a special three-hour glucose tolerance test is performed. This involves following a special diet for three



A woman with gestational diabetes injects herself with insulin daily to treat her condition. (Photograph by Mark Clarke. Science Source/Photo Researchers. Reproduced by permission.)

days prior to the test. This diet is designed to contain at least 150 grams of carbohydrate each day. Just before the test, the patient is instructed to eat and drink nothing (except water) for 8–14 hours. A blood sample is then tested to determine the fasting glucose level. The patient then drinks a special solution containing exactly 100 grams of glucose, and her blood is tested every hour for the next three hours. If two or more of these levels are elevated over normal, the patient is considered to have GDM.

Treatment

Treatment for GDM will depend on the severity of the diabetes. Mild forms can be treated with diet (i.e., decreasing the intake of sugars and **fats**). Many women are put on strict, detailed diets, and are asked to stay within a certain range of calorie intake. **Exercise** is sometimes used to keep blood sugar levels lower. Patients are often asked to regularly measure their blood sugar. This

KEY TERMS

Corticosteroids—Hormonal steroid substances that originate in the cortex of the adrenal gland.

Estrogen—A female sex hormone responsible for secondary sexual characteristics and cyclic changes in women.

Glucose—A form of sugar. The final product of the breakdown of carbohydrates (starches).

Insulin—A hormone produced by the pancreas that is central to the processing of sugars and carbohydrates in the diet.

Ketoacidosis—Excessive acidic condition in the body caused by excess production of ketone bodies.

Lactogen—A substance that stimulates the production of milk in female animals.

Placenta—An organ that is attached to the inside wall of the mother's uterus and to the fetus via the umbilical cord. The placenta allows oxygen and nutrients from the mother's bloodstream to pass into the unborn baby.

Progesterone—A hormone that is responsible for the changes that occur in the second half of the menstrual cycle.

is done by poking a finger with a needle called a lancet, putting a drop of blood on a special type of paper, and feeding the paper into a meter that analyzes and reads the blood sugar level. When diet and exercise do not keep blood glucose levels within an acceptable range, a patient may need to take regular shots of insulin.

Many babies born to women with GDM are large enough to cause more difficult deliveries, and they may require the use of cesarean section. Once the baby is born, it is important to carefully monitor its blood glucose levels. These levels may drop sharply and dangerously once the baby is no longer receiving large quantities of sugar from the mother. When this occurs, it is easily resolved by giving the baby glucose.

Prognosis

Prognosis for women with GDM, and their babies, is generally good. Mothers who develop GDM need to be evaluated for glucose intolerance six to eight weeks after the birth of the baby. This evaluation usually involves a two-hour oral glucose tolerance test with 75 grams of

glucose, although follow-up methods may vary. Almost all such women stop being diabetic after the baby's birth. However, clinicians have also demonstrated that nearly 50% of these women will develop a permanent form of diabetes within 15 years. A woman who has had GDM during one pregnancy has about a 66% chance of having it again during any subsequent pregnancies. In addition, women with GDM are at increased risk for developing complications, such as infections, temporary low blood sugar, high **blood pressure**, and ketoacidosis.

Health care team roles

Women with GDM will likely be evaluated and treated by a variety of personnel in the allied health field. The obstetric nurse, physician, or nurse midwife will gather a detailed medical history, which may provide information suggesting the patient is at increased risk for developing GDM. Laboratory technicians play an important role in the diagnosis of GDM by testing urine and blood for excessive glucose levels. An **amniocentesis** conducted by an imaging technician is often performed in women with GDM because of the potential abnormal growth changes in the fetus.

Most patients with GDM can manage their blood sugar levels through dietary changes. A nutritional therapist plays a critical role in planning a regimen for these women. An exercise therapist can also play a significant role in the prevention and ongoing treatment of women with GDM. Exercise can help prevent excessive weight gain by the mother, which can reduce the severity of the diabetes. In addition, exercise tends to normalize blood glucose levels. If the patient requires insulin, then the nurse or physician will generally instruct the patient on how to administer the insulin. The nurse will also likely advise on how to perform blood glucose monitoring. The pharmacist can play a role in the education of the patient in this matter as well.

Prevention

There is no known way to actually prevent GDM, particularly since this condition is due to the effects of normal hormones of pregnancy. However, the effects of insulin resistance can be best handled through careful attention to diet, avoiding becoming overweight throughout life, and participating in a reasonable exercise program.

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GIFT see **Fertility treatments**

Gingivitis

Definition

Gingivitis is a disorder involving inflammation of the gingiva (gum tissue). It is sometimes called gum disease.

Description

Periodontal disease is a worldwide problem. This mildest form of periodontal disease, gingivitis, is inflammation strictly limited to the gingiva and does not manifest changes in the underlying bone. When bony changes become evident, the condition is termed **periodontitis**.

There is commonly little or no discomfort with gingivitis. The only people who escape gingivitis are very young infants; otherwise, it affects all age groups and people of all ethnic and racial backgrounds. A bacterial **infection** of the gums, it causes the gum tissues to turn red and swollen. Mild gingivitis causes little **pain**, and may be overlooked by the dentist; however, if left unchecked, it can turn into severe gingivitis. Many people experience varying degrees of gingivitis throughout their lives, but overlook it. It commonly develops during **puberty** or in early adulthood, and may persist or recur frequently.

In studies cited by the American Academy of Periodontology (AAP) in Boston, Massachusetts, 1,259 patients between the ages of 13 and 65 were studied. Of

those 1,259 between ages 13 and 15, 80% had some form of gingivitis, while 95% had gingivitis at age 60. Males were more frequently affected than females, with the overall average being 88% and 80%, respectively.

Causes and symptoms

The etiology of gingivitis is especially varied and has been divided into local and systemic factors.

Local factors

- microorganisms
- food impaction
- faulty or irritating restorative **orthodontic appliances**
- breathing through the mouth, rather than the nose
- tooth malposition
- chemical or drug application

Microorganisms are the **bacteria** found in plaque. The bacteria that destroy living tissue release many destructive enzymes. Specific microorganisms sometimes cause inflammatory reactions in the gingiva. Streptococcal and Staphylococcal are the bacteria known to destroy tissue and cause inflammation.

Food impaction, or general oral neglect, is the most common cause of gingivitis. The food impacts around the teeth and accumulation of debris on the teeth causes irritation of the gingiva by the toxins in the plaque. The byproducts of the toxins cause swelling of the tissue and redness to occur.

Faulty or irritating restoration, or appliances, may act as irritants to the gum tissue and thus induce gingivitis. Overhanging margins on **dental fillings** may directly irritate the gingiva and cause food to become impacted; this further adds to making the gum tissue even more tender. When prosthetic or orthodontic appliances encroach on the gingival tissues, gingivitis may occur—the result of the pressure and the trapping of food and bacteria. The tissue may become inflamed, redden, and become painful to the touch.

Mouth breathing (not breathing through the nose) causes drying of the oral mucous membrane and irritates the gum tissue, causing inflammation and hyperplasia of the tissue.

Tooth malposition results in repeated abnormal forces during the eating and chewing of food. Calculus may be deposited on the surface of the tooth that has no force to aid in keeping it clean. Bacteria may begin to attack the tissue around the tooth, resulting in a combination of inflammation and gum recession.

KEY TERMS

Calculus—A hard deposit that forms on the teeth, also known as hardened plaque and tartar.

Edematous—An abnormal accumulation of serous fluid in the tissues.

Gingiva—The gum tissue.

Gum recession—The gum tissue backing away from the crown of tooth towards the root.

Hyperemia—Swelling of the gum tissue.

Local—Pertaining to or being in one particular place.

Systemic—Pertaining to, or affecting the whole body.

Chemical or drug application may cause many gum tissue anomalies. A number of drugs are at least potentially capable of inducing gingivitis. Over-the-counter (OTC) drugs can be harmful to the gum tissue and act as an acid burn if used. Silver nitrate and general aspirin have acidic affects on the gum tissue, causing redness and tenderness to the touch. Dilantin sodium produces swelling of the gum tissue due to the chemicals in the drug.

Systemic factors

- nutritional disturbances
- **pregnancy**
- diabetes and other conditions that cause endocrine dysfunction

Nutritional disturbances can create imbalances in the body system that effect changes in the gum tissue. Insufficient **vitamin C** may cause redness and swelling, along with tenderness. The inadequate intake, absorption, and utilization of some other **vitamins, minerals,** and food can affect the gum tissue, causing swelling and redness.

Pregnancy gingivitis refers to the changes the gingiva undergoes during pregnancy. The clinical appearance of the gingiva in pregnant women may vary—from no change to a smooth, shiny, deeply reddened, marginal gingival hyperemia (swelling of the gum tissue) of the papilla on the upper roof of the mouth. Gingivitis commonly appears at the end of the first trimester of pregnancy, and may remit or even completely disappear at the termination of the pregnancy.

Diabetes mellitus is also associated with severe periodontal disease. Uncontrolled diabetes can cause a metabolic change in the gum tissue and decrease an individual's resistance to infection.

Endocrine dysfunctions during puberty may lead to changes in the gum tissue (puberty gingivitis). The gingiva appears hyperemic (having an excess of **blood**) and edematous (swollen). Most studies have revealed that the main cause of these changes in the gingiva is caused by breathing through the mouth.

Diagnosis

A patient may have gingivitis and periodontitis in different parts of the mouth at the same time. A general dentist can examine the patient and look for calculus deposits on the teeth and under the gum line. A dental explorer or a cleaning instrument will then be used by the dentist to probe the gum tissue or to check for plaque buildup. Commonly, the practitioner will ask the patient if the gums bleed while flossing and brushing. The dentist needs to be made aware of any medications being taken that might be a causative factor in the gingivitis. Information provided by the patient may lead to a gingivitis diagnosis.

Treatment

The goal of treating gingivitis is for reduction of the gingival inflammation. The general dentist, or registered dental hygienist (RDH) commonly cleans the teeth. This may involve the use of various instruments or devices to loosen and remove deposits from the teeth (scaling). Gingivitis is reversible with professional treatment and good home **oral hygiene** care. Changing toothbrushes every three months commonly improves **dental hygiene** in eliminating the bacteria in the mouth. Increased intake of vitamin C may aid in the development of healthy gum tissue. It is strongly recommended that strict oral hygiene be maintained for one's lifetime, or gingivitis will probably recur.

Prognosis

The prognosis for gingivitis is excellent. Once a program of good dental hygiene, such as proper toothbrushing and frequent prophylaxis (cleaning) is implemented, the symptoms of gingivitis will begin to disappear; this can happen in as little as one week. If there is poor response to good local therapy, a search should be made for systemic factors, which might be complicating the case.

Regular dental cleanings and exams are recommended at least every six to twelve months.

Health care team roles

An RDH is usually the first person seen by the patient when a cleaning is scheduled. The RDH role is to inform the patient of the condition of the gum tissues and consult with the general dentist about the treatment plan. After evaluating the case, ways to improve oral hygiene or to identify the irritant causing the gingivitis—such as a popcorn kernel, seed, or tartar buildup—will be suggested. Removal will then be done by the dentist.

Proper brushing and flossing is usually demonstrated by the RDH. This will aid in the maintenance of oral hygiene. The front desk receptionist may be responsible for keeping track of the recall records and following up with patients, by phone, who need appointment every six months.

Prevention

Prevention of gingivitis is simple and easy. Proper brushing techniques and proper flossing to remove any irritants or bacteria helps to stop gingivitis from growing. Regular dental checkups and cleanings will aid in reducing the risk of gingivitis.

For people who are prone to gingivitis, it may be recommended that they brush and floss after every meal, and at bedtime. Electric toothbrushes may be recommended for patients who have problems with strength or dexterity of their hands. Special appliances or tools, such as toothpicks, special toothbrushes, and water irrigation devices may be recommended for patients who are particularly prone to plaque deposits. These supplements do not replace brushing and flossing, but are enhancements in the prevention of gingivitis.

Resources

ORGANIZATIONS

- Adam.com Health and Medical Association Online.
adam.com. 90 Tehama Street, San Francisco, CA 94105
(415) 541-9164. <<http://www.adam.com/home.htm>>.
- American Academy of Periodontology, 4157 Mountain Road,
PBN 249 Pasadena, MD 21122, (410) 437-3749.
<<http://www.perio.org>>.
- American Dental Association, 211 East Chicago Avenue,
Chicago, IL 60611. (312) 440-2500.
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- InteliHealth Dental. InteliHealth Inc. 960C Harvest Drive P.O.
Box 1097, Blue Bell, PA 19422(215) 775-5155.
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Glasses see **Eye glasses**

Glaucoma

Definition

Glaucoma is a condition where the optic nerve is subject to damage—usually, but not always, because of excessively high intraocular pressure (pressure within the eye, also called IOP). If untreated, the optic nerve damage results in progressive, permanent **vision** loss, starting with unnoticeable blind spots in the field of vision, progressing to tunnel vision, and then to blindness.

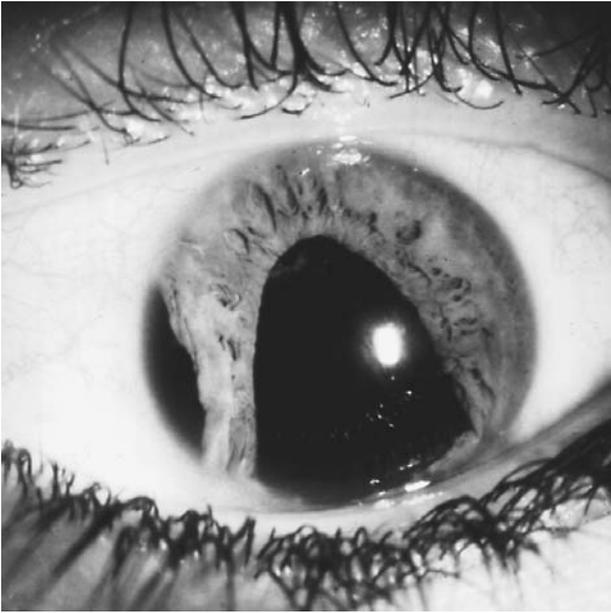
Description

More than 2 million people in the United States have glaucoma, and 80,000 of them are legally blind as a result. It is the leading cause of preventable blindness in the United States and the most frequent cause of blindness in African-Americans, whose glaucoma risk is three times higher than the rest of the population. The risk of glaucoma increases with age, but it can strike any age group, even newborns and fetuses.

Glaucoma is a class of diseases. There are at least 20 different forms that can be divided into two categories: open-angle glaucoma and narrow-angle glaucoma. To understand glaucoma, it is useful to understand eye structure.

The eyes are spherical. A tough, non-leaky protective sheath (the sclera) covers the eye with the exception of the clear cornea at the front and the optic nerve at the back. Light comes into the eye through the cornea, then passes through the lens, which focuses it onto the retina (the innermost surface at the back of the eye). The rods and cones of the retina transform the light energy into electrical messages, which are transmitted to the **brain** by the optic nerve.

The iris is located between the dome-shaped cornea and the lens. It controls the amount of light that enters the



A close-up view of an inflamed eye in acute glaucoma, with an irregularly enlarged pupil. (Custom Medical Stock Photo. Reproduced by permission.)

eye by opening and closing the pupil. The iris, cornea, and lens are bathed in a liquid called the aqueous humor, which is similar to plasma. This liquid is continually produced by the nearby ciliary body and moved out of the eye into the bloodstream by a system of drainage canals (the trabecular meshwork). The drainage area is located in front of the iris, in the angle formed between the iris and the cornea.

Glaucoma occurs if the aqueous humor is not removed rapidly enough or if it is made too rapidly, causing pressure to build up. This high pressure distorts the shape of the optic nerve and destroys nerve cells. The destruction of nerve cells results in blind spots—spots where the image from the retina is not transmitted to the brain.

Open-angle glaucoma accounts for over 90% of all cases. It is called “open-angle” because the angle between the iris and the cornea is open, allowing drainage of the aqueous humor. It is usually chronic and progresses slowly. In narrow-angle glaucoma, the angle where aqueous fluid drainage occurs is narrower than normal, thus causing the fluid to drain more slowly and increasing the risk that the flow may be blocked. When the drainage area is blocked, a closed-angle glaucoma attack results. This can occur, for example, if the iris and lens suddenly adhere to each other and the iris is pushed forward. In patients with very narrow angles, this can occur when the eyes dilate (e.g., when entering a dark room or when taking certain medications).

One rare form of open-angle glaucoma is different. People with normal-tension glaucoma have optic nerve damage in the presence of normal IOP. As of 2001, the mechanism of this disease is unknown.

Glaucoma is also a secondary condition of over 60 widely diverse diseases and can result from injury as well.

Causes and symptoms

The cause of vision loss in all forms of glaucoma is optic nerve damage. There are many underlying causes and forms of glaucoma. Most causes are not known, but it is evident that different processes are involved, and a malfunction in any one of them could cause glaucoma. For example, eye trauma may result in the angle becoming blocked, or, as a person ages, the lens may become larger and push the iris forward. The cause of optic nerve damage in normal-tension glaucoma is also unknown, but there is speculation that the optic nerves of these patients are susceptible to damage at lower pressures than what is usually considered to be abnormally high. It is probable that most glaucoma is inherited. At least 10 defective genes that cause glaucoma have been identified.

Initially, chronic open-angle glaucoma has no noticeable symptoms. The pressure build-up is gradual and there is no discomfort. Moreover, the vision loss is gradual and one eye fills-in the image where its partner has a blind spot. However, left untreated, vision loss becomes evident, and the condition can be painful.

Acute closed-angle glaucoma is obvious from the beginning of an attack. The symptoms are blurred vision, severe **pain**, sensitivity to light, nausea, and halos around lights. The normally clear cornea may be hazy. This is an ocular emergency and needs to be treated immediately. Similarly, congenital glaucoma is evident at birth. Symptoms include bulging eyes, cloudy corneas, excessive tearing, and sensitivity to light.

Diagnosis

The initial glaucoma diagnosis is made through an **eye examination** by an optometrist (O.D.) or ophthalmologist (M.D.). The examination begins with an ophthalmic assistant, technician, or scribe gathering patient information, including any family history of glaucoma. Then the ophthalmic assistant takes a reading of the patient’s intraocular pressure (IOP). IOP is measured with an instrument called a tonometer, using a technique called applanation tonometry. The test is performed after anesthetic drops are administered to the eye. The anesthetic allows the examiner to touch the patient’s eyeball without causing discomfort for the patient. Another type

of tonometry called noncontact applanation shoots a puff of air into the patient's eye. This is slightly less accurate than applanation tonometry.

Next, an O.D., M.D., or skilled ophthalmic assistant uses an ophthalmoscope (a hand-held instrument with a light source) to examine the optic nerve, retina, and back of the eye. Other types of lenses may also be used to examine the back of the eye. A slit lamp (biomicroscope) allows the physician or assistant examine the cornea, iris, and lens.

Visual field tests (perimetry), performed by an O.D., M.D., or ophthalmic assistant, can detect blind spots in a patient's field of vision before the patient is aware of them. Certain defects may indicate glaucoma.

Another test, gonioscopy, is used to distinguish between narrow-angle and open-angle glaucoma. A gonioscopy lens, which is a hand-held contact lens with a mirror, allows visualization of the angle between the iris and the cornea.

Physicians may also perform a nerve fiber layer assessment which can show early damage to the eye. Fundus photography or stereoscopic photography through a dilated pupil may also be performed by an O.D., M.D., or ophthalmic assistant to document the appearance of the optic nerve so that changes may be detected on subsequent examinations.

Blood pressure also is monitored, as some prescribed treatments may raise pressure and **heart** rate.

Intraocular pressure can vary throughout the day. For that reason, patients should schedule several return visits to measure the IOP at different times of day. This yields the most accurate diagnosis.

Treatment

The first line of glaucoma treatment is the use of prescription eyedrops. Several classes of medications are effective at lowering IOP and thus preventing optic nerve damage in chronic and neonatal glaucoma. Beta blockers (e.g. timolol), carbonic anhydrase inhibitors (e.g. acetazolamide), and alpha-2 agonists (e.g. brimonidine tartrate) inhibit aqueous humor production. Miotics (e.g. pilocarpine) and prostaglandin analogues (e.g. latanoprost) increase the outflow of aqueous humor.

It is important for patients to inform their doctors of any health conditions they have or any medications they take, including over-the counter drugs. Certain drugs used to treat glaucoma are not prescribed for patients with pre-existing conditions. The drugs prescribed to treat glaucoma all have side effects, so patients taking them should be monitored closely, especially for cardio-

vascular, pulmonary, and behavioral symptoms. Each medication lowers IOP by a different amount, and a combination of medications may be necessary. To ensure that IOP is lowered sufficiently, it is important that patients take their medications and be monitored regularly. IOP should be measured three to four times per year.

Normal-tension glaucoma is treated by reducing IOP to less-than-normal levels, on the theory that overly susceptible optic nerves are less likely to be damaged at lower pressures. Research underway may point to better treatments for this form of glaucoma.

Attacks of acute closed-angle glaucoma are medical emergencies. IOP is rapidly lowered by successive deployment of acetazolamide, hyperosmotic agents, a topical beta-blocker, and pilocarpine. Epinephrine should not be used because it exacerbates angle closure.

Trabeculectomy, to open the drainage canals or make an opening in the iris, can be effective in increasing the outflow of aqueous humor. This surgery is usually successful, but the effects often last less than one year. Nevertheless, this is an effective treatment for patients whose IOP is not sufficiently lowered by drugs and for those who can't tolerate the drugs.

Laser peripheral iridotomy is a procedure used almost exclusively to treat narrow angle glaucoma. It involves creating a small opening in the peripheral iris that allows aqueous fluid to drain from behind the iris directly to the anterior chamber. This procedure typically result in "opening up" the narrow angle between the iris and the cornea, in essence converting a narrow angle into an open angle.

Argon laser trabeculoplasty is usually recommended when medications have not been able to sufficiently control IOP, although it is increasingly advocated as primary therapy for patients who are not good candidates for the use of glaucoma medications or who cannot use eyedrops. In this procedure, the beam of an argon laser is directed at the trabecular meshwork. Typically about 180° of the trabecular meshwork is treated with laser spots. As a result of this procedure, the drainage of aqueous fluid out of the eye increases, thus lowering IOP.

Gene therapy may also be part of future treatments. A mutation in the gene myocilin is believed to cause most cases of juvenile glaucoma, and 3–4% of adult glaucoma. As of 2001, researchers are investigating drugs that inhibit myocilin production. The drug therapy would not just treat IOP, but also could be used before glaucoma's onset.

KEY TERMS

Agonist—A drug that mimics one of the body's own molecules.

Alpha-2 agonist (alpha-2 adrenergic receptor agonist)—A class of drugs that binds to and stimulates alpha-2 adrenergic receptors, causing responses similar to those of adrenaline and noradrenaline. They inhibit aqueous humor production and have a wide variety of side effects, including dry mouth, fatigue, and drowsiness.

Aqueous humor—A transparent liquid, contained in the anterior chamber (between the cornea and lens) of the eye, that is composed of water, sugars, vitamins, proteins, and other nutrients.

Beta blocker (beta-adrenergic blocker)—A class of drugs that binds to beta-adrenergic receptors and thereby decreases the ability of the body's own natural epinephrine to bind to those receptors, leading to inhibition of various processes in the body's sympathetic system. Beta blockers can slow the heart rate, constrict airways in the lungs, lower blood pressure, and reduce aqueous secretion by ciliary tissues in the eye.

Carbonic anhydrase inhibitor—A class of diuretic drugs that inhibits the enzyme carbonic anhydrase, an enzyme involved in producing bicarbonate, which is required for aqueous humor production by the ciliary tissues in the eye. Thus, inhibitors of this enzyme decrease aqueous humor production. Some side effects of these drugs are urinary frequency, kidney stones, loss of the sense of taste, depression, and anemia.

Cornea—Clear, bowl-shaped structure at the front of the eye. It is located in front of the colored part of the eye (iris). The cornea lets light into the eye and partially focuses it.

Gonioscope—An instrument used to examine the trabecular meshwork. It consists of a magnifier and a lens equipped with mirrors, which sits on the patient's cornea.

Hyperosmotic drugs—A class of drugs for glaucoma that increases the osmotic pressure in the blood, which then pulls water from the eye into the blood.

Iris—The colored part of the eye just behind the cornea and in front of the lens that controls the amount of light sent to the retina.

Lens (the crystalline lens)—A transparent structure in the eye that focuses light onto the retina.

Miotic—A drug that causes pupils to contract.

Ophthalmoscope—An instrument, with special lighting, designed to view structures in the back of the eye.

Optic nerve—The nerve that carries visual messages from the retina to the brain.

Prostaglandin—A group of molecules that exerts local effects on a variety of processes including fluid balance, blood flow, and gastrointestinal function.

Prostaglandin analogue—A class of drugs that are similar in structure and function to prostaglandin.

Retina—The inner, light-sensitive layer of the eye containing rods and cones.

Sclera—The tough, fibrous, white outer protective covering that surrounds the eye.

Tonometry—The measurement of pressure.

Trabecular meshwork—A sponge-like tissue located near the cornea and iris that functions to drain the aqueous humor from the eye into the blood.

Vitamin C, vitamin B₁ (**thiamine**), chromium, **zinc**, and rutin may reduce IOP.

Patients using alternative methods to attempt to prevent optic nerve damage should be advised they also need the care of a traditionally trained ophthalmologist or optometrist who is licensed to treat glaucoma, so that IOP and optic nerve damage can be monitored.

Prognosis

About half of the people who have glaucoma are not aware of it. For them, the prognosis is not good, and

many of them will become blind. On the other hand, the prognosis for treated glaucoma is excellent.

Health care team roles

Nursing and allied health professionals play an important part in the diagnosis and treatment of glaucoma. Skilled ophthalmic technicians and assistants record the patient history and perform many of the preliminary tests. Depending on skill level, these ophthalmic assistants may perform measurement of visual acuity under both low and high illumination, assessment of ocular

motility and binocularity, visual fields, measurement of IOPs with tonometers, evaluation of pupillary responses, and refraction.

Before surgical procedures, nurses and assistants also prepare the operating room (OR). Many ophthalmologists now have their own ambulatory surgery centers where skilled technicians and ophthalmic nurses play a critical role in preparing the OR and patients for the surgery. Ophthalmic nurses also assist the ophthalmologists during surgery and discuss outcomes with patients post-operatively.

Nurses and assistants assist patients by explaining the sometimes difficult regimen of glaucoma medication. In some cases, patients require several doses of a combination of medications. Ophthalmic nurses and assistants show patients the correct technique for inserting eye-drops, and reinforce the physician's instructions for medication compliance.

Patient education

Ophthalmic assistants and nurses help to ensure that patients return to the physician's office in a timely manner so that IOPs can be monitored. Nurses and assistants also emphasize the importance of adhering to the eyedrop schedule to keep IOPs at a lower level, and answer any questions concerning proper **eyedrop instillation**.

Prevention

Because glaucoma may not initially cause symptoms, the best form of prevention is to have regular eye exams.

Patients with narrow angles should avoid certain medications (including some over-the-counter medications, such as some cold or allergy medications). Patients who are glaucoma-susceptible (i.e. have narrow angles and borderline IOPs) should be advised to read the warning labels on over-the-counter medicines and inform physicians of products they are considering taking. Steroids may also raise IOP, so patients may need to be monitored more frequently if it is necessary for them to use steroids.

Not enough is known about the underlying mechanisms of glaucoma to prevent the disease itself. However, prevention of optic nerve damage from glaucoma is essential and can be accomplished when glaucoma is diagnosed and treated. As more is learned about the genes that cause glaucoma, it may become possible to

test DNA and identify potential glaucoma patients, so they can be treated before IOPs become elevated.

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ORGANIZATIONS

American Academy of Ophthalmology. P.O. Box 7424, San Francisco, CA 94120-7424. (415) 561-8500. <<http://www.eyenet.org>>.

American Glaucoma Society. P.O. Box 193940, San Francisco, CA 94119-3940. (415) 561-8587. Fax: (415) 561-8531. <<http://www.glaucomaweb.org>>.

Glaucoma Research Foundation. 490 Post Street, Suite 830, San Francisco, CA 94102. (415) 986-3162. (800) 826-6693. info@glaucoma.org. <<http://www.glaucoma.org/>>.

National Eye Institute. 2020 Vision Place, Bethesda, MD 20892-3655. (301) 496-5248. <<http://www.nei.nih.gov>>.

Prevent Blindness America. 500 East Remington Road, Schaumburg, IL 60173. (800) 331-2020. <<http://www.prevent-blindness.org>>.

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Mary Bekker

Gliding joint

Definition

A gliding joint is a synovial joint in which the bony surfaces that the joint holds together are flat, or only slightly rounded. (A synovial joint is the living material that holds two or more bones together but also permits these bones to move relative to each other.) A more precise interpretation of the international Latin anatomical term for the gliding joint would be “joint that joins flat bony surfaces.” The wrists have good examples of gliding joints (as well as joints of other types).

Description

If the bony surfaces of two bones which meet at a joint actually touched each other, then motion would cause friction that would soon produce wear and tear on the touching ends of the bones. An engineer designing a mechanical counterpart would arrange for lubricating oil to prevent such wear and tear and facilitate smooth movement between the two metal “bones.” A joint thus joins bones together (indeed, it is called a “joint” because it “joins” them) but also keeps them slightly separated to prevent their damaging each other in motion.

A kind of cartilage special to joints covers the ends of the bones being joined. A membrane hermetically seals two (or more) bone-ends with their cartilage, enclosing them in a kind of living capsule. For the sake of simplicity, the following example discusses a joint with only two bones. Inside this membrane capsule, there is a short distance between the cartilage of one bone and the cartilage of the other, because even cartilage rubbing directly against cartilage would produce wear and tear. But the gap between the cartilage surfaces is not a vacuum and is not filled with air. It is filled with synovial fluid. This synovial fluid is in a sense the equivalent of the motor oil which lubricates moving parts of an automobile engine.

The interior of a synovial joint has negative pressure in relation to air pressure. For this reason, air pressure pushes the bones together tightly into the capsule while the fluid keeps them from actually touching. The hermetically sealed membrane capsule in this paradoxical fashion aids the tight joining while it ensures the slight separation.

This negative pressure in the joint continues to work even after death. Of course, the two bones are kept together in a living body not only by the membrane capsule and the synovial fluid but also by the tissues around the bones. If in dissecting a corpse one removes the tissues leaving only the membrane capsule, the pair of

KEY TERMS

Articulation—A synonym for “joint.”

Carpals—The eight small bones that form the wrist and are joined to the metacarpals of the hand and to the bones of the forearm.

Metacarpals—The five bones of the hand that are joined to the carpal bones of the wrist and to the digits.

Neoplasm—New and abnormal growth of tissue, which may be non-cancerous (benign) or cancerous (malignant)

Synovial fluid—A transparent, sticky fluid that lubricates joints and nourishes the cartilage in a joint. (It is also found in tendons, sheaths, and bursae.)

Tarsals—The seven bones located between the bones of the lower leg and the metatarsals.

Vertebrae—Bones of the spine.

bones will remain tightly joined. But if one pierces the capsule and allows air to rush inside, one then has normal atmospheric pressure inside the capsule instead of the negative pressure of the interior of the joint when it is hermetically sealed by the capsule, and now the bones come easily apart.

Synovial fluid has another important quality. Most bodily tissues are nourished by **blood vessels**, but the cartilage on bone-ends in joints does not have blood vessels. Synovial fluid provides the **nutrition** for the cartilage that keeps it alive, strong, and healthy. The wall of the membrane capsule has two layers. The outer layer is fibrous. The inner layer produces the synovial fluid, and hence is called the synovial layer.

Function

A gliding joint allows three different kinds of motion: linear motion, such as smooth sliding of bone past bone (the bones seem to glide past each other, hence the name “gliding” joint), angular motion such as bending and stretching, and circular motion. The ends of the bones that a gliding joint joins are nearly flat or only slightly curved and thus facilitate the characteristic sliding, bending, and twisting movements.

Role in human health

The role of gliding joints in human health (the same as that played by the other types of synovial joints) is to

allow freedom of movement and thus provide flexibility to the skeleton.

Common diseases and disorders

The gliding joints (and the other joints) can be affected by such conditions as the following:

- **Ankylosis:** The fusion of bones across a joint. It is often a complication of arthritis.
- **Ankylosing spondylitis:** A type of inflammatory arthritis that progresses to ankylosis. It occurs chiefly in young men.
- **Capsulitis:** Inflammation of the membrane capsule that produces and encloses the synovial fluid.
- **Dislocation:** The displacing of a bone from its normal position, causing tendons to stretch and strain.
- **Neoplasms:** Abnormal growths (neoplasms) involving the gliding joints are rare. If such growths occur, they usually involve non-cancerous (benign) growths of cartilage or of tendons and their sheaths at the joints of the wrists. Synovial sarcoma is a cancerous (malignant) growth of cells resembling those of the synovial layer of the membrane capsule. It is found at the contact surfaces of bones in a joint, usually in the larger joints of young adults.
- **Rheumatoid arthritis:** A common form of chronic inflammation of the joints. It causes swelling, **pain**, stiffness, elevated temperature, and redness of the joints. It is a disease of connective tissue and leads to the destruction of bone, cartilage, and ligaments in the joint.

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Monique Laberge, Ph.D.

Glioma see **Brain tumor**

Glucose tests

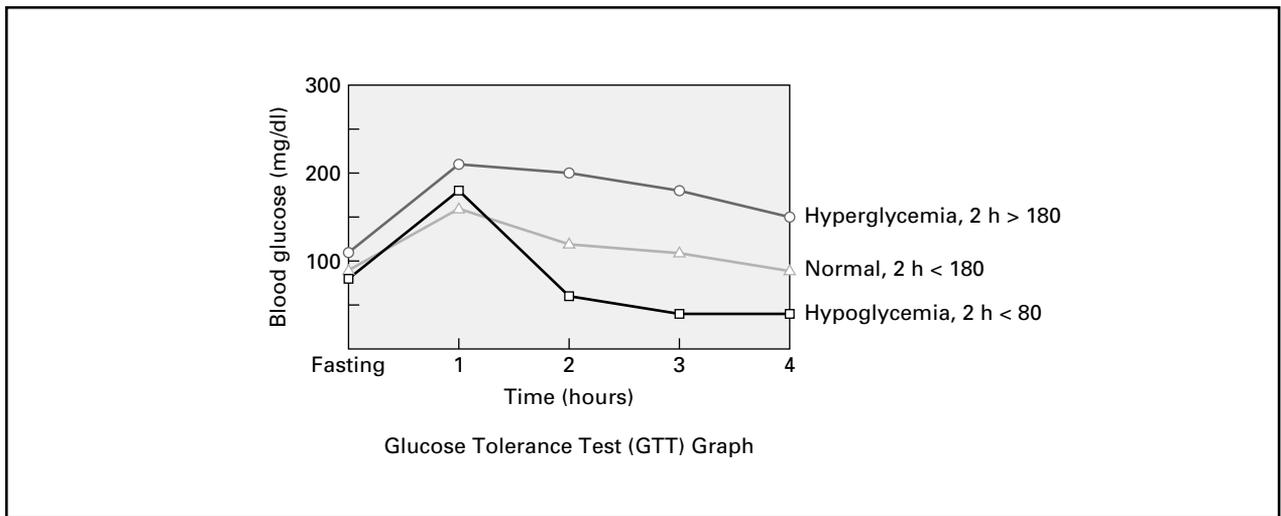
Definition

Glucose tests are used to determine the concentration of glucose in **blood**, urine, cerebrospinal fluid, and other body fluids. These tests are used to detect an increased blood glucose (hyperglycemia), a decreased blood glucose (hypoglycemia), increased glucose in the urine (glycosuria), and a decrease in cerebrospinal, serous, and synovial fluid glucose.

Purpose

Glucose tests are used in a variety of situations including:

- **Screening persons for diabetes mellitus.** The American Diabetes Association (ADA) recommends that a fasting plasma glucose (fasting blood sugar) be used to diagnose diabetes. People without symptoms of diabetes should be tested when they are 45 years old and again every three years. People in high-risk groups should be tested before the age of 45 and tested more frequently. If the person already has symptoms of diabetes, a blood glucose test without fasting, called a casual plasma glucose test, may be performed. In difficult diagnostic cases, a glucose challenge test called a two-hour oral glucose tolerance test is recommended. If the result of any of these three tests is abnormal, it must be confirmed with a second test performed on another day. The same test or a different test can be used, but the result of the second test must be abnormal as well in order to establish a diagnosis of diabetes.
- **Screening for gestational diabetes.** Diabetes that occurs during **pregnancy** is called gestational diabetes. This condition is associated with **hypertension**, increased birth weight, and a higher risk for pre-eclampsia. Women who are at risk are screened when they are 24-28 weeks pregnant. A woman is considered at risk if she is older than 25 years, is not at her normal body weight, has a parent or sibling with diabetes, or is in an ethnic group that has a high rate of diabetes (Hispanic, Native American, Asian, African-American).
- **Blood glucose monitoring.** Daily measurement of whole blood glucose identifies diabetics who require intervention to maintain their blood glucose within an acceptable range as determined by their physician. The Diabetes Control and Complications Trial (DCCT) demonstrated that persons with diabetes who maintained blood glucose and glycated hemoglobin at or near normal decreased their risk of complications by 50-75%. Based on results of this study, the American Diabetes Association (ADA) recommends routine gly-



Glucose tolerance test (GTT). (Delmar Publishers, Inc. Reproduced by permission.)

cated hemoglobin testing to measure long-term control of blood sugar.

- Diagnosis and differentiation of hypoglycemia. Low blood glucose associated with neuroglycopenia produces symptoms such as confusion, **memory** loss, and seizure. Demonstration that such symptoms are the result of hypoglycemia requires evidence of a low blood glucose at the time of symptoms and reversal of the symptoms by glucose. In documented hypoglycemia, blood glucose tests are used along with measurements of insulin and C-peptide (a fragment of proinsulin) to differentiate between fasting and postprandial causes.
- Analysis of glucose in body fluids. High levels of glucose in body fluids reflect a hyperglycemic state and is otherwise not clinically significant. However, low body fluid glucose levels indicate increased glucose utilization which is often caused by **infection** (e.g., **meningitis** causes a low CSF glucose); inflammatory disease (e.g., rheumatoid arthritis causes a low pleural fluid glucose); or malignancy (e.g., a leukemia or lymphoma such as Hodgkin's disease infiltrating the **central nervous system** or serous cavity).

Precautions

Diabetes must be diagnosed as early as possible. If left untreated, it will result in progressive vascular disease that may damage the **blood vessels**, nerves, **kidneys**, **heart**, and other organs. **Brain** damage can occur from glucose levels below 40 mg/dL and **coma** from levels above 450 mg/dL. For this reason, plasma glucose levels below 40 mg/dL or above 450 mg/dL are com-

monly used as alert values. Point-of-care and home glucose monitors measure glucose in whole blood rather than plasma and are accurate generally within a range of glucose concentration between 40 and 450 mg/dL. In addition, whole blood glucose measurements are generally 10% lower than serum or plasma glucose owing to the greater water content of the red blood cells. Results are not definitive beyond the manufacturer's stated measuring range, and should be repeated as soon as possible to avoid hypoglycemic **shock**, cardiac arrest, coma, and other complications of an extremely abnormal glucose result.

Other endocrine disorders and several medications can cause both hyperglycemia and hypoglycemia. For this reason, abnormal glucose test results must be interpreted by a physician.

A nurse or phlebotomist who collects the sample for a plasma glucose test should follow standard precautions for the prevention of transmission of bloodborne pathogens. Glucose is a labile substance; therefore, plasma or serum must be separated from the blood cells and refrigerated as soon as possible. Samples that must be transported unrefrigerated to a distant site should be collected in a tube with an additive such as sodium fluoride to inhibit glycolysis. Blood glucose methods are largely free of interferences. However, hemolysis may increase the glucose result when measured by the hexokinase method, and high levels of ascorbic acid may reduce the glucose result when measured by the glucose oxidase method. Glycated hemoglobin measurements may be affected by abnormal hemoglobin pigments, such as methemoglobin and structural hemoglobin abnormalities such as hemoglobin S. Splenectomy can result in an

increase and hemolytic anemia a decrease in glycated hemoglobin.

Exercise, diet, anorexia, and smoking affect the results of the oral glucose tolerance test. Drugs that decrease tolerance to glucose and affect the test include steroids, oral contraceptives, estrogens, and thiazide diuretics.

Description

The body uses glucose to produce the majority of the energy it needs to function. Glucose is absorbed from the gastrointestinal tract directly and is also derived from digestion of other dietary **carbohydrates**. It is also produced inside cells by the processes of glycogen breakdown (glycogenolysis) and reverse glycolysis (gluconeogenesis). Insulin is made by the **pancreas** and facilitates the movement of glucose from the blood and extracellular fluids into the cells. Insulin also promotes cellular production of **lipids** and glycogen and opposes the action of glucagon which increases the formation of glucose by cells.

Diabetes may result from a lack of insulin or a subnormal response to insulin. There are three forms of diabetes: Type I or insulin dependent (IDDM), type II or noninsulin dependent (NIDDM), and gestational diabetes (GDM). Type I diabetes usually occurs in childhood and is associated with low or absent blood insulin and production of ketones even in the absence of stressed metabolic conditions. It is caused by autoantibodies to the islet cells in the pancreas that produce insulin, and persons must be given insulin to control blood glucose and prevent ketosis. Type II accounts for 85% or more of persons with diabetes. It usually occurs after age 40, and is usually associated with **obesity**. Persons who have a deficiency of insulin may require insulin to maintain glucose, but those who have a poor response to insulin may not. Ketosis does not develop under normal metabolic conditions but may occur with **stress**. Gestational diabetes is a form of glucose intolerance that first appears during pregnancy. It abates after delivery, but over a 10-year span approximately 30-40% of females with gestational diabetes go on to develop noninsulin dependent diabetes.

There are a variety of ways to measure a person's blood glucose.

Whole blood glucose tests

Whole blood glucose testing can be performed by a person in his or her home, or by a member of the health care team outside the laboratory. The test is usually performed using a drop of whole blood obtained by finger

puncture. Care must be taken to wipe away the first drop of blood because this is diluted with tissue fluid. The second drop is applied to the dry reagent test strip or device. All whole blood glucose analyzers use the glucose oxidase reaction to measure glucose concentration. In the home test kits, the enzymes glucose oxidase and peroxidase, a buffer, and dye are immobilized on the testing device. When the blood contacts the reaction zone, it hydrates the reagents. The glucose oxidase utilizes oxygen to oxidize the glucose forming gluconic acid and hydrogen peroxide. The peroxidase enzyme catalyzes the oxidation of the dye by the hydrogen peroxide producing a colored product. The test strip or device is inserted into a portable analyzer that measures the amount of color produced. Concentration of glucose is determined by comparing the color intensity, called the reflectance density, to that for a standard measured the same way. Point-of-care devices often utilize the same method. However, some devices employ the polarographic glucose oxidase method. In this procedure, the glucose oxidase is impregnated into a glucose permeable membrane that covers an electrode. Peroxidase and dye are not required. Glucose from the sample diffuses through the membrane and the glucose oxidase catalyzes the formation of hydrogen peroxide inside the electrode. The peroxide is unstable and reforms oxygen and water. The oxygen is reduced at the cathode of the electrode producing a current that is proportional to glucose concentration.

Fasting plasma glucose test

The fasting plasma glucose test requires an eight-hour fast. The person must have nothing to eat or drink except water. The person's blood is usually collected by a nurse or phlebotomist via venipuncture. Either serum, the liquid portion of the blood after it clots, or plasma may be used. Plasma is the liquid portion of unclotted blood that is collected in an anticoagulant. The glucose is measured by an enzymatic glucose method. The glucose oxidase-peroxidase or glucose oxidase-polarographic methods may be used and are similar to those described above. Two additional methods used are the hexokinase and glucose dehydrogenase methods. These methods both result in the production of NADH (NADPH) in proportion to the glucose concentration in the sample. The reaction is measured in an automated chemistry analyzer which measures light absorption. The amount of light absorbed by the NADH at 340 nm is directly proportional to the glucose in the sample. Enzymatic methods measure no sugar other than glucose, and the same normal range can be used. The ADA recommends a normal range for fasting plasma glucose of 55-109 mg/dL. A glucose level equal to greater than 126 mg/dL is indica-

Normal findings for glucose tolerance test (GTT, oral glucose tolerance test [OGTT])**Blood test**

Fasting	70–115 mg/dl (<6.4 mmol/L)
30 minutes	<200 mg/dl (<11.1 mmol/L)
1 hour	<200 mg/dl (<11.1 mmol/L)
2 hours	<140 mg/dl (<7.8 mmol/L)
3 hours	70–115 mg/dl (<6.4 mmol/L)
4 hours	70–115 mg/dl (<6.4 mmol/L)
Urine test	Negative

SOURCE: Pagana, K.D. and T.J. Pagana. *Mosby's Diagnostic and Laboratory Test Reference*. 3rd ed. St. Louis: Mosby, 1997.

tive of diabetes. A fasting plasma glucose level of 110–125 mg/dL is referred to as “impaired fasting glucose.”

Oral glucose tolerance test (OGTT)

The oral glucose tolerance test is done to see how well the body handles a standard amount of glucose. There are many variations of this test. A two-hour OGTT as recommended by the ADA is described below. The person must have at least 150 grams of carbohydrate each day, for at least three days before this test. The person must take nothing but water and abstain from exercise for 12 hours before the glucose is given. At 12 hours after the start of the fast, the person is given 75 grams of glucose to ingest in the form of a drink or standardized jelly beans. A health care provider draws a sample of venous blood two hours following the dose of glucose. The serum or plasma glucose is measured by an enzymatic method. A glucose concentration equal to or greater than 200 mg/dL is indicative of diabetes. A level below 140 mg/dL is considered normal. A level of 140–199 mg/dL is termed “impaired glucose tolerance.”

Testing for gestational diabetes

The screening test for gestational diabetes is performed between 24 and 28 weeks of pregnancy. No special preparation or fasting is required. The patient is given an oral dose of 50 grams of glucose and blood is drawn one hour later. A plasma or serum glucose less than 140 mg/dL is normal and requires no follow-up. If the glucose is 140 mg/dL or higher, a three-hour oral glucose tolerance test is performed. The same pretest preparation is followed as for the two-hour OGTT described earlier except that 100 grams of glucose is given orally. Blood is drawn at the end of the fast and at one, two, and three hours after the glucose is ingested. Gestational diabetes is diagnosed if two or more of the following results are obtained:

- fasting plasma glucose greater than 105 mg/dL
- one-hour plasma glucose greater than 190 mg/dL
- two-hour plasma glucose greater than 165 mg/dL
- three-hour plasma glucose greater than 145 mg/dL

Glycated hemoglobin blood glucose test (G-Hgb)

The glycated (glycosylated) **hemoglobin test** is used to monitor the effectiveness of diabetes treatment. Glycated hemoglobin is a test that indicates how much glucose was in a person's blood during a two- to three-month window beginning about four weeks prior to sampling. The N-terminal valine of the beta globin chain of hemoglobin forms an irreversible amide bond with glucose and other carbohydrates. The additional carbohydrate increases the negative charge of the hemoglobin molecule. When the various hemoglobins are separated by chromatography the hemoglobin bound to glucose is located in the fastest fraction called HbA_{1c}. Since the glucose inside the red cells is in equilibrium with the plasma glucose, a spurious increase in the plasma level will increase the percentage of glycated hemoglobin. The test is a measure of the time-averaged blood glucose over the 120-day life span of the red blood cells. The normal range for glycated hemoglobin measured as HbA_{1c} is 3–6%. Values above 8% indicate that a hyperglycemic episode occurred sometime during the window monitored by the test (two to three months beginning four weeks prior to the time of blood collection). The following formula estimates the average blood glucose during this window: (% G-Hgb x 33.3 mg/dL) - 86 = average blood glucose. Methods available to measure glycated hemoglobin include column and high performance liquid chromatography, electrophoresis, and ion capture. The first three are based upon the fact that glycated hemoglobin has a greater negative charge than nonglycated hemoglobin. Ion capture is a novel method based upon the ability of glycated hemoglobin to suppress the fluorescence of a dye.

The ADA recommends that glycated hemoglobin testing be performed during a person's first diabetes evaluation, again after treatment is begun and glucose levels are stabilized, then repeated semiannually. If the person does not meet treatment goals, the test should be repeated quarterly.

A related blood test, fructosamine assay, measures the amount of albumin in the plasma that is bound to glucose. Albumin has a shorter half-life than red blood cells, and this test reflects the time-averaged blood glucose over a period of two to three weeks prior to sample collection.

Preparation

Blood glucose tests require either whole blood, serum or plasma collected by venipuncture or finger puncture. No special preparation is required for a casual blood glucose test. An eight-hour fast is required for the fasting plasma or whole blood glucose test. A 12-hour fast is required for the two-hour OGTT and three-hour OGTT tests. In addition, the person must abstain from exercise in the 12-hour fasting period. Medications known to affect carbohydrate **metabolism** should be discontinued three days prior to an OGTT test if possible, and the person must maintain a diet of at least 150 grams of carbohydrate per day for at least three days prior to the fast.

Aftercare

After the test or series of tests is completed (and with the approval of his or her doctor), the person should eat, drink, and take any medications that were stopped for the test.

The patient may feel discomfort when blood is drawn from a vein. Bruising may occur at the puncture site or the person may feel dizzy or faint. Pressure should be applied to the puncture site until the bleeding stops to reduce bruising. Warm packs can also be placed over the puncture site to relieve discomfort.

Complications

The patient may experience weakness, fainting, sweating, or other reactions while fasting or during the test. If this occurs, he or she should immediately inform their physician or nurse.

Results

Normal values listed below are for children and adults. Results may vary slightly from one laboratory to another depending upon the method of analysis used.

- fasting plasma glucose test: 55-109 mg/dL
- oral glucose tolerance test at two hours: less than 140 mg/dL.
- glycated hemoglobin: 3-6%
- fructosamine: 1.6-2.7 mmol/L for adults (5% lower for children)
- gestational diabetes screening test: less than 140 mg/dL
- cerebrospinal glucose: 40-80 mg/dL
- serous fluid glucose: equal to plasma glucose

Blood glucose test (blood sugar, fasting blood sugar [FBS])

	Normal findings	Possible critical values
Cord	45–96 mg/dl (2.5–5.3 mmol/L)	
Premature infant	20–60 mg/dl (1.1–3.3 mmol/L)	
Newborn	30–60 mg/dl (1.7–3.3 mmol/L)	<30 and >300 mg/dl
Infant	40–90 mg/dl (2.2–5.0 mmol/L)	<40 mg/dl
Child <2 years	60–100 mg/dl (3.3–5.5 mmol/L)	
Child >2 years to adult	70–105 mg/dl (3.9–5.8 mmol/L)	Male: <50 and >400 mg/dl Female: <40 and >400 mg/dl
Elderly	increase in normal range after age 50 years	

SOURCE: Pagana, K.D. and T.J. Pagana. *Mosby's Diagnostic and Laboratory Test Reference*. 3rd ed. St. Louis: Mosby, 1997.

- synovial fluid glucose: within 10 mg/dL of the plasma glucose

- urine glucose (random semiquantitative): negative

For the diabetic person, the ADA recommends an ongoing blood glucose goal of less than or equal to 120 mg/dL.

The following results are suggestive of diabetes mellitus, and must be confirmed with repeat testing:

- fasting plasma glucose test: greater than or equal to 126 mg/dL
- oral glucose tolerance test at two hours: equal to or greater than 200 mg/dL
- casual plasma glucose test (nonfasting, with symptoms): equal to or greater than 200 mg/dL
- gestational diabetes three-hour oral glucose tolerance test: two or more of the limits below are exceeded
- fasting plasma glucose: greater than 105 mg/dL
- one-hour plasma glucose greater than 190 mg/dL
- two-hour plasma glucose greater than 165 mg/dL
- three-hour plasma glucose greater than 145 mg/dL

Health care team roles

Prior to the test the health care professional administering an OGGT should describe the symptoms of hypoglycemia to the patient and tell the patient to alert a health care worker should he or she experience any of those symptoms. A phlebotomist, or sometimes a nurse, collects the blood, and a clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) or clinical laboratory technician CLT(NCA)/medical laboratory

KEY TERMS

Diabetes mellitus—A disease in which a person cannot effectively use glucose to meet the needs of the body. It is caused by a lack of the hormone insulin.

Glucose—The main form of sugar (chemical formula $C_6H_{12}O_6$) used by the body for energy.

Glycated hemoglobin—A test that measures the amount of hemoglobin bound to glucose. It is a measure of how much glucose has been in the blood during a 2-3 month period beginning approximately one month prior to sample collection.

technician MLT(ASCP) performs the testing. Results are interpreted by a physician. Critically high or low glucose levels should be immediately called to the attention of the patient's nurse or doctor. Physicians and nurses are responsible for educating patients about how to best manage their diabetes.

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- Centers for Disease Control and Prevention (CDC). Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion. TISB Mail Stop K-13, 4770 Buford Highway NE, Atlanta, GA 30341-3724. (770) 488-5080. <<http://www.cdc.gov/diabetes>>.
- National Diabetes Information Clearinghouse (NDIC). 1 Information Way, Bethesda, MD 20892-3560. (301) 907-8906. <<http://www.niddk.nih.gov/health/diabetes/ndic.htm>>.
- National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). National Institutes of Health, Building 31, Room 9A04, 31 Center Drive, MSC 2560, Bethesda, MD 20879-2560. (301) 496-3583. <<http://www/niddk.nih.gov>>.

Victoria E. DeMoranville

Glucose tolerance test see **Glucose tests**

Gluten-free diet see **Diet therapy**

Gout

Definition

Gout is a form of acute arthritis that causes severe **pain** and swelling in the joints. It most commonly affects the big toe, but may also affect the heel, ankle, hand, wrist, or elbow. Attacks of gout usually come on suddenly, stop after five to 10 days, and can keep recurring.

Description

Gout is different from other forms of arthritis because it occurs when there are high levels of uric acid circulating in the **blood**, which can cause urate crystals to settle in the tissues of the joints. Uric acid, which is found naturally in the bloodstream, is formed as the body breaks down waste products, mainly those containing purine, a substance that is produced by the body and found in high concentrations in some foods, including brains, **liver**, sardines, anchovies, and dried peas and beans. Normally, the **kidneys** filter uric acid out of the blood and excrete it in the urine. Sometimes, however, the body produces too much uric acid or the kidneys

aren't efficient enough at filtering it from the blood. As a result, it builds up in the blood stream, a condition known as hyperuricemia. Some people are more susceptible to gout because of inherited genes. Being overweight and eating a rich diet also increases susceptibility. In some cases, another disease (such as lymphoma, leukemia, or hemolytic anemia) may be the underlying cause of the uric acid buildup that results in gout.

Hyperuricemia doesn't always cause gout. However, over the course of years, sharp urate crystals build up in the synovial fluid of the joints. Often, some precipitating event, such as an **infection**, surgery, a stubbed toe, or even a heavy drinking binge can cause inflammation. White blood cells, mistaking the urate crystals for a foreign invader, flood into the joint and surround the crystals, causing inflammation (the redness, swelling, and pain that are the hallmarks of a gout attack).

Causes and symptoms

As a result of high levels of uric acid in the blood, needle-like urate crystals gradually accumulate in the joints. Urate crystals may be present in the joint for a long time without causing symptoms. Infection, injury to the joint, surgery, drinking too much, or eating the wrong kinds of foods may suddenly bring on the symptoms, which include pain, tenderness, redness, warmth, and swelling of the joint. In many cases, the gout attack begins in the middle of the night. The pain is often so excruciating that the patient cannot bear weight on the joint or tolerate the pressure of bedcovers. The inflamed skin over the joint may be red, shiny, and dry, and the inflammation may be accompanied by a mild **fever**. These symptoms may go away in about a week and disappear for months or years at a time. However, over the course of time, attacks of gout recur more and more frequently, last longer, and affect more joints. Eventually, stone-like deposits known as tophi may build up in the joints, ligaments, and tendons, leading to permanent joint deformity and decreased motion. In addition to causing the tophi associated with gout, hyperuricemia can cause **kidney stones**, also called renal calculi or uroliths.

Gout affects an estimated one million Americans. Men are more commonly affected than women by a ratio of 4 to 1. Uric-acid levels tend to increase in men at **puberty**, and, because it takes 20 years of hyperuricemia to cause gout symptoms, men commonly develop gout in their late 30s or early 40s. Women more typically develop gout later in life, starting in their 60s. According to some medical experts, estrogen protects against hyperuricemia. When estrogen levels fall during **menopause**, urate crystals can begin to accumulate in the joints. Excess body weight, regular excessive alcohol intake, the

use of **blood pressure** medications called diuretics, and high levels of certain fatty substances in the blood (serum triglycerides) associated with an increased risk of heart disease can all increase a person's risk of developing gout.

Diagnosis

Usually, physicians can diagnose gout based on the **physical examination** and medical history (a person's description of symptoms and other information). Doctors can also administer a test that measures the level of uric acid in the blood. While normal uric acid levels don't necessarily rule out gout and high levels don't confirm it, the presence of hyperuricemia increases the likelihood of gout. The development of a tophus can confirm the diagnosis of gout. The most definitive way to diagnose gout is to take a sample of fluid from the joint and test it for urate crystals.

Treatment

The goals of treatment for gout consist of alleviating pain, avoiding severe attacks in the future, and preventing long-term joint damage. In addition to taking pain medications as prescribed by their doctors, people having gout attacks are encouraged to rest and to increase the amount of fluids that they drink.

Acute attacks of gout can be treated with nonaspirin, **nonsteroidal anti-inflammatory drugs** (NSAIDs) such as naproxen sodium (for example, Aleve), ibuprofen (for example, Advil), or indomethacin (for example, Indocin). In some cases, these drugs can aggravate a peptic ulcer or existing kidney disease and cannot be used. Doctors sometimes also use colchicine (for example, Colbenemid), especially in cases where nonsteroidal anti-inflammatory drugs cannot be used. Colchicine may cause **diarrhea**, which tends to go away once the patient stops taking it. **Corticosteroids** such as prednisone (for example, Deltasone) and adrenocorticotropic hormone (for example, Acthar) may be given orally or may be injected directly into the joint for a more concentrated effect. While all of these drugs have the potential to cause side effects, they are used for only about 48 hours and are not likely to cause major problems. However, aspirin and closely related drugs (salicylates) should be avoided because they can ultimately worsen gout.

Once an acute attack has been successfully treated, doctors try to prevent future attacks of gout and long-term joint damage by lowering uric acid levels in the blood. There are two types of drugs for correcting hyperuricemia. Uricosuric drugs, such as probenecid (for example, Benemid) and sulfinpyrazone (for example,

KEY TERMS

Allopurinol—A drug that corrects hyperuricemia by inhibiting urate production.

Colchicine—A drug used to treat painful flare-ups of gout.

Corticosteroids—Medications related to a natural body hormone called hydrocortisone, which are used to treat inflammation.

Hyperuricemia—High levels of a waste product called uric acid in the blood.

Probenecid—A drug that corrects hyperuricemia by increasing the urinary excretion of urate.

Purine—A substance found in foods that is broken down into urate and may contribute to hyperuricemia and gout.

Sulfinpyrazone—A drug that corrects hyperuricemia by increasing the urinary excretion of urate.

Synovial fluid—Fluid surrounding the joints which acts as a lubricant, reducing friction between the joints.

Tophi—Stone-like deposits of uric acid crystals that may build up in the joints, ligaments, and tendons, and lead to permanent joint deformity and decreased motion.

Urate crystals—Crystals formed by high levels of uric acid in the blood.

Anturane), lower the levels of urate in the blood by increasing its removal from the body (excretion) through urine. These drugs may promote the formation of kidney stones, and they may not work for all persons, especially those with kidney disease. Allopurinol (for example, Zyloprim), a type of drug called a xanthine-oxidase inhibitor, blocks the production of urate in the body and can dissolve kidney stones as well as treating gout. The potential side effects of allopurinol include rash, a skin condition known as dermatitis, and liver dysfunction. Once people begin taking these medications, they must take them for life or the attacks of gout will continue to return.

Alternative treatment

The alternative medicine approach to gout focuses on correcting hyperuricemia by losing weight and limiting the intake of alcohol and purine-rich foods. In addition, consuming garlic (*Allium sativum*) has been recom-

mended to help prevent gout. Increasing fluid intake, especially by drinking water, is also recommended. During an acute attack, contrast **hydrotherapy** (alternating three-minute hot compresses with 30-second cold compresses) can help dissolve the crystals and quickly resolve pain.

Prognosis

Gout cannot be cured but usually it can be successfully managed. As tophi dissolve, joint mobility generally improves. In some cases, however, medicines alone do not dissolve the tophi and they must be surgically removed. Lowering uric acid in the blood also helps to prevent or improve the kidney problems that may accompany gout.

Health care team roles

Family practitioners or internists, nurse practitioners, and physician assistants commonly make a diagnosis of and treat gout. Nurses also provide **patient education** and monitor the patient's progress after treatment is begun.

Prevention

For centuries, gout has been known as a “rich man's disease” or a disease of overindulgence in food and drink. While this view is perhaps a little overstated and oversimplified, lifestyle factors clearly influence a person's risk of developing gout. Since **obesity** and excessive alcohol intake are associated with hyperuricemia and gout, losing weight and limiting alcohol intake can help ward off gout. **Dehydration** may also promote the formation of urate crystals, so people taking diuretics or “water pills” may be better off switching to another type of blood pressure medication. All people are advised to drink at least six to eight glasses of water each day. Since purine is broken down in the body into urate, it may also be helpful to avoid foods high in purine, such as organ meats, sardines, anchovies, red meat, gravies, beans, beer, and wine.

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- American College of Rheumatology. 1800 Century Place, Suite 250, Atlanta, GA, 30345. (404) 633-3777. E-mail: acr@rheumatology.org. <<http://www.rheumatology.org>>.
- American Podiatric Medical Association. 9312 Old Georgetown Road, Bethesda, MD 20814-1698. (800) 366-8227. (301) 571-9200. E-mail: askapma@apma.org. <<http://www.apma.org/>>.

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Gram stain

Definition

The Gram stain test is the most extensively performed procedure in diagnostic microbiology. It is used to classify **bacteria** as either gram-positive or gram-negative based upon their ability to retain the crystal violet stain following decolorization. In addition, the Gram stain provides vital diagnostic information, aids in the selection of culture media, and dictates initial selection of **antibiotics** for treatment and antimicrobial susceptibility testing.

Purpose

The Gram stain is used to detect the presence of bacteria, yeast, and other cells in direct smears prepared from swabs, aspirates, secretions, etc. from any part of the body where **infection** is suspected. Direct smears are often made of throat swabs, sputum, genital swabs, **wounds**, abscesses, cerebrospinal fluid (CSF), serous fluids, joint fluid, urine, and stool. Gram stain is also performed to help identify colonies isolated from cultures. In addition to gram-negative or gram-positive, organisms are evaluated for size, shape, arrangement, number, and any special characteristics such as bipolar staining and the presence of spores. These characteristics often point the way to the most efficient selection of biochemical tests needed to identify the organism. The finding of organisms on direct examination of some specimens is sufficient to establish a preliminary diagnosis and justify immediate antibiotic treatment pending confirmation by culture or other means. The Gram stain is very useful in identifying anaerobic bacteria by comparing the microscopic morphology and number of organisms to culture results. Significant numbers of characteristic bacteria on Gram stain not appearing on aerobic culture often signals the presence of an anaerobic infection.

The Gram stain will identify male patients with *Neisseria gonorrhoeae* genital infections with a specificity approaching 100% and a sensitivity above 90%. In female patients, the sensitivity and specificity are lower owing to the presence of other genital flora, but the test is still sufficiently specific to justify immediate antibiotic therapy when symptoms of pelvic inflammatory disease are present. The presence of bacteria on Gram stain of concentrated CSF is presumptive evidence of bacterial **meningitis** and reason to begin antibiotic therapy. The Gram stain is positive in the majority of bacterial meningitis cases. Recovery of bacteria from other normally sterile fluids including exudative pleural, pericardial, and abdominal fluid and inflammatory joint fluid is also pre-

KEY TERMS

Crystal violet—A rosaniline dye staining all bacterial cells but retained only by gram-positive bacteria.

Decolorizer—A solution of alcohol or acetone-alcohol which removes crystal violet from the cell wall of gram-negative bacteria.

Gram stain—A test for classifying and characterizing bacteria by microscopic analysis following staining by the procedure developed by Hans Christian Gram.

Gram's iodine—A solution of iodine and potassium iodide which causes crystal violet to adhere more tightly to the bacterial cell wall.

Safranin O—A water soluble counterstain that is used to visualize gram-negative bacteria.

sumptive evidence of an infectious process. Gram stain detects approximately 70% of pleural fluids and 50% of pericardial fluids that are infected.

Description

The Gram stain was discovered by Hans Christian Gram in the late 1800s. There are several modifications but all Gram stain procedures involve four steps: staining with crystal violet, reaction with Gram's iodine, decolorization, and counterstaining. Material from a direct specimen or culture is transferred to the slide using a dropper, needle, or swab. The material is spread in the center of a glass slide until visible, and allowed to air dry. The slide is heat-fixed and allowed to cool before staining. The slide is flooded with an alcoholic solution of basic crystal violet for 30 seconds. This dye stains all cells a bright blue or purple color. Excess dye is removed with a stream of tap water and the slide is flooded with Gram's iodine (mordant) solution which should remain on the slide for one minute. The iodide displaces chloride in the dye causing it to adhere more strongly to the cell wall. The slide is rinsed in tap water to remove the mordant. Next, a stream of decolorizer is used to rinse the slide for 10 seconds followed immediately by tap water. The most commonly used decolorizer is a 1:1 solution of acetone and 95% ethanol. Gram-positive cells have a thick cell wall rich in teichoic acid. The gram-negative bacteria have a thin cell wall that is rich in **lipids**. The decolorizer is able to penetrate through the thinner lipopolysaccharide-rich cell wall of the gram-negative bacteria and wash

away the crystal violet. The slide is flooded with Safranin O counterstain and then blotted or air-dried.

The slide is examined using a light **microscope** first under low power and then using an oil immersion lens at 1000X. The nature and number of leukocytes and epithelial cells are recorded along with the number, size, shape, and gram-stain reaction of any bacteria. Gram-positive bacteria and yeast stain blue or purple while gram-negative bacteria, white cells, epithelial cells, and trichomonads stain red. Some gram-positive bacteria, especially old colonies and those from treated patients, may not resist decolorization and appear gram-negative. Some species, for example, *Mycobacterium tuberculosis* may stain gram-negative or gram-positive and are referred to as gram-variable. In addition to staining, bacteria are classified according to shape as round (coccus) or rod-shaped (bacillus). This gives four general categories; gram-positive cocci (eg. *Staphylococcus* spp.), gram-positive bacilli (eg. *Clostridium* spp.), gram-negative cocci (eg. *Neisseria* spp.), and gram-negative bacilli (*Salmonella* spp.). Other organisms may fall between these shapes (cocci) or may be variable (pleomorphic) or cigar-shaped (fusiform). Such characteristics are important leads to identification.

Preparation

For collection of samples, patients may need to be properly positioned and given specific instructions (e.g. how to produce sputum). Urine specimens should be collected from a catheter or using the midstream void technique after cleansing of the outer genitalia. **Blood**, CSF, synovial and serous fluids, and aspiration needle biopsy specimens require disinfection of the puncture site with alcohol followed by an iodine solution. Specimens should be transported in a syringe or transferred to an airtight sterile container. Swabs should be placed in transport medium to prevent drying. When collecting specimens (with the exception of urine), health care workers must follow standard precautions for the prevention of occupational exposure to bloodborne pathogens.

Aftercare

All positive Gram stain results should be confirmed by culture, DNA analysis, or serological evidence. However, in the appropriate clinical setting (e.g. the finding of bacteria in cerebrospinal fluid) antibiotics should be administered immediately. In these situations the Gram stain result provides critical information for the selection of proper antibiotic therapy. For example, gram-positive bacteria are most likely susceptible to penicillins, cephalosporins, vancomycin, and erythromy-

cin. Gram-negative bacteria are most likely susceptible to aminoglycosides, cephalosporins, and tetracyclines.

Health care team roles

Specimens may be collected or collection assisted by a physician, nurse, or physician assistant. Gram stain is performed by a clinical laboratory scientist, NCA(CLS) or medical technologist, MT(ASCP) or by a clinical laboratory technician, NCA(CLT) or medical laboratory technician, MLT(ASCP).

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ORGANIZATIONS

- American Society for Microbiology. 1752 N Street NW, Washington, DC 20036. (202) 737-3600. <<http://www.asmsusa.org>>.

Robert Harr

Grapefruit diet see **Fad diets**

Gross motor skills

Definition

Gross motor skills encompass the abilities required to control the large muscles of the body for walking, running, sitting, crawling, and other activities. The muscles required to perform gross motor skills are generally found in the arms, legs, back, abdomen, and torso.

Description

Motor skills are deliberate and controlled movements requiring both muscle development and maturation of the **central nervous system**. In addition, the **skeletal system** must be strong enough to support the movement and weight involved in any new activity. Once these conditions are met, children learn new physical skills by practicing them until each skill is mastered.

Gross motor skills involve control of the extremities (arms, legs, hands, and feet) and torso. There is an orderly sequence for development of these muscles. Although

norms for motor development have been charted in great detail by researchers and clinicians over the past 50 years, the pace of development varies considerably from one child to the next. As skills become more complex, the degree of variation increases among normal children. The normal age for learning to walk has a range of several months, while the age range for turning one's head, a simpler skill that occurs much earlier, is considerably shorter. In addition to variations among children, an individual child's rate of progress varies as well, often including rapid spurts of development and frustrating periods of delay. Although rapid motor development in early childhood is often a good predictor of coordination and athletic ability later in life, no strong correlation has been demonstrated between a child's rate of motor development and intelligence. In most cases, a delay in mastering a specific motor skill is temporary and does not indicate a serious problem. However, medical advice should be sought when children lag significantly behind their peers in motor development or if they regress and lose previously acquired skills.

Function

Gross motor skills develop over a relatively short period of time. Most development occurs during childhood. However, soldiers, some athletes, and others who engage in activities requiring high degrees of endurance may spend years improving their level of muscle and body coordination and gross motor skills.

Infancy and toddler period

The sequence of gross motor development is determined by two developmental principles that also govern physical growth. The cephalo-caudal pattern, or head-to-toe development, refers to the way the upper parts of the body, beginning with the head, develop before the lower ones. Thus, infants can lift their heads and shoulders before they can sit up, which, in turn, precedes standing and walking. The other pattern of both development and maturation is proximal-distal, or trunk to extremities. One of the first things an infant achieves is head control. Although they are born with virtually no head or neck control, most infants can lift their heads to a 45-degree angle by the age of four to six weeks, and they can lift both their heads and chests at an average age of eight weeks. Most infants can turn their heads to both sides within 16 to 20 weeks and lift their heads while lying on their backs within 24 to 28 weeks. By about 36 to 42 weeks, or nine to ten months, most infants can sit up unassisted for substantial periods of time with both hands free for playing.

One of the major tasks in gross motor development is locomotion, or the ability to move from one place to another. Infants progress gradually from rolling (eight to ten weeks) to creeping on their stomachs and dragging their legs behind them (six to nine months) to actual crawling (seven months to a year). While infants are learning these temporary means of locomotion, they are gradually becoming able to support increasing amounts of weight while in a standing position. In the second half year of life, babies begin pulling themselves up on furniture and other stationary objects. By the ages of 28 to 54 weeks, on average, they begin “cruising,” or navigating a room in an upright position by holding on to the furniture to keep their balance. Eventually, they are able to walk while holding on to an adult with both hands, and then requiring only one adult hand. They usually take their first uncertain steps alone between the ages of 36 and 64 weeks and are competent walkers by the ages of 52 to 78 weeks. By the age of two years, children have begun to develop a variety of gross motor skills. They can run fairly well and negotiate stairs holding on to a banister with one hand and putting both feet on each step before going on to the next one. Most infants this age climb (some very actively) and have a rudimentary ability to kick and throw a ball.

Preschool

During a child’s first two years, most parents consider gross motor skills a very high priority. A child’s first steps are the most universally celebrated developmental milestone. By the time a child is a preschooler, however, many parents shift the majority of their attention to the child’s cognitive development in preparation for school. In addition, gross motor activity at these ages requires increasing amounts of space, equipment, and supervision. However, gross motor skills remain very important to a child’s development, and maintaining a youngster’s instinctive love of physical activity can make an important contribution to future fitness and health.

By the age of three, children walk with good posture and without watching their feet. They can also walk backwards and run with enough control for sudden stops or changes of direction. They can hop, stand on one foot, and negotiate the rungs of a jungle gym. They can walk up stairs alternating feet but usually still walk down putting both feet on each step. Other achievements include riding a tricycle and throwing a ball, although they have trouble catching it because they hold their arms out in front of their bodies independently of the direction of the ball. Four-year-olds can typically balance or hop on one foot, jump forward and backward over objects, and climb and descend stairs alternating feet. They can bounce and catch balls and throw with accuracy. Some four-year-olds

can also skip. Children this age have gained an increased degree of self-consciousness about their motor activities that leads to increased feelings of pride and success when they master a new skill. However, it can also create feelings of inadequacy when they think they have failed. This concern with success can also lead them to try daring activities beyond their abilities, so they need to be very carefully monitored.

School-age

School-age children who are not going through the rapid, unsettling growth spurts of early childhood or adolescence are quite skilled at controlling their bodies and are generally good at a wide variety of physical activities, although the ability varies on the level of maturation and the physique of each child. Motor skills are approximately equal in boys and girls at this stage, except that boys have more forearm strength and girls have greater flexibility. Five-year-olds can skip, jump rope, catch a bounced ball, walk on their tiptoes, balance on one foot for more than eight seconds, and engage in beginning acrobatics. Many can even ride a small two-wheeler bicycle. Eight- and nine-year-olds typically can ride a bicycle, swim, roller-skate, ice-skate, jump rope, scale fences, use a saw, hammer, and garden tools, and play a variety of sports. However, many of the sports prized by adults, often scaled down for play by children, require higher levels of distance judgment and hand-eye coordination, as well as quicker reaction times, than are reasonable for middle childhood. Games that are well suited to the motor skills of elementary school-age children include kick ball, dodge ball, and team relay races.

In adolescence, children develop increasing coordination and motor ability. They also gain greater physical strength and prolonged endurance. Adolescents are able to develop better distance judgment and hand-eye coordination than their younger counterparts. With practice, they can master the skills necessary for adult sports.

For some persons, the development of gross motor ability and endurance continues into adulthood. Athletes and members of the military routinely engage in activities designed to further enhance their gross motor development.

Role in human health

Encouraging gross motor skills requires a safe, open play space, peers to interact with, and some adult supervision.

Promoting the development of gross motor abilities is considerably less complicated than developing **fine motor skills**. Helping a child succeed in gross motor

tasks requires patience and opportunities for a child to practice desired skills. Parents and other persons must understand the level of development before assisting a child to master gross motor skills. Children reach developmental milestones at different rates. Pushing a child to perform a task which is impossible due to development status promotes frustration and disappointment. Children should be allowed to acquire gross motor skills at their own rates.

Common diseases and disorders

There are a range of diseases and disorders that affect gross motor skill development and skills. Among young persons, developmental problems such as genetic disorders, **muscular dystrophy**, **cerebral palsy**, and some neurological conditions adversely impact gross motor skill development. Among older persons, arthritis is a common condition. Arthritis affects the joints of the hands and feet, thus impairing the ability of muscles to perform desired movements. Stroke can impair gross motor coordination. **Parkinson's disease** affects motor movements. **Alcoholism** and drug use and withdrawal each cause motor problems.

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KEY TERMS

Fine motor skill—The abilities required to control the smaller muscles of the body for writing, playing an instrument, artistic expression and craft work. The muscles required to perform fine motor skills are generally found in the hands, feet and head.

Locomotion—Movements such as walking.

Motor—A term referring to muscles and movement.

Proximal-distal—Direction from the center of a body to the tips of the extremities.

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- American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. Fax: (847) 434-8000. <<http://www.aap.org/default.htm>>. kidsdoc@aap.org.
- American Academy of Physical Medicine and Rehabilitation, One IBM Plaza, Suite 2500, Chicago, IL 60611-3604. (312) 464-9700. (312) 464-0227. <<http://www.aapmr.org/consumers/public/amputations.htm>>. info@aapmr.org.
- Coping.org, 6319 Chauncy Street, Tampa, FL 33647. (813) 631-5176. Fax: (813) 631-1119. <<http://www.coping.org>>. jjmess@tampabay.rr.com.

OTHER

- Apraxia Kids. <<http://apraxia-kids.org/links/linksot.html>>.
- BabyCentre (UK). <<http://www.babycentre.co.uk/expert/6562.html>>.
- Flinders University of South Australia School of Education. <<http://www.ed.sturt.flinders.edu.au/DLT/2000/FINAL/grossmotors.htm>>.
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University of Scranton. <<http://www.academic.uofs.edu/student/DACORTAR2/motor.html>>.

Wabash University. <http://www.wabash.edu/depart/psych/Courses/Psych20/LABNET_2000/gross.html>.

L. Fleming Fallon, Jr., MD, DrPH

Growth hormone tests see **Pituitary hormone tests**

Gum disease see **Gingivitis**

Günther's disease see **Porphyrias**

Gynecologic sonogram see **Pelvic ultrasound**

H

***H. pylori* test**

Definition

H. pylori tests are used in gastroenterology to detect the presence of the *Helicobacter pylori* bacterium that causes peptic ulcer disease. *H. pylori* is a Gram-negative, motile, microaerophilic **bacteria** so named because of its spiral shape.

Purpose

H. pylori **infection** of the mucosal lining of the duodenum is a known cause of duodenal ulcers. *H. pylori* is also strongly implicated in other gastric conditions, including acute and chronic **gastritis**, gastric ulcers, **stomach cancer**, and lymphoma associated with the lymphoid tissues of the gastrointestinal mucosa.

There are different kinds of *H. pylori* tests, but they all have the same purpose: to determine if a person has the *H. pylori* bacteria in his or her gastrointestinal tract. After a patient has been diagnosed with a peptic ulcer disease, the gastroenterologist usually tests for the bacteria and, if it is present, treats it with a combination of two **antibiotics**. Following treatment the patient may be tested again to determine that the treatment was successful.

H. pylori may be diagnosed from tests performed on endoscopic biopsy specimens from the stomach or duodenal mucosa, breath analysis, tests on plasma or serum for specific antibodies, or tests on stool for *H. pylori* antigens.

ENDOSCOPIC BIOPSY. A culture can be done on tissue obtained by biopsy, but is generally not performed because recovery of organisms is variable. Biopsy specimens taken from the stomach or duodenum may also be examined for Gram-negative spiral rods indicative of infection, but more often are tested for *H. pylori* by adding a sample of the tissue to a broth containing urea. The bacterium produces urease, which hydrolyses the

urea and forms carbon dioxide and ammonia. The ammonia increases the pH of the medium causing the pH indicator to turn red.

BREATH TESTS. These tests are based on detection of carbon dioxide gas produced from the hydrolysis of urea. Breath tests are non-invasive and highly accurate in determining if the bacterium is present. They are often used when an endoscopy is contraindicated and to follow-up antibiotic treatment. The patient is given an oral dose of urea labeled with radioactive carbon. The carbon is carried to the **lungs** by the **blood**. The patient exhales into a vial and the radioactivity of the expelled air in the vial is measured. A nonradioisotopic breath test is also available.

SEROLOGICAL TESTS FOR ANTIBODIES TO *H. PYLORI*. ELISA (enzyme-linked immunosorbent assay) and other immunoassay methods are available for IgG, IgA, and IgM antibodies to *H. pylori*. The IgM test detects antibodies formed two to four weeks after infection. IgG and IgA tests require up to two months after infection before becoming positive. These tests are accurate and reliable screening tests for exposure to *H. pylori*. However, antibodies persist after successful treatment. For this reason, the breath test is preferred after treatment to identify drug resistant cases.

Precautions

Endoscopy may be contraindicated by a history of gastrointestinal (GI) bleeding, recent GI surgery, and diverticula in the esophagus. Breath testing using a radioisotopic preparation is contraindicated in **pregnancy**. The breath test may be negative if the patient is receiving antibiotic therapy and certain medications.

Preparation

Endoscopy is an invasive procedure, and is performed in a hospital or clinic usually on an outpatient basis. Overnight fasting is required. To reduce the dis-

KEY TERMS

Endoscope—A thin, lighted tube with a tiny camera attached to the end. It allows the doctor to see the lining of the esophagus, stomach, and duodenum.

Endoscopy—A procedure that uses an endoscope.

Gastroenterology—The study of the digestive system and diseases and disorders affecting it.

Invasive procedure—A medical procedure that requires entrance of a foreign object into the human body.

Non-invasive procedure—A medical procedure that does not require entrance of a foreign object into the human body.

Serology—Blood tests.

Urea—A waste product of the breakdown of proteins.

comfort associated with the procedure, the patient is mildly sedated and a topical anesthetic is sprayed in the throat. **Vital signs** and history are important to insure that the patient does not have a condition that contraindicates the procedure. An intravenous line is used to instill fluids and the sedative.

For the breath test, a dose of radiolabeled urea is given orally to the patient. For serological tests, venipuncture is performed using standard precautions for prevention of exposure to bloodborne pathogens.

Aftercare

Following endoscopy, patients should be observed while recovering from sedating medications for any signs of GI bleeding or **pain** and treated accordingly. The patient should remain under medical supervision until fully alert. After venipuncture, hemostasis should be accomplished by applying direct pressure to the puncture site.

Complications

Endoscopy may be associated with GI bleeding, allergic reaction to medications, and throat or abdominal pain. Rare complications also include perforation of an upper GI organ, aspiration of gastric fluid, and phlebitis. Breath and serological tests are not associated with significant complications.

Health care team roles

Endoscopy is performed by a gastroenterologist with the assistance of registered nurses. Breath testing can be administered by a physician or nurse. Venipuncture is performed by a physician, nurse or phlebotomist. Serological testing is performed by a clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) or clinical laboratory technician, CLT(NCA)/medical laboratory technician, MLT(ASCP).

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ORGANIZATIONS

- National Digestive Diseases Information Clearinghouse. 2 Information Way, Bethesda, MD 20892-3570. <<http://www.niddk.nih.gov>>.

Peggy Elaine Browning

Hand and arm splints see **Upper limb orthoses**

Haptoglobin test see **Plasma protein tests**

HCT see **Hematocrit**

Head and neck cancer

Definition

The term head and neck cancers refers to a group of cancers found in the head and neck region. This includes tumors found in:

- The oral cavity (mouth): the lips, the tongue, the teeth, the gums, the lining inside the lips and cheeks, the floor of the mouth (under the tongue), the roof of the mouth, and the small area behind the wisdom teeth are all included in the oral cavity.
- The oropharynx: includes the back one-third of the tongue, the back of the throat, and the tonsils.

- **Nasopharynx:** includes the area behind the nose.
- **Hypopharynx:** the lower part of the throat.
- **The larynx** (voice box, located in front of the neck in the region of the Adam's apple): in the larynx, the **cancer** can occur in any of the three regions—the glottis (where the vocal cords are); the supraglottis (the area above the glottis), and the subglottis (the area that connects the glottis to the windpipe).

The most frequently occurring cancers of the head and neck area are oral cancers and laryngeal cancers. Almost half of all the head and neck cancers occur in the oral cavity, and a third are found in the larynx. By definition, the term “head and neck cancers” usually excludes tumors that occur in the **brain**.

Description

Head and neck cancers involve the respiratory tract and the digestive tract, and they interfere with the functions of eating and breathing. Laryngeal cancers affect speech. Loss of any of these functions is significant. Hence, early detection and appropriate treatment of head and neck cancers is of utmost importance.

Roughly 10% of all cancers are related to the head and the neck. For cancer of the pharynx and oral cavity, there was an estimated 30,200 new cases in 2000. Incidence rates are highest in women and men over age 40, and more than twice as high in men as in women. The rates of oral cancers and deaths due to this cancer have been declining.

Among the major cancers, the survival rate for head and neck cancers is one of the poorest. Less than 50% of the patients survive five years or more after initial diagnosis. This is because the early signs of head and neck cancers are frequently ignored. Hence, when they are first diagnosed, these types of cancers are often in an advanced stage and not very amenable to treatment.

The risk for both **oral cancer** and laryngeal cancer seems to increase with age. Most of the cases occur in individuals over 40 years of age, the average age at diagnosis being 60. While oral cancer strikes men twice as often as it does women, laryngeal cancer is four times more common in men than in women. Both diseases are more common in African Americans than among Caucasians.

Causes and symptoms

Although the exact cause for these cancers is unknown, tobacco is regarded as the single greatest risk factor: 75–80% of the oral and laryngeal cancer cases occur among smokers. Heavy alcohol use has also been

included as a risk factor. A combination of tobacco and alcohol use increases the risk for oral cancer by six to 15 times more than for users of either substance alone. In rare cases, irritation to the lining of the mouth, due to jagged teeth or ill-fitting dentures, has been known to cause oral cancer. Exposure to asbestos also appears to increase the risk of developing laryngeal cancer.

In the case of lip cancer, just like skin cancer, exposure to sun over a prolonged period has been shown to increase the risk. In the Southeast Asian countries (India and Sri Lanka), chewing of betel nut has been associated with cancer of the lining of the cheek. An increased incidence of nasal cavity cancer has been observed among furniture workers, probably due to the inhalation of wood dust. A virus (Epstein-Barr) has also been shown to cause nasopharyngeal cancer.

Head and neck cancers are one of the easiest to detect. The early signs can be both seen and felt. The signs and symptoms depend on the location of the cancer:

- **Mouth and oral cavity:** a sore that does not heal within two weeks, unusual bleeding from the teeth or gums, a white or red patch in the mouth, or a lump or thickening in the mouth, throat, or tongue.
- **Larynx:** persistent hoarseness or **sore throat**, difficulty breathing, or **pain**.
- **Hypopharynx and oropharynx:** difficulty in swallowing or chewing food or ear pain.
- **Nose, sinuses, and nasopharyngeal cavity:** pain, bloody discharges from the nose, blocked nose, and frequent sinus infections that do not respond to standard **antibiotics**.

When detected early and treated appropriately, head and neck cancers have an excellent chance of being cured completely.

Diagnosis

Specific diagnostic tests used depend on the location of the cancer. The standard tests are:

Physical examination

The first step in diagnosis is a complete and thorough examination of the oral and nasal cavity, using mirrors and other visual aids. The tongue and the back of the throat are examined as well. Any suspicious looking lumps or lesions are examined with fingers (palpation). In order to look inside the larynx, the doctor may sometimes perform a procedure known as **laryngoscopy**. In indirect laryngoscopy, the doctor looks down the throat with a small, long handled mirror. Sometimes the doctor inserts a lighted tube (laryngoscope or a fiberoptic scope)

through the patient's nose or mouth. As the tube goes down the throat, the doctor can observe areas that cannot be seen by a simple mirror. This procedure is called a direct laryngoscopy. Sometimes patients may be given a mild sedative to help them relax, and a local anesthetic to ease any discomfort.

Blood tests

The doctor may order **blood** or other immunological tests. These tests are aimed at detecting antibodies to the Epstein-Barr virus.

Imaging tests

X rays of the mouth, the sinuses, the **skull**, and the chest region may be required. A computed tomography scan (CT scan), a procedure in which a computer takes a series of x ray pictures of areas inside the body, may be done. Ultrasonograms (images generated using sound waves) or an MRI (**magnetic resonance imaging**) a procedure in which a picture is created using magnets linked to a computer), are alternate procedures which a doctor may have done to get detailed pictures of the areas inside the body.

Biopsy

When a sore does not heal or a suspicious patch or lump is seen in the mouth, larynx, nasopharynx, or throat, a biopsy may be performed to rule out the possibility of cancer. The biopsy is the most definitive diagnostic tool for detecting the cancer. If cancerous cells are detected in the biopsied sample, the doctor may perform more extensive tests in order to find whether, and to where, the cancer may have spread.

Treatment

The cancers can be treated successfully if diagnosed early. The choice of treatment depends on the size of the tumor, its location, and whether it has spread to other parts of the body.

In the case of lip and mouth cancers, sometimes surgery is performed to remove the cancer. Radiation therapy, which destroys the cancerous cells, is also one of the primary modes of treatment, and may be used alone or in combination with surgery. If lip surgery is drastic, rehabilitation cosmetic or reconstructive surgery may have to be considered. Some cancers of the lip may be removed by Mohs' surgery, also known micrographic surgery. Using this method, the surgeon removes the tumor in thin slices, examining them immediately under the **microscope** to look for cancer cells. More slices are taken until

the cancer is completely removed. The amount of normal tissue removed is minimized using this method.

Cancers of the nasal cavity are often diagnosed late because they have no specific symptoms in their early stages, or the symptoms may just resemble chronic sinusitis. Hence, treatment is often complex, involving a combination of **radiotherapy** and surgery. Surgery is generally recommended for small tumors. If the cancer cannot be removed by surgery, then radiotherapy is used alone.

Treatment of oropharynx cancers (cancers that are either in the back of the tongue, the throat, or the tonsils) generally involves radiation therapy and/or surgery. After aggressive surgery and radiation, rehabilitation is often necessary and is an essential part of the treatment. The patient may experience difficulties with swallowing, chewing, and speech and may require a team of health care workers, including speech therapists, prosthodontists, occupational therapists, etc.

Cancers of the nasopharynx are different from the other head and neck cancers in that there does not appear to be any association between alcohol and tobacco use and the development of the cancer. In addition, the incidence is seen primarily in two age groups: young adults and 50–70 year-olds. The Epstein-Barr virus has been implicated as the causative agent in most patients. While 80–90% of small tumors are curable by radiation therapy, advanced tumors that have spread to the bone and cranial nerves are difficult to control. Surgery is not very helpful and, hence, is rarely attempted. Radiation remains the only treatment of choice to treat the cancer that has metastasized (traveled) to the lymph nodes in the neck.

In the case of cancer of the larynx, radiotherapy is the first choice to treat small lesions. This is done in an attempt to preserve the voice. If the cancer recurs later, surgery may be attempted. If the cancer is limited to one of the two vocal cords, laser excision surgery is used. In order to treat advanced cancers, a combination of surgery and radiation therapy is often used. Because the chances of a cure in the case of advanced laryngeal cancers are rather low with current therapies, the patient may be advised to participate in clinical trials so they may get access to new experimental drugs and procedures, such as **chemotherapy**, that are being evaluated.

When only part of the larynx is removed, a relatively slight change in the voice may occur—the patient may sound slightly hoarse. However, in a total laryngectomy, the entire voice box is removed. The patients then have to re-learn to speak using different approaches, such as esophageal speech, tracheo-esophageal (TE) speech, or by means of an artificial larynx.

In esophageal speech, the patients are taught how to create a new type of voice by forcing air through the esophagus (food pipe) into the mouth. This method has a high success rate of approximately 65% and patients are even able to go back to jobs that require a high level of verbal communication, such as telephone operators and salespersons.

In the second approach, TE speech, a small opening called a fistula, is created surgically between the trachea (breathing tube to the **lungs**) and the esophagus (tube into the **stomach**) to carry air into the throat. A small tube, known as the “voice prosthesis,” is placed in the opening of the fistula to keep it open and to prevent food and liquid from going down into the trachea. In order to talk, the stoma (or the opening made at the base of the neck) must be covered with one’s thumb during exhalation. As the air is forced out from the trachea into the esophagus, it vibrates the walls of the esophagus. This produces a sound that is then modified by the lips and tongue to produce normal sounding speech.

In the third approach, an artificial larynx, a battery driven vibrator, is placed on the outside of the throat. Sound is created as air passes through the stoma (opening made at the base of the neck) and the mouth forms words.

Recent developments have been made with the use of lasers for treating many types of cancer. Laser therapy destroys cancer cells by the use of high-intensity light. It is often used to relieve symptoms of cancer such as bleeding or obstruction, particularly when other treatments are ineffective. **Laser surgery** can also treat cancer by shrinking or destroying tumors. Laser surgery is a standard treatment for certain stages of glottis. Although there are several different kinds of lasers, only the Carbon dioxide (CO₂) laser, Neodymium:yttrium–aluminum–garnet (Nd:YAG) laser, and argon laser are widely used in medicine. The CO₂ and Nd:YAG lasers are used to shrink or destroy tumors. Laser surgery is also used to help relieve symptoms caused by cancer (palliative care) in addition to its use in destroying cancer cells.

Since cancer cannot grow or spread without forming new **blood vessels**, research is being conducted to find ways to stop angiogenesis. Scientists are exploring the use of natural and synthetic angiogenesis inhibitors, also called anti-angiogenesis agents, in anticipation that these chemicals will prevent tumor spread by inhibiting new blood vessel formation.

Taxanes are a group of cancer drugs that includes paclitaxel (Taxol) and docetaxel (Taxotere). Taxanes inhibit cancer cell growth by arresting **cell division**. They are also known as antimetabolic or antimicrotubule agents or mitotic inhibitors.

Photodynamic therapy (also called PDT, photoradiation therapy, **phototherapy**, or photochemotherapy) is a treatment for some types of cancer including larynx and oral cavity.

Important research is being conducted investigating new treatments for several head and neck cancers. There are many new promising treatments and improvements to current therapies such as:

- Tumor growth factors. These hormone-like substances that are naturally occurring in the body typically promote cell growth. Some tumors may grow quickly because of excessive growth factors. New drugs like C-225 may help inhibit tumor growth. C-225 targets a specific area on the cancer cells’ surface; it may eventually be used to treat other cancers such as colon, prostate, bladder, ovarian, and non-small cell **lung cancer**.
- New chemotherapy techniques. Intraarterial chemotherapy, where drugs are injected into arteries feeding the cancer, is being tested in combination with radiation therapy in an attempt to improve their effectiveness. Another new approach uses intralesional chemotherapy (injecting the drug directly into the tumor). Preliminary results have been promising with these new chemotherapies.
- New radiotherapy methods. Studies have been underway testing the efficacy of new radiation regimens delivering twice-a-day irradiation. Higher cure rates have been demonstrated.
- Vaccines may be effective by helping the **immune system** to recognize and attack the cancer cells.

Prognosis

Comorbidities (other illnesses) that may be present are an important determinant of overall survival in people with head and neck cancer.

Oral cavity

With early detection and immediate treatment, survival rates can be dramatically improved. For lip and oral cancer, if detected at its early stages, almost 80% of the patients survive five years or more. However, when diagnosed at the advanced stages, the five year survival rate drops to a mere 18%.

Nose and sinuses

Cancers of the nasal cavity often go undetected until they reach an advanced stage. If diagnosed at the early stages, the five-year survival rates are 60–70%. However,

KEY TERMS

Angiogenesis—The formation of blood vessels around a tumor.

Biopsy—The surgical removal and microscopic examination of living tissue for diagnostic purposes.

Chemotherapy—Treatment of cancer with synthetic drugs that destroy the tumor either by inhibiting the growth of the cancerous cells or by killing the cancer cells.

Clinical trials—Highly regulated and carefully controlled patient studies, where either new drugs to treat cancer or novel methods of treatment are investigated.

Computerized tomography scan (CT scan)—A medical procedure where a series of x rays are taken and put together by a computer in order to form detailed pictures of areas inside the body.

Growth factors—Growth factors or human growth factors are compounds made by the body that function to regulate cell division and cell survival. Some growth factors are also produced in the laboratory by genetic engineering and are used in biological therapy. Growth factors are significant because they can induce angiogenesis, the formation of blood vessels around a tumor. These growth factors also encourage cell proliferation, differentiation, and migration on the surfaces of the endothelial cells.

Laryngoscopy—A medical procedure that uses flexible, lighted, narrow tubes inserted through the

mouth or nose to examine the larynx and other areas deep inside the neck.

Magnetic resonance imaging (MRI)—A medical procedure used for diagnostic purposes where pictures of areas inside the body can be created using a magnet linked to a computer.

p53 gene—A tumor suppressor gene that typically inhibits the tumor growth. This gene is often altered in many types of cancer.

Radiation therapy—Treatment using high energy radiation from x-ray machines, cobalt, radium, or other sources.

Stoma—When the entire larynx must be surgically removed, an opening is surgically created in the neck so that the windpipe can be brought out to the neck. This opening is called the stoma

Taxanes—Anticancer drugs that inhibit cancer cell growth by arresting cell division. Also known as antimetabolic or antimicrotubule agents or mitotic inhibitors.

Ultrasonogram—A procedure where high-frequency sound waves that cannot be heard by human ears are bounced off internal organs and tissues. These sound waves produce a pattern of echoes which are then used by the computer to create sonograms, or pictures of areas inside the body.

X rays—High energy radiation used in high doses, either to diagnose or treat disease.

if cancers are more advanced, only 10–30% of the patients survive five years or more.

Oropharynx

In cancer of the oropharynx, 60–80% of the patients survive five years or more if the cancer is detected in the early stages. As the cancer advances, the survival rate drops to 15–30%.

Nasopharynx

Patients who are diagnosed with early stage cancers that have originated in the nasopharynx have an excellent chance of a complete cure (almost 95%). Unfortunately, most of the time the patients are in an advanced stage at the time of initial diagnosis. With the new chemotherapy

drugs, the five year survival rate has improved and 5–40% of the patients survive five years or longer.

Larynx

Small cancers of the larynx have an excellent five-year survival rate of 75–95%. However, as with most of the head and neck cancers, the survival rates drop dramatically as the cancer advances. Only 15–25% of the patients survive five years or more after being initially diagnosed with advanced laryngeal cancer.

Advances in detecting head and neck cancer at an early stage are being made. Patients' prognoses will improve as technological advances are made. Some of the research that is being conducted includes DNA mutations (changes) that occur in genes. Damage to certain DNA can lead to increased growth of abnormal cells and

formation of cancers. Recent studies suggest that tests to detect p53 gene alterations may allow very early detection of oral and oropharyngeal tumors. Other substances under investigation that may help early prognosis of cancers are epidermal growth factor receptor, transforming growth factor-alpha, and cyclin D1.

Using targeted chemoradiation, one clinical study revealed that statistical projections for overall and cancer-related five-year survival was 38.8% and 53.6%, respectively for patients with advanced (stage III-IV) carcinoma of the head and neck.

Health care team roles

Depending on the diagnosis, disease stage, level of nursing care required, and different psychosocial factors, the patient's health care needs will vary. The care required is unique to each patient and family. For patients who will be in transitional care, an optimal integration between inpatient and outpatient care is needed to ensure the best care possible. Outpatient care includes **home care**, rehabilitation centers, **nursing homes**, and hospice care. Health care teams should make the transition from the different types of inpatient and outpatient care as easy as possible. Effective communication between professionals is critical.

A dental team with experience in oral oncology, may reduce the risk of oral complications for patients with oral cancers.

Prevention

Refraining from the use of all tobacco products (cigarettes, cigars, pipe tobacco, chewing tobacco), consuming alcohol in moderation, and practicing good **oral hygiene** are some of the measures that one can take to prevent head and neck cancers. Since there is an association between excessive exposure to the sun and lip cancer, people who spend a lot of time outdoors in the sun should protect themselves from the sun's harmful rays. Regular physical examinations, or mouth examination by the patient himself, or by the patient's doctor or dentist, can help detect oral cancer in its very early stages.

Since working with asbestos has been shown to increase one's risk of getting cancer of the larynx, asbestos workers should follow safety rules to avoid inhaling asbestos fibers. Also, malnutrition and vitamin deficiencies have been shown to have some association with an increased incidence of head and neck cancers. The American Cancer Society recommends eating a healthy diet, consisting of at least five servings of fruits and vegetables every day, and six servings of food from other plant sources such as cereals, breads, grain products, rice, pasta,

and beans. Reducing one's intake of high-fat food from animal sources is advised. Following the *The Dietary Guidelines for Americans* published by the United States Department of Agriculture and Health and Human Services can provide a broad overall view of good **nutrition**.

These dietary guidelines include these seven basic recommendations:

- Eat a variety of foods.
- Control your weight.
- Eat a low-fat, low-cholesterol diet.
- Eat plenty of vegetables, fruits, and grains.
- Eat sugar in moderation.
- Use salt in moderation.
- If you drink alcohol, do so in moderation; no more than two drinks per day of wine, beer, or spirits.

The Food Guide Pyramid was created by the United States Department of Agriculture to help Americans choose foods from each food grouping. The food pyramid, developed by nutritionists, provides a visual guide to healthy eating.

Resources

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ORGANIZATIONS

American Association of Oral and Maxillofacial Surgeons. 9700 W. Bryn Mawr; Rosemont, IL 60018. (800) 467-5268. <<http://www.aaoms.org>>.

American Dietetic Association. 216 W. Jackson Blvd. Chicago, IL 60606-6995. (312) 899-0040. <<http://www.eatright.org>>.

International Association of Laryngectomees (IAL). 7440 North Shadeland Avenue, Suite 100, Indianapolis, IN 46250. <<http://www.larynxlink.com/welcome.html>>.

National Cancer Institute (National Institutes of Health). 9000 Rockville Pike, Bethesda, MD 20892. (800) 422-6237. <<http://cancernet.nci.nih.gov>>.

National Oral Health Information ClearingHouse. 1 NOHIC Way, Bethesda, MD 20892-3500. (301) 402-7364. <<http://www.nohic.nih.gov>>.

Oral Health Education Foundation, Inc. 5865 Colonist Drive, P.O. Box 396, Fairburn, GA 30213. (770) 969-7400.

Support for People with Oral and Head and Neck Cancer (SPOHNC). P.O. BOX 53 Locust Valley, NY 11560-0053. (800) 377-0928. <<http://www.spoync.org>>.

Crystal Heather Kaczowski, MSc.

Head injury

Definition

Injury to the head may damage the scalp, **skull**, or **brain**. The most important consequence of head injury is traumatic brain injury. Head injury may occur either as a closed head injury such as the head hitting a car's windshield, or as a penetrating head injury such as when a bullet pierces the skull. Both may cause damage that ranges from mild to profound. Very severe injury can be fatal because of profound brain damage.

Description

External trauma to the head is capable of damaging the brain, even if there is no external evidence of damage. More serious injuries can cause skull fracture, **blood** clots between the skull and the brain, or bruising and tearing of the brain tissue itself.

Injuries to the head can be caused by traffic accidents, **sports injuries**, **falls**, workplace accidents, assaults, or bullets. Most people have had some type of head injury at least once in their lives, but rarely do they require a hospital visit.

Each year, approximately two million people suffer from a serious head injury. Up to 750,000 of them are severe enough to require hospitalization. Brain injury is most likely to occur in males between ages 15 and 24, usually as a result of car and motorcycle accidents. About 70% of all accidental deaths are due to head injuries, as are most of the disabilities that occur after trauma.

A person who has had a head injury and who is experiencing the following symptoms should seek immediate medical care:

- serious bleeding from the head or face
- loss of consciousness, however brief
- confusion and lethargy
- lack of pulse or breathing
- clear fluid drainage from the nose or ear

Causes and symptoms

A head injury may cause damage both from the direct physical injury to the brain and from secondary factors such as lack of oxygen, brain swelling, and disturbance of blood flow. Both closed and penetrating head injuries can cause swirling movements throughout the brain, tearing nerve fibers and causing widespread bleeding or a blood clot in or around the brain. Swelling may

raise pressure within the skull (intracranial pressure) and may block the flow of oxygen to the brain.

Head trauma may cause a **concussion**, in which there is a brief loss of consciousness without visible structural damage to the brain. In addition to loss of consciousness, initial symptoms of brain injury may include:

- **memory** loss and confusion
- vomiting
- dizziness
- partial **paralysis** or numbness
- shock
- anxiety

After a head injury, there may be a period of impaired consciousness, followed by a period of confusion and impaired memory with disorientation and a breakdown in the ability to store and retrieve new information. Others may experience temporary (retrograde) amnesia following head injury. As a person recovers, memory slowly returns. Post-traumatic amnesia refers to loss of memory for events during and after an accident.

Epilepsy occurs in 2–5% of those who have experienced a head injury. It is much more common in people who have had severe or penetrating injuries. Most cases of epilepsy appear immediately after an accident or within the first year. They become less likely with increased time following an accident.

Closed head injury

Closed head injury refers to brain trauma without any penetrating injury to the brain. It may be the result of a direct blow to the head, of a moving head being rapidly stopped, or by a sudden deceleration of the head without striking another object. The kind of injury the brain receives in a closed head injury is determined by whether or not the head was unrestrained upon impact and the direction, force, and velocity of the blow. If a head was resting on impact, the maximum damage will be found at the impact site. A moving head will cause a *contrecoup* injury in which the brain damage occurs on the side opposite the point of impact, as a result of the brain slamming into that side of the skull. A closed head injury also may occur without the head being struck, such as when a person experiences **whiplash**, because the brain is of a different density than the skull, and can be injured when delicate brain tissues hit against the rough, jagged inner surface of the skull.

Penetrating head injury

If the skull is fractured, bone fragments may be driven into the brain. Any object that penetrates the skull may

implant foreign material and dirt into the brain, leading to an **infection**.

Skull fracture

A skull fracture is a medical emergency that must be treated promptly to prevent possible brain damage. Such an injury may be obvious if blood or bone fragments are visible. It is possible for a fracture to have occurred without any apparent damage. A skull fracture should be suspected if any of the following are observed:

- blood or clear fluid leaking from nose or ears
- unequal pupil size
- bruises or discoloration around the eyes or behind the ears
- swelling or depression of the part of the head

Intracranial hemorrhage

Bleeding (hemorrhage) inside the skull may accompany a head injury and cause additional damage to the brain. A blood clot (hematoma) may occur if a blood vessel between the skull and the brain ruptures. When the blood leaks out and forms a clot, it can press against brain tissue, causing symptoms that may arise within a few hours to a few weeks after the injury. If the clot is located between the bones of the skull and the covering of the brain (dura), it is called an epidural hematoma. If the clot is between the dura and the brain tissue itself, the condition is called a subdural hematoma. In other cases, bleeding may occur deeper inside the brain. This condition is called intracerebral hemorrhage, or intracerebral contusion.

If the blood flow within the skull is not stopped, it can lead to unconsciousness and death. The signs and symptoms of bleeding within the skull include:

- nausea and vomiting
- headache
- loss of consciousness
- unequal pupil size
- lethargy

Post-concussion syndrome

If a head injury is mild, there may be no symptoms other than a slight headache, or there also may be confusion, dizziness, and blurred **vision**. While the head injury may seem to have been quite mild, in many cases symptoms persist for days or weeks. Up to 60% of persons who sustain a mild brain injury continue to experience a range of symptoms called post-concussion syndrome, for as long as six months or a year after the injury.



A three-dimensional computed axial tomography (CAT) scan of a human skull showing a depressed skull fracture above the right eye. (Custom Medical Stock Photo. Reproduced by permission.)

The symptoms of postconcussion syndrome can result in a puzzling interplay of behavioral, cognitive, and emotional complaints that can be difficult to diagnose, including:

- headache
- dizziness
- mental confusion
- behavior changes
- memory loss
- cognitive deficits
- depression
- emotional outbursts

KEY TERMS

Amnesia—Loss of memory.

Computed tomography (CT) scan—A diagnostic technique in which the combined use of a computer and x rays produce clear cross-sectional images of tissue.

Contrecoup injury—Brain damage occurring on the side opposite to the point of impact.

Contusion—Bruise.

Electroencephalogram (EEG)—A record of the tiny electrical impulses produced by the brain's activity.

Hematoma—Blood clot.

Hemorrhage—Heavy or uncontrolled bleeding.

Magnetic resonance imaging (MRI)—A diagnostic technique that provides high quality cross-sectional images of organs within the body without using x rays or other radiation.

Positron emission tomography (PET) scan—A computerized diagnostic technique that uses radioactive substances to examine structures of the body.

Post-traumatic amnesia—Loss of memory for events during and after an accident.

Retrograde amnesia—Memory loss for events in the past that occurs over a period of time.

Diagnosis

The extent of damage in a severe head injury can be assessed with computed tomography (CT) scan, **magnetic resonance imaging (MRI)**, **positron emission tomography (PET) scan**, electroencephalograms (EEG), and routine neurological and neuropsychological evaluations.

Physicians use the Glasgow **Coma Scale** to evaluate the extent of brain damage based on observing a person's ability to open his or her eyes, respond verbally, and respond to stimulation by moving (motor response). Persons can score from three to 15 points on this scale. People who score below eight when they are admitted usually have suffered a severe brain injury and will need rehabilitative therapy as they recover. In general, higher scores on the Glasgow Coma Scale indicate less severe brain injury and a better prognosis for recovery.

Persons with a mild head injury who experience symptoms are advised to seek out the care of a specialist. Unless a family physician is thoroughly familiar with medical literature in this newly emerging area, experts warn that there is a good chance that a complaint after a mild head injury will be downplayed or dismissed. In the case of mild head injury or postconcussion syndrome, CT and MRI scans, electroencephalograms (EEG), and routine neurological evaluations may all be normal because the damage is so subtle. In many cases, these tests cannot detect the microscopic damage that occurs when fibers are stretched in a mild, diffuse injury, in which the axons in the brain lose some of their covering and become less efficient. This mild injury to the white matter reduces the quality of communication between different parts and the brain. A PET scan, which evaluates cerebral blood flow and brain **metabolism**, may be of help in diagnosing mild head injury, although many experts still considered this to be an experimental procedure.

Persons with continuing symptoms after a mild head injury should call a local chapter of a head-injury foundation that can refer them to the best nearby expert.

Treatment

If a concussion, bleeding inside the skull, or skull fracture is suspected, a person should be kept quiet in a darkened room, with head and shoulders raised slightly on pillow or blanket.

After initial emergency treatment, a team of specialists may be needed to evaluate and treat any problems that result. A penetrating wound may require surgery. Those individuals with severe injuries or with a deteriorating level of consciousness may be kept hospitalized for observation. If there is bleeding inside the skull, the blood may need to be surgically drained. If a clot has formed, it may need to be removed. Severe skull **fractures** also require surgery. Supportive care and specific treatments may be required if a person experiences further complications. People who experience seizures, for example, may be given anticonvulsant drugs, and people who develop fluid on the brain (hydrocephalus) may have a shunt inserted to drain the fluid.

In the event of long-term disability that occurs as a result of head injury, a variety of treatment programs are available, including long-term rehabilitation, coma treatment centers, transitional living programs, behavior management programs, life-long residential or day treatment programs, and independent living programs.

Prognosis

Prompt diagnosis and treatment can help alleviate some of the problems after a head injury. However, it is usually difficult to predict the outcome of a brain injury in the first few hours or days. A person's prognosis may not be known for many months or even years.

The outlook for someone with a minor head injury is generally good, although recovery may be delayed, and symptoms such as headache, dizziness, and cognitive problems can persist for up to a year or longer after an accident.

Serious head injuries can be devastating, producing permanent mental and physical disability. Epileptic seizures may occur after a severe head injury, especially a penetrating brain injury, a severe skull fracture, or a serious brain hemorrhage. Recovery from a severe head injury may take five years or longer to completely heal. Risk factors associated with an increased likelihood of memory problems or seizures after head injury include age, length and depth of coma, duration of post-traumatic and retrograde amnesia, presence of focal brain injuries, and initial Glasgow Coma Scale score.

Health care team roles

First aid may be given by **emergency medical technicians**. Physicians trained in emergency medicine often provide initial care in a hospital. Neurosurgeons and neurologists may be asked to assist with care. Rehabilitation specialists such as physicians, physical therapists, speech therapists, or occupational therapists may provide rehabilitation. Nurses provide supportive care throughout, including 24-hour care, home nursing care, and **patient education**.

Prevention

Many severe head injuries could be prevented by wearing protective headgear during certain sports, or helmets when riding a bike or motorcycle. Seat belts and airbags can prevent many head injuries that result from motor vehicle accidents. Appropriate protective headgear should always be worn on the job where head injuries are a possibility.

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ORGANIZATIONS

- American Academy of Neurology. 1080 Montreal Avenue, St. Paul, Minnesota 55116. (651) 695-1940. (651) 695-2791. <<http://www.aan.com/>>. info@aan.org.
- American Academy of Pediatrics. 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. (847) 434-8000. <<http://www.aap.org/default.htm>>. kidsdoc@aap.org.
- American College of Emergency Physicians. P.O. Box 619911, Dallas, TX 75261-9911. (800) 798-1822. (972) 550-0911. (972) 580-2816. <<http://www.acep.org/>>. info@acep.org.
- American College of Osteopathic Emergency Physicians. 142 E. Ontario Street, Suite 550, Chicago, IL 60611. (312) 587-3709. (800) 521-3709. (312) 587-9951. <<http://www.acoep.org>>.
- Brain Injury Association. 105 North Alfred Street, Alexandria, VA 22314. (800) 444-6443. (703) 236-6000. (703) 236-6001. <<http://www.biausa.org/Sportsfs.htm>>. prevention@biausa.org.
- Emergency Nurses Association. 915 Lee Street, Des Plaines, IL 60016-6569. (800) 900-9659. (847) 460-4001. <<http://www.ena.org/about/index.htm>>.
- International Brain Injury Association. 1150 South Washington Street, Suite 210, Alexandria, VA 22314. (703) 683-8400. (703) 683-8996. <<http://www.internationalbrain.org/>>. info@internationalbrain.org.

National Center for Injury Prevention and Control. Centers for Disease Control and Prevention, Mailstop F41, 4770 Buford Highway NE, Atlanta, GA 30341-3724. (770) 488-4031. (770) 488-4338.
<<http://www.cdc.gov/ncipc/dacrrdp/tbi.htm>>.
dardinfo@cdc.gov.

OTHER

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American Academy of Pediatrics. <<http://www.aap.org/policy/ac9858.html>>.
Brain Injury Association. <<http://www.biausa.org/>>.
Glasgow Coma Score.
<<http://www.trauma.org/scores/gcs.html>>.
Head Injury Association of Waterloo-Wellington, Canada.
<<http://www.ahs.uwaterloo.ca/~cahr/headfall.html>>.
Head Injury Hotline.
<<http://www.headinjury.com/faqpcs.htm>>.
Pashby Sport Concussion Safety Website. <<http://www.concussionsafety.com/>>.
University of California Los Angeles.
<http://neurosurgery.ucla.edu/Diagnoses/BrainInjury/BrainInjuryDis_6.html>.
University of Missouri Health Center.
<<http://www.muhealth.org/~neuromedicine/concussion.shtml>>.

L. Fleming Fallon, Jr., M.D., Dr.P.H.

Head trauma see **Head injury**

Health care financing

Definition

Health care financing provides people in the United States with access to health care programs. Health care financing is directed and administered by the United States Department of Health and Human Services and the Health Care Financing Administration. Some health care financing benefits and privileges are also provided through the Department of Veteran's Affairs.

Description

Health care financing provides health care benefits to people who are either elderly or needy, or who otherwise meet the criteria for specific benefit programs. The three largest health care programs provided by the federal and state governments to citizens of the United States are **Medicare**, **Medicaid**, and the State Children's Health Insurance Program. Together Medicare, Medicaid, and

SCHIP provide health insurance for over 74 million Americans. Each program targets a different portion of the population and the health care needs of that particular population.

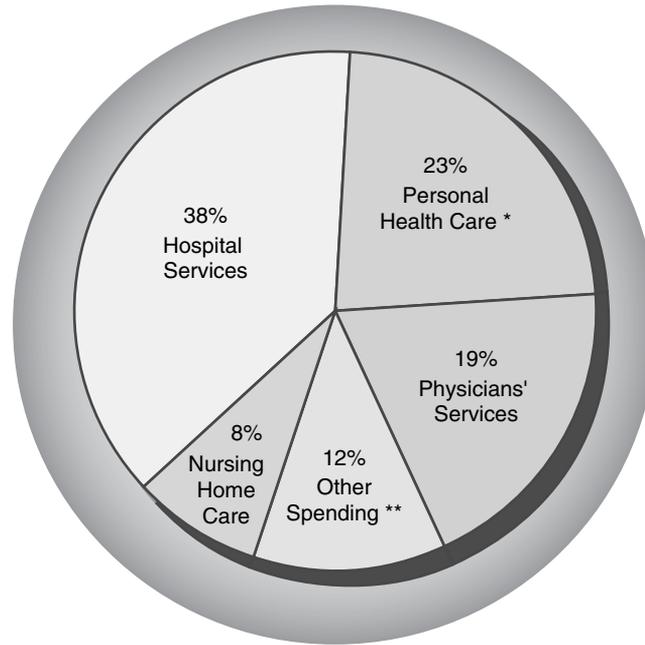
Medicare is a federal health insurance program to which all Americans aged 65 years or older are entitled. The program was started in 1965 by the Social Security Administration to provide health care for the aged. The program went into effect in 1966. In 1973, Medicare was expanded to include people who suffer from certain specific debilitating diseases such as permanent kidney failure. Medicare is an entitlement program like Social Security and does not rely on financial need to qualify a recipient. Approximately 40 million people are currently enrolled in the Medicare federal health insurance program.

Medicaid is a health insurance program for financially needy people. The Medicaid program was developed in 1965 along with the Medicare program and was put into effect in 1966. The program receives federal and state funds. Medicaid follows the operation guidelines set by the HCFA, but is operated by state welfare or health departments. Benefits vary from state to state. The people who qualify for Medicaid benefits are primarily children and their families who also qualify for public financial assistance such as the food stamp program. Elderly and disabled adults may also receive Medicaid assistance if they live in a qualifying, low-income household. Medicaid benefits have been expanded to include women with breast or cervical **cancer**, people living with **AIDS**, and home health care for people who qualify for long-term care.

SCHIP is a medical insurance program for children through the age of 18 years whose parents earn too much money to qualify for Medicaid, but who still earn too little to pay for insurance through a private company. The funds are regulated and delivered to each of the 50 states through the HCFA, but specific benefits are distributed at the discretion of each state. Benefits vary from state to state.

Other health care programs and benefits that are available to American citizens are Tricare and the Indian Health Service. Both programs target specific groups of beneficiaries and are distributed through government services.

Tricare, formerly known as CHAMPUS, is the health care program for the United States military. It benefits both active-duty and retired military personnel and their dependants. It also benefits veterans of foreign wars. The Tricare system allows recipients to choose their own doctor through a civilian health care system or to make use of the comprehensive health care services offered through military hospitals and clinics. Coverage



Note:

*Other personal health care = dental, home health care, medications, vision care.

** Other spending = administrative cost of private insurance and public programs, research, and construction.

Health care expenditures. (Delmar Publishers, Inc. Reproduced by permission.)

is nation-wide and benefits remain constant throughout the entire United States. It is administered through the Department of Veteran’s Affairs.

The Indian Health Service is an agency within the U.S. Department of Health and Human Services. The IHS is responsible for providing federal health services to Alaska natives and other native Americans. IHS maintains comprehensive health care delivery system of hospitals and clinics nationwide for approximately 1.5 million members of the 550 federally recognized Indian tribes and their descendants.

Viewpoints

Health care financing is the point of much disagreement and dissension on many fronts. While many advances are being made in health care, the number of people who are not covered by private health policies is growing. Even though federal funds provide health care financing programs, many children and disabled people

continue to be under-insured and under-served by the medical community.

Professional implications

The cost of health care financing by the federal government is likely to continue growing for several reasons.

- The large, aging “baby boomer” population will soon be eligible for Medicare benefits.
- Advanced medical technology keeps people alive and living longer with disabilities.
- Longer life expectancy increases need for medical care and long term care.
- Improved preventive practices are covered by health care financing.
- An increasing number of people are living longer with chronic diseases.

KEY TERMS

DHHS—Department of Health and Human Services, formerly the Department of Welfare.

HCFA—Health Care Financing Administration.

Medicaid—A jointly-funded, federal-state health insurance program that provides health care for the aged and the financially needy.

Medicare—A federally funded health insurance program for all persons aged 65 or older.

SCHIP—State Children’s Health Insurance Program. It provides health care insurance for children up to the age 18 years do not qualify for Medicaid, but are not covered by private insurance.

- There is a growing trend for employers to not offer medical benefits to employees and their families.

Resources

ORGANIZATIONS

Health Care Financing Administration, United States
Department of Health and Human Services. 200
Independence Avenue SW, Washington, D.C. 20201.
<<http://www.hcfa.gov>>.

United States Department of Health and Human Services. 200
Independence Avenue SW, Washington, D.C. 20201.
<<http://www.hhs.gov>>.

Peggy Elaine Browning

Health care, quality of

Definition

There is no single, universally accepted definition of health care quality. This is because health care quality involves descriptions of many different, complex aspects of care from several different perspectives. Quality may be measured in terms of outcomes, the end results of care and treatment, or it may be evaluated in terms of process, the way in which the care is delivered. The definition also depends on who is describing quality. Researchers, health care providers, government, and consumers may all assess health care quality differently.

Description

During the early 1980s, Donabedian described high quality care as “...care which is expected to maximize an inclusive measure of patient welfare, after one has taken account of the balance of expected gains and losses that attend the process in all its parts...”

In 1984, the American Medical Association (AMA) characterized high quality care as “care which consistently contributes to the improvement or maintenance of quality and/or duration of life.” The AMA specified the aspects, or features, of care that should be measured to determine quality. These features included:

- attention to evidence-based, scientific medicine
- timely and efficient use of resources
- emphasis on disease prevention and health promotion
- informed participation of patients

Another more concise definition, offered by the Institute of Medicine in 1990, stated that quality is the “degree to which health outcomes are consistent with current professional knowledge.”

Today, health care quality is understood to involve many dimensions of care. Measuring quality of care requires relating disease-specific outcome measures to assessments of general, physiological, mental, physical, and social health along with patient preferences and level of satisfaction. Effective measurement of quality enables researchers, practitioners, payors (health plans, insurance companies, government, employers, and health care coalitions) and other stakeholders to identify aspects of quality care and medical practice. It also enables comparisons to be made between institutions, health plans and providers.

Though definitions of quality and how to best measure it vary, there is agreement about the goal of measuring and monitoring health care quality; it is to evaluate and improve both the processes and outcomes of care. Hospitals, health plans, medical groups, and managed care organizations devote resources and personnel to quality assurance and quality improvement initiatives.

Quality assurance and quality management programs include data, utilization, and case management activities. Data management is used to measure and monitor outcomes and identify best practices; it is the foundation for quality improvement efforts. Examples of data used to evaluate the quality of health care delivered to a patient population include:

- rates of immunization
- disease-specific hospital lengths of stay

- rates of health screening tests performed, such as **mammography**, **hypertension** (high **blood pressure**) screening
- percentage of patients with congestive **heart failure** who receive ACE inhibitors
- results of patient satisfaction surveys

Utilization management is the process of evaluating the necessity, appropriateness, and efficiency of health care services. Case management is patient-centered action aimed at improving health care delivery and outcomes. Quality management enables health care organizations and providers to identify deviations from accepted standards of clinical practice, measure outcome standards, and support opportunities for improvement.

The most beneficial use of health care quality data is as inspiration and incentive to systematically improve care. When evidence of quality problems is identified, health care providers, professionals, and organizations are better prepared to address and promptly resolve problems.

Viewpoints

The American health care system delivers some of the finest, most sophisticated services and treatment available. Nonetheless, it is possible to identify areas of health care delivery that need improvement. A 1998 U.S. Department of Health Services report, *The Challenge and Potential for Assuring Quality Health Care for the 21st Century*, described existing problems and successful efforts to address these problems. The report described four key quality of care issues: underuse of services; overuse of services; misuse of services; and variation of services.

Underuse of services, when patients do not receive needed medical care, clearly contributes to higher rates of morbidity (illness) and mortality (death). Overuse of services, when patients receive unnecessary care, can be just as dangerous. For example, prescribing **antibiotics** to treat viral illnesses, such as colds, not only creates antibiotic resistance but also results in adverse drug reactions and excess costs. Misuse of services refers to errors in health care delivery. These errors range from minor mistakes that have virtually no impact on patients' health to misread laboratory results that delay diagnosis and incorrect administration of medications that may even result in patient deaths.

Variation of services refers to the ways in which medical practice differs between communities and even within a community. For example, studies have found significant geographical differences in the rates of surgical procedures such as Cesarean section. The use of med-

ical practice guidelines, written plans detailing diagnosis and treatment of specific conditions, is considered an effective strategy for reducing variation of services.

All health care providers face pressure not only to demonstrate their ability to effectively deliver health care services but also to document and communicate measures of clinical quality and fiscal accountability. Providers, employers, accreditors (agencies such as the Joint Commission on the Accreditation of Healthcare Organizations and the National Committee for Quality Assurance), and consumers are demanding substantial evidence of quality health care.

Publication of medical outcomes report cards, disease and procedure-specific morbidity and mortality rates has attracted media attention and sparked controversy. Advocates of the public release of clinical outcomes and other health care performance measures believe that despite their limitations, these studies offer consumers a useful way to compare providers.

Others argue that measures such as surgical mortality (death rates resulting from a specific surgical procedure) are incomplete indicators of quality. They feel that the data are often misleading, and unreliable guides for health care decisions. Critics cite problems with data collection that compromise the utility and validity of published reports.

Despite concern about the reliability, validity, and interpretation of data, there is consensus that investigation and disclosure of health care quality data will intensify. Recently, consumer interest has focused on individual providers, such as local hospitals and physicians. Employers, choosing between **managed care plans** involving the same group of participating hospitals and physicians, are requesting plan-specific information to guide contracting decisions. Companies and employer-driven health care coalitions seeking to compare and choose provider networks rely on physician and hospital-specific quality data during the selection process.

The impact of increasingly frequent, public release of clinical performance measures on consumer and provider decision-making, utilization, and the delivery of health care is not yet fully understood.

Professional implications

Traditionally, researchers, health care professionals, and practitioners tend to view quality in technical terms, such as the skills of the practitioners, the appropriateness of care, and the outcomes (results) of treatment. Health care consumers are more likely to focus on process measures such as waiting time for a scheduled appointment, whether they are treated courteously, the extent to which

KEY TERMS

Outcomes—Results or consequences of care or treatment.

Process—The steps, actions, or operations used to bring about the desired outcome.

they feel health care practitioners have answered their questions, and the nature of the interpersonal relationships they have with their providers.

Today, there is increasing awareness and appreciation among health care professionals of the importance of patient satisfaction with care. It is generally accepted that when patients are satisfied with the quality of care they have received, they are more likely to adhere to prescribed treatment, return for necessary follow-up, and recover more quickly and completely.

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Young, Wendy B., et al. "How Wide Is the Gap in Defining Quality Care?: Comparison of Patient and Nurse Perceptions of Important Aspects of Patient Care." *The Journal of Nursing Administration* 26 (May 1996): 14-20.

ORGANIZATIONS

Agency for Healthcare Research and Quality. 2101 E. Jefferson Street, Suite 501, Rockville, MD 20852. (301) 594-1364. <<http://www.ahrp.gov/>>.

American Healthcare Quality Association. 1140 Connecticut Avenue, Suite 105, Washington, DC 20036. (202) 331 5790. <<http://www.ahqa.org/>>.

Barbara Wexler

Health education see **Health promotion and education**

Health history

Definition

The health history is a current collection of organized information unique to the individual patient. Relevant aspects of the history include biographical, demographic, physical, mental, emotional, sociocultural, sexual, and spiritual data.

Purpose

The history aids the patient and health care provider by supplying essential information that will assist with diagnosis, treatment decisions, and establishment of trust and rapport between patient and medical professional. The information also helps determine the patient's baseline, or what is normal and expected for the patient.

Description

The clinical interview is the most common method for obtaining a health history. When the patient or a designated representative of the patient can communicate effectively, the clinical interview is a valuable means of soliciting information.

The information that comprises the health history may be obtained from the patient's previous records, the patient, or in some cases the patient's significant others or caretakers. The depth and length of the history-taking process is affected by factors such as the purpose of the visit, the urgency of the complaint or condition, the patient's willingness or ability to contribute information, and the environment. When circumstances allow, a history may be holistic and comprehensive, but at times only a cursory review of the most pertinent facts is possible. In cases where the history-gathering process needs to be abbreviated, the history focuses on the patient's medical experiences.

Health histories can be organized in a variety of ways. Often an organization such as a hospital or clinic will provide a form or computer database that serves as a guide and documentation tool for the history. Generally the first aspect covered by the history is identifying data.

Identifying data includes facts such as:

- name
- gender
- age
- date of birth
- occupation
- family/social situation

HEALTH HISTORY		
Name _____	Date _____	Time _____
Demographic Data: Date of birth _____ Gender _____ Marital status _____		
Reason for Seeking Health Care: _____		
Perception of Health Status: _____		
Previous Illness/Hospitalization/Surgeries: _____		
Client/Family Medical History:		
Addiction(drugs/alcohol) _____	Diabetes _____	Mental disorders _____
Arthritis _____	Heart disease _____	Sickle cell anemia _____
Cancer _____	Hypertension _____	Stroke _____
Chronic lung disease _____	Kidney disease _____	Other _____
Immunizations/Exposure to Communicable Disease: _____		
Allergies: _____		
Home Medications: _____		
Developmental Level: _____		
Psychosocial History:		
Alcohol use: _____		
Tobacco use: _____		
Drug use: _____		
Caffeine intake: _____		
Self-perception/Self-concept: _____		
Sociocultural History:		
Family structure _____		
Role in family _____		
Cultural/ethnic group _____		
Occupation/work role _____		
Relationships with others _____		
Activities of Daily Living:		
Nutrition: Type of diet _____	Usual weight _____	
Eating patterns _____		
Types of snacks _____		
Food likes/dislikes _____		
Fluid intake: Type _____	Amount _____	
Elimination (usual patterns): Urinary _____	Bowel _____	
Sleep/Rest:		
Usual sleep patterns _____		
Relaxation techniques/patterns _____		
Activity/Exercise:		
Usual exercise patterns _____		
Ability to perform self-care activities _____		
Review of Systems:		
Respiratory _____		
Circulatory _____		
Integumentary _____		
Musculoskeletal _____		
Neurosensory _____		
Reproductive/Sexuality _____		

Health history form. (Delmar Publishers, Inc. Reproduced by permission.)

KEY TERMS

Holistic—Pertaining to all aspects of the patient, including biological, psychosocial, and cultural factors.

Subjective—Influenced by the perspective of the information provider; potentially biased.

- source of referral

Once the identifying data is collected, the history addresses the reason for the current visit in expanded detail. The reason for the visit is sometimes referred to as the chief complaint or the presenting complaint. Once the reason for the visit is established, additional data is solicited by asking for details that provide a full picture of the current clinical situation. For example, in the case of **pain**, aspects such as location, duration, intensity, precipitating factors, aggravating factors, relieving factors, and associated symptoms would need to be recorded. The full picture or “story” that accompanies the chief complaint is often referred to as the history of present illness (HPI).

The review of systems is a useful method for gathering medical information in an orderly fashion. This review is a series of questions about the patient’s current and past medical experiences that follows a head-to-toe pathway.

The names for categories in the review of systems may vary but generally consist of variations on the following list:

- head, eyes, ears, nose, throat (HEENT)
- cardiovascular
- respiratory
- gastrointestinal
- genitourinary
- integumentary
- joint/muscular
- endocrine
- central nervous system (includes psychiatric)

An orderly and thorough review of systems is often completed by asking the patient about each system in a head-to-toe fashion, moving from current to past and from general to specific information. A thorough record of relevant dates is important in determining relevance of past illnesses or events to the patient’s current condition.

Past and current medical history includes details on medicines taken by the patient, as well as **allergies**, ill-

ness, hospitalizations, procedures, pregnancies, environmental factors such as exposure to toxins or carcinogens, and health maintenance habits such as self breast examination or immunizations.

An example of a line of questioning might be:

- How are your ears?
- Are you having any trouble hearing?
- Have you ever had any trouble with your ears or with your hearing?

If the patient indicates a history of auditory difficulties, this would prompt further questions about medicines, surgeries, procedures, or associated problems related to their current or past condition.

In addition to identifying data, chief complaint, and review of systems, a comprehensive health history also includes factors such as the patient’s family and social life, family medical history, mental or emotional illnesses or stressors, detrimental or beneficial habits such as smoking or **exercise**, and aspects of culture, sexuality, and spirituality that are relevant to the individual patient. The clinician also tailors his or her interviewing style to the age, culture, educational level, and attitudes of the patient whom they are interviewing.

Preparation

Because the information obtained from the interview is subjective, it is important that the interviewer assess the patient’s level of understanding, education, communication skills, potential biases, or other information that may affect accurate communication. Thorough training and practice in techniques of interviewing such as asking open-ended questions, listening effectively, and approaching sensitive topics such as substance abuse, domestic violence, or sexual practices assists the clinician in obtaining a maximum amount of information without upsetting the patient or disrupting the interview. The interview should be preceded by a review of the chart and an introduction by the clinician. The clinician should explain the scope and purpose of the interview and provide privacy for the patient. Others should only be present with the patient’s consent.

Health care team roles

Physicians, physician assistants, nurses, nurse practitioners, and many allied health professionals are trained to obtain a patient’s health history. The clinician primarily responsible for this task may vary according to the clinical setting.

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Katherine Hauswirth, APRN

Health information management

Definition

Health information management is a phrase used to describe the process of collecting and using data gathered by many different people in different places about services provided to individual patients or groups. Health information management describes both a process and a career choice in that people who are hired to manage health information are employed in a wide variety of health and health related settings.

Description

People who choose to work in health related fields must have a working knowledge of the way health information is gathered, stored, retrieved, and used in today's marketplace. When a patient is seen by a health care agency, regardless of type, for the first time, basic demographic information is gathered by having the patient fill out a paper form, or by interview. Demographic information includes many things such as age, sex, marital status, address, phone number, social security number, insurance carrier, employer name and address, and next of kin. Each agency collects particular information for a reason. This data is then entered, saved, and stored in a computer. The computer is often networked or connected by a line that transmits the data to other computers within the

agency or facility. The data can also be stored on a disk or in a special file, similar to a drawer in a filing cabinet, so the information can be used to collect facts and figures about the services provided by the agency at a later date. This data can be automatically sent to computers within the same building or at remote sites via telephone lines. The computer information can be accessed by other computers that are part of the network (shared function, software, and computer applications).

After the initial paper work or interview is completed, the patient is then directed to a diagnostic center, where a test is done to help the provider make a diagnosis, or to a therapeutic treatment center, where a particular treatment is given. It is usual that some additional personal information is collected at the center itself. This additional information will include particulars needed to provide a service to that patient in that specific center. As an example, if a patient is sent to a hospital for a chest radiology or x ray by a private physician, the patient fills out demographic information at the ambulatory admission desk. Then the patient is sent to the radiology department, where the technician enters the height and weight of the patient so the proper amount of energy is used to take the chest radiology x-ray correctly. The radiology x-ray machine takes the chest radiology x ray (a picture of the **heart** and **lungs** and the underlying structures) and puts the picture onto a film similar to the negative of a picture taken by a camera. The film is printed to a hard copy and/or the image is stored on a computer. The radiologist (a physician with special training) reads or interprets the chest x-ray and dictates the result of the film to a report. The report is printed and stored in the files in the computer. The results of the radiology x ray are also printed by the computer to a piece of paper that is mailed or transmitted to the patient's primary physician. The radiology department then initiates a request that the insurance company be billed for the cost of the service.

Data retrieval describes the process of accessing the stored information and then using the data for a specific purpose. In the example provided above, the billing department can access all of the different types of radiology x rays done in a day, and then issue a request for payment for these services. The payment can be sought from the individual patient, the private insurance company, **Medicare** for patients over the age of 65, or from **Medicaid** for patients who are on state public assistance. The radiology department can total up the number of radiology x rays of each type, for each day, to develop a report that identifies the volume of each particular service rendered for a specific period of time such as quarterly (every three months) or annually at the end of the year. The charge of the individual radiology x-ray can be handled in the same way.

This is a specific example of health information management. Although this is a brief description of how health information is managed, it does represent a rudimentary introduction to the process.

Viewpoints

To expand on the concept of health information and how it is managed, the above example stated basic information is collected and stored. However, health information management includes evaluating the process of collecting and storing data, so that cost-effective and efficient changes can be made to improve outcomes or profits. The process can also be the transformation of a paper-based system into a high-tech computer database. Innovative approaches that might improve the system include developing a series of computer screens that are easy for the average patient or staffer to use. Computer screens modeled after those used by banks such as when people use an automatic teller machine (ATM) to get money out of their bank accounts are very easy to use. If the computer screens are carefully developed, the clerk in the admissions department is no longer needed to input the data about the individual patient, and thus a salary can be saved, or the staffer's time put to better use. Putting patient information into a database software package that can also be used to track billing charges allows manipulation of the data to provide more meaningful information to the facility or person using the data.

Professional implications

Within health care organizations, health information management is a task completed by assorted computer-literate individuals whose goal is to track costs, research, or services. Health information management professionals are people with advanced education, often at the master's degree level, who possess some knowledge of clinical medicine, patient records, national coding and classification systems, database software, and computer applications. The management professional integrates skills and knowledge to provide the agency, organization, or individual researcher with exact information. Thus, the way data is processed, analyzed, and reported back to users changes the overall outcomes for the agencies.

Health information management requires technical skills so that data manipulation provides useful reports. This means that a working knowledge of the integration of the data with database storage software and statistical analysis of the data is needed. The reports generated must serve as a communication link between many different individuals. Providers use information to make health care decisions, and health care facilities and organiza-

tions use it to make business decisions. Health information includes tracking data with the intent to make improvements in the system in some way, or to provide solutions to problems such as those related to research, planning, provision of care, and the evaluation of health care services. Thus the process of collecting and disseminating information must have a positive end goal, such as improving patient care. Outcomes that support quality patient care, medical research, health planning, health care evaluation, and financial reimbursement are a required component of the job. In the modern world of health care, an individual who develops and uses innovative approaches to solve problems, save money, or redesign work habits is highly sought.

The individual who is hired to manage health care information is required to have a working knowledge of **medical ethics** and the legal ramifications of inappropriate use of personal data. For example, the federal government is very clear about the rights of an individual patient, especially in medical research. It is imperative to store data in a way that protects the anonymity of the individual and his or her privacy rights when the data is accessed for research purposes. In addition, data must be stored to insure that confidentiality is maintained, and that access is denied to those individuals who have no need for the specific information about the individual patient. Data must be stored so that it can be used to compare a patient's care with standards of care and quality indicators, which are needed for evidence-based practice.

Those working with health information may be asked to produce a needs analysis, complete a systems analysis, or redesign the existing system, addressing quality of care, costs, care delivery processes, and financial questions. Tying reports to the volume of services, charges, costs, and reimbursements are current and future expectations. Managers of health information work in a wide variety of settings, such as with private physicians; in hospitals or **nursing homes**; with insurance companies, law firms, and government agencies; and for companies who specialize in information technology. In summary, the entire process of health information management is focused on securing, analyzing, and integrating the information so that it can be used for a specific purpose.

Resources available about health information management are extensive. Universities, the world wide web, local hospitals, newspapers, and government agencies are resources that can be tapped to provide more specific information to the reader.

Resources

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Health maintenance organizations see
Managed care plans

Health promotion and education

Definition

Health promotion and education is the exchange of ideas and the dissemination of facts about illness and disease. These ideas and facts serve to help people make decisions that affect their health care and well-being. Local government programs, universities, hospitals, health clinics, public and private associations and agencies, and the workplace are some of the places where health promotion and education take place.

Description

When managed care emerged within the American health care system in the 1990s, the focus shifted from treating illness to preventive medicine. Insurance compa-

nies began using words like "wellness," and encouraged individuals to have routine check-ups, and workplaces began to offer incentives to employees to quit bad habits, such as smoking. Because the emphasis turned to prevention of illness, injury, and disease—rather than cure, or healing—there has been an influx of health education programs aimed at giving people the information they need to be proactive and responsible for their own well-being.

The Association of State and Territorial Directors of Health Promotion and **Public Health** Education (AST-DHPPHE) was created in 1946. The agency's mission is to promote health education and provide a clearinghouse through which local health education leaders could disseminate and gather information on methods and techniques for education programs. The ASTDHPPHE offers programs in the prevention of chronic disease, injury, the human **immunodeficiency** virus (HIV) and the acquired immunodeficiency syndrome (**AIDS**), and tobacco use. The emphasis turned to good **nutrition**, physical activity, and healthy schools and workplaces.

The U.S. Department of Health and Human Services' Office of Disease Prevention and Health Promotion created "Healthy People 2010," a set of initiatives and health objectives for Americans to focus on achieving optimum health. Ten high priority areas of focus were identified: physical activity, **obesity**, tobacco use, substance abuse, responsible sexual behavior, mental health, injury and violence, environmental quality, immunization, and access to health care. Focus areas within each of those 10 priorities include community-based health education programs, family planning, medical product safety, occupational safety and health, sexually transmitted diseases, immunization and infectious diseases, and physical activity and fitness.

The goal of "Healthy People 2010" is not only to increase the quality of life for people and help them to live longer, but also to eliminate the disparity in health care delivery. The life expectancy of Americans has increased more than 30 years since 1900, with many older Americans living well into their 70s, 80s, and even 90s. Physical health, as well as mental health, has become more and more important as many older adults want to "age in place," and not be forced to live in long-term-care facilities. Older adults are concerned about their quality of life (QOL). It is with good health education that all individuals can become empowered to take care of themselves.

Helping Americans maintain a good QOL is only part of the "Healthy people 2010" effort. Disparities still exist among minority groups; minorities have not enjoyed the same health improvement progress as other

Americans. Minority Americans have higher rates of diabetes, HIV and AIDS, infant mortality, and **heart** disease. Life expectancy for these populations is less than that of others, and minority groups living in poverty often do not have access to adequate health care.

The Cooperative Actions for Health Program (CAHP) is a collaborative grant program that is co-sponsored by the American Public Health Association and the American Medical Association (AMA). Its purpose is to build, support, and strengthen state and local collaboration between medical and public health professionals to improve the public's health. The program fosters collaboration through grant funding, developing a communication network to share ideas and coordinate policy-making efforts between the APHA and the AMA.

Viewpoints

There is some debate among health insurance companies and policy makers on whether health education programs are a cost-effective means of preventing illness and disease. For example, although a smoking cessation program offered in the workplace is believed to be an effective means of helping employees quit smoking, not many of these programs are covered by company insurance policies; the increase in premiums is often not very cost-effective. These health care organizations are seeking research-based evidence that proves that health education and promotion are effective and contribute to maintaining, rather than increasing, the cost of health care.

With the explosion of the information age, however, and the ease with which individuals can access information through computers and the World Wide Web, it has become much easier for the heads of health education programs to reach consumers with information. Still, the concern remains that Internet-based information does not reach poor minority consumers, as they are less likely to own a computer or hold a professional job in which they have computer access. In addition, some sites may not contain accurate health information; consumers and health professionals alike need to make sure that online sources are credible.

Professional implications

The implications for health care professionals is huge, particularly for primary care physicians (PCPs), who are on the front lines of health care for many Americans. Under most **managed care plans**, an individual must first see a primary care doctor regarding almost any problem prior to being referred to a specialist. Further, the referral must be written by the PCP. Primary

care physicians must be well-rounded in general health education and have knowledge in many disciplines in physical and mental health. Physicians must be prepared to address a multitude of questions regarding general health care.

Resources

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ORGANIZATIONS

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Centers for Disease Control and Prevention (CDC). 1600 Clifton Road, Atlanta, GA 30333. <<http://www.cdc.gov>>.

U.S. Department of Health and Human Services (USDHHS), Offices of Disease Prevention and Health Promotion. 200 Independence Ave., SW, Washington, DC 20201. (202) 401-6295. <<http://odphp.osophs.dhhs.gov>>.

Meghan M. Gourley

Health services administration

Definition

Health services administration is a phrase that describes the career opportunities for individuals with a college education—often a master's degree—who choose to work in a health-related arena as a manager or administrator.

Description

The roles of individuals in health services administration are most commonly site specific but in general include skills in leadership, financial management, health informatics, marketing, and human resources. Because the health field is so diverse, an individual can choose to specialize in one division of a hospital, for example surgery, or in a specialty area in outpatient services such as managing an independent primary care center. An individual who is hired as a surgical health services adminis-

trator would function under the direction of either a hospital administrator or a surgeon. Coordination of services for surgical patients, acquisition of supplies, scheduling of surgical procedures, financial billing, and evaluation of quality outcomes would likely be job expectations. For the individual who is hired as a manager of a primary care center, responsibilities might include coordination of the hiring and firing of clerical staff, instituting community outreach, marketing the services of the center within the community, financial planning, and overseeing the billing sequence. In both these examples, the roles are site specific in that the needs of the different types of health services determine what responsibilities logically belong to the administrator.

Leadership skills needed for success in health service administration are centered around effective communication and understanding the principles of many theories used to characterize organization management. Situational leadership is a theory that states an individual in a leadership position varies the response to employees and the publics served by gathering data, fully analyzing the incident or occurrence, and then adapting the leadership style to the event. As an example, in a fire, a leader is not democratic but must use the situation (the fire) and then becomes autocratic and directive to avoid injury or harm to staff, patients, and the facility. As an another example, if the organization wanted to expand services in an unknown area of the city, the administrator might choose to use a *laissez faire* leadership style to elicit information from employees who live in the area of interest. *Laissez faire* leadership means that the administrator identifies the task (the seeking of information about the new area in the city) and does not direct the group but waits and watches as the group interacts to achieve the goal of identifying information. The administrator then simply records the information gleaned from the group meeting. Management by objectives is another commonly used management theory. This theory states that the best way for any individual to manage the performance of others is to make sure the overall goal is clear to everyone and that knowledge of the objectives helps all employees meet expected outcomes. The health services administrator is responsible for choosing the objectives (along with a Board of Trustees) and then defining and explaining these objectives to all employees.

Financial management includes the ability to develop and assess a budget, to determine where monies are best spent, to set up systems to monitor and evaluate the outcomes, to complete a cost benefit analysis of the service provided, and the ability to write up the needed reports. A meaningful budget that avoids overpayment of anything is a must in today's marketplace. Thus, health services administration is focused on insuring that costs

(output) are offset by income through budgetary and fiduciary oversight. Health informatics is a phrase used to describe the management of all types of data that compose computerized health records. It includes setting up, modifying, manipulating, and evaluating systems and the output from the systems using appropriate statistics to determine the cost of the service provided. The health services administrator combines knowledge of financial management and informatics to direct and oversee the organization as a whole.

Marketing is a word that is used to identify the skill needed to interact with employees and the public in an articulate way to achieve a favorable perception about the organization. This includes good verbal communication skills and a positive outlook about the organization when interacting with the media, multiple levels of professionals employed by the organization, and patients and their families. The health services administrator uses both knowledge and information as marketing tools to drive the agenda for the organization forward. Marketing includes developing networks with other organizations to maximize something of value for the establishment. As an example, the administrator might want to develop a local network to enhance buying power for the equipment and disposable supplies used for care. In addition, the administrator would be responsible for assessing the market relevance before any planned organizational change was implemented.

Human resources deals with the personnel component of any organization. For a health services administrator, the responsibilities would include developing policy for hiring, discipline, and termination of personnel through direct management or as a supervisor of the individual assigned to these services. Adherence to state employment law is an integral part of this responsibility. In a unionized setting it includes overseeing that all unionized personnel adhere to the union contract. In a non-unionized setting it might include approving the utilization of employee benefits as well as assessing what these benefits are and determining when the employee meets the requirements to earn the benefits. Human resources administrators insure that employee records are kept to meet state and federal regulatory requirements to document who is in the facility on any given day and the type of services provided by all employees on a daily basis.

Strategic planning is a process of working within an organization to develop a master plan that provides for survival and continuity of the organization, with planned growth in selected areas while insuring quality indicators of the services provided are met. This strategic plan provides clear and simple goals and direction to avoid confusion within the organization. Leadership and the strate-

gic directions provided to employees determine whether or not the organization is successful. Overseeing the development of the plan and evaluation of the outcomes are the responsibility of the health services administrator. Avoiding common mistakes such as creating large, unwieldy teams of people to oversee a service or instituting systems that interfere with economic effectiveness are part of the expectations in health services administration. For all organizations positive outcomes are the goal. The strategy for effective leadership in any health care organization is focused on positive outcomes. An old adage that has meaning for anyone choosing a career in health services administration runs something like “a happy customer, makes a happy administrator which leads to happy employees.” Basically when services are provided as promised or as promoted, then all levels of personnel have achieved the desired positive outcome. This also leads to financial success. The focus within the organization remains at all times on cost reduction and quality improvement. The effective strategic plan leads to that outcome.

Work settings

The work sites for individuals who choose health services administration include **public health**, public administration, business administration, allied health administration, or **hospital administration**. Job titles commonly used in the field are supervisor, director, executive director, administrator, executive, superintendent, overseer, governor, steward, and foreman. In the vernacular, the title of the health services administrator usually represents the chief, boss, or head for a division within an organization or for the entire organization. Individuals who select careers in health services administration can choose to work in government, the penal system, public health service, managed care organizations, or in any aspect of health care. In addition, a background in health services administration provides opportunities for selected professionals to work in other service firms such as accounting, law, or management consulting.

At the government level, health services administration is often focused on policy issues. Several ongoing topics that fall in this category include any aspect of health care reform and expansion of the coverage provided by tax levy monies. From a health services administration perspective, fear of expanded government regulation to the point of oppression can have a negative effect on any organization. An example that describes oppressive regulation would be a federal law mandating that the specifics of all health education be documented in the medical record. In this example the health care provider, the nurse or the doctor, would then spend more time doc-

umenting what was taught than the time actually spent teaching patients. The role of the health services administrator is to monitor potential legislation that would have a negative effect on the organization and to then organize appropriate staff to participate in a lobby effort to prevent this type of legislation from becoming law.

Managed care describes a delivery system for health care based on paid insurance coverage that often includes a written plan outlining the specific aspects of care usually provided to patients with a specific medical diagnosis. Managed care refers to the process of regulating care to avoid unnecessary treatments of all kinds and thus limiting costs. If employed by a managed care company, the health services administrator functions as a proponent of the company’s care options and the rules covering services with an overall goal of helping to prevent any further regulation of the insurance provider or the managed care corporation. In the same way, if employed by a hospital or an organization providing health service, the health services administrator is responsible for interpreting the rules and regulations mandated by the managed care organization and helping insure that the hospital or other provider receive maximum reimbursement for allowed services.

The roots of all public health services rest with public education about disease potential and avoidance, and health screening. Health service administrators employed in the public health arena are responsible for the management of many health issues. The role might include employment in centers with specific health functions such as: **asthma** education, services for the homeless, well child care, direct observational treatment for **tuberculosis**, prevention/treatment of sexually transmitted disease, HIV outreach and prevention services, or preventive care for all types of substance abuse, including smoking cessation and alcohol and drug rehabilitation.

Future outlook

The future is extremely positive for individuals who seek careers in health services administration. With the continued movement away from in-patient hospital services, small, independent, stand-alone health service agencies are opening all over the nation. Each of these independent facilities needs an administrator who understands the overall goals of the agency and is willing to join with the professional staff to make the organization a successful venture.

In conclusion, a career in health services administration is a management level position that is focused on achieving positive outcomes, using good internal controls, insuring sound financial management, keeping a pointed focus on the services provided and having over-

all management skills that insure organization survival and success. The National Association of Health Services Executives (NAHSE) offers additional information about this health care career.

Resources

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Hearing

Definition

Hearing is the ability of the human ear to collect, process, and interpret sound.

Description

Sound vibrations travel through air, water, or solids in the form of pressure waves. When a sound wave hits a flexible object, such as the eardrum, it causes it to vibrate, which begins the process of hearing. The process of hearing involves the conversion of acoustical energy (sound waves) to mechanical, hydraulic, chemical, and finally, electrical energy where the signal reaches the **brain** and is interpreted.

The basis of sound is simple: there is a vibrating source, a medium in which sound travels, and a receiver. For humans the most important sounds are those which

carry meaning, for example, speech and environmental sounds. Sounds can be described in two ways, by their frequency (pitch) or by their intensity (loudness).

Frequency (the number of vibrations or sound waves per second) is measured in Hertz (Hz). A sound that is 4,000 Hz (like the sound the letter 'F' makes) has 4,000 waves per second. Healthy young adults can hear frequencies between 20 and 20,000 Hz. However, the frequencies most important for understanding speech are between 2,000 and 8,000 Hz. As adults age, the ability to hear frequency sounds decreases. An example of a high frequency sound is a bird chirping, while a drum beating is a low frequency sound.

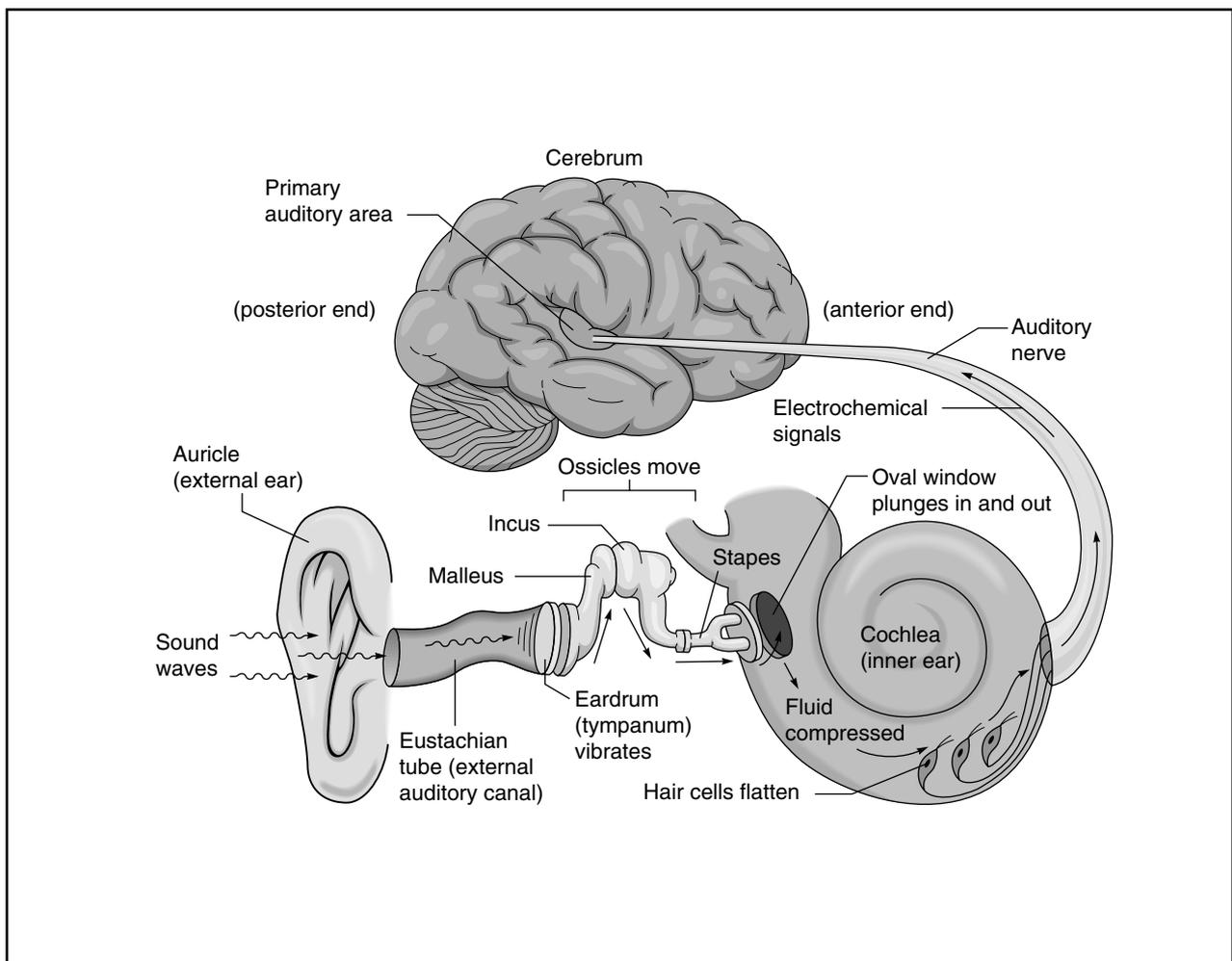
Intensity (loudness) is the amount of energy of a vibration, and is measured in decibels (dB). A zero decibel sound (like leaves rustling in the wind), can barely be heard by young healthy adults. In contrast, a 120 dB sound (like a jet engine at 20 ft [7 m]) is perceived as very loud and/or painful. Extremes in both loudness or pitch may seriously damage the human ear and should be avoided.

The difference between frequency or pitch and intensity or loudness can be illustrated using the piano as an analogy. The piano keyboard contains 88 keys that represent different frequencies or notes. The low frequencies or bass notes are on the left, the higher frequencies or treble notes are on the right. Middle C on the keyboard represents approximately 256 Hz. The intensity or loudness of a note depends on how hard you hit the key. A light touch on middle C may produce a 30 dB, 256 Hz note, while a hard strike on middle C may produce a 55 dB, 256 Hz note. The frequency, or note, stays the same, but the intensity of loudness varies as the pressure on the key varies.

Function

Human hearing involves a complicated process of energy conversion. This process begins with two ears located at opposite sides of the human head. The ability to use two ears for hearing is called binaural hearing. The primary advantages of binaural hearing are the increased ability to localize sounds and the increased ease of listening to a particular sound while having other noises in the background. Sound waves from the world around us enter the ear and are processed and relayed to the brain.

The actual process of sound transmission differs in each of the three parts of the human ear. The three parts of the human ear are the outer ear, middle ear, and inner ear.



The process of hearing. (Delmar Publishers, Inc. Reproduced by permission.)

Role in human health

The outer ear plays an important role in hearing. The pinna of the outer ear gathers sound waves from the environment and transmits them through the external auditory canal and eardrum to the middle ear. In the process of collecting sounds, the outer ear also modifies the sound. The external ear, or pinna, in combination with the head, can slightly amplify or increase as well as attenuate or decrease certain frequencies. The amplification or attenuation is due to individual differences in the dimensions and contours of the head and pinna.

The external auditory canal can also modify sound. This tube-like canal is able to amplify specific frequencies in the 3,000 Hz region. An analogy would be an opened, half-filled soda bottle. If you empty some of the fluid and blow into the bottle again, the frequency of the sound will change. Since the size of the human ear canal is consistent, the specific frequency it amplifies is also

constant. Sound waves travel through the ear canal until they reach the tympanic membrane or eardrum. Together, the head, pinna, and external auditory canal amplify sounds in the 2,000–4,000 Hz range by 10–15 dB. This boost is needed since the process of transmitting sound from the outer to the middle ear requires added energy.

The middle ear is separated from the outer ear by the tympanic membrane or eardrum. The membrane vibrates in response to pressure from sound waves traveling through the external auditory canal. The initial vibration causes the membrane to be displaced (pushed) inward by an amount equal to the intensity of the sound, so that loud sounds push the eardrum more than soft sounds. Once the eardrum is pushed inwards, the pressure within the middle ear causes the eardrum to be pulled outward, setting up a back-and-forth motion that begins the conversion and transmission of acoustical energy (sound waves) to mechanical energy (bone movement).

The three small, connected bones of the middle ear, together called the ossicle, are: the hammer or malleus, the anvil or incus, and the stapes or stirrup. The tiny, interconnected bones move as a unit in a type of lever-like action. The first bone, the malleus, is attached to the tympanic membrane and the back-and-forth motion of the tympanic membrane sets all three bones in motion. The final result of this bone movement is pressure of the foot plate of the last and smallest bone, the stapes, on the oval window. The window is one of two small membranes that allow communication between the middle ear and the inner ear. The lever-like action of the bones amplifies the mechanical energy from the eardrum to the oval window. The energy in the middle ear is also amplified due to the difference in surface size between the tympanic membrane and the oval window, which has been calculated to be a difference of about 14 to one.

The relationship of the eardrum or tympanic membrane to the oval window can be compared to that of a thumbtack. The eardrum would be the head of the thumbtack and the oval window would be the pin point of the thumbtack. The eardrum or the head of the tack would collect and apply pressure and then focus it on the oval window or the pin point, driving it into the surface. The overall amplification in the middle ear is approximately 25 dB. The conversion from mechanical energy or bone movement to hydraulic energy or fluid movement requires added energy since sound does not travel easily through fluids.

The inner ear is the site where hydraulic energy or fluid movement is converted first to chemical energy or hair cell activity and finally to electrical energy or nerve transmission. Once the signal is transmitted to the nerve, it will travel up to the brain to be interpreted.

The bone movements in the middle ear cause movement of the stapes foot plate in the membrane of the oval window. This pressure causes fluid waves or hydraulic energy throughout the entire two-and-a-half turns of the cochlea. The design of the cochlea allows for very little fluid movement, therefore the pressure at the oval window is released by the interaction between the oval and round windows. When the oval window is pushed forward by the stapes foot plate, the round window bulges outward and vice versa. This action permits the fluid wave motion in the cochlea. The cochlea is the fluid-filled, snailshell-shaped, coiled organ in the inner ear that contains the actual sense receptors for hearing. The fluid motion causes a corresponding, but not equal, wave-like motion of the basilar membrane. Internally, the cochlea consists of three fluid filled chambers: the scala vestibuli, the scala timpani, and the scala media. The basilar membrane is located in the scala media portion of the cochlea, and separates the scala media from the scala

timpani. The basilar membrane holds the key structure for hearing, the organ of Corti.

The physical characteristics of the basilar membrane are important, as is its wave-like movement, from its base or originating point to its apex or tip. The basilar wave motion slowly builds to a peak and then quickly dies out. The distance the wave takes to reach the peak depends on the speed at which the oval window is moved. For example, high frequency sounds have short wavelengths, causing rapid movements of the oval window, and peak movements on the basilar membrane near the base of the cochlea. In contrast, low frequency sounds have long wavelengths and cause slower movements of the oval window, and peak movements of the basilar membrane near the apex. The place of the peak membrane movements corresponds to the frequency of the sounds. Sounds can be located or “mapped” on the basilar membrane. High frequency sounds are near the base, middle frequency sounds are in the middle, and low frequency sounds are near the apex. In addition to the location on the basilar membrane, the frequency of sounds can be identified based on the number of nerve impulses sent to the brain.

The organ of Corti lies upon the basilar membrane and contains three to five outer rows (12,000 to 15,000) of hair cells and one inner row (3,000) of hair cells. The influence of the inner and outer hair cells has been widely researched. The common view is that the numerous outer hair cells respond to low intensity sounds below 60 dB. The inner hair cells act as a booster, by responding to high intensity, louder sounds. When the basilar membrane moves, it causes the small hairs on the top of the hair cells or stereo cilia to bend against the overhanging tectorial membrane. The bending of the hair cells causes chemical actions within the cell itself creating electrical impulses in the nerve fibers attached to the bottom of the hair cells. The nerve impulses travel up the nerve to the temporal lobe of the brain. The intensity of a sound can be identified based on the number of hair cells affected and number of impulses sent to the brain. Loud sounds cause a large number of hair cells to be moved, and many nerve impulses to be transmitted to the brain.

Each of the separate nerve fibers join and travel to the lowest portion of the brain, the brain stem. Nerves from the vestibular, or balance, part of the inner ear combine with the cochlear nerves to form the VIII cranial nerve (auditory or vestibulocochlear nerve). Once the nerve impulses enter the brain stem, they follow an established pathway, known as the auditory pathway. The organization within the auditory pathway allows for a large amount of crossover. “Cross-over” means that the sound information or nerve impulses from one ear do not travel exclusively to one side of the brain. Some of the

KEY TERMS

Amplify—To increase.

Attenuate—To decrease.

Bilateral—Both sides of an object.

Binaural—Both ears.

Decibel—Unit of measurement of the intensity of sound, abbreviated dB.

Equilibrium—Balance, the ability to maintain body position.

Frequency—Pitch, the number of vibrations or sound waves per second.

Hertz—Unit of measurement for frequency, abbreviated Hz.

Hydraulic—Fluid in motion.

Intensity—Loudness, the amount of energy of a vibration or sound wave.

Localization—Ability to identify where a sound is coming from.

nerve impulses cross over to the opposite side of the brain. The impulses travel bilaterally on both sides of the brain up the auditory pathway until they reach a specific point in the temporal lobe called Heschl's gyrus. Crossovers act like a safety net. If one side of the auditory pathway is blocked or damaged, the impulses can still reach Heschl's gyrus to be interpreted as sound.

Common diseases and disorders

There are several common diseases, disorders, and conditions that occur in the external ear, middle ear, eardrum, and inner ear that can affect the sense of hearing in humans.

- External otitis (swimmer's ear), an inflammation or **infection** of the external ear.
- Furunculosis or recurring **boils** in the ear canal.
- Exostoses or benign tumors of the ear canal.
- Foreign bodies or anything that gets stuck in the ear. These can range from insects or seeds to earplugs that can't be removed.
- Trauma to the eardrum.
- Bullous myringitis, an inflammation of the eardrum.
- Retracted eardrum or blocked eustachian tube.

- Barotitis media or eardrum retracted by change of atmospheric pressure while the eustachian tube is blocked.
- Otitis media, a middle ear infection.
- Acute mastoiditis, a severely infected mastoid process.
- Otosclerosis or ear bone degeneration.
- Cholesteatoma or epithelial inclusion cyst.
- Meniere's disease or vertigo.
- Acoustic neurinoma, a tumor on the vestibular nerve.
- Presbycusis or sensorineural **hearing loss** due to aging.
- Labyrinthitis, an infection of the inner ear.
- Vestibular neuronitis, a sudden loss of the balance mechanism in one ear.
- Tinnitus or the sensation of sound in the ear when there is no sound.

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- National Institute on Deafness and Other Communication Disorders. National Institutes of Health. 31 Center Dr., MSC 2320, Bethesda, MD 20892-2320. <<http://www.nidcd.nih.gov>>.

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Peggy Elaine Browning

Hearing aids

Definition

A **hearing aid** is a device that can amplify sound waves in order to help a deaf or hard-of-hearing person hear sounds more clearly. There are two major types of **hearing loss**, conductive hearing loss and sensory hearing loss. Conductive hearing loss is often mechanical in nature, resulting in external or middle ear problems. This type of hearing loss often can be corrected by medicine and/or surgery. Possible causes for conductive hearing loss include otitis media and otosclerosis. Sensory hearing loss is due to a disorder in the inner ear, specifically involving the cochlea. This type of hearing loss may be congenital or the result of an acquired condition, such as meningitis. Hearing aids are primarily used by patients with sensory hearing loss.

Purpose

Recent technology can help most people with hearing loss understand speech better and achieve better communication.

Precautions

It is important that a person being fitted for a hearing aid understand what an aid can and can not do. An aid can help a person hear better, but it will not return hearing to normal levels. Hearing aids boost all sounds, not just those the person wishes to hear. Especially when the source of sound is far away (such as up on a stage), environmental noise can interfere with good speech perception. And, while the aid amplifies sound, it does not necessarily improve the clarity of the sound. A hearing aid is a machine and can never duplicate the true sound that people with normal hearing experience, but it will help the person take advantage of the hearing that remains.

Description

More than one thousand different models of hearing aids are available in the United States. All of them include a microphone (to pick up sound), an amplifier (to boost sound strength), and a receiver or speaker (to deliver sound to the ear). All hearing aids are powered by a battery. Depending on the style, it is possible to add features to filter or block out background noise, minimize feedback, lower sound in noisy settings, or boost power when needed.

Hearing aids are either monaural, a hearing aid for one ear, or binaural, for two ears; more than 65% of all

users have binaural aids. Hearing aids are divided into several different types:

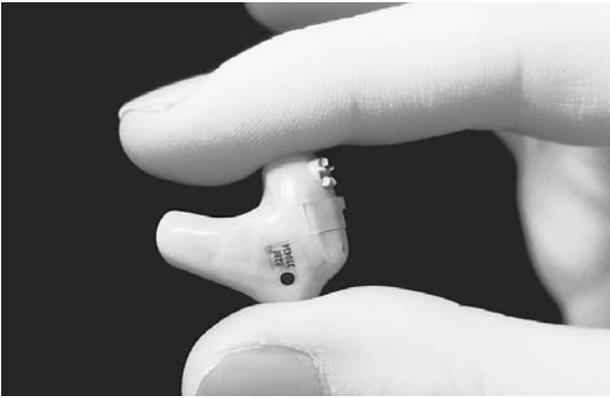
- digital
- in-the-ear
- in-the-canal
- behind-the-ear
- on-the-body

Digital aids are sophisticated, expensive aids that borrow computer technology to allow a person to tailor an aid to a specific hearing loss pattern. Using miniature computer chips, the aids can selectively boost certain frequencies while leaving others alone. This means a person could wear such an aid to a loud party, and screen out unwanted background noise, while tuning in on one-on-one conversations. The aid is programmed by the dealer to conform to the person's specific hearing loss. Some models can be programmed to allow the wearer to choose different settings depending on the noise of the environment.

In-the-ear aids are lightweight devices whose custom-made housings contain all the components; this device fits into the ear canal with no visible wires or tubes. It is possible to control tone but not volume with these aids, so they are helpful only for people with mild hearing loss. Some people find these aids are easier to put on and take off than behind-the-ear aids. However, because they are custom-fit to a person's ear, it is not possible to try on before ordering. Also, some people find them uncomfortable in hot weather.

In-the-canal aids fit far into the ear canal, with only a small bit extending into the external ear. The smallest is the MicroCanal, which fits out of sight down next to the eardrum and is removed with a small transparent wire. These aids are extremely expensive, but they are not visible, offer better acoustics, and are easier to maintain. They can more closely mimic natural sound because of the position of the microphone; this position also cuts down on wind noise. Because of their small size, these aids are harder to handle, and their battery is especially small and difficult to insert. Adjusting the volume may be hard, since a person must stick a finger down into the ear to adjust volume, and this very tiny aid does not have the power of larger aids.

Behind-the-ear aids include a microphone, amplifier, and receiver inside a small curved case worn behind the ear; the case is connected to the earmold by a short plastic tube. The earmold extends into the ear canal. Some models have both tone and volume control, plus a telephone pickup device. Many users think them unattractive and out of date, however, and those who wear glasses find that the glasses interfere with the aid's fit. Others do



Woman holding a cochlear implant by L. Steinmark.
(*Custom Medical Stock Photo. Reproduced by permission.*)

not have space behind the ear for the mold to fit comfortably. They do offer a few advantages.

Behind-the-ear aids:

- do not require as much maintenance
- are easily interchangeable if they need to be serviced
- are more powerful
- are easier to handle than smaller aids
- provide better sound quality
- are more reliable

Eyeglass models are the same as behind-the-ear devices, except that the case fits into an eyeglass frame instead of resting behind the ears. Not many people buy this type of aid, but those who do believe it is less obvious, although there is a tube that travels from the temple of the glasses to the earmold. It can be hard to fit this type of aid, and repairs can be problematic. Also, if the aid breaks, the person also loses the benefit of the glasses.

The crossover system type of hearing aid is often used in conjunction with the eyeglass model. The contralateral routing of signal (CROS) system features a microphone behind the ear that feeds the amplified signal to the better ear, eliminating “head shadow,” which occurs when the head blocks sound from the better ear. This type may help make speech easier to understand for people with a high-frequency loss in both ears.

A BI-CROS system uses two microphones (one above each ear) that send signals to a single amplifier. Sound then travels to a single receiver, which transfers it to the better ear via a conventional earmold.

On-the-body aids feature a larger microphone, amplifier, and power supply inside a case carried inside the pocket or attached to clothing. The receiver attaches directly to the earmold; its power comes through a flexible wire from the amplifier. Although larger than other

aids, the on-the-body aids are more powerful and easier to adjust than other devices. While not popular for everyone, they are often used by those with a profound hearing loss, or by very young children. Some people who are almost totally deaf find they need the extra power boost available only from a body aid.

Cochlear implants, which are implanted through a surgical procedure, are taking hearing technology to a new level. Different from a hearing aid, cochlear implants are composed of an external portion (including a microphone worn behind the ear, a speech processor, and a transmitter) and an internal portion (including an implanted receiver and electrodes), a cochlear implant is designed to bypass damaged sound-sensing cells of the inner ear (cochlear hair cells) and provide electrical stimulation of the auditory nerve. The result is the sensation of sound for individuals who would otherwise be deprived. The best candidates for cochlear implants are individuals with profound hearing loss to both ears who have not received much benefit from traditional hearing aids and are of good general health. Children as young as 14 months have been successfully implanted.

Preparation

The first step in getting a hearing aid is to have a medical exam and a hearing evaluation. (Most states prohibit anyone selling a hearing aid until the patient has been examined by a physician to rule out medical problems.) After performing a hearing evaluation, an audiologist should be able to determine whether a hearing aid will help and which one will do the most good. This is especially important because aids can be very expensive (between \$500 and \$4,000) and are often not covered by health insurance. Hearing aids come in a wide range of styles and types, requiring careful testing to make sure the aid is the best choice for a particular hearing loss.

Some audiologists sell aids; others can make a recommendation, or provide a list of competent dealers in a patient’s area. Patients should shop around and compare prices. In all but three states, hearing aids must be fitted and sold only by licensed specialists called dealers, specialists, dispensers, or dispensing audiologists.

The audiologist or hearing aid dealer will make an impression of the consumer’s ear canals using a putty-like material, from which a personalized earmold will be created. It is the dealer’s job to make sure the aid fits properly. The person may need several visits to find the right hearing aid and learn how to use it. The dealer will help the consumer learn how to put the aid on, adjust the controls, and maintain the device. The dealer should be willing to service the aid and provide information about

what to do if sensitivity to the earmold develops. (Some people are allergic to the materials in the mold.)

Aftercare

Within several weeks, the wearer should return to the dealer to have the aid checked and to discuss the progress in wearing the aid. About 40% of all aids need some modification or adjustment in the beginning.

Within the first month of getting an aid, the patient should make an appointment for a full hearing examination to determine if the aid is functioning properly.

Complications

While there are no medical complications to hearing aids, there is a risk associated with hearing aids: many people end up not wearing their aids because they say everything seems loud when wearing them. This may be because they have lived for so long with a hearing problem that they have forgotten how loud “normal” sound can be. Other potential problems with hearing aids include earmold discomfort and a build up of excess ear wax after getting a hearing aid.

Results

A hearing aid boosts the loudness of sound, which can improve a person’s ability to understand speech.

Health care team roles

Physicians, audiologists, and nurses are involved in the diagnosis and treatment of hearing loss. Audiologists prescribe, dispense, and service hearing aids.

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American Academy of Otolaryngology-Head and Neck Surgery. One Prince St., Alexandria, VA 22314-3357. (703) 836-4444. <<http://www.entnet.org>>.

American Speech-Language-Hearing Association (ASHA). 10801 Rockville Pike, Rockville, MD 20852. (888) 321-ASHA. <<http://www.asha.org>>.

KEY TERMS

Audiologist—A person with a degree and/or certification in the areas of identification and measurement of hearing impairments and rehabilitation of those with hearing problems.

Cochlea—A conical bony structure or the inner ear; perforated by numerous openings for passage of the cochlear division of the acoustic nerve.

Conductive hearing loss—Hearing loss resulting from external or middle ear problems.

Eardrum—A paper-thin covering stretching across the ear canal that separates the middle and outer ears.

Middle ear—The small cavity between the eardrum and the oval window that houses the three tiny bones of hearing.

Oval window—A tiny opening at the entrance to the inner ear.

Sensory hearing loss—Hearing loss due to disorders of the inner ear.

National Institute on Deafness and Other Communication Disorders. 1 Communication Avenue, Bethesda, MD 20892-3456. (800) 241-1044. <<http://www.nidcd.nih.gov>>.

Self Help for Hard of Hearing People, Inc. 7910 Woodmont Ave, Suite 1200, Bethesda, MD 20814. (301) 657-2248. TTY: (301) 657-2249. <<http://www.shhh.org>>.

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Carol A. Turkington

Hearing loss

Definition

Hearing loss is any degree of impairment of the ability to comprehend sound.

Description

Sound can be accurately measured. The term decibel (dB) refers to an amount of energy moving sound from its source to the ears of one or more listeners or to a microphone. A decrease of more than 10 dB in the level of sound a person can hear is significant.

Sound travels through a medium, such as air or water, as waves of compression and rarefaction. These waves are collected by the external ear and cause the tympanic membrane (ear drum) to vibrate. The chain of ossicles connected to the ear drum—the incus, malleus, and stapes—carries the vibrations to the oval window, increasing their amplitude 20 times along the way. There, the energy creates a standing wave in the watery liquid (endolymph) inside the organ of Corti. (A standing wave is one that does not move. A vibrating cup of coffee will demonstrate standing waves.) The shape of the standing wave is determined by the frequency of the sound. Many thousands of tiny nerve fibers detect the highs and lows of the standing wave. Motions in the nerve endings are converted into electrical impulses. These are transmitted to the **brain** via a nerve. Specialized areas of the brain interpret the signals as sound.

To summarize, sound energy passes through the air of the external ear, the bones of the middle ear, and the liquid of the inner ear. It is then translated into nerve impulses, sent to the brain through the acoustic nerve, and understood there as sound. It follows that there are five steps in the hearing process:

- air conduction through the external ear to the ear drum
- bone conduction through the middle ear to the inner ear
- water conduction inside the organ of Corti
- nerve conduction into the brain
- interpretation by the brain

Causes and symptoms

Hearing can be interrupted in several ways at each of the five steps noted above.

The external ear canal can be blocked with ear wax (cerumen), foreign objects, **infection**, and tumors. Overgrowth of the bone, a condition that occurs when the ear canal has been flushed with cold water repeatedly for years, can also narrow the passageway, making blockage and infection more likely. This condition occurs often among northern Californian surfers and is aptly called “surfer’s ear.”

The ear drum is so thin that a physician can see through it, into the middle ear. Sharp objects, pressure from an infection in the middle ear, or even a firm cuff-

ing or slapping of the ear, can rupture the ear drum. The eardrum is also susceptible to pressure changes, such as those that occur when one is scuba diving.

Several conditions can diminish the mobility of the ossicles (small bones) in the middle ear. Otitis media (an infection in the middle ear) occurs when fluid cannot escape into the throat because of blockage of the eustachian tube. The fluid that accumulates, whether it is pus or mucus, dampens the motions of the ossicles. A disease called otosclerosis can bind the stapes in the oval window, thereby cause deafness.

All of the problems and conditions that occur in the external and middle ear are causes of conductive hearing loss. The second category, sensory hearing loss, refers to damage to the organ of Corti, or the acoustic nerve. Prolonged exposure to loud noise is the leading cause of sensory hearing loss. More than a million people have been identified as having this condition. The cause is often believed to be prolonged exposure to loud music. Occupational noise exposure is the other leading cause of noise induced hearing loss (NIHL) and is an ample reason for wearing ear protection on the job. Jobs in construction and loud offices may contribute to ear damage, as may noises of recreation, such as loud music or the engine of a motorcycle. Both types of noises may lead to loss of hairs in one’s inner ear. Thousands of these tiny hairs are attached to nerve cells in the cochlea (a snail-shaped structure in the inner ear). These tiny hairs aid the conversion of sound vibrations into electrical signals, which are then transmitted to the brain. When hairs become broken or bent, the transmission of the electric signals isn’t as good, and sound may become muffled. Words may become difficult to distinguish against background noises.

One-third of people over 65 have presbycusis (gradual loss of hearing that occurs as one ages) and one-half of those older than age 75 have a hearing impairment. Both NIHL and presbycusis are primarily high frequency losses. The human speech frequencies are in relatively low ranges. People with presbycusis hear noise but cannot easily make sense of it. They have particular trouble distinguishing speech from background noise. Brain infections, such as **meningitis**, drugs such as the aminoglycoside **antibiotics** (e.g., streptomycin, kanamycin, tobramycin), and Menière’s disease may also cause permanent sensory hearing loss. Menière’s disease combines attacks of hearing loss with attacks of vertigo. The symptoms may occur together or separately. High doses of salicylates, like aspirin and quinine, can cause a temporary high-frequency loss. Prolonged high doses can lead to permanent deafness. There is an hereditary form of sensory deafness and a congenital form most often caused by rubella (German measles).

DECIBEL RATINGS AND HAZARDOUS LEVELS OF NOISE

<i>Decibel Level</i>	<i>Example Of Sounds</i>
30	Soft whisper
35	Noise may prevent the listener from falling asleep
40	Quiet office noise level
50	Quiet conversation
60	Average television volume, sewing machine, lively conversation
70	Busy traffic, noisy restaurant
80	Heavy city traffic, factory noise, alarm clock
90	Cocktail party, lawn mower
100	Pneumatic drill
120	Sandblasting, thunder
140	Jet airplane
180	Rocket launching pad
<p>Above 110 decibels, hearing may become painful</p> <p>Above 120 decibels is considered deafening</p> <p>Above 135 decibels, hearing will become extremely painful and hearing loss may result if exposure is prolonged</p> <p>Above 180 decibels, hearing loss is almost certain with any exposure</p>	

Source: FDA Consumer, *Gale Encyclopedia of Psychology*, 1996. (Illustration by Standley Publishing. Courtesy of Gale Group.)

Sudden hearing loss—at least 30dB in less than three days—is most commonly caused by cochleitis, an inflammation of the cochlea. The source of this process is thought to be viral, but as of 2001, no causative virus has been identified.

The final category of hearing loss is neural. Damage to the acoustic nerve and the parts of the brain that integrate and interpret sounds are the most likely to produce permanent hearing loss. Strokes, **multiple sclerosis**, and acoustic neuromas are all possible causes of neural hearing loss.

Hearing can also be diminished by extra sounds generated by the ear, most of them from the same kinds of disorders that cause hearing loss. These sounds are referred to as tinnitus and can be ringing, blowing, clicking, or anything else that no one but the affected person hears.

Diagnosis

An examination of the ears and nose, combined with simple hearing tests that can be conducted in a physician's office, detect many common causes of hearing loss. Analysis of an audiogram often concludes the evaluation, since these simple imaging often enables a diag-

nosis. If the defect is in the brain or the acoustic nerve, further neurologic testing and imaging will be required.

An audiogram has many uses in diagnosing hearing deficits. The pattern of hearing loss across the audible frequencies gives clues to the cause. Several alterations in the testing procedure can give additional information. For example, speech is perceived differently than pure tones. Adequate perception of sound, combined with inability to recognize words, indicates a brain problem rather than a sensory or conductive deficit. Loudness perception is distorted by disease in certain areas of the brain, but not in others. Acoustic neuromas often distort the perception of loudness.

Treatment

Conductive hearing loss can almost always be restored to some degree, if not completely.

- Matter in the ear canal can be easily removed. This results in a dramatic improvement in hearing. In cases of earwax blockage, wax may be removed by the physician, who may loosen it and drain the ear, scoop it out, or use a suction device to removed softened wax.



An Oto-Acoustic Emission (OAE) hearing test being performed on a newborn baby. The probe emits harmless sound into the baby's ear, and the response of the inner ear is detected and registered on a computer. Early diagnosis of a hearing disorder is important in young children, who may experience difficulties in speech and language development. (Photograph by James King-Holmes, Photo Researchers, Inc. Reproduced by permission.)

- Surfer's ear gradually regresses if cold water is avoided or a special ear plug is used. In advanced cases, excess bone can be ground away by surgeons.
- Middle ear infection with fluid is also relatively easy to treat. If medications do not work, surgical drainage of the ear is accomplished through the ear drum, which heals completely after treatment.
- Traumatically damaged ear drums can be repaired with a tiny skin graft.
- Surgical repair of otosclerosis through an operating **microscope** is one of the most intricate procedures available, and substitutes tiny, artificial parts for the original ossicles.

Sensory and neural hearing loss, on the other hand, cannot readily be cured. Fortunately, the loss is not often complete, so that **hearing aids** can fill the deficit.

In-the-ear hearing aids can boost the volume of sound by up to 70 dB. (Normal speech is about 60 dB.) Federal law now requires that they be dispensed only with a physician's prescription. For complete conduction

hearing loss, there are now bone conduction hearing aids available, as well as devices that can be surgically implanted in the cochlea.

Tinnitus can sometimes be relieved by adding white noise (like the sound of wind or waves crashing on the shore) to the environment.

Decreased hearing is such a common problem that there are many organizations that provide assistance. Special language training, both in lip reading and signing, and special schools and camps for hearing-impaired children are all available in most regions of the United States.

Conductive hearing loss can be treated with alternative therapies that are specific to the particular condition. Sensory hearing loss may be helped by homeopathic therapies. Oral supplementation with essential fatty acids such as flax oil and omega-3 oil can help alleviate the accumulation of wax in the ear.

Prognosis

The prognosis for conductive hearing loss is quite good. Since there is no cure for sensory or neural hearing loss, the prognosis is poor.

Health care team roles

Hearing examinations are usually conducted by physicians. Audiologists are trained to evaluate hearing. Speech language specialists are trained to provide treatment and rehabilitation for persons with impaired hearing.

Prevention

Prompt treatment and attentive follow-up of middle ear infections in children will prevent this cause of conductive hearing loss. Control of infectious childhood diseases, such as measles, has greatly reduced sensory hearing loss as a complication of epidemic diseases. Laws that require protection from loud noise in the workplace have achieved substantial reduction in noise induced hearing loss. Wearing specially designed earmuffs that resemble earphones may be of use where the noise is still too loud. Surfers should use the right kind of ear plugs.

One should have his or her hearing tested on a regular basis if a noisy environment cannot be avoided. Early detection will enable one to take steps to prevent further hearing loss. Avoiding exposure to loud noise and using hearing protection are the best ways to prevent hearing loss and slow the onset of presbycusis.

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KEY TERMS

Compression—Narrower than average distances between wave peaks.

Decibel—A unit of the intensity of sound, a measure of loudness.

Meniere's disease—The combination of vertigo and decreased hearing caused by abnormalities in the inner ear.

Multiple sclerosis—A progressive disease of brain and nerve tissue.

Otosclerosis—A disease that scars and limits the motion of the small conducting bones in the middle ear.

Rarefaction—Wider than average distances between wave peaks.

Stroke—A sudden loss of blood supply to part of the brain.

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- American Academy of Audiology. 8300 Greensboro Dr., Suite 750, McLean, Virginia 22102. (800) 222-2336. (703) 790-8466. Fax: (703) 790-8631. <<http://www.audiology.org>>. info@audiology.org.
- American Academy of Otolaryngology, Head and Neck Surgery. One Prince Street, Alexandria, VA 22314-3357. (703) 836-4444. <<http://www.entnet.org/>> mail@entnet.org.
- American Speech-Language Hearing Association. 10801 Rockville Pike, Rockville, MD 20852. (800) 638-8255. <<http://www.asha.org>>. actioncenter@asha.org.
- Center on Deafness. 1490 Lafayette, Suite 408, Denver, CO 80203. (303) 839-8022. Fax: (303) 839-8027. <<http://www.centerondeafness.org/services.html>>. info@centerondeafness.org.
- National Institute on Deafness and Other Communication Disorders, National Institutes of Health. 31 Center Drive, MSC 2320, Bethesda, MD 20892-2320. <<http://www.nidcd.nih.gov>>.

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Hearing test with an audiometer *see*
Audiometry

Hearing tests with a tuning fork *see* **Rinne**
and Weber tests

Heart-lung machines

Definition

The heart-lung machine is medical equipment that provides cardiopulmonary bypass or mechanical circulatory support of the **heart** and **lungs**. The machine may consist of venous and arterial cannula, polyvinyl chloride (PVC) or silicone tubing, reservoir (open or closed system), bubbler or membrane oxygenator, cardiotomy, heat exchanger(s), arterial line filter, pump(s) (usually centrifugal or roller-head), flow meter, inline **blood** gas and electrolyte analyzer, and pressure monitoring devices. Treatment provides removal of carbon dioxide from the blood, oxygen delivery to the blood, blood flow to the body, and/or temperature maintenance. Pediatric and adult patients both benefit from this technology.

Purpose

In the operating room the heart-lung machine is used primarily to provide blood flow and respiration for the patient while the heart is clinically arrested. Surgeons are able to perform coronary artery bypass grafting (CABG), open-heart surgery for valve repair or repair of cardiac anomalies, and aortic aneurysm repairs, along with treatment of other cardiac related diseases.

The heart-lung machine provides the benefit of a motionless heart in an almost bloodless surgical field. Cardioplegia solution is delivered to the heart by a dedicated pump resulting in cardiac arrest. The heart-lung

machine is invaluable during this time since the patient is unable to maintain blood flow to the lungs or the body.

In critical care units and **cardiac catheterization** laboratory the heart-lung machine is used to support and maintain blood flow and respiration. The diseased heart or lungs are replaced by this technology providing time for the organ(s) to heal. Venoarterial extracorporeal membrane oxygenation (ECMO) is used primarily in the treatment of lung disease. Cardiopulmonary support is useful during percutaneous transluminal coronary **angioplasty** (PTCA) and stent procedures performed in the cardiac catheterization lab. Both treatments can be instituted in the critical care unit when severe heart or lung disease is no longer treatable by less invasive conventional treatments such as pharmaceuticals, intra-aortic balloon pump (IABP), and mechanical ventilation with a respirator.

Use of this treatment in the emergency room is not limited to patients suffering heart or lung failure. In severe cases of hypothermia, patient body temperature can be corrected by extracorporeal circulation with the heart-lung machine. Blood is warmed as it passes over the heat exchanger. The warmed blood returns to the body, gradually increasing the patients body temperature to normothermia.

Tertiary care facilities are able to support the staffing required to operate and maintain this technology. Level I trauma centers have access to this specialized treatment and equipment. Being that this technology serves both adult and pediatric patients specialized children's hospitals may provide treatment with the heart-lung machine for Venoarterial ECMO.

Description

The pump oxygenator developed by Dr. Gibbons saw its first success on May 6, 1953. A patient placed on the heart-lung machine survived an open-heart atrial septal defect repair. Continued research and design has allowed the heart-lung machine to become a standard of care in the treatment of heart and lung disease, while supporting other non-conventional treatments.

Foreign surfaces of the heart-lung machine activate **blood coagulation proteins** and platelets, which lead to clot formation. In the heart-lung machine, clot formation would block the flow of blood. As venous and arterial cannulas are inserted, pharmaceuticals are administered to provide anticoagulation of the blood. Clot formation is prevented and blood will flow through the heart-lung machine.

Large vessels, venous and arterial, are required for cannulation, to insert the tubes (cannulas) that will carry



A heart-lung machine. (Photograph by Albert Paglialunga. Phototake NYC. Reproduced by permission.)

the blood away from the patient to the heart-lung machine and return the blood from the heart-lung machine to the patient. Cannulation sites for venous access can include the inferior and superior vena cava, the right atrium, the femoral vein, or internal jugular vein. Oxygen rich blood will be returned to the aorta, femoral artery or carotid artery. By removing oxygen poor blood from the right side of the heart and returning oxygen rich blood to the left side, heart-lung bypass is achieved.

The standard heart-lung machine typically includes up to five pump assemblies. A centrifugal or roller head pump can be used in the arterial position for extracorporeal circulation of the blood. The four remaining pumps are roller pump in design to provide fluid, gas, and liquid for delivery or removal to the heart chambers and surgical field. Left ventricular blood return is accomplished by roller pump, drawing blood away from the heart. Surgical suction created by the roller pump removes accumulated

fluid from the general surgical field. The cardioplegia delivery pump is used to deliver a high potassium solution to the coronary vessels. The potassium arrests the heart so that the surgical field is motionless during surgical procedures. An additional pump is available for emergency backup of the arterial pump in case of mechanical failure.

A pump is required to produce blood flow. Pump technology has advanced from the Sigmamotor pump, a fingerlike contraction that uses peristalsis to propel blood, through tubing, from the oxygenator to the body. This technology was abandoned for more reliable roller pump technology. Currently roller and centrifugal pump designs are the standard of care. Both modern designs can provide pulsatile or non-pulsatile blood flow to the systemic circulation.

The roller assembly rotates and engages the tubing, PVC or silicone, which is then compressed against the pump's housing, propelling blood ahead of the roller

head. Rotational frequency and tubing inner diameter determine blood flow. Because of its occlusive nature the pump can be used to remove blood from the surgical field by creating negative pressure on the inflow side of the pump head.

The centrifugal pump also has a negative inlet pressure. As a safety feature this pump becomes inefficient when gaseous emboli are introduced. The centrifugal force draws blood into the center of the device. Blood is propelled and released to the outflow tract tangential to the pump housing. Rotational speed determines the amount of blood flow, which is measured by a flowmeter placed adjacent to the pump housing. If rotational frequency is too low, blood may flow in the wrong direction since the system is non-occlusive in nature. Magnetic coupling links the centrifugal pump to the control unit.

A reservoir collects blood drained from the venous circulation. Tubing connects the venous cannulae to the reservoir. Reservoir designs include open or closed systems. The open system displays graduated demarcations corresponding to blood volume in the container. The design is open to atmosphere allowing blood to interface with atmospheric gasses. The pliable bag of the closed system eliminates the air blood interface, while still being exposed to atmospheric pressure. Volume is measured by weight or by change in radius of the container. The closed reservoir collapses when emptied as an additional safety feature.

Bubble oxygenators use the reservoir for ventilation. When the reservoir is examined from the exterior the blood is already oxygen rich and appears bright red. As blood enters the reservoir gaseous emboli are mixed directly with the blood. Oxygen and carbon dioxide are exchanged across the boundary layer of the blood and gas bubbles. The blood will then pass through a filter that is coated with an antifoam solution, which helps to remove fine bubbles. As blood pools in the reservoir it has already exchanged carbon dioxide and oxygen. From here tubing carries the blood to the rest of the heart-lung machine.

In opposition to this technique is the membrane oxygenator. Tubing carries the oxygen poor blood from the reservoir through the pump to the membrane oxygenator. Oxygen and carbon dioxide cross a membrane that separates the blood from the ventilation gasses. As blood leaves the oxygenator it is oxygen rich and bright red in color.

As blood is ready to be returned from the heart-lung machine to the patient the arterial line filter will be encountered. This device is used to filter microemboli that may have entered, or been generated by the heart-lung machine. After this filter tubing completes the blood

path as it returns the blood to the arterial cannula to enter the body.

Fluid being returned from the left ventricle and surgical suction require filtration before the blood is reintroduced to the heart-lung machine. Blood enters a filtered reservoir, called a cardiotomy, which is connected with tubing to the venous reservoir. Other fluids, such as blood products and pharmaceuticals are also added in the cardiotomy for filtration, of particulate.

Heat exchangers allow body and organ temperature to be adjusted. The simplest heat exchange design is a bucket of water. As the blood passes through the tubing placed in the bath the blood temperature will change. A more sophisticated system separates the blood and water interface with a metallic barrier. As the water temperature is changed so is the blood temperature, which enters the body or organ circulation changing the tissue temperature. Once the tissue temperature reaches the desired value the water temperature is maintained. Being able to cool the blood helps to preserve the organ and body by metabolizing fewer energy stores.

Because respiration is being controlled, and a machine is meeting metabolic demand, it is necessary to monitor the patient's blood chemical makeup. Chemical sensors placed in the blood path are able to detect the amount of oxygen bound to hemoglobin. Other, more elaborate sensors can constantly trend the blood pH, partial pressure of oxygen and carbon dioxide, and electrolytes. This constant trending can quickly analyze the metabolic demands of the body.

Sensors that communicate system pressures are also a necessity. These transducers are placed in areas where pressure is high, after the pump. Readings outside of normal ranges often alert the operator to obstructions in the blood flow path. The alert of high pressure must be corrected quickly as the heart-lung machine equipment may disengage under the stress of abnormally elevated pressures. Low-pressure readings can be just as serious alerting the user to faulty connections or equipment. Constant monitoring and proper alarms help to protect the integrity of the system.

Constant scanning of all components and monitoring devices is required. Normal values can quickly change due to device failure or sudden mechanical constrictions. The diagnosis of a problem and quick troubleshooting techniques will prevent additional complications.

Operation

The perfusionist or ECMO specialist monitors hemodynamic parameters associated with the patient and the device. Therefore, they are able to use the relation-

ship of pressure, flow and resistance to make the appropriate changes to maintain adequate blood flow to vital organ beds. The standing orders from the physician, along with specific requests during the procedure are met by controlling the flow, temperature, **gas exchange**, pharmaceutical delivery and blood gas and electrolyte values. All requests and changes from protocol require documentation on the patient record.

Patient blood is drawn at 30-minute intervals to document arterial or venous blood gasses along with electrolytes and anticoagulation status. Decisions are made about device operation and pharmaceutical delivery based on these parameters. Abnormal values may indicate mechanical device failure.

Maintenance

Biannual preventive maintenance ensures proper device operation. The preventive maintenance as determined by the manufacturer should be followed. Electrical leakage tests are performed biannually on electrical components. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) requires documentation of these activities. A pre-bypass checklist is also completed before each procedure for review of the following categories: patient, sterility, pump, electrical, gas supply, lines/pump tubing, cardioplegia, safety mechanisms, monitoring, temperature control, supplies, anticoagulation and backup. Documentation of a completed checklist is kept with the patient record, and must be signed with date and time, by the device operator.

Health care team roles

At the sterile field the physician must react with the perfusionist or ECMO specialist in correcting problems that may interfere with the proper operation of the heart-lung machine. At the termination of device support the perfusionist or ECMO specialist must communicate clearly to the physician all changes in support status. This allows the entire team to assess changes in patient parameters that are consistent with the patient becoming less dependent on the device, while the native heart and lungs meet the metabolic demands of the body.

It is the responsibility of the perfusionist or ECMO specialist to be at the device controls at all times. Continuous scanning of all patient monitors is necessary for proper treatment and troubleshooting. Documentation of patient status is acquired every 15 to 30 minutes. This information allows the physician and nursing staff to follow trends that will help better manage the patient once treatment is discontinued.

KEY TERMS

Anticoagulant—Pharmaceuticals to prevent clotting proteins and platelets in the blood to be activated to form a blood clot.

Cannula—Tubes that provide access to the blood once inserted into the heart or blood vessels

Cardiopulmonary bypass—Diversion of blood flow away from the right atrium and return of blood beyond the left ventricle, to bypass the heart and lungs.

Extracorporeal—Circulation of blood outside of the body.

Training

A perfusionist earns a certificate of completion from a program accredited by the Commission on Accreditation of Allied Health Education Programs (CAAHEP). A bachelor's degree is required before entering the certificate program, or is received at the time of completion of the certificate-granting program. Professional certification can be earned from the American Board of Cardiovascular Perfusion or the International Board of Circulation Technologists. Licensure is required in some states.

Perfusionists, nurses, and respiratory therapists can receive additional training, as ECMO specialists, in the operation of ECMO equipment and institution specific protocols to operate venoarterial ECMO. The institution, in accordance with the guidelines established by the Extracorporeal Life Support Organization (ELSO), performs the training.

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Commission on Accreditation of Allied Health Education Programs. 1740 Gilpin Street, Denver, CO 80218. (303) 320-7701. <<http://www.caahep.org>>.

Joint Commission on Accreditation of Health Organizations. One Renaissance Boulevard, Oakbrook Terrace, IL 60181. (630) 792-5000. <<http://www.jcaho.org/>>.

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Heart

Definition

The heart is a muscular organ of the **cardiovascular system** that contracts to cause movement of the **blood** throughout the body.

Description

The heart is approximately fist-sized and located in the chest between the two **lungs** and behind the ribs and breastbone (sternum). It rests at a slight tilt from vertical, which makes it appear to be on the left side of the body. The walls of the heart are made up of three layers of tissue: epicardium, myocardium, and endocardium. The epicardium is a thin layer on the outer surface of the heart. The myocardium is the muscular layer, made up of cardiac muscle that contracts to do the work of the heart moving the blood. The endocardium is the smooth inner lining of the heart.

The entire structure of the heart is enclosed in a fibrous sac called the pericardium. A small amount of liquid is normally found in the space between the heart and the pericardium, which helps reduce the friction between the epicardial and pericardial membranes.

The heart is divided by a central wall (or septum) into its right and left sides. Each of these sides contains a smaller, upper chamber known as an atrium, and a lower, larger chamber known as a ventricle. The atria and ventricles are separated by a valve made of flaps of tissue that prevent blood flow in the wrong direction. The valve on the left side of the heart is the mitral (or bicuspid) valve, which has two flaps. The right atria and ventricle are separated by the tricuspid valve, which has three flaps.

There are five great vessels branching off from the heart that are responsible for carrying blood into or out of the organ. These five vessels are the aorta, the pulmonary artery and vein, and the superior and inferior venae cavae. The aorta is the main artery, carrying oxygenated blood from the heart out into the body. The pulmonary artery carries blood away from the heart to the lungs, and the pulmonary vein carries blood from the lungs to the

heart. The superior and inferior venae cavae carry deoxygenated blood from the upper and lower parts of the body back to the heart.

Unidirectional valves separate two of the great vessels from the chambers of the heart. The pulmonic (or pulmonary valve) separates the right ventricle and the pulmonary artery. The aorta and left ventricle are separated by the aortic valve.

The coronary arteries are two vessels that divide off the aorta and branch out over the entire surface of the heart. These vessels bring oxygenated blood to the heart tissue itself.

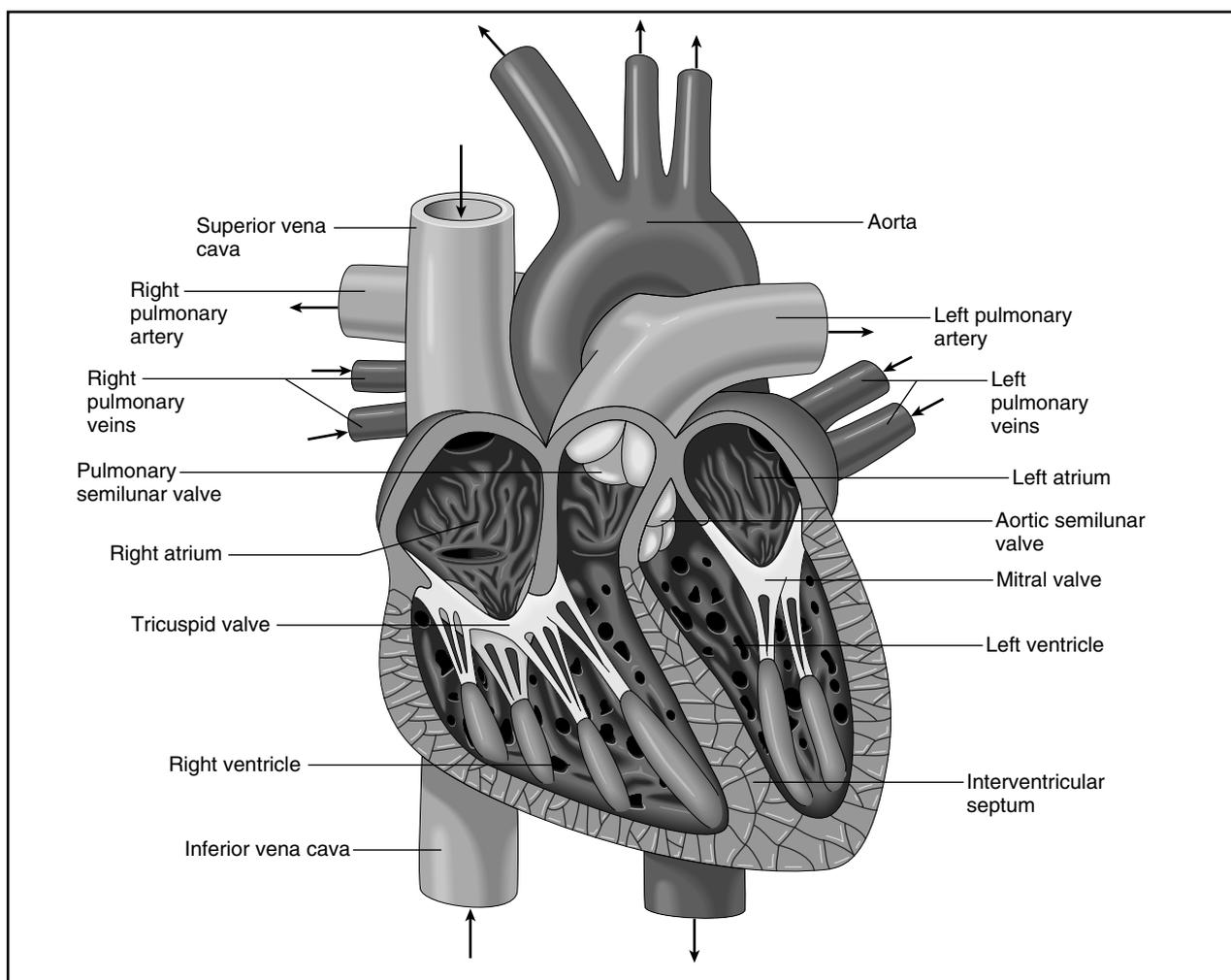
Function

The heart functions as a strong, four-chambered muscular pump. It can move more than five quarts of blood through the body each minute, the equivalent of about 2,000 gallons per day. At a typical heart rate of 72 beats per minute, the heart contracts on average 100,000 times per day. This adds up to more than 2.5 billion beats in a 70-year lifetime.

One key to the functioning of the heart is the unique characteristics of its muscular tissue. Cardiac muscle differs from other muscles of the body in that its normal function is a rhythmic contraction, which is the basis for the tissue's ability to respond to the electrical impulses that govern the beating of the heart. The natural pacemaker of the heart, the sinoatrial (SA) node, is located in the right atrium. Cardiac muscle cells that naturally contract at the fastest rate when compared to the other cells of the heart surround this cluster of nerve cells. This area of the heart therefore has the ability to initiate the contraction by sending wavelike electrical signals throughout the organ.

First, the electrical signal causes the two atria to contract, when sends the blood from those chambers into the two ventricles. Then the signal passes down through a group of nerve cells known as the atrioventricular (AV) node. This nerve cluster is located near the center of the heart. The travel through this area slows down the signal so that it reaches the ventricles after the atria have finished their contraction. Then the ventricles contract, moving the blood out of the heart, and the cycle starts again. The heart's electrical activity can be measured using **electrocardiography**.

The physical functions of the full heartbeat is known as the **cardiac cycle**. The cycle can be divided into two phases: diastole and systole. Diastole occurs when the heart relaxes and the myocardial fibers lengthen. As the heart dilates, the cavities fill with blood. Diastole of the atria occurs slightly before the diastole of the ventricles.



Cross section of the heart. Arrows indicate the direction of blood flow. (Delmar Publishers, Inc. Reproduced by permission.)

Systole happens when the part of the heart is in contraction and the myocardial fibers shorten. Again, systole of the atria precedes systolic phase of the ventricles. Systole of the ventricles cause blood to surge out of the heart and into the aorta and pulmonary artery.

Over time, the cardiac cycle occurs as follows. It begins with the diastole of the atrium, where both the left and right atria relax and fill with blood. The right atria fills with deoxygenated blood from the superior and inferior venae cavae. The pulmonary artery fills the left atria with newly oxygenated blood from the lungs. The SA node signals the beginning of systole and the atrium contract, sending blood through the tricuspid and mitral valves into the right and left ventricles, respectively. During ventricle filling, the valves of the great vessels are closed so blood already pumped out of the heart does not leak back.

The electrical signal has now reached the ventricles and they contract, sending the deoxygenated blood of the right ventricle into the pulmonary artery to the lungs and the oxygenated blood of left ventricle into the aorta to the body. During contraction, the tricuspid and mitral valves close to prevent flow back into the atrium. This cycle is repeated continuously.

Role in human health

The heart is the centerpiece of the elaborate and extensive human cardiovascular system. Responsible for moving the blood throughout the body, this system transports the necessities for life—oxygen, nutrients, hormones, immune functions—to the cells. The system also transports wastes such as carbon dioxide away from the cells to the organs responsible for their elimination from the body. The heart is the driving force behind this essen-

KEY TERMS

Diastole—Phase of the heartbeat where the ventricles relax and fill with blood.

Endocardium—The thin, innermost layer of the heart.

Epicardium—The outermost layer of the heart.

Myocardium—The middle, working layer of the heart containing the heart muscle cells.

Regurgitation—A defect of the heart valves that interferes with its ability to close completely, allowing blood to leak in the direction opposite of circulation.

Septum—A physical divider between chambers, found between the atria and the ventricles.

Stenosis—A stiffening of the heart valves, which narrows its opening and can interfere with function.

Systole—Phase of the heartbeat where the ventricles contract and force blood from the heart.

tial transport. Therefore it is not surprising that a healthy heart is necessary for a healthy body.

There are several risk factors for heart problems that can be controlled through preventative measures. These include lowering blood cholesterol levels with diet, **exercise**, or in extreme cases, medications. Lower cholesterol levels lower the probability of **coronary artery disease** (clogging of the arteries that bring oxygenated blood to the heart), a major cause of **heart failure**. Keeping **blood pressure**, blood sugar levels, and body weight within normal levels also greatly decreases the chance for heart problems. Other controllable risk factors include a sedentary lifestyle, **stress** and anger, and smoking.

Common diseases and disorders

According to 1999 estimates, approximately 58.8 million Americans have one or more types of heart disease, as it is most broadly defined. Although the cause and effect of various heart diseases can be examined in a particular patient, it is difficult to make generalizations about different diseases and disorders. Often one disease of the cardiovascular system will contribute or even cause another. In any case, the various symptoms of an unhealthy heart, whatever the cause, are quite common.

Several diseases of the heart are related to atherosclerosis, the accumulation of cholesterol in the arteries.

When this problem occurs in the coronary arteries, it is known as coronary artery disease. Three conditions which can follow from the loss of blood flow to the heart due to the clogged arteries are angina pectoris, a severe chest **pain**, **myocardial infarction** (commonly called a heart attack), or congestive heart failure, where the heart is unable to efficiently pump the blood throughout the body.

Angina pectoris is the result of temporary deprivation of oxygen and often occurs after stress or exertion. Heart attacks occur because a portion of the heart is permanently deprived of blood and the cells become damaged. Congestive heart failure involves a cascade reaction of the body to inefficient heart action that results in accumulation of fluids in the outer reaches of the body. In each of these cases, the trigger cause of the condition was the blockage of the arteries that supply the heart.

A second set of heart diseases involves an abnormality in the electrical system of the heart. Called arrhythmias, these diseases occur when the heart no longer beats in the standard pattern. Altered beat function can greatly reduce the efficiency of the heart and can result in fainting (due to lack of blood to the **brain**), palpitations (an unpleasant awareness of the beating of the heart), shortness of breath, and chest pain. Some common types of arrhythmia include bradycardia (slow heart beat), atrial fibrillation, and ventricular fibrillation.

Bradycardia is commonly treated using **pacemakers**, an implanted device that keeps the heart's rhythm steady. Fibrillations are very fast, inefficient beats of the atrium or ventricles. Fibrillation can be treated with medication or an implanted cardiac defibrillator (ICD) that delivers a shock to the heart to restart normal beating. Arrhythmias can be caused by coronary heart disease, high blood pressure, or a previous heart attack, emphasizing the interrelation of the various heart diseases.

A third kind of heart disease involves damage to one of the four valves of the heart. The frequency of damage to these structures is related to the work that they do—with the structures undergoing the greatest amount of pressure having the highest frequency of disease. Thus, valve problems occurs most frequently with the mitral valve, then the aortic, tricuspid, and pulmonic. Mitral valve prolapse is the most common condition, where excess valve tissue prevents it from closing properly. Surgery may not be necessary, however, until leaking of the valve, known as valve regurgitation, accompanies the prolapse. Regurgitation is a symptom of stenosis, a condition where the valve has become too stiff to function properly.

Untreated rheumatic **fever**, a bacterial **infection**, is the most prevalent cause of valve problems. The use of

antibiotics to treat **strep throat** has greatly reduced the incidence of this disease in the United States. Congenital defects are the second most common cause of heart valve conditions.

Congenital heart defects, in the valves and other structures, occur when the heart or its vessels do not develop normally before birth. The most common congenital heart defect is a combination of four problems called the tetralogy of Fallot. With this problem the ventricular septum is incomplete, there is an obstruction to blood flow beneath the pulmonary artery, the aorta is shifted rightward, and the right ventricular wall is thickened.

A final kind of heart disease is cardiomyopathy. This disorder occurs when the muscle of the heart degenerates. There are multiple causes of cardiomyopathy and it is the number one reason people undergo heart transplants. Categorized by the type of muscle damage, there are three general types of cardiomyopathy: dilated, hypertrophic, and restrictive. Dilated cardiomyopathy refers to the enlargement of the heart that is a response to the overall myocardial weakness. Many problems can cause dilated cardiomyopathy including viral infections, excessive alcohol intake, and myocarditis (inflammation of the heart).

Hypertrophic cardiomyopathy is an abnormal overgrowth of the heart muscle. An inherited disease, the overgrown muscle blocks the movement of blood both into and out of the heart. Restrictive cardiomyopathy is due to a stiffening of the heart muscle that prevents it from fully relaxing during diastole. This problem is a symptom of other diseases such as hemochromatosis (a defect in **iron** use by the body) or amyloidosis (overproduction of antibodies by the bone marrow that cannot be broken down).

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Heart attack see **Myocardial infarction**

Heart catheterization see **Cardiac catheterization**

Heart failure

Definition

"Heart failure" is a broad term—often used interchangeably with "congestive **heart failure**" (CHF)—to describe the heart's inability to consistently pump enough **blood** to the body's organs and tissues. Heart failure occurs either from a structural or a functional abnormality. Since blood carries oxygen and vital nutrients to cells throughout the body, a decrease in blood supply interferes with the ability of organs and other tissues to function properly.

Description

According to the American College of Cardiology, approximately 4.8 million Americans live with CHF. Patients ages 65 and older are hospitalized for complications from CHF more often than for any other medical condition, accounting for about 875,000 hospital admissions each year. Anywhere between 400,000 and 700,000 cases of CHF are discovered annually, bringing the cost of treating patients in the United States between \$10 billion and \$30 billion. CHF is either a direct or contributing cause of death for as many as 250,000 people per year. As the population ages, the incidence of heart failure increases.

The term "congestive heart failure" describes its course of action. When the heart fails for some reason to deliver adequate blood supply to the body's tissues, **edema** (swelling, or fluid buildup) develops. Where the edema occurs in the body depends on the part of the heart that is failing in some way. For example, when the left ventricle (lower left chamber of the heart) is damaged, blood fails to get out to other parts of the body as quickly as it returns from the **lungs**. When blood cannot get back to the heart, it backs up inside **blood vessels** in the lungs. Some of the fluid in the blood is then forced into the breathing space of the lungs, causing pulmonary

edema. Pulmonary edema causes varying degrees of breathing difficulty. The degree of severity depends on the amount of excess fluid in the lungs and can be life-threatening in severe cases. Abnormalities in heart structure or rhythms can also cause left-ventricular CHF. Patients often complain of feeling very tired, due to the lack of circulating oxygen and nutrients caused by an inadequate blood supply.

When the right side of the heart fails, the right ventricle (lower right chamber of the heart) cannot pump blood to the lungs as quickly as blood returns from areas throughout the body, via the veins. The blood then engorges the right side of the heart and veins. Fluid begins to back up in the veins and pushes out into the tissues, causing edema, most often in the feet, ankles, and lower legs. Abnormalities of the heart valves and lung disorders often cause right-ventricular CHF.

The failing heart keeps pumping, but not as efficiently as it should. Sometimes the heart tries to compensate for its lack of pumping ability by becoming hypertrophic (larger). When this happens the heart chamber grows larger and the muscle in the wall of the heart thickens, sometimes helping to improve the pumping ability of the heart. Another way in which the damaged heart tries to compensate for declining pumping ability is by stepping up the frequency of heartbeats to improve blood output and circulation. Eventually the **kidneys** join the fight to compensate for the failing heart; they hold on to more salt and water in order to increase blood volume. But this extra fluid can also cause edema. This can further complicate the situation and make treatment even more difficult. As the condition worsens over time, these compensatory measures are not enough to keep the heart pumping enough blood to meet the body's demand.

For most people, heart failure is a chronic disease with no real cure. However, depending on the individual circumstances, heart transplantation is considered in some cases when all other treatment options fail. While there is no cure, heart failure can often be managed and treated effectively using medications, proper diet, modified **exercise**, and other lifestyle changes as needed.

Causes and symptoms

The most common causes of heart failure are:

- coronary artery disease (CAD)
- heart attack (which may be “silent”)
- cardiomyopathy
- high **blood pressure** (HBP, or **hypertension**)
- heart valve disease
- **infection** of the heart valves or heart muscle
- congenital structural abnormality
- alcohol and drug abuse

CAD is the most common cause of heart failure. The arteries that supply the heart muscle with blood begin to narrow over time. Eventually they may become completely blocked. When the blood cannot reach a specific area of the heart, a heart attack occurs. Some heart attacks are so slight that they go unrecognized, while others prove lethal. The heart muscle is damaged when the blood supply is greatly reduced or blocked entirely. If the damage markedly impairs the heart's pumping ability, heart failure follows.

Cardiomyopathy is a general term describing disease of the heart-muscle tissue. It can be caused by CAD, an inherited abnormality, severe **alcoholism** or drug abuse, or a viral infection. When the cause of the condition cannot be identified, it is termed idiopathic cardiomyopathy. Some types of **cancer** treatments have been associated with the development of cardiomyopathy. Cardiomyopathy brought on by anthracycline or other cardiotoxic agents is termed toxic cardiomyopathy. Regardless of the cause of the condition, the heart muscle weakens and eventually fails.

Sustained and uncontrolled high blood pressure is another common cause of heart failure. The persistent high pressure exerted on arterial walls makes them thicker and less pliable, and resistant to normal blood flow. As a result, the heart compensates by pumping harder, in an attempt to regain normal blood flow. Eventually the heart cannot keep up with the increased demand and heart failure results.

Defective heart valves, congenital heart diseases, severe alcohol and drug abuse, cardiotoxic cancer treatments, and specific **viruses** can cause the heart to fail.

The patient with heart failure can experience any number of the following symptoms:

- swollen, prominent veins in the neck area
- shortness of breath (causing crackling noises in the lungs)
- frequent coughing, especially when lying down
- swollen feet, ankles, and legs (edema)
- abdominal swelling (acites) and **pain** (caused by organ engorgement)
- fatigue
- dizziness or fainting
- increased exercise intolerance
- sudden death

The person with left-sided heart failure may experience shortness of breath and increased episodes of coughing caused by fluid buildup in the lungs. Pulmonary edema often causes a patient to cough up bubbly, blood-tinged phlegm. In right-sided heart failure, fluid builds up in the veins and tissues, causing swelling of the lower extremities and the abdomen. When body tissues fail to get the oxygen and nutrients they require, they begin to lose their efficiency, causing increased dizziness and fatigue.

Diagnosis

Physicians base their diagnosis of heart failure on the results of the following evaluations:

- symptoms
- medical history
- **physical examination**
- blood work
- **chest x ray**
- electrocardiogram (ECG; also called EKG)
- metabolic exercise testing (**stress test** with gas-exchange measurement)
- **cardiac catheterization**

A person's symptoms can provide important clues to the presence of heart failure. Patients who come to see a doctor, whether at the office or in an emergency room, will be examined by a physician, and in some cases also by a physician's assistant, a nurse, nurse practitioner, or nurse clinician. A patient who complains of shortness of breath while performing activities of daily living (ADL) and/or episodes of shortness of breath that wakes him or her from sleep is exhibiting classic symptoms of heart failure.

The health care professional who first examines the patient will also write down the patient's medical history. Often, something in the patient's medical history, such as a history of rheumatic **fever** or sustained hypertension, can help support the diagnosis of heart failure.

The physician will complete a thorough physical examination. He or she will listen to the heart and the lungs using a **stethoscope**, looking and listening for signs of heart failure. Irregular heart sounds (gallops), rapid heartbeats, and murmurs of the heart valves may be heard. A crackling sound in the lungs tells the physician that fluid is present in the lungs. Quick or shallow breathing may be present, along with a rapid pulse.

The physician will palpate (press down firmly with the fingertips of both hands) the patient's abdomen to feel if the **liver** is enlarged. He or she will also check the skin

and nail beds on fingers and toes, looking for a bluish tint and a feeling of coolness to the skin. The bluish tint and coolness reflect a lack of oxygen in those regions.

At least one, but preferably two different views of the patient's chest will be taken in the upright position, by a licensed radiologic technologist, to determine whether there is fluid in the lungs and/or the heart is enlarged. Some heart-valve or other structural abnormalities can also be identified on plain chest films. A radiologist (a physician who specializes in radiology) reads the x ray and gives the report to the patient's doctor. If the patient is in distress, the radiologist may call the ordering physician with a "wet" (immediate) reading; otherwise, the chest films will be read and dictated, and the patient's doctor will receive a transcribed report the next day.

Routine blood work can sometimes give insight into both the cause of the heart failure and the extent of damage to the heart. For example, an abnormally low level of sodium can indicate advanced heart failure with a poor prognosis. Conversely, a high creatinine (used to assess kidney function) level can reflect kidney malfunction that either is contributing to the heart failure or is caused by the failing heart. Medical assistants, phlebotomists, medical technicians, and nurses are all trained to draw blood from veins. The blood samples are evaluated in the laboratory by laboratory technicians, medical technologists, pathologists, and/or other trained and licensed medical-laboratory professionals.

An electrocardiogram gives information about heart rhythm and size. It can demonstrate an enlarged heart chamber and whether or not damage to the heart muscle is caused by narrowing or blocked arteries.

Besides a chest x ray, the physician may order an echocardiogram or an ultrasound of the heart to help reach a diagnosis. **Echocardiography** uses sound waves to make images of the heart. These images can show whether the heart wall or chambers are enlarged, or if there are any abnormalities of the heart valves. An echocardiogram can also be used to find out how much blood the heart is pumping. It helps determine the amount of blood the ventricle pumps each time the heart beats (called the ejection fraction). A healthy heart pumps at least one half the amount of blood in the left ventricle with each heartbeat. A test called a radionuclide ventriculography is sometimes ordered to measure the ejection fraction. It uses very low doses of an injected radioactive substance and is imaged as it travels through the heart.

Cardiac catheterization involves threading a small tube (catheter) into either the arm or groin area and up into the heart. The test is used to measure pressure in the heart and the amount of blood pumped by the heart. It

can detect abnormalities of the coronary arteries, heart valves, heart muscle, and other blood vessels. Cardiac catheterization is not always necessary in diagnosing heart failure, but when used in concert with echocardiography and other tests, it can help to pinpoint the cause of the condition.

Chest x rays, echocardiography, cardiac catheterization, and radionuclide ventriculography are all performed by radiologic technologists and radiologists who are specifically trained in these specialty areas. The chest x ray and echocardiogram can be performed using a portable bedside unit if the patient is too ill to travel to the x-ray department.

Metabolic exercise testing provides a noninvasive method for getting a lot of information about the patient in heart failure. It not only gives the physician a good idea of the functional capacity of the heart, but also demonstrates the patient's maximal oxygen consumption during peak exercise. The test offers insight into any functional disability that the patient is experiencing, so that the physician can discuss individualized plans for rehabilitation in light of any physical limitations. This test is often performed by a cardiologist with a nurse, physical therapist, medical assistant, or technician present to assist.

Treatment

Heart failure is most often treated with different medications and lifestyle changes. In some cases, surgery is performed to correct abnormalities of the heart or heart valves. Heart transplantation is a last resort, considered only in certain cases.

Dietary changes designed to help the patient reach and maintain a proper weight and to reduce salt intake to reduce fluid buildup may be required (reducing salt intake helps decrease swelling in the lower extremities and abdomen). An individualized exercise program may be recommended, but only after a full evaluation by the physician. The physician works with cardiac-rehabilitation nurses, physical therapists, and the patient to determine what each patient can tolerate safely. The patient performs the exercise regimen in the cardiac-rehabilitation department for a number of weeks under the careful supervision of staff. The patients are hooked up to monitors, their **vital signs** taken at intervals throughout their program, to ensure their safety. Once exercise tolerance is established, the patient is encouraged to follow the program consistently and is cautioned not to change it in any way once he or she returns home, in order to avoid complications. The patient is also reminded to report any unusual symptoms to his or her physician. Depending on the patient's specific limitations and exercise needs,

walking, bicycling, swimming, or even low-impact aerobic exercises may be recommended. Homebound patients will work with home health care nurses, therapists, and aides in much the same way to help manage their symptoms. Most medium- to larger-size hospitals in the United States have good cardiac-rehabilitation programs.

Other lifestyle changes that may reduce the severity of symptoms associated with heart failure include quitting smoking or other tobacco use, eliminating or reducing alcohol consumption, and not using certain drugs.

One or more of the following types of medications may be prescribed for heart failure:

- diuretics
- digitalis
- vasodilators
- beta blockers
- angiotensin-converting enzyme inhibitors (ACE inhibitors)
- angiotensin-receptor blockers (ARBs)
- calcium-channel blockers

Diuretic medication helps eliminate excess salt and water from the kidneys by making patients urinate more often. This increased flushing action helps reduce the swelling caused by fluid buildup in the tissues. It is important to monitor patients for electrolyte imbalance when they used diuretics regularly. Digitalis gives the heart muscle stronger pumping ability. Vasodilators, ACE inhibitors, ARBs, and calcium-channel blockers all help to lower blood pressure via different methods, expanding the blood vessels so that blood can move more freely through them. This expansion makes it easier for the heart to pump blood through the vessels.

Surgery is used to correct certain heart conditions that cause heart failure. Congenital heart defects and abnormal heart valves may be repaired with surgery. Narrowing or completely blocked coronary arteries can be effectively treated with **angioplasty** or coronary-artery bypass surgery.

In patients with severe heart failure, the heart muscle itself may become so damaged that available treatments cannot help. Patients in this condition are said to be in end-stage heart failure. The only available treatment option for patients in end-stage heart failure and for which all other treatments are no longer working is heart transplantation. However, the patient's age and a number of other health-related issues are taken into account in the decision-making process.

Support staff, including pharmacists, dieticians, physicians' assistants, nurses, technicians, physical ther-

apists, respiratory therapists, and nurses' aides can play an important role in the effective management of the patient with heart failure. In communicating responsibly with one another and with the patient and his or her caregivers, many complications can be avoided and quality of life improved.

Prognosis

Most patients in mild or moderate heart failure can be successfully managed with a combination of dietary and exercise programs and the right medications. Many patients are able to participate in normal daily activities and lead relatively active lives. However, the patient's success with any treatment program depends a great deal on effective communication among members of the health care team and the patient's compliance with treatment recommendations.

Patients in severe heart failure may eventually have to consider heart transplantation. About 50% of patients diagnosed with CHF live for at least five years with the condition. Women who have heart failure often live longer than men with the same condition. However, survival statistics continue to improve some with newer and more advanced treatments.

Health care team roles

Each professional in the health care team plays an important role in helping to diagnose and treat a patient in any stage of heart failure. From the person who writes down the patient's medical history to the pharmacist who explains the patient's medications, attention to detail, effective communication, and a positive attitude are key to the patient's ability to realize good outcomes.

Cardiac-rehabilitation nurses—registered nurses who see the patient either in the hospital or at the doctor's office—will be responsible for assessing the patient's condition from the time the patient first presents with symptoms and complaints, and throughout return visits. All nurses take vital signs and monitor the patient's compliance with medications, diet, and exercise regimens. Nurses are expected to document their findings thoroughly in progress notes and to communicate any problems with the physician or other appropriate health care professional. Nurses explain and teach patients about their disease and different aspects of their treatment programs, and serve as the pipeline between the patient and the physician. They are also the patient's advocate. Nurses spend more time with patients than the other members of the health care team do, so they get a better opportunity to gain insight into the patient's total health picture.

Radiologic technologists are responsible for performing certain diagnostic procedures, either directly or by assisting a radiologist or cardiologist. Prior to the exam, the technician is responsible for explaining any procedure to the patient and for getting a consent form signed whenever contrast material will be injected into the body. The technician needs to ask whether the patient has any known **allergies** and communicate those findings to the radiologist before any contrast material is injected.

Respiratory therapists and physical therapists are required to explain any procedures or therapy they administer to patients. Dieticians explain different diet plans with patients and family caregivers to help patients get used to buying and preparing foods in ways that reduce both salt and caloric intake.

Patient education

Each member of the health care team is responsible for explaining the connection between his or her specific discipline and the patient's condition. For example, if breathing treatments are ordered by a physician to help keep a patient from getting **pneumonia**, the therapist needs to explain the procedure and the reason for the procedure to the patient. When a patient gets a chest x ray, the radiologic technologist should tell the patient that he or she will need to take in a deep breath and hold it in, so that the lungs fully expand and the radiologist can determine whether the lungs are clear and get an accurate measurement of heart size.

Nursing staff teach patients about the signs and symptoms of heart failure, treatment interventions, and expected outcomes. They are required to teach the patient about his or her specific heart failure and why certain interventions are necessary. For example, if a patient tells the nurse that he or she gets very short of breath walking from one end of the house to the other, the nurse can suggest that the patient choose a point in between to sit down for a few moments to rest. Nursing staff look for physical signs and symptoms of heart failure, chart assessments and vital signs, and review treatments with patients, keeping an eye out for compliance issues and whether treatment appears effective.

Patients who undergo cardiac catheterization are asked a number of questions before the procedure takes place, and then are asked to sign a consent form. Contrast material will be injected into the patient through a small catheter that may require a small incision in the groin or elbow area. The radiologist or technologist explains what physical sensations to expect while the contrast media is being injected, as well as any allergic-reaction potential, including symptoms and side effects.

KEY TERMS

Angioplasty—A technique used for treating blocked coronary arteries by inserting a catheter with a tiny balloon at the tip into the artery and then inflating it.

Angiotensin-converting enzyme (ACE) inhibitor—A drug that relaxes blood-vessel walls and lowers blood pressure.

Arrhythmia—Abnormal heartbeat.

Atherosclerosis—Buildup of a fatty substance called a plaque inside blood vessels.

Calcium-channel blocker—A drug that relaxes blood vessels and lowers blood pressure.

Cardiac catheterization—A diagnostic test for evaluating heart disease; a catheter is inserted into an artery and passed into the heart.

Cardiomyopathy—Disease of the heart muscle.

Catheter—A thin, hollow tube.

Congenital heart defects—Abnormal formation of structures of the heart or of its major blood vessels, present at birth.

Congestive heart failure—A condition in which the heart cannot pump enough blood to supply the body's tissues with sufficient oxygen and nutrients; backup of blood in vessels and the lungs causes buildup of fluid (congestion) in the tissues.

Coronary arteries—Arteries that supply blood to the heart muscle.

Coronary artery bypass—A surgical procedure to reroute blood around a blocked coronary artery.

Coronary artery disease—Narrowing or blockage of coronary arteries by atherosclerosis.

Diuretic—A type of drug that helps the kidneys eliminate excess salt and water.

Edema—Swelling caused by fluid buildup in tissues.

Ejection fraction—A measure of the portion of blood that is pumped out of a filled ventricle.

Heart valves—Valves that regulate blood flow into and out of the heart chambers.

Hypertension—High blood pressure.

Hypertrophic—Enlarged.

Idiopathic cardiomyopathy—Cardiomyopathy without a known cause.

Pulmonary edema—Buildup of fluid in the tissue of the lungs.

Vasodilator—Any drug that relaxes blood-vessel walls.

Ventricles—The two lower chambers of the heart.

Patients who undergo metabolic exercise testing will be monitored carefully throughout the procedure and asked to let the doctor know immediately if they feel any chest pain or dizziness during the procedure.

Prevention

Heart failure is usually caused by the effects of some type of heart disease. The best way to try to prevent heart failure is to eat a healthy diet and get regular exercise, but many causes of heart failure cannot be prevented. People with risk factors for coronary disease (such as high blood pressure and high cholesterol levels) should work closely with their physician to reduce their likelihood of heart attack and heart failure.

Heart failure can sometimes be avoided by identifying and treating any conditions that might lead to heart disease. These include HBP, alcoholism or drug abuse, **obesity**, and CAD. Regular blood-pressure checks and seeking immediate medical care for symptoms of CAD,

such as chest pain, will help to get these conditions diagnosed and treated early, before they progress and damage the heart muscle.

Finally, diagnosing and treating heart failure before the heart becomes severely damaged can improve the prognosis. With proper treatment, many patients may continue to lead active lives for a number of years.

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Susan Joanne Cadwallader

Heart sonogram see **Echocardiography**

Heat cramps see **Heat disorders**

Heat disorders

Definition

Heat disorders are a group of physically related illnesses caused by prolonged exposure to hot temperatures, restricted fluid intake, or failure of temperature regulation mechanisms of the body. Disorders of heat exposure include heat cramps, heat exhaustion, and heat stroke (also called sunstroke). Hyperthermia is the general name given to heat-related illnesses. The two most common forms of hyperthermia are heat exhaustion and heat stroke. Heat stroke is especially dangerous and requires immediate medical attention.

Description

Heat disorders are harmful to people of all ages, but their severity is likely to increase as people age. Heat cramps in a 16-year-old may be heat exhaustion in a 45-year-old and heat stroke in a 65-year-old. The body's temperature-regulating mechanisms rely on the thermal-

regulating centers in the **brain**. Through these complex centers, the body tries to adapt to high temperatures by adjusting the amount of salt in the perspiration. Salt helps the cells in body tissues retain water. In hot weather, a healthy body will lose enough water to cool the body while generating the minimum level of chemical imbalance. Regardless of extreme weather conditions, a healthy human body keeps a steady temperature of approximately 98.6°F (37°C). In hot weather, or during vigorous activity, the body perspires. As perspiration evaporates from skin, the body is cooled. If the body loses too much salt and fluids, the symptoms of **dehydration** can occur.

Heat cramps

Heat cramps are the least severe of the heat-related illnesses. This heat disorder is often the first signal that a body is having difficulty with increased temperature. Individuals exposed to excessive heat should think of heat cramps as a warning sign to a potential heat-related emergency.

Heat exhaustion

Heat exhaustion is a more serious and complex condition than heat cramps. Heat exhaustion can result from prolonged exposure to hot temperatures, restricted fluid intake, or failure of temperature regulation mechanisms of the body. It often affects athletes, firefighters, construction workers, factory workers, and anyone who wears heavy clothing in hot or humid weather.

Heat stroke

Heat exhaustion can develop rapidly into heat stroke, which can be life threatening. Heat stroke, like heat exhaustion, is also a result of prolonged exposure to hot temperatures, restricted fluid intake, or failure of temperature regulation mechanisms of the body. However, the severity of impact on the body is much greater with heat stroke.

Causes and symptoms

Heat cramps

Heat cramps are painful muscle spasms caused by the excessive loss of salts (electrolytes) due to heavy perspiration. This disorder occurs more often in the legs and abdomen than in other areas of the body. Muscle tissue becomes less flexible, causing **pain**, difficult movement, and involuntary tightness. Heavy exertion in extreme heat, restricted fluid intake, or failure of temperature regulation mechanisms of the body may lead to heat cramps. Individuals at higher risk are those working in extreme

KEY TERMS

Convulsions—Also termed seizures; a sudden violent contraction of a group of muscles.

Electrolytes—An element or compound that when melted or dissolved in water dissociates into ions and is able to conduct an electrical current. Careful and regular monitoring of electrolytes and intravenous replacement of fluid and electrolytes are part of the acute care in many illnesses.

Rehydration—The restoration of water or fluid to a body that has become dehydrated.

heat, elderly people, young children, people with health problems, and those who are unable to naturally and properly cool their bodies. Individuals with poor circulation and who take medications to reduce excess body fluids can be at risk when conditions are hot and humid.

Heat exhaustion

Heat exhaustion is caused by exposure to high heat and humidity for many hours, resulting in excessive loss of fluids and salts through heavy perspiration. The skin may appear cool, moist, and pale. An individual may complain of headache and nausea with a feeling of overall weakness and exhaustion. Dizziness, faintness, and mental confusion are often present, as is rapid and weak pulse. Breathing becomes fast and shallow. Fluid loss reduces **blood** volume and lowers **blood pressure**. Yellow or orange urine is often a result of inadequate fluid intake, along with associated intense thirst. Insufficient water and salt intake or a deficiency in the production of sweat can place an individual at high risk for heat exhaustion.

Heat stroke

Heat stroke is caused by overexposure to extreme heat, resulting in a breakdown in the body's heat-regulating mechanisms. The body's temperature reaches a dangerous level, as high as 106°F (41.1°C). An individual with heat stroke has a body temperature higher than 104°F (40°C). Other symptoms include mental confusion with possible combativeness and bizarre behavior, staggering, and faintness.

The pulse becomes strong and rapid (between 160 and 180 beats per minute) with the skin taking on a dry and flushed appearance. There is often very little perspiration. An individual can quickly lose consciousness or have convulsions. Before heatstroke, an individual suf-

fers from heat exhaustion and the associated symptoms. When the body can no longer maintain a normal temperature, heat exhaustion becomes heatstroke. Heat stroke is a life-threatening medical emergency that requires immediate initiation of life-saving measures.

Diagnosis

The diagnosis of heat cramps usually involves the observation of individual symptoms such as muscle cramping and thirst. Diagnosis of heat exhaustion or heat stroke, however, may require a physician to review the medical history, document symptoms, and obtain a blood pressure and temperature reading. The physician may also take blood and urine samples for further laboratory testing. A test to measure the body's electrolytes can also give valuable information about chemical imbalances caused by the heat-related illness.

Treatment

Heat cramps

The care for heat cramps includes placing an individual at rest in a cool environment, while giving cool water with a teaspoon of salt per quart, or a commercial sports drink. Usually, rest and liquids are all that is needed for a person to recover. Mild stretching and massaging of the muscle area follows once the condition improves. An individual should not take salt tablets, since this may actually worsen the condition. When the cramps stop, a person can usually start activity again if there are no other signs of illness. An individual needs to continue drinking fluids and should be watched carefully for further signs of heat-related illnesses.

Heat exhaustion

An individual suffering from heat exhaustion should stop all physical activity and move immediately to a cool place out of the sun, preferably a cool, air-conditioned location. The person should then lie down with feet slightly elevated, loosen or remove clothing, and drink cold (but not iced), slightly salty water or a commercial sports drink. Rest and replacement of fluids and salt are usually all the treatment that is needed; hospitalization is rarely required. Following rehydration, the person usually recovers rapidly.

Heat stroke

Simply moving an individual afflicted with heat stroke to a cooler place is not enough to reverse the internal overheating. Emergency medical assistance should be called immediately. While waiting for help to arrive,

move the person to a cool place, loosen or remove clothes, and allow air to circulate around the body. The next important step is wrapping the individual in wet towels or clothing, and placing ice packs in those areas with the greatest blood supply, such as the neck, under the arm and knees, and in the groin. Once the person is under medical care, **cooling treatments** may continue as appropriate. The person's body temperature will be monitored constantly to guard against overcooling. Breathing and **heart** rate will be monitored closely, and fluids and electrolytes will be replaced intravenously. Anti-convulsant drugs may be given. After severe heat stroke, bed rest may be recommended for several days.

Prognosis

Prompt treatment for heat cramps is usually very effective, allowing an individual to return to activity soon thereafter. Treatment of heat exhaustion usually brings full recovery in one to two days. Heatstroke is a very serious condition, and its outcome depends upon general health and age. Due to the high internal temperature of heat stroke, permanent damage to internal organs is possible.

Health care team roles

Persons trained in **first aid** may provide initial treatment. **Emergency medical technicians** may be necessary, if additional treatment is required. Physicians provide treatment in hospitals. Nurses assist and provide supportive care.

Prevention

Because heat cramps, heat exhaustion, and heat stroke have a cascade effect on each other, the prevention of the onset of all heat disorders is similar. Avoid strenuous **exercise** when it is very hot. Individuals exposed to extreme heat conditions should drink plenty of fluids, and not wait until thirst develops. Wearing light and loose-fitting clothing in hot weather is important, regardless of the activity. If perspiration is excessive, fluid intake should be increased. When urine output decreases, fluid intake should increase. Eating lightly salted foods can help replace salts lost through perspiration. Ventilation in any working areas in warm weather must be adequate.

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Heat exhaustion see **Heat disorders**

Heat treatments

Definition

Heat treatments are therapeutic applications of superficial or deep-heating agents to areas of the body.

Purpose

Thermal agents are used therapeutically to:

- decrease **pain**
- decrease muscle spasm
- decrease muscle tightness and increase flexibility
- prepare joints and muscles for **exercise**
- increase local **blood** flow to the area, thus promoting tissue healing

Precautions

Therapeutic heat treatments should not be used in individuals who have bleeding or recent hemorrhage, an acute inflammatory process, or local **infection** near the point of application. Furthermore, heat treatments should not be used over areas of malignancy, decreased sensation, or vascular disease. Heat treatments also should be used with caution on individuals with **heart**, lung, or kidney diseases. Deep heat treatments should not be used on areas above the eye, heart, or on a pregnant patient. Deep heat treatments over areas with metal surgical implants should be avoided in case of rapid temperature increase and potential for injury.

Description

There are two type of heat treatments: superficial and deep. Superficial treatments are applied to the skin over the involved area. Depth of heat depends on types of tissue and ranges from 0.19 in (0.5 cm) to 0.39–0.78 in (1–2 cm). Heat depth also depends on amount of fat in the area, as fat is an insulator. There are four different ways to convey heat:

- Conduction is the transfer of heat between two objects in direct contact with each other.

- Conversion is the transition of one form of energy to heat.
- Radiation involves the transmission and absorption of electromagnetic waves to produce a heating effect.
- Convection occurs when a liquid or gas moves past a body part creating heat.

Hot packs, water bottles, and heating pads

Hot packs are a very common form of heat treatment using conduction as a form of heat transfer. Moist heat packs are readily available in most hospitals, **physical therapy** centers, and athletic training rooms. Treatment temperature should not exceed 131°F (55°C). The pack is used over multiple layers of toweling to achieve a comfortable warming effect for approximately 30 minutes. More recently, several manufacturers have developed packs that may be warmed in a microwave prior to use.

Hot-water bottles are another form of superficial heat treatment. The bottles are filled half way with hot water between 115–125°F (46.1–52°C). Covered by a protective toweling, the hot-water bottle is placed on the treatment area and left until the water has cooled off.

Electrical heating pads continue to be used as a home treatment, but safety and convenience issues limit their use in healthcare settings.

Paraffin

Paraffin, a conductive form of superficial heat, is often used for heating uneven surface of the body such as the hands. It consists of melted paraffin wax and mineral oil. Paraffin placed in a small bath unit becomes solid at room temperature, and is used as a liquid heat treatment when heated at 126–127.4°F (52–53°C). The most common form of paraffin application is called the dip and wax method. In this technique, the patient will dip eight to 12 times and then the extremity will be covered with a plastic bag and a towel for insulation. Most treatment sessions last about 20 minutes.

Hydrotherapy

Hydrotherapy is used in a form of heat treatment for many musculoskeletal disorders. The hydrotherapy tanks and pools are all generally set at warm temperatures. Because the patient often performs resistance exercises while in the water, higher water temperatures become a concern as the treatment becomes more physiologically draining. Because of this, many hydrotherapy baths are now being set at 95–110°F (35–43.3°C). There are also units available with moveable turbine jets that provide a light massage effect. Hydrotherapy is helpful as a warm-up prior to exercise.

Fluidotherapy

Fluidotherapy is a form of heat treatment developed in the 1970s. It is a dry heat modality consisting of cellulose particles suspended in air. Units come in different sizes and some are restricted to only treating a hand or foot. The turbulence of the gas-solid mixture provides thermal contact with objects that are immersed in the medium. Temperatures of this treatment range from 110–123°F (43.3–50.5°C). Fluidotherapy allows the patient to exercise the limb during the treatment and also massages the limb, increasing blood flow.

Ultrasound

Ultrasound heat treatments penetrate the body to provide relief to inner tissue, thus it is a deep heating agent. Ultrasound energy comes from the acoustic or sound spectrum and is undetectable to the human ear. By using conducting agents such as gel or mineral oil, the ultrasound transducer warms tissue by conversion of sound waves to heat. Some areas of the musculoskeletal system absorb ultrasound better than others. Muscle tissue and other connective tissue such as ligaments and tendons absorb this form of energy very well, but fat absorbs to a much lesser degree. Ultrasound has a relatively long lasting effect, continuing up to one hour.

Diathermy

Diathermy is another deep heat treatment. An electrode drum is used to apply heat to an affected area. It consists of a wire coil surrounded by dead space and other insulators such as a plastic housing. Both short-wave and microwave frequencies have been used in therapeutic deep-heating devices. Prior to ultrasound technology, diathermy was a popular heat therapy of the 1940s–1960s.

Preparation

Before administering any form of heat treatment, nurses and allied health professionals need to assess a patient's sensation and sensitivity to heat. The skin over the area to be heated should be clean. When a patient is undergoing any form of heat treatment supervision should always be present, especially in the treatment of hydrotherapy.

Aftercare

Once the heat treatment has been completed, any symptoms of dizziness and nausea should be noted and documented along with any skin irritations or discoloring not present prior to the heat treatment. A one hour inter-

val between treatments should be adhered to in order to avoid restriction of blood flow.

Complications

All heat treatments have the potential of tissue damage resulting from excessive temperatures. Proper insulation and treatment duration should be carefully administered for each method. Overexposure during a superficial heat treatment may result in redness, blisters, **burns**, or reduced blood circulation. During ultrasound therapy, excessive treatment over bony areas with little soft tissue (such as hand, feet, and elbow) can cause excessive heat resulting in pain and possible tissue damage. Diathermy may produce hot spots, and is contraindicated for patients with metal implants.

Health care team roles

Nurses and allied health care professionals must realize that there are metabolic, vascular, and connective tissue effects secondary to therapeutic heat treatments. When heat is required to deep structures such as deep into a joint, deep heat is appropriate. Superficial heating is variable and depends on area and goal of the heat treatment.

Patient education

Nurses and allied health care professionals may need to provide patients with instructions on home therapeutic treatments. There are many heating agents available commercially which operate either electrically, heated in a microwave, or heated in hot water. Nurses and allied health care professionals need to educate patients on precautions, heating times per day, duration of heating, proper positioning, and any specific instructions related to pathology.

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ORGANIZATIONS

American Physical Therapy Association. 1111 North Fairfax Street. Alexandria, VA 22314. (703) 684-APTA.

Mark Damian Rossi

Heatstroke see **Heat disorders**

Heavy metal poisoning see **Trace metal tests**

Heimlich maneuver

Definition

The Heimlich maneuver is an emergency procedure for removing a foreign object lodged in the airway that is preventing a person from breathing.

Purpose

Each year, approximately 3,000 adults die in the United States because they accidentally inhale rather than swallow food. The food gets stuck and blocks their trachea (windpipe), making breathing impossible. Death follows rapidly unless the food or other foreign material can be displaced from the airway. This condition is so common it has been nicknamed the “café coronary.”

In 1974, Dr. Henry Heimlich first described an emergency technique for expelling foreign material blocking the trachea. This technique, now called the Heimlich maneuver or abdominal thrust, is simple enough that it can be performed immediately by anyone trained in the maneuver. The Heimlich maneuver is a standard part of all **first aid** courses.

The theory behind the Heimlich maneuver is that by compressing the abdomen below the level of the diaphragm, air is forced out of the **lungs** under pressure. This air dislodges the obstruction in the trachea and brings the foreign material back up into the mouth.

The Heimlich maneuver is used mainly when solid materials such as food, coins, vomit, or small toys are blocking the airway. There has been some controversy about whether the Heimlich maneuver is appropriate to use routinely on **near-drowning** victims. After several studies of the effectiveness of the Heimlich maneuver on reestablishing breathing in near-drowning victims, the American Red Cross and the American **Heart Association** both recommend that the Heimlich maneuver be used only as a last resort after traditional airway clearance techniques and **cardiopulmonary resuscitation (CPR)** have been tried repeatedly and failed; or if it is clear that a solid foreign object is blocking the airway.

Precautions

Incorrect application of the Heimlich maneuver can damage the chest, ribs, heart or internal organs of the person on whom it is performed. People may also vomit after being treated with the Heimlich maneuver. It is important to prevent aspiration of the vomitus.

Description

The Heimlich maneuver can be performed on all people. Modifications are necessary if the person choking is very obese, pregnant, a child, or an infant.

Indications that a person’s airway is blocked include:

- inability to speak or cry out
- face turning blue from lack of oxygen
- desperate grabbing at the throat
- weak cough with labored breathing producing a high-pitched noise
- all of the above, followed by unconsciousness

Performing the Heimlich maneuver on adults

To perform the Heimlich maneuver on a conscious adult, the rescuer stands behind the affected person, who may be either sitting or standing. The rescuer makes a fist with one hand and places it, thumb toward the person choking, below the rib cage and above the waist. The rescuer encircles the other person’s waist, placing the other hand on top of the fist.

In a series of six to 10 sharp and distinct thrusts upward and inward, the rescuer attempts to develop enough pressure to force the foreign object back up the trachea. If the maneuver fails, it is repeated. It is important not to give up if the first attempt fails. As the choking person is deprived of oxygen, the muscles of the trachea relax slightly. Because of this loosening, it is possible that a foreign object may be expelled on a second or third attempt.

If the individual choking is unconscious, the rescuer should place the person supine on the floor; bend the chin forward; make sure the tongue is not blocking the airway; and feel in the mouth for any foreign objects, being careful not to push them further into the airway. The rescuer kneels astride the choking person’s thighs and places the fists between the bottom of the choking person’s breastbone and navel. The rescuer then executes a series of six to 10 sharp compressions by pushing inward and upward.

After the abdominal thrusts, the rescuer repeats the process of lifting the chin, moving the tongue, feeling for and possibly removing any foreign material. If the airway is not clear, the rescuer repeats the abdominal thrusts as

often as necessary. If the foreign object has been removed, but the victim is not breathing, the rescuer starts CPR.

Performing the Heimlich maneuver under special circumstances

OBVIOUSLY PREGNANT AND VERY OBESE PEOPLE.

The main difference in performing the Heimlich maneuver on this group of people is in the placement of the fists. Instead of using abdominal thrusts, chest thrusts are used. The fists are placed against the middle of the breastbone (sternum), and the motion of the chest thrust is in and downward, rather than upward. If the person choking is unconscious, the chest thrusts are similar to those used in CPR.

CHILDREN. The technique in children over one year of age is the same as in adults, except that the amount of force used is less than that used with adults, in order to avoid damaging a child's ribs, breastbone, and internal organs.

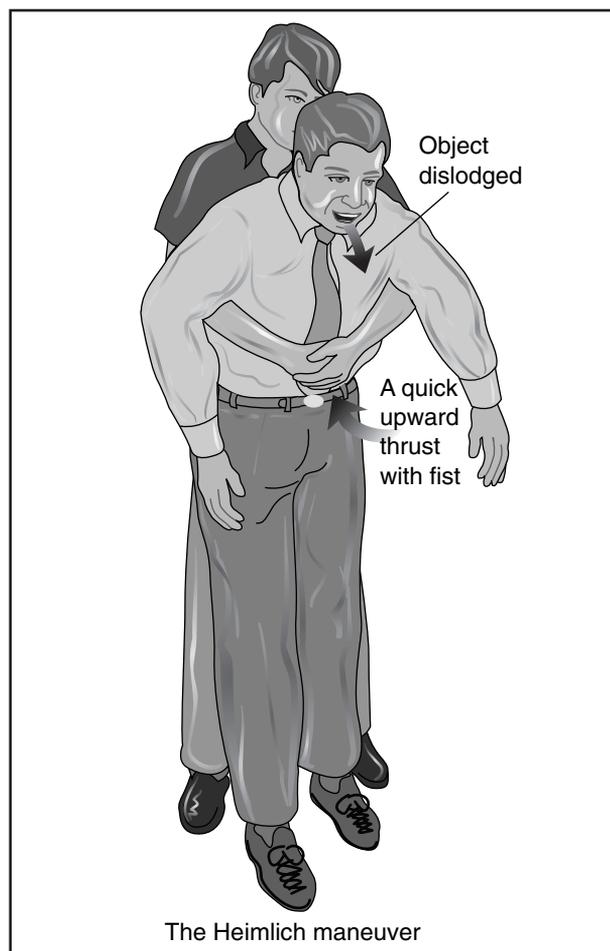
INFANTS UNDER ONE YEAR OLD. The rescuer sits down and positions the infant along the rescuer's forearm with the infant's face pointed toward the floor and at a lower level than the infant's chest. The rescuer's hand supports the infant's head. The forearm rests on the rescuer's own thigh for additional support. Using the heel of the other hand, the rescuer administers four or five rapid blows to the infant's back between the shoulder blades.

After administering the back blows, the rescuer sandwiches the infant between both arms. The infant is turned over so that it lies face up, supported by the rescuer's opposite arm. Using the free hand, the rescuer places the index and middle finger on the center of the breastbone and makes four sharp chest thrusts. This series of back blows and chest thrusts is alternated until the foreign object is expelled.

SELF-ADMINISTRATION OF THE HEIMLICH MANEUVER. To apply the Heimlich maneuver to oneself, a choking person should make a fist with one hand and place it in the middle of the body at a spot above the navel and below the breastbone, then grasp the fist with the other hand and push sharply inward and upward. If this fails, the choking person should press the upper abdomen over the back of a chair, edge of a table, porch railing or something similar, and thrust up and inward until the object is dislodged.

Preparation

Any person can be trained to perform the Heimlich maneuver. Knowing how to perform it may save someone's life. Before doing the maneuver, it is important to



To perform the Heimlich maneuver on a conscious adult (as illustrated above), the rescuer stands behind the victim and encircles his waist. The rescuer makes a fist with one hand and places the other hand on top, positioned below the rib cage and above the waist. The rescuer then applies pressure by a series of upward and inward thrusts to force the foreign object back up the victim's trachea. (Illustration by Electronic Illustrators Group.)

determine if the airway is completely blocked. If the choking person can talk or cry, the Heimlich maneuver is not appropriate. If the airway is not completely blocked, the choking person should be allowed to try to cough up the foreign object without assistance.

Aftercare

Once the obstruction is removed, most persons who experience an episode of choking recover without any further care. Persons who have an obstruction that cannot be dislodged but are able to breathe should be taken to an emergency room for treatment.

KEY TERMS

Diaphragm—The thin layer of muscle that separates the chest cavity, which contains the lungs and heart, from the abdominal cavity, which contains the intestines and digestive organs.

Sternum—The breastbone. The sternum is located over the heart, is the point of attachment for ribs at the front of the body and provides protection to the heart beneath it.

Trachea—The windpipe. A tube extending from below the voice box into the chest where it splits into two branches, the bronchi, that lead to each lung.

Complications

Many people vomit after being treated with the Heimlich maneuver. Depending on the length and severity of the choking episode, the person may need to be taken to a hospital emergency room. Occasionally, one or more ribs of the choking person may be broken during administration of the Heimlich maneuver. Applying the Heimlich maneuver too vigorously may result in an injury to the internal organs of the choking person. There may be some local **pain** and tenderness at the point where the rescuer's fist was placed. In infants, a rescuer should never attempt to sweep the baby's mouth without looking to remove foreign material. This is likely to push the material farther down the trachea. If the foreign material is not removed, the person choking will die from lack of oxygen.

Results

The Heimlich maneuver usually results in the expulsion and removal of an obstruction in the throat. The choking person suffers no permanent effects from the episode.

Health care team roles

Anyone can be trained to successfully apply the Heimlich maneuver. Most of the applications each year are provided by trained volunteers. Health professionals may become involved. Paramedics may apply the Heimlich maneuver to a choking person. Physicians, physician assistants and nurses may provide additional treatment in a hospital emergency room. Nurses may provide some follow-up care.

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ORGANIZATIONS

- American College of Emergency Physicians. P.O. Box 619911, Dallas, TX 75261-9911. (800) 798-1822 or (972) 550-0911. Fax: (972) 580-2816. <<http://www.acep.org/>>. info@acep.org.
- American College of Osteopathic Emergency Physicians. 142 E. Ontario Street, Suite 550, Chicago, IL 60611. (312) 587-3709 or (800) 521-3709. Fax: (312) 587-9951. <<http://www.acoep.org/>>.
- Heimlich Institute. PO Box 8858, Cincinnati, OH 45208. <<http://www.heimlichinstitute.org/index.htm>>. heimlich@iglou.com.

OTHER

- Harvard Medical School web site. <<http://www.health.harvard.edu/fhg/firstaid/heimlichChild.shtml>>.
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L. Fleming Fallon, Jr., MD, PhD, DrPH

HELLP see **Preeclampsia and eclampsia**

Hematocrit

Definition

The hematocrit is a test that measures the volume of **blood** by the percentage that is comprised of red blood cells. The hematocrit is also called the packed red cell volume because classically it is measured by centrifuging the blood in a capillary tube.

Purpose

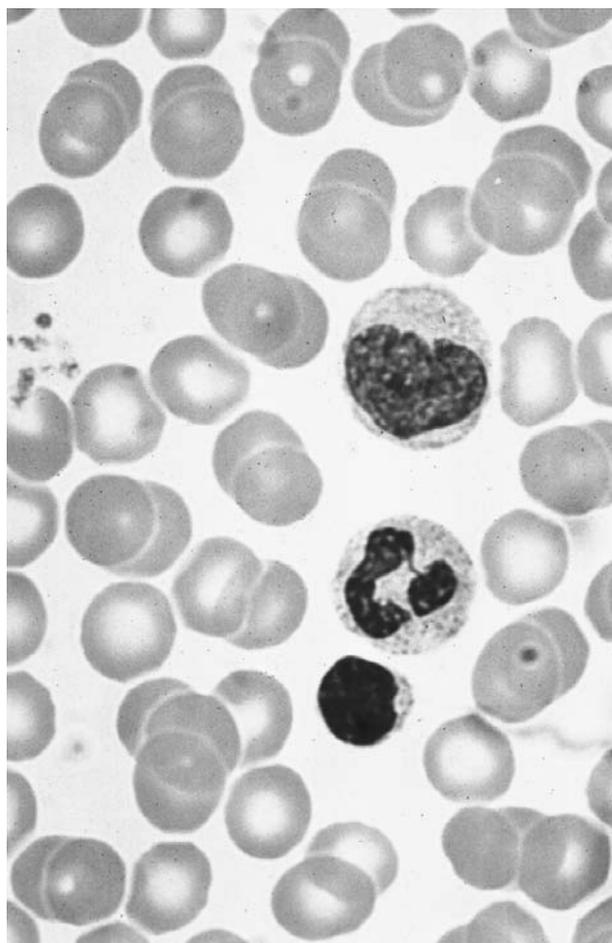
The hematocrit is used to screen for anemia, or is measured on a person to determine the extent of anemia. An anemic person has fewer or smaller than normal red blood cells. A low hematocrit, combined with other abnormal blood tests, confirms the diagnosis. The hematocrit is decreased in a variety of common conditions including chronic and recent acute blood loss, some cancers, kidney and **liver** diseases, malnutrition, **vitamin B₁₂** and **foliac acid** deficiencies, **iron** deficiency, **pregnancy**, systemic lupus erythematosus, rheumatoid arthritis and peptic ulcer disease. An elevated hematocrit is most often associated with severe **burns**, **diarrhea**, **shock**, Addison's disease, and **dehydration**. These conditions reduce the volume of plasma water causing a relative increase in RBCs or hemoconcentration. An elevated hematocrit may also be caused by an absolute increase in blood cells called polycythemia. This may be secondary to hypoxia or the result of a proliferation of blood forming cells in the bone marrow (polycythemia vera).

Transfusion decisions are based upon the results of laboratory tests, including the hematocrit. Generally, transfusion is not considered necessary if the hematocrit is below 21%. The hematocrit is also used as a guide to how many transfusions are needed. Each unit of packed red blood cells administered to an adult is expected to increase the hematocrit by approximately 4%.

Precautions

Fluid volume in the blood affects hematocrit values. Accordingly, the blood sample should not be taken from an arm receiving IV fluid or during hemodialysis. It should be noted that pregnant women have extra fluid, which dilutes the blood, decreasing the hematocrit. Dehydration concentrates the blood, which increases the hematocrit.

In addition, care should be taken to avoid hemolysis, as this will invalidate test results. Certain drugs such as penicillin and chloramphenicol may decrease the hematocrit, while glucose levels above 400 mg/dL are known to elevate results. Blood should be collected in heparin or



Red blood cells. (Photograph by Biophoto Associates. Photo Researchers, Inc. Reproduced by permission.)

EDTA (edetic acid) and measured within six hours to avoid RBC (red blood cell) swelling. Prolonged use of the tourniquet during collection will increase the hematocrit. Excess EDTA caused by an incomplete filling of the tube will falsely lower the hematocrit. Blood for hematocrit may be collected either by finger puncture or venipuncture. When performing a finger puncture, the first drop of blood should be wiped away because it dilutes the sample with tissue fluid. A nurse or phlebotomist usually collects the sample following standard precautions for the prevention of transmission of blood-borne pathogens.

Description

Blood is made up of red blood cells, white blood cells (WBCs), platelets, and plasma. A decrease in the number or size of red cells also decreases the amount of space they occupy, resulting in a lower hematocrit. Conversely, an increase in the number or size of red cells

KEY TERMS

Anemia—A lack of oxygen carrying capacity commonly caused by a decrease in red blood cell number, size, or function.

Hematocrit—The volume of blood occupied by the red blood cells expressed in percent.

increases the amount of space they occupy, resulting in a higher hematocrit. Thalassemia minor is an exception in that it usually causes an increase in the number of red blood cells, but because they are small, it results in a decreased hematocrit.

The hematocrit may be measured manually by centrifugation. A thin capillary tube called a microhematocrit tube is filled with blood and sealed at the bottom. The tube is centrifuged at 10,000 RPM (revolutions per minute) for five minutes. The RBCs have the greatest mass and are forced to the bottom of the tube. The WBCs and platelets form a thin layer between the RBCs and the plasma called the buffy coat, and the liquid plasma rises to the top. The height of the red cell column is measured as a percent of the total blood column. The higher the column of red cells, the higher the hematocrit. Most commonly, the hematocrit is measured indirectly by an automated blood cell counter. The counter measures the RBCs by impedance. A RBC displaces electrolyte in the counting aperture causing a voltage pulse proportional to the cell size. The instrument calculates the mean cell volume (MCV) from the voltage pulses. The MCV is multiplied by the RBC count to give the hematocrit. Whole blood electrolyte analyzers measure the hematocrit using a conductivity electrode. The electrical conductivity of the sample is inversely related to the hematocrit after correcting for the sodium concentration. It is important to recognize that different results may be obtained when different measurement principles are used. For example, the microhematocrit tube method will give slightly higher results than the electronic methods when RBCs of abnormal shape are present because more plasma is trapped between the cells.

Aftercare

Discomfort or bruising may occur at the puncture site. Pressure to the puncture site until the bleeding stops reduces bruising; warm packs relieve discomfort. Some people feel dizzy or faint after blood has been drawn and should be treated accordingly.

Complications

Other than potential bruising at the puncture site, and/or dizziness, there are no complications associated with this test.

Results

Normal values vary with age and sex. Some representative ranges are:

- at birth: 42-60%
- six to 12 months: 33-40%
- adult males: 42-52%
- adult females: 35-47%

Health care team roles

Laboratory scientists perform hematocrit tests using manual or automated procedures. Critically high or low levels should be immediately called to the attention of the patient's nurse or doctor. Nurses should bring high or low hematocrit levels to the attention of the patient's physician, and should also report any signs and symptoms that could be associated with the increase or decrease such as medications, excessive thirst, tachycardia, low **blood pressure**, weakness, etc.

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Victoria E. DeMoranville

Hemiballismus *see* **Movement disorders**

Hemiplegia *see* **Paralysis**

Hemodialysis *see* **Dialysis, kidney**

Hemodialysis shunt, graft, and fistula care

Definition

A hemodialysis shunt, graft, or fistula provides vascular access for hemodialysis, a treatment that cleans the

blood by removing wastes and excess water from the body.

Purpose

Kidneys remove wastes from the blood through the urine, regulate the amount of water and **minerals** needed by the body, and produce hormones. When the kidneys lose their ability to filter wastes and excess water from the blood, hemodialysis is required. During hemodialysis, the blood is circulated through a hemodialysis (artificial kidney) machine. Hemodialysis cleans blood similar to the way kidneys do. A vascular site, such as an arteriovenous (AV) fistula or graft, provides access for the removal and return of blood during hemodialysis. The patient's blood is removed and circulated through a machine that contains a dialyzer. The wastes and excess water from the patient's blood pass through the dialysis machine's membrane into the dialysate, and are then discarded. The dialyzed (cleaned) blood is returned to the patient's bloodstream.

Description

The patient is attached to the hemodialysis machine through several means. The most common method of providing permanent access to the bloodstream for hemodialysis is an arteriovenous (AV) fistula. An AV fistula is created surgically by connecting an artery to a vein, usually in the forearm. An AV fistula requires planning more than other kinds of access because it takes two to six months to develop. During this time, the stronger blood flow from the artery causes the vein to become larger. This allows the fistula to take repeated needle insertions, and for blood to flow quickly to the dialyzer. Another way to provide vascular access to the bloodstream is through an internal graft surgically connecting an artery to a vein with a synthetic or bovine graft placed under the skin. A hemodialysis graft does not need to develop as a fistula does and so can be used soon after it has been placed. Other types of vascular access, such as catheters and shunts, are temporary forms of access.

Complications

The primary complications of vascular access are clotting and **infection**. After an AV fistula has developed, it is less likely to form clots or get infected. Grafts typically have more problems with infection and clotting and need revisions or replacement sooner than fistulas. Proper hemodialysis depends on fistulas and grafts that work well.

To preserve and protect AV access:

KEY TERMS

Arteriovenous (AV) fistula—Surgical connection of an artery to a vein.

Bovine graft—Transplanted vein from a cow.

Dialysate—The cleansing solution used in hemodialysis.

Dialyzer—A part of the hemodialysis machine that contains two sections, one for the dialysate and one for the patient's blood.

Hemodialysis—The use of a machine to clean wastes from the blood when the kidneys cannot do it.

Hormone—A natural chemical produced by a part of the body to trigger or regulate particular functions.

Kidneys—Two bean-shaped organs that filter wastes from the blood and create urine.

Nephrologist—Physician who specializes in diseases of the kidney.

Nephropathy—Disease of the kidney.

Renal—Having to do with the kidneys.

- Keep the access site clean at all times to prevent infection.
- Avoid injections, intravenous (IV) needles or fluids, or taking blood samples in the access site arm.
- Needle insertions for hemodialysis treatments should be rotated so that one spot is not repeatedly stuck and weakened.
- Do not take **blood pressure** or put pressure on the access arm.
- Advise patients to avoid wearing jewelry or tight clothing, sleeping on, or lifting heavy objects with the access arm.
- Check the temperature and color of the fingers and the pulse of the access arm for adequate circulation.
- Check for signs of infection at the access site.

Results

AV fistulas usually last longer and have less complications than other kinds of vascular access.

Health care team roles

The health care team can help patients prepare and maintain their vascular access. The type of vascular access selected for patients depends on their individual needs such as vein size. The health care team provides the information and support for patients and families on how to preserve and protect their vascular access.

Resources

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American Nephrology Nurses' Association. East Holly Ave., Box 56, Pitman, NJ 08071. (888) 600-2662. <<http://anna.inurse.com/>>.

National Institute of Diabetes and Digestive and Kidney Diseases. 3 Information Way, Bethesda, MD 20892.

National Kidney Foundation. 30 East 33rd St., New York, NY 10016. (800) 622-9010. <<http://www.kidney.org>>.

National Kidney and Urologic Diseases Information Clearinghouse. 3 Information Way, Bethesda, MD 20892. (800) 891-5390.

Deborah E. Parker, R.N.

Hemoglobin test

Definition

Hemoglobin is a protein inside red **blood** cells that carries oxygen. A hemoglobin test reveals how much hemoglobin is in a person's blood. This information can be used to help physician's diagnose and monitor anemia and polycythemia vera, a condition in which the bone marrow produces too many blood cells.

Purpose

A hemoglobin test is performed to determine the amount of hemoglobin in a person's red blood cells (RBCs). This is important because the amount of oxygen available to tissues depends upon how much oxyhemoglobin is in the RBCs, and local perfusion of the tissues. Without sufficient hemoglobin, the tissues lack oxygen and the **heart** and **lungs** must work harder to compensate.

A low hemoglobin measurement usually means the person has anemia. Anemia results from a decrease in the number, size, or function of RBCs. Common causes include excessive bleeding, a deficiency of **iron**, **vitamin B₁₂**, or **follic acid**, destruction of red cells by antibodies or mechanical trauma, and structurally abnormal hemoglobin. Hemoglobin levels are also decreased due to **cancer**, kidney diseases, and excessive IV fluids. An elevated hemoglobin may be caused by **dehydration**, hypoxia, or polycythemia vera. Hypoxia may result from high altitudes, chronic obstructive lung diseases, and congestive **heart failure**. Hemoglobin levels are also used to determine if a person needs a blood transfusion. Usually a person's hemoglobin must be below 8 g/dL before a transfusion is considered. The hemoglobin concentration is also used to determine how many units of packed red blood cells should be transfused. A common rule of thumb is that each unit of red cells should increase the hemoglobin by approximately 1.5 g/dL.

Precautions

Fluid volume in the blood affects hemoglobin values. Accordingly, the blood sample should not be taken from an arm receiving IV fluid. It should also be noted that pregnant women and people with cirrhosis have extra fluid, which dilutes the blood, decreasing the hemoglobin. Dehydration concentrates the blood, which may cause an increased hemoglobin result.

Certain drugs such as **antibiotics**, aspirin, antineoplastic drugs, doxapram, indomethacin, sulfonamides, primaquine, rifampin, and trimethadione, may also decrease the hemoglobin level.

A nurse or phlebotomist usually collects the sample by venipuncture or fingerstick following standard precautions for the prevention of transmission of bloodborne pathogens.

Description

Hemoglobin is a complex protein composed of four subunits. Each subunit consists of a polypeptide chain that enfolds a heme group. Each heme contains iron

(Fe²⁺) which can bind a molecule of oxygen. The iron gives blood its red color. After the first year of life, 95-97% of the hemoglobin molecules contain two pairs of polypeptide chains designated alpha and beta. This form of hemoglobin is called hemoglobin A.

Hemoglobin is most commonly measured by the cyanmethemoglobin method. Whole blood is mixed with a buffered solution of potassium ferricyanide and potassium cyanide. The potassium ferricyanide oxidizes the heme iron forming methemoglobin (Fe³⁺). This reacts with potassium cyanide forming cyanmethemoglobin which is orange-red. The absorbance of the solution measured at 540 nm is proportional to the hemoglobin concentration. Hemoglobin is most often performed as part of a **complete blood count** (CBC), a test that includes counts of the red blood cells, white blood cells, and platelets (thrombocytes).

Some people inherit hemoglobin with an abnormal structure. The abnormal hemoglobin results from a point mutation in one or both genes that code for the alpha or beta polypeptide chains. Examples of abnormal hemoglobins resulting from a single amino acid substitution in the beta chain are sickle cell and hemoglobin C disease. Most abnormal hemoglobin molecules can be detected by hemoglobin electrophoresis. This procedure separates hemoglobin molecules with different net charges.

Preparation

No special preparation is required. Blood is collected by venipuncture in a tube containing EDTA anticoagulant after disinfecting the puncture site.

Aftercare

Discomfort or bruising may occur at the puncture site. Pressure to the puncture site until the bleeding stops reduces bruising; warm packs relieve discomfort. Some people feel dizzy or faint after blood has been drawn and should be treated accordingly.

Complications

Other than potential bruising at the puncture site, and/or dizziness, there are no complications associated with this test.

Results

Normal values vary with age and sex, with women generally having lower hemoglobin values than men. Normal results for men range from 13.6-17.2 g/dL. For women the normal range is 12-15 g/dL. Critical limits

KEY TERMS

Anemia—A diminished oxygen carrying capacity caused by a decrease in the size, number, or function of red blood cells.

Hemoglobin—A protein inside red blood cells that carries oxygen to body tissues.

Polycythemia vera—A disease in which the bone marrow makes too many blood cells.

(panic values) for both males and females are below 5.0 g/dL or above 20.0 g/dL.

A low hemoglobin value usually indicates the person has anemia. Further tests are done to discover the cause and type of anemia. Dangerously low hemoglobin levels put a person at risk of a heart attack, congestive heart failure, or stroke. A high hemoglobin value indicates the body is making too many red cells. Further tests are performed to differentiate the cause.

Health care team roles

Laboratory scientists perform hemoglobin tests using automated laboratory equipment. Critically high or low levels should be immediately called to the attention of the patient's nurse or doctor. Nurses should bring high or low hemoglobin levels to the attention of the patient's physician, and should also report any signs and symptoms that could be associated with an abnormal hemoglobin: medications, excessive thirst, tachycardia, low **blood pressure**, weakness, etc.

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Hemopexin test see **Plasma protein tests**

Hemophilia

Definition

Hemophilia is a genetic disorder of the mechanism of **blood** clotting that is usually inherited. Depending on the degree of the disorder present in an individual, excess bleeding may occur only after specific, predictable events (such as surgery, dental procedures, or injury), or occur spontaneously, with no known initiating event.

Description

The normal mechanism for blood clotting is a complex series of events involving the interaction of injured blood vessels, blood cells (called platelets), and over 20 different **proteins** that also circulate in the blood.

When a blood vessel is injured in a way that causes bleeding, platelets collect over the injured area, and form a temporary plug to prevent further bleeding. This temporary plug, however, is too disorganized to serve as a long-term solution. A series of chemical events occur, resulting in the formation of a more reliable plug. The final plug involves tightly woven fibers of a material called fibrin. The production of fibrin requires the interaction of several chemicals, in particular a series of proteins called clotting factors. At least thirteen different clotting factors have been identified.

The clotting cascade, as it is called, is the series of events required to form the final fibrin clot. The cascade uses a technique called amplification to rapidly produce the proper sized fibrin clot from the small number of molecules initially activated by an injury.

In hemophilia, certain clotting factors are either decreased in quantity, absent, or improperly formed. Because the clotting cascade uses amplification to plug a bleeding area rapidly, absence or inactivity of just one clotting factor can greatly increase bleeding time and slow the formation of a clot.

Hemophilia A is the most common type of bleeding disorder and involves decreased activity of factor VIII. There are three levels of factor VIII deficiency: severe, moderate, and mild. This classification is based on the percentage of normal factor VIII activity present:

- Individuals with less than 1% of normal factor VIII activity level have severe hemophilia. Half of all people with hemophilia A fall into this category. Such individuals frequently experience spontaneous bleeding, most frequently into their joints, skin, and muscles. Surgery or trauma can result in life-threatening hemorrhage, and must be carefully managed.

- Individuals with 1-5% of normal factor VIII activity level have moderate hemophilia, and are at risk for heavy bleeding after seemingly minor traumatic injury.
- Individuals with 5-40% of normal factor VIII activity level have mild hemophilia, and must prepare carefully for any surgery or dental procedures.

Individuals with hemophilia B have symptoms very similar to those of hemophilia A, but the deficient factor is factor IX. This type of hemophilia is also known as Christmas disease.

Hemophilia C involves factor XI, is very rare, and much more mild than hemophilia A or B.

Hemophilia A and B are both caused by a genetic defect present on the X chromosome. (Hemophilia C is inherited in a different fashion.) About 70% of all people with hemophilia A or B inherited the disease. The other 30% develop the disease as a result of a spontaneous genetic mutation.

The following concepts are important to understanding the inheritance of these diseases. All humans have two chromosomes determining their gender: females have XX, males have XY. Because the trait is carried only on the X chromosome, it is termed sex-linked. The chromosomes are comprised of units referred to as genes.

Both factors VIII and IX are produced by genes located on the X chromosome, so hemophilia A and B are both sex-linked diseases. Because a female child always receives two X chromosomes, she nearly always will receive at least one normal X chromosome. Therefore, even if she receives one abnormal X chromosome, she will still be capable of producing a sufficient quantity of factors VIII and IX to avoid the symptoms of hemophilia. Such a person who has one abnormal chromosome, but does not actually experience disease symptoms, is called a carrier. She carries the abnormal gene that causes hemophilia and can pass it on to her offspring. If, however, she has a son who receives her abnormal X chromosome, he will be unable to produce the right quantity of factors VIII or IX, and he will have some degree of hemophilia. (Males inherit one X and one Y chromosome, and therefore have only one X chromosome.)

In rare cases, a hemophiliac father and a carrier mother can pass on the right combination of parental chromosomes to result in a hemophiliac female child. This situation, however, is rare. The vast majority of people with hemophilia A or B are male.

About 30% of all people with hemophilia A or B are the first member of their family to ever have the disease. These individuals have had the unfortunate occurrence of a spontaneous mutation; meaning that in their early development, some random genetic accident befell their

X chromosome, resulting in the defect causing hemophilia A or B. Once such a spontaneous genetic mutation takes place, offspring of the affected person can inherit the newly-created, abnormal chromosome.

Hemophilia A affects between one in 5,000 to one in 10,000 males in most populations.

One recent study estimated the prevalence of hemophilia to be 13.4 cases per 100,000 U.S. males (10.5 hemophilia A and 2.9 hemophilia B). By race or ethnicity, the prevalence was 13.2 cases per 100,000 among white, 11.0 among African-American, and 11.5 among Hispanic males.

Causes and symptoms

In the case of severe hemophilia, the first bleeding event usually occurs prior to 18 months of age. In some babies, hemophilia is suspected immediately when a routine circumcision (removal of the foreskin of a penis) results in unusually heavy bleeding. Toddlers are at particular risk because they fall frequently, and may bleed into the soft tissue of their arms and legs. These small bleeds result in bruising and noticeable lumps but usually don't need treatment. As a child becomes more active, bleeding may occur into the muscles. This is a much more painful and debilitating problem. Such muscle bleedings result in **pain** and pressure on the nerves in the area of the bleeding. Damage to nerves can cause numbness and decreased ability to use the injured limb.

Some of the most problematic and frequent bleeds occur into the joints, particularly into the knees and elbows. Repeated bleeding into joints can result in scarring within the joints and permanent deformities. Individuals may develop arthritis in joints that have suffered continued irritation from the presence of blood. Mouth injuries can result in compression of the airway, and, therefore, can be life-threatening. A blow to the head, which might be totally insignificant in a normal individual, can result in bleeding into the **skull** and **brain** in someone with hemophilia. Because the skull has no room for expansion, a hemophiliac individual is at risk for brain damage due to blood taking up space and exerting pressure on the delicate brain tissue.

People with hemophilia are at very high risk of hemorrhage (severe, heavy, uncontrollable bleeding) from injuries such as motor vehicle accidents and also from surgery.

Some other rare clotting disorders such as Von Willebrand disease present similar symptoms but are not usually called hemophilia.

Diagnosis

Various tests are available to measure, under very carefully controlled conditions, the length of time it takes to produce certain components of the final fibrin clot. Tests called assays can also determine the percentage of factors VIII and IX present compared to normal percentages. This information can help in demonstrating the type, as well as the severity, of hemophilia present.

Individuals with a family history of hemophilia may benefit from **genetic counseling** before deciding to have a baby. Families with a history of hemophilia can also have tests done during a **pregnancy** to determine whether the fetus has hemophilia. The test, called chorionic villous sampling, examines proteins for the defects that lead to hemophilia. This test, which is associated with a 1% risk of **miscarriage**, can be performed at 10-14 weeks of gestation. The test called **amniocentesis** examines the DNA of fetal cells shed into the amniotic fluid for genetic mutations. Amniocentesis, which is associated with a one in 200 risk of miscarriage, is performed at 15-18 weeks of gestation.

Treatment

The most important thing that individuals with hemophilia can do to prevent complications of their disease is to avoid injury. Those individuals who require dental work or any surgery may need to be pre-treated with an infusion of factor VIII to avoid hemorrhage. Also, hemophiliacs should be vaccinated against hepatitis. Medications or drugs that promote bleeding, such as aspirin, should be avoided.

Various types of factors VIII and IX are available to replace a person's missing factors. These are administered intravenously (directly into a person's veins by needle). These factor preparations may be obtained from a single donor, by pooling the donations of as many as thousands of donors, or by laboratory creation through highly advanced genetic techniques.

The frequency of treatment with factors depends on the severity of a person's disease. People with relatively mild disease will only require treatment in the event of injury, or to prepare for scheduled surgical or dental procedures. Individuals with more severe disease will require regular treatment to avoid spontaneous bleeding.

While appropriate treatment of hemophilia can both decrease discomfort and be life-saving, complications associated with treatment can also be quite serious. About 20% of all people with hemophilia A begin to produce chemicals in their bodies that rapidly destroy infused factor VIII. The presence of such a chemical may

KEY TERMS

Amplification—A process by which something is made larger. In clotting, only a very few chemicals are released by the initial injury; they result in a cascade of chemical reactions which produces increasingly larger quantities of different chemicals, resulting in an appropriately-sized, strong fibrin clot.

Factors—Coagulation factors are substances in the blood, such as proteins and minerals, that are necessary for clotting. Each clotting substance is designated with roman numerals I through XIII.

Fibrin—The final substance created through the clotting cascade, which provides a strong, reliable plug to prevent further bleeding from the initial injury.

Hemorrhage—Very severe, massive bleeding which is difficult to control. Hemorrhage can occur in hemophiliacs after what would be a relatively minor injury to a person with normal clotting factors.

Mutation—In genetic inheritance, a permanent change in part of a chromosome.

Platelets—Blood cells involved in the clotting process.

Trauma—Injury.

greatly hamper efforts to prevent or stop a major hemorrhage.

Individuals who receive factor prepared from pooled donor blood are at risk for serious infections that may be passed through blood. Hepatitis, a severe and potentially fatal viral **liver infection**, may be contracted from pooled factor preparations. Recently, much concern has been raised about the possibility of hemophiliacs contracting a fatal slow virus infection of the brain (CJD or **Creutzfeldt-Jakob disease**) from blood products. Unfortunately, pooled factor preparations in the early 1980s were contaminated with human **immunodeficiency virus (HIV)**, the virus that causes **AIDS**. A large number of hemophiliacs were infected with HIV and some statistics show that HIV is still the leading cause of death among hemophiliacs. Currently, careful methods of donor testing, as well as methods of inactivating **viruses** present in donated blood, have greatly lowered this risk.

The most exciting new treatments currently being studied involve efforts to transfer new genes to hemo-

philiacs. These new genes would have the ability to produce the missing factors. As yet, these techniques are not being performed on humans, but there is great hope that eventually this type of **gene therapy** will be available.

Prognosis

Prognosis is very difficult to generalize because there are so many variations in the severity of hemophilia, and because much of what befalls a person with hemophilia will depend on issues such as physical activity level and accidental injuries. Statistics on prognosis are not generally available.

Health care team roles

Hemophilia is usually diagnosed by a pediatrician or family physician. These doctors, assisted by a hematologist, usually also provide care. Nurses may provide supportive care.

Prevention

People who know that their family includes hemophiliacs should receive careful genetic counseling before deciding to have a baby. There is no way to prevent the 30% of hemophilia cases that are caused by new, spontaneous mutations.

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ORGANIZATIONS

American Academy of Family Physicians, 11400 Tomahawk Creek Parkway, Leawood, KS 66211-2672. (913) 906-6000. <<http://www.aafp.org>>. fp@aafp.org.

American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. Fax: (847) 434-8000. <<http://www.aap.org/default.htm>>. kidsdoc@aap.org.

American College of Physicians, 190 N. Independence Mall West, Philadelphia, PA 19106-1572. (800) 523-1546, x 2600 or (215) 351-2600. <<http://www.acponline.org>>.

American Medical Association, 515 N. State Street, Chicago, IL 60610. (312) 464-5000. <<http://www.ama-assn.org>>.

American Society of Hematology, 1900 M Street NW, Suite 200, Washington, DC 20036. (202) 776-0544. Fax: (202) 776-0545. <<http://www.hematology.org>>. ash@hematology.org.

National Hemophilia Foundation, 116 West 32nd Street, 11th Floor, New York, NY 10001. (800) 424-2634 or (212) 328-3700. Fax: (212) 328-3777. <<http://www.hemophilia.org/home.htm>>. info@hemophilia.org.

World Federation of Hemophilia, 1425 René Lévesque Boulevard West, Suite 1010, Montréal, Quebec, Canada, H3G 1T7. (514) 875-7944. Fax: (514) 875-8916. <<http://www.wfh.org>>. wfh@wfh.com.

OTHER

Blood Net. <<http://bloodnet.org/toppage2.htm>>.

Canadian Hemophilia Society. <<http://www.hemophilia.ca/english>>.

Hemophilia Federation of America. <<http://www.hemophili-fed.org>>.

Hemophilia Home Page. <<http://www.web-depot.com/hemophilia>>.

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National Heart, Lung and Blood Institute. <http://www.nhlbi.nih.gov/health/public/blood/other/hemo_97.htm>.

Vanderbilt University College of Medicine. <<http://www.mc.vanderbilt.edu/peds/pidl/hemeonc/hemophil.htm>>.

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Hepatic carcinoma see **Liver cancer**

Hepatitis-associated antigen (HAA) test see **Hepatitis virus tests**

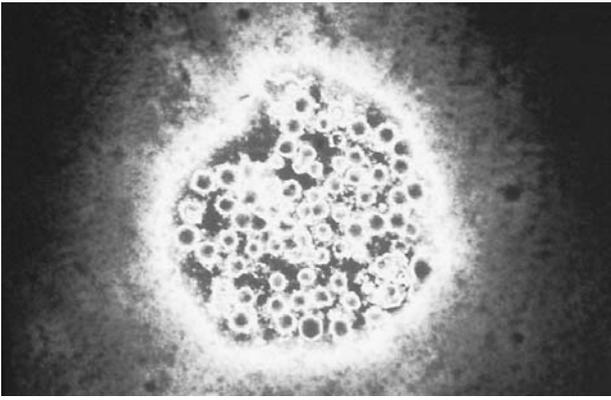
Hepatitis virus tests

Definition

Viral hepatitis is any type of **liver** inflammation caused by a viral **infection**. The three most common **viruses** now recognized to cause liver disease are hepatitis A (infectious hepatitis), hepatitis B (serum hepatitis), and hepatitis C (non-A, non-B hepatitis). Several other types of viral hepatitis have been recognized recently, including hepatitis D (delta hepatitis), hepatitis E (epidemic hepatitis), and hepatitis G. A seventh type called transfusion-transmitted virus (TTV), a single-stranded DNA virus, has been implicated in post transfusion hepatitis. Commercial tests are not yet available to screen for HGV, and TTV infections. All **blood** and blood products donated for transfusion in the United States are screened for hepatitis B and hepatitis C.

Purpose

The different types of viral hepatitis produce similar symptoms, but they differ in terms of transmission, clinical course, and prognosis. Common symptoms are **jaundice**, malaise, nausea, and anorexia. It is estimated that approximately 600,000 cases of viral hepatitis occur in the United States each year, about half being caused by hepatitis B virus (HBV). Viral hepatitis infection is diagnosed by identifying specific viral antigens and/or anti-



Hepatitis A virus, magnified x225,000. (Custom Medical Stock Photo. Reproduced by permission.)

bodies associated with each type of viral hepatitis. An antigen is a substance, usually a protein, that is foreign to the body. An antibody is a protein manufactured by lymphocytes, a type of white blood cell, to neutralize the antigen. Hepatitis testing is also used to monitor the course of viral hepatitis.

Precautions

False negative and positive test results may occur in a small number of persons tested. Fibrin deposits, heterophile antibodies, sample carryover, and autoantibodies such as rheumatoid factor have been reported to cause false positive results for some hepatitis tests. Repeat testing of reactive samples eliminates most false positives. False negatives may be caused when antigen or antibody levels are too low to detect, as in the “window phase” of infection. This is defined as the period between initial infection and the appearance of IgG antibodies.

Hepatitis B vaccine is recommended for health care workers who may be exposed to blood or body fluids. Health care workers should be familiar with procedures for post-exposure prophylaxis. Standard (universal) precautions for prevention of exposure to bloodborne pathogens should be followed at all times. Healthcare staff working in hemodialysis and other high prevalence environments should request education regarding more strict precautions.

Description

There are five major types of viral hepatitis. The diseases, along with the tests available to aid in diagnosis, are described below.

Hepatitis A

Hepatitis A infection, formerly called infectious hepatitis, is caused by the hepatitis A virus (HAV), a single-stranded RNA virus. It is usually a mild disease, most often spread by food and water contamination with fecal material containing the virus. HAV can also be spread by sexual contact. Virus can be detected in stool samples prior to symptoms and for approximately three months thereafter. However, the virus cannot be isolated from the blood. Two types of antibodies to HAV can be detected. IgM antibody (anti-HAV/IgM), appears approximately three to four weeks after exposure and returns to normal within three to six months. IgG (anti-HAV/IgG) appears approximately two weeks after the IgM begins to increase, remains positive for years, and can often be detected for life. A diagnosis of infection with hepatitis A virus is usually made when symptoms including jaundice occur along with elevated levels of transaminases and a positive test for either IgM or total anti-HVA. Transaminases are enzymes released into the plasma in large amounts in necrotic liver diseases. If anti-HAV/IgG is elevated without anti-HAV/IgM, a convalescent stage of HAV infection or prior infection is presumed. Enzyme immunoassay (EIA) and radioimmunoassay (RIA) are the methods used to measure anti-HAV. Molecular diagnostic assays for the detection of HAV in stools and tissues have been developed but are not available commercially.

Hepatitis B

Hepatitis B infections, formerly known as serum hepatitis, are caused by the hepatitis B virus (HBV), a double stranded DNA virus. The disease can be mild or severe, and it can be acute (of limited duration) or chronic (ongoing). It is usually spread by sexual contact with another infected person, or through contact with infected blood. It is also transmitted from mother to child at birth (vertical transmission).

The incubation period for HBV is longer than for HAV (six to 25 weeks versus two to six weeks). The disease ranges from mild (asymptomatic) to severe and lasts for one to six months. Mortality from HBV infection is 1-2%. Approximately 10% of adults and 25% of children with acute HBV infection will develop chronic disease. About 90% of infants who are infected at birth will develop chronic hepatitis or become carriers. Chronic hepatitis may last from 1-20 years and varies greatly in severity. It is usually followed by an asymptomatic phase which lasts for many years called the chronic carrier state. Chronic carriers are capable of transmitting the virus to others. Chronic HBV infection results in cirrho-

sis of the liver in about 2%, and hepatic carcinoma in about 40% of cases.

HBV, also called the Dane particle, is composed of an inner protein core surrounded by an outer protein capsule. The outer capsule contains the hepatitis B surface antigen (HBsAg), formerly called the Australia antigen, that is excreted by infected hepatocytes into the bloodstream. The inner core contains HBV core antigen (HBcAg), and HBV e-antigen (HBeAg). Antibodies to these antigens are called anti-HBs, anti-HBc, and anti-HBe. The diagnostic utility of tests for HBV infection is described below:

- Hepatitis B surface antigen (HBsAg). This is the first test for HBV to become abnormal. HBsAg is detected before the onset of clinical symptoms, peaks during the first week of symptoms, and usually disappears by the time the accompanying jaundice (yellowing of the skin and other tissues) begins to subside (three months). In a very small number of cases, HBsAg may disappear from the blood sooner, causing a negative test result before the presence of antibodies can be detected. HBsAg is commonly detected by a double antibody sandwich immunoassay. The presence of HBsAg indicates infection with HBV. The test will be positive in the acute, chronic, or carrier state. A positive test for both HBsAg and anti-HBs/IgM indicates an active HBV infection. A person is considered to be a chronic carrier if HBsAg persists in the blood for six or more months. Carriers test negative for anti-HBs, but test positive for total anti-HBc.
- Hepatitis B surface antibody (anti-HBs). This appears approximately one month after the disappearance of the HBsAg, signaling the end of the acute infection period. Anti-HBs is the antibody that demonstrates immunity after administration of the hepatitis B vaccine. Its presence also indicates immunity to subsequent infection. Failure to detect anti-HBs in a person who is positive for HBsAg signals the development of chronic hepatitis or a carrier state. Tests for anti-HBs use particles coated with HBsAg to bind antibodies in the plasma. The antibodies are detected using an enzyme labeled or radiolabeled anti-human immunoglobulin.
- Hepatitis B DNA (HBV DNA) can be measured in the serum of persons in both the acute and chronic phases. This is accomplished through sensitive DNA hybridization techniques. The viral DNA is amplified using the polymerase chain reaction (PCR), and the amplicon products are detected using an enzyme-conjugated probe. This test measures the amount of virus in the blood and is used to monitor persons receiving antiviral therapy.

Hepatitis testing

Hepatitis test	Appears/disappears	Significance
HBsAg (hepatitis B surface antigen)	2–6 weeks/1–3 months	Indicates active infection. If antigen level persists in blood, patient is considered a carrier.
HBsAb (hepatitis B surface antibody)	2–6 weeks/life	Patient is in convalescent stage. Antigen presence denotes immunity to HBV.
HBcAb (hepatitis B core antibody)	2 weeks/3–6 months	Indicates past infection. Also present in patients with chronic hepatitis.
HBeAg (hepatitis B e-antigen)	3–5 days/2–4 weeks	Its presence correlates with early and active disease and high infectivity in acute HBV infection.
HBeAb (hepatitis B e-antibody)	1–4 weeks/4–6 years	Indicates convalescent stage and denotes decreased infectivity.

SOURCE: Pagana, K.D. and T.J. Pagana. *Mosby's Diagnostic and Laboratory Test Reference*. 3rd ed. St. Louis: Mosby, 1997.

- Hepatitis B core antibody (anti-HBc). There are two tests, anti-HBc/IgM and total anti-HBc. The former detects only the IgM antibody to the core antigen and the latter detects both IgG and IgM antibodies to the core antigen. The IgM component is the first antibody produced in HBV infection. It appears just before acute hepatitis develops and remains elevated for six to 18 months. After this time the IgM anti-HBc will be undetectable. Anti-HBc (owing to the IgM component) will be the only hepatitis test that is positive during the “window phase” of infection. This is the period when HBsAg levels are too low to detect, and IgG antibodies have not yet developed. The IgG component appears shortly after the IgM. Although the level slowly declines, it remains detectable for years and often for life. Therefore, total anti-HBc is a marker that detects both current or prior infection. Total anti-HBc is positive in chronic HBV infection. Anti-HBc/IgM is typically negative in chronic infection. Testing for anti-HBc/IgM and total anti-HBc is similar to that for anti-HBs except that the antigen used is HBc.
- Hepatitis B e-antigen (HBeAg). This test is used as an index of infection, rather than for diagnostic purposes. The presence of this antigen correlates with early and active disease, as well as with high infectivity in patients with acute HBV infection. When HBeAg levels persist in the blood, the development of chronic HBV infection is suspected. This test is also used to determine if antiviral therapy has been effective.

KEY TERMS

Antibody—A protein manufactured by lymphocytes that binds to a specific antigen

Antigen—A protein that is foreign to the body, not part of “self.”

Lymphocyte—A type of white blood cell involved in the immune response.

Hepatitis A—Commonly called infectious hepatitis, caused by the hepatitis A virus (HAV). Most often spread by food and water contamination.

Hepatitis B—Commonly known as serum hepatitis, it is caused by the hepatitis B virus (HBV). The disease can be mild or severe, and it can occur as an acute or chronic disease. Frequently spread by sexual contact with another infected person, contact with infected blood, intravenous drug use, or from mother to child at birth.

Hepatitis C—Hepatitis caused by the hepatitis C virus (HCV). Usually a more mild form of the disease initially, but carries a greater chance to lead to chronic liver disease, possible liver failure, and the eventual need for transplant. Chronic carrier state is also a risk.

Measurement of HBeAg is similar to HBsAg except that the antibody used is anti-HBe.

- Hepatitis B e-antibody (anti-HBe). This antibody rises after anti-HBc and correlates with the disappearance of HBeAg. Therefore, the presence of anti-HBe and disappearance of HBeAg signal recovery and indicate a reduced risk of infectivity in patients who have previously been HBeAg positive. Chronic hepatitis B and carriers can be positive for either HBeAg or anti-HBe, but are less infectious when anti-HBe is present. Anti-HBe can persist for years, but usually disappears earlier than anti-HBs or anti-HBc. Measurement is similar to anti-HBs except that HBeAg is used instead of HBsAg.

Hepatitis C

Hepatitis C, previously known as non-A, non-B hepatitis, is caused by the hepatitis C virus (HCV), a single-stranded RNA virus. Transmission is mainly via contact with blood through contaminated needles, tattoos, and other parenteral means. The incidence of HCV infection by sexual transmission or close contact is much less than for HBV. Vertical transmission occurs in about 5% of cases. The course of acute disease is variable but gener-

ally is mild and often asymptomatic. HCV is more likely than HBV to lead to chronic liver disease, possible liver failure, and the eventual need for a liver transplant. Chronic carrier states develop in more than 80% of patients, and chronic liver disease with cirrhosis develops in approximately 20%. Persons with HCV are also at risk for hepatic carcinoma.

Hepatitis C is detected by demonstrating the presence of anti-HCV in the blood (HCV serology). The test is a sandwich-type enzyme immunoassay and detects the IgG antibody to HCV. The addition of this test to those for HbsAg and anti-HBc has greatly reduced the incidence of post-transfusion hepatitis. Since false positive results do occur with this test, a positive finding is confirmed by a more specific test, the recombinant immunoblot assay (RIBA) which also measures anti-HCV. New tests are available to measure HCV RNA in the blood. These viral load tests make use of the reverse transcription-polymerase chain reaction (RT-PCR) and are helpful in measuring the effect of interferon and other antiviral treatments.

Hepatitis D

Hepatitis D, previously called delta hepatitis, is caused by the hepatitis D virus (HDV). This is a single stranded RNA virus that requires coinfection with HBV in order to enter the hepatocyte. The disease occurs only in those who have HBV surface antigen in the blood from a past or simultaneously occurring infection. Transmission is mainly through intravenous drug use via contaminated needles, and in persons who have received multiple transfusions, but experts believe that transmission may also occur through sexual contact. Infection usually causes severe (fulminant) hepatitis and has a mortality rate of approximately 30%. It is diagnosed by demonstrating IgG antibodies to HDV in plasma of persons with documented HBV infection. Although not available commercially, research methods for IgM anti-HDV and HDV RNA have been developed.

Hepatitis E

Hepatitis E, once called epidemic hepatitis, is caused by hepatitis E virus (HEV), a single stranded RNA virus. It is also called enteric non-A, non-B hepatitis. Infection with HBE is transmitted when water or food becomes contaminated with feces containing the virus. Although not frequent in the United States, epidemic outbreaks have occurred in many other countries worldwide. The incubation time and course of the disease is similar to hepatitis A. Hepatitis E is usually a self-limiting disease, and chronic infection is infrequent. However, it is associated with a high mortality rate (about 20%) when con-

tracted during **pregnancy**. Infection with HEV is diagnosed by demonstrating antibodies to the virus in the plasma of an infected person.

Preparation

Hepatitis virus tests require a blood sample. It is not necessary for the patient to withhold food or fluids before any of these tests, unless requested to do so by the physician. A nurse or phlebotomist usually collects the blood by venipuncture following standard precautions for prevention of exposure to bloodborne pathogens.

Aftercare

Pressure should be applied to the site of venipuncture.

Complications

Complications for these tests are minimal for the patient, but may include slight bleeding from the blood-drawing site, fainting or feeling lightheaded after venipuncture, or hematoma (blood accumulating under the puncture site).

Results

Testing for hepatitis infection requires a panel of tests. A typical screening panel for acute hepatitis consists of tests for anti-HAV/IgM, HBsAg, and anti-HBc/IgM. A positive test for total antibodies to HAV or HBV may indicate current infection, prior infection, or **vaccination** for hepatitis B. Therefore, when positive, these tests are evaluated in conjunction with other tests, the patient's history, and clinical findings. Normal results are as follows:

- hepatitis A antibody (IgM or total): negative
- hepatitis B core antibody (IgM or total): negative
- hepatitis B e antibody: negative
- hepatitis B e-antigen: negative
- hepatitis B surface antigen: negative
- hepatitis C antibody: negative
- hepatitis D antibody: negative
- hepatitis E antibody: negative

Abnormal results

HEPATITIS A. A single positive total anti-HAV test may indicate HAV infection or previous exposure to the virus because these antibodies persist so long in the bloodstream. A positive test for anti-HAV/IgM or evi-

dence of a rising total anti-HAV titer confirms hepatitis A. A negative anti-HAV test rules out hepatitis A.

HEPATITIS B. A positive test for HBsAg indicates acute or chronic infection or a carrier state. High levels of HBsAg that continue for three or more months after onset of acute infection suggest development of chronic hepatitis or carrier status. A positive test for total anti-HBc indicates current infection or previous exposure. A negative test for HBsAg and total anti-HBc rules out hepatitis. A positive test for anti-HBc/IgM indicates acute infection and may be the only HBV marker that is positive during the window phase of infection. Anti-HBc/IgM is not positive in the chronic phase of infection. Detection of anti-HBs signals late convalescence or recovery from infection. This antibody remains in the blood to provide immunity to reinfection. A positive test for HBeAg indicates acute infection and a high state of infectivity. Disappearance of HBeAg and appearance of anti-HBe indicates recovery from HBV infection.

HEPATITIS C. (non-A, non-B hepatitis) Anti-HBc develops after exposure to hepatitis C.

HEPATITIS D. Anti-HDV develops after exposure to hepatitis D.

HEPATITIS E. Anti-HEV develops after exposure to hepatitis E.

Health care team roles

Hepatitis tests are ordered and interpreted by a physician. A phlebotomist, or sometimes a nurse, collects the blood, and a clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) or clinical laboratory technician CLT(NCA)/medical laboratory technician MLT(ASCP) performs the testing.

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Herbalism, Western

Definition

Western herbalism is a form of the healing arts that draws from herbal traditions of Europe and the Americas, and that emphasizes the study and use of European and Native American herbs in the treatment and prevention of illness. Western herbalism is based on physicians' and herbalists' clinical experience and traditional knowledge of medicinal plant remedies preserved by oral tradition and in written records over thousands of years. Western herbalism, like the much older system of traditional Chinese medicine, relies on the synergistic and curative properties of the plant to treat symptoms and disease and maintain health.

Western herbalism is based upon pharmacognosy, the study of natural products. Pharmacognosy includes the identification, extraction methods, and applications of specific plant constituents responsible for specific therapeutic actions, such as the use of digoxin from *Digitalis* leaf for **heart failure**. These constituents are extracted, purified and studied in vitro, in vivo, and in clinical research. They may be concentrated to deliver standardized, set doses. Sometimes, the natural constituent can be synthesized in the lab, or changed and patented. Practitioners may choose to use fresh medicinal plants, simple extracts, or standardized extracts.

In standardized extracts, a specific quantity of a constituent is called a marker compound, and it may or may not be the active constituent(s) in the plant medicine. There are preparations with standardized active constituent quantities, and preparations with greater emphasis on quality of crude plant material and traditional preparation methodology than on finalized total quantity of marker compounds. The preference between the two for precision dosing is philosophical, practical and vari-

able. When using plant extracts in which the active constituents and their cofactors are well established, or the therapeutic and lethal dose are close, standardized products are often preferred. When using plant extracts whose active constituents remain obscure, or the active constituents when purified produce weaker therapeutic results or more undesirable side effects, the products produced under good manufacturing processes and according to the traditional *National Formulary U. S. Dispensatory* or *U. S. Pharmacopeia* are preferred.

Origins

Over 2,500 years ago Hippocrates wrote, "In medicine one must pay attention not to plausible theorizing but to experience and reason together." This Greek physician and herbalist from the fourth century B.C. is considered the father of western medicine. He stressed the importance of diet, water quality, climate, and social environment in the development of disease. Hippocrates believed in treating the whole person, rather than merely isolating and treating symptoms. He recognized the innate capacity of the body to heal itself, and emphasized the importance of keen observation in the medical practice. He recommended simple herbal remedies to assist the body in restoring health.

Ancient Greek medicine around the fifth century B.C. was a fertile ground for contrasting philosophies and religions. Greek physicians were influenced by the accumulated medical knowledge from Egypt, Persia, and Babylon. Medical advances flourished and practitioners and scholars were free to study and practice without religious and secular constraints. In the fourth century B.C., Theophrastus wrote the *Historia Plantarum*, considered to be the founding text in the science of botany.

During the first century A.D., Dioscorides, a Greek physician who traveled with the Roman legions, produced five medical texts. His herbal text, known as the *De Materia Medica* is considered to be among the most influential of all western herbal texts. It became a standard reference for practitioners for the next 1,500 years. This influential book also included information on medicinal herbs and treatments that had been used for centuries in Indian Ayurvedic medicine. Galen of Pergamon, who also lived in the first century A.D., was a Roman physician and student of anatomy and physiology. He authored a recipe book containing 130 antidotes and medicinal preparations. These elaborate mixtures, known as galenicals, sometimes included up to one hundred herbs and other substances. This complex approach to herbal medicine was a dramatic change from the simple remedies recommended by Hippocrates and employed by traditional folk healers. Galen developed a

rigid system of medicine in which the physician, with his specialized knowledge of complex medical formulas, was considered the ultimate authority in matters of health care. The Galenic system, relying on theory and scholarship rather than observation, persisted throughout the Middle Ages. The galenic compounds, along with bloodletting and purging, were among the drastic techniques practiced by the medical professionals during those times; however, traditional herbal healers persisted outside the mainstream medical system.

During the eighth century a medical school was established in Salerno, Italy, where the herbal knowledge accumulated by Arab physicians was preserved. The Arabian Muslims conducted extensive research on medicinal herbs found in Europe, Persia, India, and the Far East. Arab businessmen opened the first herbal pharmacies early in the ninth century. The *Leech Book of Bald*, the work of a Christian monk, was compiled in the tenth century. It preserved important medical writings that had survived from the work of physicians in ancient Greece and Rome.

The Middle Ages in Europe were a time of widespread death by plagues and pestilence. The Black Plague of 1348, particularly, and other health catastrophes in later years, claimed so many lives that survivors began to lose faith in the dominant Galenic medical system. Fortunately, the knowledge of traditional herbal medicine had not been lost. Medieval monks who cultivated extensive medicinal gardens on the monastery grounds, also patiently copied the ancient herbal and medical texts. Folk medicine as practiced in Europe by traditional healers persisted, even though many women herbalists were persecuted as witches and enemies of the Catholic church and their herbal arts were suppressed.

The growing spice trade and explorations to the New World introduced exotic plants, and a whole new realm of botanical medicines became available to Europeans. Following the invention of the printing press in the fifteenth century, a large number of herbal texts, also simply called herbals, became available for popular use. Among them were the beautifully illustrated works of the German botanists Otto Brunfels and Leonhard Fuchs published in 1530, and the Dutch herbal of Belgian physician Rembert Dodoens, a popular work that was later reproduced in English. In 1597, the physician and gardener John Gerard published one of the most famous of the English herbals, still in print today. Gerard's herbal, known as *The Herbal or General Historie of Plantes* was not an original work. Much of the content was taken from the translated text of his Belgian predecessor Dodoens. Gerard did, however, include descriptions of some of the more than one thousand species of rare and exotic plants and English flora from his own garden.

The correspondence of astrology with herbs was taught by Arab physicians who regarded astrology as a science helpful in the selection of medicines and in the treatment of diseases. This approach to western herbalism was particularly evident in the herbal texts published in the sixteenth and seventeenth centuries. One of the most popular and controversial English herbals is *The English Physician Enlarged* published in 1653. The author, Nicholas Culpeper, was an apothecary by trade. He also published a translation of the Latin language *London Pharmacopoeia* into English. Culpeper was a nonconformist in loyalist England, and was determined to make medical knowledge more accessible to the apothecaries, the tradesmen who prescribed most of the herbal remedies. Culpeper's herbal was criticized by the medical establishment for its mix of magic and astrology with botanical medicine, but it became one of the most popular compendiums of botanical medicine of its day. Culpeper also accepted the so-called "Doctrine of Signatures," practiced by medieval monks in their medicinal gardens. This theory teaches that the appearance of plants is the clue to their curative powers. Plants were chosen for treatment of particular medical conditions based on their associations with the four natural elements and with a planet or sign. The place where the plant grows, its dominant physical feature, and the **smell** and taste of an herb determined the plant's signature. Culpeper's herbal is still in print in facsimile copies, and some pharmacognosists and herbalists in the twenty-first century voice the same criticisms that Culpeper's early critics did.

European colonists brought their herbal knowledge and plant specimens to settlements in North America where they learned from the indigenous Americans how to make use of numerous nutritive and medicinal plants native to the New World. Many European medicinal plants escaped cultivation from the early settlements and have become naturalized throughout North America. The first record of Native American herbalism is found in the manuscript of the native Mexican Indian physician, Juan Badianus published in 1552. The American Folk tradition of herbalism developed as a blend of traditional European medicine and Native American herbalism. The pioneer necessity for self-reliance contributed to the perseverance of folk medicine well into the twentieth century.

In Europe in the seventeenth century, the alchemist Paracelsus changed the direction of western medicine with the introduction of chemical and mineral medicines. He was the son of a Swiss chemist and physician. Paracelsus began to apply chemicals, such as arsenic, mercury, sulfur, **iron**, and **copper** sulfate to treat disease. His chemical approach to the treatment of disease was a forerunner to the reliance in the twentieth century on

chemical medicine as the orthodox treatment prescribed in mainstream medical practice.

The nineteenth and twentieth centuries brought a renewed interest in the practice of western herbalism and the development of natural therapies and health care systems that ran counter to the mainstream methods of combating disease symptoms with synthetic pharmaceuticals.

In the late eighteenth century, the German physician Samuel Hahnemann developed a system of medicine known as **homeopathy**. This approach to healing embraces the philosophy of “like cures like.” Homeopathy uses extremely diluted solutions of herbs, animal products, and chemicals that are believed to hold a “trace memory” or energetic imprint of the substance used. Homeopathic remedies are used to amplify the patient’s symptoms with remedies that would act to produce the same symptom in a healthy person. Homeopathy holds that the symptoms of illness are evidence of the body’s natural process of healing and eliminating the cause of the disease.

In 1895, the European medical system known as Naturopathy was introduced to North America. Like homeopathy, this medical approach is based on the Hippocratic idea of eliminating disease by assisting the body’s natural healing abilities. The naturopath uses non-toxic methods to assist the body’s natural healing processes, including nutritional supplements, herbal remedies, proper diet, and **exercise** to restore health.

Western herbalism is regaining popularity at a time when the world is assaulted by the **stress** of overpopulation and development that threatens the natural biodiversity necessary for these valuable medicinal plants to survive. The American herb market is growing rapidly and increasing numbers of individuals are choosing alternative therapies over the mainstream allopathic western medicine. It is projected that by the year 2002 consumers will spend more than seven billion dollars a year on herbal products. An estimated 2,400 acres of native plant habitat is lost to development every day. As much as 29% of all plant life in North America is in danger of extinction, including some of the most important native medicinal plants, according to the 1997 World Conservation Union Red List of Threatened Plants.

Though research into the efficacy and safety of traditional herbal remedies is increasing, it has been limited by the high costs of clinical studies and laboratory research, and by the fact that whole plants and their constituents are not generally patentable (therefore, there is no drug profit after market introduction). Outside the United States, herbalism has successfully combined with conventional medicine, and in some countries is fully integrated into the nations’ health care systems. At the

beginning of the twenty-first century, 80% of the world’s population continues to rely on herbal treatments. The World Health Organization, an agency of the United Nations, promotes traditional herbal medicine for treatment of many local health problems, particularly in the third world where it is affordable and already well-integrated into the cultural fabric.

In the United States, the re-emergence in interest in holistic approaches to health care is evident. Citizens are demanding access to effective, safe, low-cost, natural medicine. Legislative and societal change is needed, however, before natural therapies can be fully integrated into the orthodox allopathic health care system and provide citizens with a wide range of choices for treatment. If the current trend continues, U. S. citizens will benefit from a choice among a variety of safe and effective medical treatments.

Benefits

The benefits of botanical medicine may be subtle or dramatic, depending on the remedy used and the symptom or problem being addressed. Herbal remedies usually have a much slower effect than pharmaceutical drugs. Some herbal remedies have a cumulative effect and work slowly over time to restore balance, and others are indicated for short-term treatment of acute symptoms. When compared to the pharmaceutical drugs, herbal remedies prepared from the whole plant have relatively few side effects. This is due to the complex chemistry and synergistic action of the full range of phytochemicals present in the whole plant, and the relatively lower concentrations. They are generally safe when used in properly designated therapeutic dosages, and less costly than the isolated chemicals or synthetic prescription drugs available from western pharmaceutical corporations.

Description

Herbs are generally defined as any plant or plant part that may be used for medicinal, nutritional, culinary, or other beneficial purposes. The active constituents of plants (if known) may be found in varying amounts in the root, stem, leaf, flower, and fruit, etc. of the plant. Herbs may be classified into many different categories. Some western herbalists categorize herbal remedies according to their strength, action, and characteristics. Categories may include sedatives, stimulants, **laxatives**, febrifuges (to reduce **fever**), and many others. One system of classification is based on a principle in traditional Chinese medicine that categorizes herbs into four classes: tonics, specifics, heroics, or cleansers and protectors. Within these broad classifications are the numerous medicinal

actions of the whole herb which may be due to a specific chemical or combination of chemicals in the plant.

- **Tonics.** Herbs in this classification are also known as alteratives in western herbalism. They are generally mild in their action and act slowly in the body, providing gentle stimulation and **nutrition** to specific organs and systems. Tonic herbs act over time to strengthen and nourish the whole body. These herbs are generally safe and may be used regularly, even in large quantities. These tonic herbs are known as “superior” remedies in traditional Chinese medicine. The therapeutic dose of tonic remedies is far removed from the possible toxic dose. American ginseng is an example of a tonic herb.
- **Specifics.** Herbs in this classification are strong and specific in their therapeutic action. They are generally used for short periods of time in smaller dosages to treat acute conditions. Herbs classified as specifics are not used beyond the therapeutic treatment period. Echinacea is a specific herb.
- **Heroic.** These herbs offer high potency but are potentially toxic, and should not be used in self-treatment. Because the therapeutic dosage may be close to the lethal dosage, these herbs are presented cautiously and closely monitored or avoided by trained clinicians. They should not be used continuously or without expert supervision. Poke (*Phytolacca americana*) is an example of a heroic remedy.
- **Cleansers and protectors.** These herbs, plants, and plant tissues remove wastes and pollutants, while minimally affecting regular body processes. An example of a cleanser is pectin. Pectins are the water soluble substances that bind cell walls in plant tissues, and some believe that they help remove heavy metals and environmental toxins from the body.

Preparations

Herbal preparations are commercially available in a variety of forms including tablets or capsules, tinctures, teas, fluid extracts, douches, washes, suppositories, dried herbs, and many other forms. The medicinal properties of herbs are extracted from the fresh or dried plant parts by the use of solvents appropriate to the particular herb. Alcohol, oil, water, vinegar, glycerin, and propylene glycol are some of the solvents used to extract and concentrate the medicinal properties. Steam distillation and cold-pressing techniques are used to extract the essential oils. The quality of any herbal remedy and the potency of the phytochemicals found in the herb depends greatly on the conditions of weather and soil where the herb was grown, the timing and care in harvesting, and the manner of preparation and storage.

Precautions

Herbal remedies prepared by infusion, decoction, or alcohol tincture from the appropriate plant part, such as the leaf, root, or flower are generally safe when ingested in properly designated therapeutic dosages. However, many herbs have specific contraindications for use when certain medical conditions are present. Not all herbal remedies may be safely administered to infants or small children. Many herbs are not safe for use by pregnant or lactating women. Some herbs are toxic, even deadly, in large amounts, and there is little research on the chronic toxicity that may result from prolonged use. Herbal remedies are sold in the United States as dietary supplements and are not regulated for content or efficacy. Self-diagnosis and treatment with botanical medicinals may be risky. A consultation with a clinical herbalist, Naturopathic physician, or certified clinical herbalist is prudent before undertaking a course of treatment.

Essential oils are highly concentrated and should not be ingested as a general rule. They should also be diluted in water or in a non-toxic carrier oil before application to the skin to prevent contact dermatitis or photo-sensitization. The toxicity of the concentrated essential oil varies depending on the chemical constituents of the herb.

The American Professor of Pharmacognosy, Varro E. Tyler, believes that “herbal chaos” prevails in the United States with regard to herbs and phytomedicinals. In part he blames the herb producers and marketers of crude herbs and remedies for what he terms unproven hyperbolic, poor quality control, deceptive labeling, resistance to standardization of dosage forms, and continued sale of herbs determined to be harmful.

Side effects

Herbs have a variety of complex phytochemicals that act on the body as a whole or on specific organs and systems. Some of these chemical constituents are mild and safe, even in large doses. Other herbs contain chemicals that act more strongly and may be toxic in large doses or when taken continuously. **Drug interactions** are possible with certain herbs when combined with certain pharmaceutical drugs. Some herbs are tonic in a small amount and toxic in larger dosages.

Research and general acceptance

Western herbalism is experiencing a revival of popular and professional interest. The number of training schools and qualified herbal practitioners is growing to meet the demand. Western herbalism is incorporated into the medical practice of licensed Naturopathic doctors, who receive special training in clinical herbalism. Folk

KEY TERMS

In vitro—A biological reaction occurring in a laboratory apparatus.

In vivo—Occurring in a living organism.

Phyto-, as in phytochemical, phytomedicinal, and phytotherapy—Meaning, or pertaining to, a plant or plants.

Wildcrafting—Gathering of herbs or other natural materials.

herbalists, heir to the continuing oral traditions passed from generation to generation in many rural areas, as well as amateur, self-taught herbalists, keep the practice of botanical medicine alive at the grassroots level. Traditional western herbalism relies on traditional use and materia medica, folk wisdom, and recent clinical research and advances in the extraction processes. These advances provide increased quality control on the concentration and potency of the active ingredients. Western physicians, educated in allopathic medicine, typically receive no training in the use of herbs. These doctors rely on pharmaceutical drugs for their patients, and some cite the following reasons for continuing to do so: lack of standardized dosages, lack of quality control in the preparation of herbal medicinals, and the dearth of clinical research verifying the safety and effectiveness of many traditional herbal remedies.

Herbalism is widely practiced throughout Europe, particularly in England, France, Italy, and Germany where phytomedicinals are available in prescription form and as over-the-counter remedies. In Germany, plant medicines are regulated by a special government body known as the Commission E. In the United States, however, despite increasing popularity, traditional herbalism is not integrated into the allopathic medical system. Phytomedicinals are sold as dietary supplements rather than being adequately researched and recognized as safe and effective drugs. The Dietary Supplement Health and Education Act of 1994 circumvented a U. S. Food and Drug Administration (FDA) effort to effectively remove botanicals from the marketplace and implement regulations restricting sale. Massive popular outcry against the proposed regulations on the sale of herbs and phytomedicinals resulted in this Congressional action. In 2000, U.S. President Bill Clinton, by executive order, created the White House Commission on Alternative Medicine in an effort to hold alternative medicine therapies “to the same standard of scientific rigor as more traditional health care interventions.” That Commission is charged

with recommending federal guidelines and legislation regarding the use of alternative medical therapies in the twenty-first century.

Training and certification

In the United States, courses of study in Western herbalism are available in almost all of the fifty states. The study of traditional herbalism is part of the course curriculum in Naturopathic medical colleges that offer four-year degree programs leading to licensure as a Doctor of Naturopathy. The oldest of these institutions is the National College of Naturopathic Medicine, established in 1956. Western clinical herbalism is taught through a growing number of institutions and organizations offering training and certification through residential and apprenticeship programs, and by correspondence. Some programs are comprehensive, with curricula in physiology, clinical diagnosis and treatment, ethnobotany, pharmacognosy, phytotherapy, plant identification, ethical wildcrafting and cultivation, and preparation and application of herbal remedies. Other programs are brief, geared more to the amateur herbalist and gardener. The Southwest School of Botanical Medicine in Bisbee, Arizona, is one of the oldest herbal schools, established in 1978. No licensing body yet exists in the United States to regulate the practice of herbal medicine.

In the United States herbal remedies are sold as dietary supplements. They are not regulated as to content and efficacy, and few are prepared in standardized dosages. Many of the supplements commercially available base claims for efficacy on traditional use and anecdotal evidence that has not been duplicated by clinical studies. In Germany, an expert committee known as the Commission E, was established by that government in 1978 to evaluate the safety and efficacy of the three hundred herbs and herb combinations sold in that country. No equivalent regulatory commission exists in the United States. Permits are required in some states for the wildcrafting of rare and endangered herbs, such as goldenseal and American ginseng, two commercially valuable herbs in high demand in the growing medical botanicals industry.

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Clare Hanrahan

Herniated disk

Definition

Disk herniation is a rupture of fibrocartilagenous material (annulus fibrosis) that surrounds the intervertebral disk. This rupture involves the release of the disk's center portion containing a gelatinous substance called the nucleus pulposus. Pressure from the vertebrae above and below may cause the nucleus pulposus to be forced outward, placing pressure on a spinal nerve and causing considerable **pain** and damage to the nerve. This condition most frequently occurs in the lumbar region and is also commonly called herniated nucleus pulposus, prolapsed disk, ruptured intervertebral disk, or slipped disk.

Description

The spinal column is made up of 26 vertebrae that are joined together and permit forward and backward bending, side bending, and rotation of the spine. Five distinct regions comprise the spinal column, including the cervical (neck) region, thoracic (chest) region, lumbar (low back) region, sacral and coccygeal (tailbone) region. The cervical region consists of seven vertebrae, the thoracic region includes 12 vertebrae, and the lumbar region contains five vertebrae. The sacrum is composed of five fused vertebrae, which are connected to four fused vertebrae forming the coccyx. Intervertebral disks lie between each adjacent vertebra.

Each disk is composed of a gelatinous material in the center, called the nucleus pulposus, surrounded by rings of a fibrous tissue (annulus fibrosus). In disk herniation, an intervertebral disk's central portion herniates through the surrounding annulus fibrosus into the spinal canal, putting pressure on a nerve root. (There is often a progression of small fissures in the annulus fibrosis before the disk herniates.) Disk herniation most commonly affects the lumbar region between the fifth lumbar vertebra and the first sacral vertebra. However, disk herniation can also occur in the cervical spine. The incidence of cervical disk herniation is most common between the fifth and sixth cervical vertebrae. The second most common area for cervical disk herniation occurs between the sixth and seventh cervical vertebrae. Disk herniation is less common in the thoracic region.

Predisposing factors associated with disk herniation include age, gender, and work environment. The peak age for occurrence of disk herniation is between 20–45 years of age. Studies have shown that males are more commonly affected than females in lumbar disk herniation by a 3:2 ratio. Genetic factors are suspected of playing a role in disk herniation. Prolonged exposure to a bent-forward work posture is correlated with an increased incidence of disk herniation. Pain from a herniated disk is usually greatest when sitting and is lessened when standing.

There are four classifications of disk pathology:

- A protrusion may occur where a disk bulges without rupturing the annulus fibrosis.
- The disk may prolapse where the nucleus pulposus migrates to the outermost fibers of the annulus fibrosis.
- There may be a disk extrusion, which is the case if the annulus fibrosis perforates and material of the nucleus moves into the epidural space.
- The sequestered disk may occur as fragments from the annulus fibrosis and nucleus pulposus are outside the disk proper.

Causes and symptoms

Any direct, forceful, and vertical pressure on the lumbar disks can cause the disk to push its fluid contents into the vertebral body. Herniated nucleus pulposus may occur suddenly from lifting, twisting, or direct injury, or it can occur gradually from degenerative changes with episodes of intensifying symptoms. As individuals age, the intervertebral disk changes in shape and volume. Changes in the chemical and mechanical characteristics of the disk also occur. It is these changes that predispose certain individuals to disk herniation. The annulus may also become weakened over time, allowing stretching or tearing and leading to a disk herniation. Depending on the location of the herniation, the herniated material can also press directly on nerve roots or on the **spinal cord**, causing a shock-like pain (**sciatica**) down the legs, weakness, numbness, or problems with bowels, bladder, or sexual function.

Diagnosis

A variety of non-invasive physical tests can be performed to help diagnose disk herniation. A straight-leg raising test may be performed by the health practitioner. If severe pain is produced in the back of the leg, then it may suggest a lumbar nerve root problem. A crossed straight-leg raising test may also be performed. This involves raising the leg opposite to that with current pain. This test tends to produce a more localized but less intense pain than the straight-leg raising test. Several radiographic tests are useful for confirming a diagnosis of disk herniation and locating the source of pain. These tests also help the surgeon indicate the extent of the surgery needed to fully decompress the nerve. X rays show structural changes of the lumbar spine. **Myelography** is a special x ray of the spine in which a dye or air is injected into the patient's spinal canal. The patient lies strapped to a table as the table tilts in various directions and spot x rays are taken. X rays showing a narrowed dye column in the intervertebral disk area indicate possible disk herniation.

Computed tomography, or computed axial tomography (CT or CAT) scans reveal the details of pathology necessary to obtain consistently good surgical results. **Magnetic resonance imaging** (MRI) analysis of the disks can accurately detect the early stages of disk aging and degeneration. MRI is most useful in assessing how the disk and nerve roots change over time. The MRI has become the standard diagnostic imaging tool for disk herniation. A newer technology called magnetic resonance myelography does not provide a better overall image of the spine than an MRI, but it can improve diagnosis of disk herniation in some cases.

Treatment

Drugs

Unless serious neurologic symptoms occur, herniated disks can initially be treated with pain medication and up to 48 hours of bed rest. There is no proven benefit from resting more than 48 hours. Many patients benefit from lying on a very firm mattress or an ordinary mattress with a board placed underneath. Heat or cold applied to the affected region often helps many patients. Patients are then encouraged to gradually increase their activity. Pain medications, including non-steroidal anti-inflammatory drugs, muscle relaxers, or in severe cases, narcotics, may be continued if needed.

Epidural steroid injections have been used to decrease pain by injecting an anti-inflammatory drug, usually a corticosteroid, around the nerve root to reduce inflammation and **edema** (swelling). This partly relieves the pressure on the nerve root as well as resolves the inflammation. Some physicians are using trigger point injections of lidocaine without epinephrine to provide localized pain relief for extended periods of time. Some of these physicians also use electrical or ultrasound therapy over these localized areas, but these methods have not been scientifically validated.

Physical therapy

Physical therapists are skilled in treating acute back pain caused by disk herniation. The physical therapist can provide noninvasive therapies, such as ultrasound or diathermy to project heat deep into the tissues of the back or administer manual therapy, if mobility of the spine is impaired. They may help improve posture and develop an **exercise** program for recovery and long-term protection. Appropriate exercise can help take pressure off inflamed nerve structures, while improving overall posture and flexibility. Traction can be used to try to decrease pressure on the disk. A lumbar support can be helpful for a herniated disk at this level as a temporary measure to reduce pain and improve posture.

Surgery

Surgery is often appropriate for conditions that do not improve with the usual treatment. In this event, a strong, flexible spine is important for a quick recovery after surgery. There are several surgical approaches to treating a herniated disk, including the classic discectomy, microdiscectomy, or percutaneous discectomy. The basic differences among these procedures are the size of the incision, how the disk is reached surgically, and how much of the disk is removed.

Discectomy is the surgical removal of the portion of the disk that is putting pressure on a nerve causing the back pain. In the classic discectomy, the surgeon first enters through the skin and then removes a bony portion of the vertebra called the lamina, hence the term laminectomy. The surgeon removes the disk material that is pressing on a nerve. Rarely is the entire lamina or disk removed. Often, only one side is removed and the surgical procedure is termed hemilaminectomy.

In microdiscectomy, through the use of an operating **microscope**, the surgeon removes the offending bone or disk tissue until the nerve is free from compression or stretch. This procedure is possible using **local anesthesia**. Microsurgery techniques vary and have several advantages over the standard discectomy, such as a smaller incision, less trauma to the musculature and nerves, and easier identification of structures by viewing into the disk space through microscope magnification.

Percutaneous disk excision is performed on an outpatient basis, is less expensive than other surgical procedures, and does not require a **general anesthesia**. The purpose of percutaneous disk excision is to reduce the volume of the affected disk indirectly by partial removal of the nucleus pulposus, leaving all the structures important to stability practically unaffected. In this procedure, large incisions are avoided by inserting devices that have cutting and suction capability. Suction is applied and the disk is sliced and aspirated.

Arthroscopic microdiscectomy is similar to percutaneous discectomy, however it incorporates modified arthroscopic instruments, including scopes and suction devices. A suction irrigation of saline solution is established through two entry sites. A video discoscope is introduced from one site and the deflecting instruments from the opposite side. In this way, the surgeon is able to search and extract the nuclear fragments under direct visualization.

Laser disk decompression is performed using similar means as percutaneous excision and arthroscopic microdiscectomy, however laser energy is used to remove the disk tissue. Here, laser energy is percutaneously introduced through a needle to vaporize a small volume of nucleus pulposus, thereby dropping the pressure of the disk and decompressing the involved neural tissues. One disadvantage of this procedure is the high initial cost of the laser equipment. It is important to realize that only a very small percentage of people with herniated lumbar disks go on to require surgery. Further, surgery should be followed by appropriate rehabilitation to decrease the chance of reinjury.

Chemonucleolysis

Chemonucleolysis is an alternative to surgical excision. Chymopapain, a purified enzyme derived from the papaya plant, is injected percutaneously into the disk space to reduce the size of the herniated disks. It hydrolyses **proteins**, thereby decreasing water-binding capacity, when injected into the nucleus pulposus inner disk material. The reduction in size of the disk relieves pressure on the nerve root.

Spinal fusion

Spinal fusion is the process by which bone grafts harvested from the iliac crest (thick border of the ilium located on the pelvis) are placed between the intervertebral bodies after the disk material is removed. This approach is used when there is a need to reestablish the normal bony relationship between the vertebrae. A total discectomy may be needed in some cases because lumbar spinal fusion can help prevent recurrent lumbar disk herniation at a particular level.

Alternative treatment

Acupuncture involves the injection of fine needles to relieve pain. An acupuncturist determines the location of the nerves affected by the herniated disk and positions the needles appropriately. Massage therapists may also provide short-term relief from a herniated disk. Following manual examination and x-ray diagnosis, chiropractic treatment usually includes manipulation to correct muscle and joint malfunctions, while care is taken not to place an additional strain on the injured disk. If a full trial of conservative therapy fails, or if neurologic problems (weakness, bowel or bladder problems, and sensory loss) develop, the next step is usually evaluation by an orthopedic surgeon.

Health care team roles

Nurses play an important role in the diagnosis and treatment of disk herniation disease. They assist health care practitioners in performing basic physical testing, such as the straight-leg raising test. They also play an important role in determining the history of the patient and how the patient developed the herniated disk. They also will often assist in procedures such as the steroid or lidocaine injection. Surgical nurses assist in the operative repair of herniated disks.

Physical therapists play an important role in the prevention and treatment of patients with herniated disk disease. They can create an exercise and posture program that can reduce the risk of developing the condition in the

KEY TERMS

Annulus fibrosus—The outer portion of the intervertebral disk made primarily of fibrocartilage rings.

Epidural space—The space immediately surrounding the outer most membrane of the spinal cord.

Excision—The process of excising, removing, or amputating.

Fibrocartilage—Cartilage that consists of dense fibers.

Nucleus pulposus—The center portion of the intervertebral disk that is made up of a gelatinous substance.

Percutaneous—Performed through the skin.

first place as well as generate a course of therapy that will help restore function in those with serious disease.

Radiologic technologists play a critical role in the diagnosis of disk herniation. They are involved in the three most important diagnostic imaging tests: CAT scans, MRI procedures, and x rays.

Patient education

Nurses play a critical role in **patient education** in the prevention and treatment of disk herniation. One of the most important areas in which they educate patients is following disk herniation surgery. These **postoperative care** instructions are vital to the success of the surgery. Pharmacists play a key role in dispensing accurate information about the proper use of drugs, particularly non-steroidal anti-inflammatory agents, **muscle relaxants**, and narcotic-based compounds. They also provide instructions to patients on the proper use of drugs prescribed following surgery. Physical therapists instruct individuals on how to properly lift heavy objects, how to maintain good posture while working and during other activities, and how to perform certain exercises to prevent or treat disk herniation. Occupational therapists provide information to individuals and employers on how to minimize back and neck strain in the workplace. Dietitians can design a weight-loss program in those cases where extra weight helped precipitate and aggravate disk herniation.

Prognosis

Only 5–10% of patients with unrelenting sciatica and neurological involvement, leading to chronic pain of the lumbar spine, need to have a surgical procedure performed. This strongly suggests that many patients with herniated disks at the lumbar level respond well to conservative treatment. For those patients who do require surgery for lumbar disk herniation, the reviewed procedures of nerve root decompression caused by disk herniation is favorable. Results of studies varied from 60–90% success rates. Disk surgery has progressively evolved in the direction of decreasing invasiveness. Each surgical procedure is not without possible complications, which can lead to chronic low back pain and restricted lifestyle.

Prevention

Proper exercises to strengthen the lower back and abdominal muscles are key in preventing excess stress and compressive forces on lumbar disks. Good posture will help prevent problems on cervical, thoracic, and lumbar disks. A good flexibility program is critical for prevention of muscle and spasm that can cause an increase in compressive forces on disks at any level. Proper lifting of heavy objects is important for all muscles and levels of the individual disks. Good posture in sitting, standing, and lying down is helpful for the spine. Losing weight, if needed, can prevent weakness and unnecessary stress on the disks caused by **obesity**. Choosing proper footwear may also be helpful to reduce the impact forces to the lumbar disks while walking on hard surfaces. Wearing special back support devices may be helpful if heavy lifting is required with combinations of twisting.

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National Chronic Pain Outreach Association. P.O. Box 274, Millboro, VA 24460. 1-540-862-9437. ncpoa@cfw.com.

Mark Mitchell

Herpes genitalis *see* **Genital herpes**

Herpes simplex test *see* **TORCH test**

Herpes type 1 *see* **Cold sore**

Herpes type 2 *see* **Genital herpes**

High-protein diet *see* **Fad diets**

High-risk pregnancy

Definition

A **pregnancy** that has maternal or fetal complications requiring special medical attention or bed rest is considered to be high-risk. Complications, as used here, mean the risk of illness or death before or after delivery is greater than normal for the mother or baby.

Description

Risk factors in pregnancy are those findings discovered during prenatal assessment that are known to have a potentially negative effect on the outcome of the pregnancy, either for the woman or the fetus. This evaluation determines whether or not the mother has characteristics or conditions that make her or her baby more likely to become sick or die during the pregnancy.

Causes and symptoms

All risk factors do not threaten pregnancy to the same extent. The risk of complications is increased by smoking, poor nutritional habits, drug and alcohol abuse, domestic violence, prepregnancy maternal health status, psychosocial factors, prior health care, the presence of chronic medical problems in the mother, past history of repeated preterm delivery, multiple gestation, and abnormalities of the fetus or placenta. A woman with a high-risk pregnancy may have an earlier labor and delivery depending upon the fetal or maternal complication present and, likewise, present with symptoms dependent upon the condition. Since the placenta supplies the baby with its nutrients and oxygen, any condition that threatens the **blood** supply to it threatens **fetal development**.

The threat of a preterm delivery is the most common reason for a referral to a perinatal center, which is linked to obstetric and newborn services that provide the highest level of care for a pregnant woman and her baby. A preterm delivery may occur because of a premature rupture of membranes (the bag of water surrounding the baby breaks) or **preterm labor**. There is a strong correlation of vaginal or uterine **infection** with the pregnant woman’s water breaking, and there are lab tests that can be predictive of a woman’s risk of experiencing preterm labor.

According to a 2001 report from the U.S. Centers for Disease Control and Prevention, there were 29.6 deaths per 100,000 births among African-American women between 1991 and 1997. The rate for women of Hispanic origin was 10.3, and for white women it was 7.3. The rate for Asian women was unavailable. The second most common causes of death in women are problems related to pregnancy and delivery, including blood clots that travel to the **lungs**, anesthesia complications, bleeding, infection, and high **blood pressure** complications. A baby dies before, during, or after birth in 16 out of 1,000 deliveries in the United States. Almost 50% of these deaths are stillbirths, which are sometimes unexplained. The rest of the deaths occur in babies up to 28 days old, and the leading cause of these is birth defects, followed by prematurity. Risk factors can be present before pregnancy occurs and others develop during pregnancy.

Diagnosis

A risk-scoring sheet is utilized by many healthcare agencies during the prenatal assessment to establish if a woman may be at risk for complications during her pregnancy. This score sheet is implemented at the first prenatal visit, becomes a part of the woman’s record, and is updated throughout the pregnancy as necessary. A

KEY TERMS

Amniocentesis—A procedure that uses ultrasound to guide a needle into the amniotic sac (bag of waters) surrounding the baby and obtain fluid to analyze for genetic abnormalities.

Antepartum—This refers to the time period of the woman's pregnancy from conception and onset of labor.

Perinatal—Refers to the period shortly before and after birth, generally from around the 20th week of pregnancy to one to four weeks after birth.

Perinatologist—A specialist in the branch of obstetrics that deals with the high-risk pregnant woman and her fetus.

Preconceptional—This refers to the time period before pregnancy, i.e., conception, occurs.

Ultrasonographer—The person who performs the radiologic technique of ultrasound in which deep structures of the body are visualized.

woman's age affects pregnancy risk, as girls 15 years old and under are more likely to develop high blood pressure, protein in the urine and fluid accumulation (preeclampsia), or seizures (eclampsia). They also are more likely to have underweight or undernourished babies. A woman 35 or older has a greater risk of developing high blood pressure or diabetes, as well as a much higher risk of having a chromosomal abnormality such as **Down syndrome**. A woman shorter than five feet or a woman weighing less than 100 pounds before pregnancy has a greater risk of having a small or preterm baby.

Lab data and ultrasound are also utilized to determine high-risk pregnancies by specific blood tests and imaging of the baby. A pregnancy may begin as low risk and change to high risk secondary to complications determined from the ongoing assessment of the pregnant woman. Since many of these complications can be managed with proper treatment, it is essential that a pregnant woman keep her obstetric appointments.

Treatment

Treatment will vary, depending upon the maternal or fetal complication present. Generally, a woman with severe high-risk factors in pregnancy should be referred to a perinatal center to obtain the highest level of care for herself and her baby. Interventions to improve health status might include nutritional assessment, **physical**

examination, teaching modalities for smoking cessation, drug and alcohol programs, prescribing medications related to the condition, or changing pre-pregnancy medications (known to cause problems in the fetus), serial ultrasounds to learn fetal status, **amniocentesis**, fetal transfusions, fetal surgery, **antepartum testing**, bed rest, home health care, hospitalization, and early delivery. In a postterm pregnancy (greater than 42 weeks), the death of a baby is three times more likely than that of a normal term pregnancy (37–40 weeks). The treatment in this case would be to induce labor before problems start to occur with an aging placenta.

Prognosis

Advances in the management of complications in high-risk pregnancies have provided women with a means of controlling their risks, which substantially increases the potential for a successful outcome. Since it is impossible to guarantee a good outcome in a normal pregnancy, it is even more difficult to ensure that a high-risk pregnancy will result in a healthy infant and mother. A woman who strictly adheres to the medical regimen established for her, however, will greatly increase her chances of a positive result.

Health care team roles

The pregnant woman's interview at her first visit the health care provider is conducted by the nurse, who obtains the data necessary to begin the high-risk screening. The physician or midwife caring for a pregnant woman should review the prenatal assessment sheet, order lab data, and obtain ultrasounds to determine if any risk factors are present. If it is determined that a woman has a high-risk pregnancy, she should be referred to a perinatologist for advanced care. This is the specialist who establishes and implements the medical regimen needed for the particular maternal/fetal complication and the inter-disciplinary team associated with the perinatal center works in its management. The perinatal team usually comprises a nutritionist, social worker, nurse educators, geneticists, ultrasonographers, and additional nursing staff who are responsible for the monitoring and supervising of ongoing team care of the patient.

Prevention

The early weeks of pregnancy are the most crucial ones for the fetus. Many women do not know they are pregnant until several weeks after conception, so education about the need for preconceptional care is essential. **Preconception counseling** guides a woman in planning

a healthy pregnancy. These are some of the factors to which attention must be paid:

- family history
- medical history
- past pregnancies
- current medications
- lifestyle
- environment
- infections

Cigarette smoking is the most common addiction among pregnant women in the United States, and despite the health hazards of smoking being well-known, only about 20% of these women actually quit during pregnancy. One risk of smoking during pregnancy is having a baby who may die from sudden infant death syndrome (SIDS).

Drugs known to cause birth defects when taken during pregnancy include: alcohol, dilantin (phenytoin), any drug that interferes with the actions of **folic acid**, lithium, streptomycin, tetracycline, thalidomide, warfarin (Coumadin), and isotretinoin (Accutane), which is prescribed for acne. The number one preventable cause of mental retardation in infants is the abuse of alcohol during pregnancy. Alcohol can cause problems ranging from **miscarriage** to severe behavioral problems in the baby or developing child even if no obvious physical birth defects are apparent. **Fetal alcohol syndrome** is seen in about two out of 1000 live births. Infections that may cause birth defects include: herpes simplex, viral hepatitis, the flu, mumps, German measles (rubella), chickenpox (varicella), **syphilis**, toxoplasmosis (occurs from eating undercooked meat and handling kitty litter), listeriosis, and infections from the coxsackievirus or cytomegalovirus (CMV). Many adults have been exposed to coxsackievirus and CMV when they were younger, but there are many who have not been. Those who have not been exposed should pay careful attention to any illnesses they have early in their pregnancy, noting the onset, presence of **fever**, muscle aches and pains, and duration of illness to report to their physician.

Hemolytic disease of the newborn (destruction of the red blood cells) can occur when Rh incompatibility exists between child and mother. The most common cause of incompatible blood types is Rh incompatibility—such as when the mother has Rh-negative blood and the father has Rh-positive blood. The baby may have Rh-positive blood, in which case the mother's body produces antibodies against the baby's blood. Fortunately, the mother can be treated with Rhogam [Rh0(D)immune globulin], which can be given to the mother in the first 72 hours

after delivery and at the twenty-eighth week of pregnancy; it will destroy any antibodies produced by her blood and significantly decrease the risk associated with pregnancies with Rh-factor incompatibilities.

There are, however, other incompatible blood factors during the prenatal assessment period that can cause anemia in the fetus and require ongoing monitoring. The greatest gift a woman gives herself is to plan her pregnancy with preconceptional counseling. Many women are frequently deficient in folic acid, a B vitamin used in the synthesis of ribonucleic acid (RNA) and essential, in large quantities, for optimal protein synthesis in the fetus. This is especially true in the early weeks of pregnancy, when all **cell division** and organ development is occurring. Thus, the best prevention for a high risk pregnancy is good planning.

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High blood pressure see **Hypertension**

Hinge joint

Definition

Hinge joints are places in the human skeleton where the ends of bones meet and rotate uniaxially (in a single plane, like a knuckle or elbow). They are lubricated with synovial fluids, secreted by the synovial membrane, to ensure easy, pain-free movement.

Description

Hinge joints, also called ginglymi or ginglymus joints, act like the hinges on a cabinet or door to provide back and forth movement. However, unlike their hardware namesakes, hinge joints provide more movement than just back and forth swing. They have a varying spiral profile that allows some rotation. The interphalangeal (finger) and humeroulnar (elbow) joints are examples of the hinge joint. The knee is also a hinge joint.

Function

The purpose of joints is to provide movement for the body. Different types of joints move in different ways. The hinge joint is shaped to restrict movement to one plane. It has strong collateral ligaments that aid and restrict movement. The ends of the bones are covered with tough cartilage and are lined with the synovial membrane.

Each joint contains a small amount of synovial fluid which lubricates it. Synovial fluid provides protection for the hinge joint and allows for its stress-free movement.

The hinge joint provides a connection that allows articular surfaces to be closely molded together. This molding together permits extensive motion in one plane. The joint has stabilizing ligaments that limit the directions and extent to which the bones can be moved. The hinge joint moves back and forth with some rotation allowed.

Role in human health

Because synovial joints are the most mobile and intricate of all the joints, they are also the most prone to disease. Healthy hinge joints allow effortless, painfree mobility; diseased hinge joints are not only a source of physical **pain**, but also place severe limitations on movement. These limitations, in turn, can have adverse psychological consequences.

Common diseases and disorders

There are many disorders and diseases that can afflict the joints, making the hinge joints vulnerable to pain and discomfort. Degenerative and inflammatory diseases, conditions involving the membranes around the joints, generalized and congenital disorders, and dislocation and **fractures** can all cause damage to the hinge joints.

Arthritis is one of the conditions that causes pain and dysfunction in the hinge joint. There are several types of arthritis, but **osteoarthritis** and rheumatoid arthritis are the most common.

Osteoarthritis is a degenerative disease that affects the cartilage in the joints, and can cause inflammation in the tissues surrounding the affected joint or joints. Degeneration is commonly thought to be caused by stress on the joints or by injury to the joint lining. Osteoarthritis can affect all joints, but it is usually found in the fingers, feet, hips, spine, and knees. It causes joint stiffness and pain. Symptoms of osteoarthritis can be treated, but the disease is irreversible.

Rheumatoid arthritis is an inflammatory disease of the muscles and the membrane linings of cartilage and joints. The areas commonly affected are the hands, hips, knees, legs, and joints. The symptoms include low-grade **fever**, stiffness in the morning, and redness, pain, warmth, and tenderness in the affected joints. Rheumatoid arthritis can cause crippling pain and deformities of the hands and causes painful swelling of the joints.

Bursitis is a common disorder that affects the hinge joints and other joints. It is most often found in the elbow, knee, and shoulders. Bursitis is the inflammation of the bursa, flat sacs that surround the joints. Symptoms of bursitis are swelling, tenderness, pain, and warmth around the joint. The inflammation of the bursa is usually caused by overuse or injury of the joint. Two common types of bursitis are “housemaid’s knee,” which is caused by kneeling on hard surfaces for an extended period of time and “student’s elbow,” which is caused by leaning the arm against a desk or other hard surface.

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KEY TERMS

Axis—A central or principal structure about which something turns or is arranged. The hinge joint has one axis.

Bursitis—Inflammation of the bursa—flat sacs that surround the joints—usually caused by overuse or injury of the joint. “Housemaid’s knee” and “student’s elbow” are common forms of bursitis.

Osteoarthritis—A degenerative disease, usually found in the fingers, feet, hips, spine, and knees, that affects cartilage in the joints, and can cause inflammation in the surrounding tissues.

Rheumatoid arthritis—An inflammatory disease, related to a streptococcus infection, that affects muscles and the membrane linings of cartilage and joints. It can cause crippling pain, deformities of the hands, and painful swelling of the joints.

Synovial fluid—A transparent, viscous fluid found in the synovial joints. It lubricates the joint for easier movement.

Uniaxial—Having only one axis. The hinge joint is a uniaxial joint.

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National Arthritis and Musculoskeletal and Skin Diseases Information Clearinghouse (NAMSIC), National Institutes of Health, 1 AMS Circle, Bethesda, MD 20892 3675. (301) 495 4484 or (877) 22-NIAMS. TTY: (301) 565 2966. Fax: (301) 718 6366. <<http://www.nih.gov/niams/>>.

Osteoarthritis Research Society International. <<http://www.oarsi.org>>.

Peggy E. Browning

Hip fractures rehabilitation

Definition

The hip is a ball and socket type joint that has an influence on the pelvis and lumbar spine. The hip joint helps control and stabilize the lower limb, and plays an

integral part in lower limb mechanics including walking and climbing stairs. The hip joint is formed by the head of the femur and the acetabulum area of the pelvis. The femoral head sits deep into the concave acetabulum and is bound firmly by ligaments, a joint capsule, and muscles. The muscles around the hip act to move the lower limb. An example would be the moving of one’s thigh (femur) forward by contracting the muscles that flex the hip. Muscles act to stabilize the hip but also provide mobility and control (i.e. walking). It is quite apparent that through contraction of muscles and weight-bearing there can be large forces generated on the hip joint. Therefore, it is very important that hip musculature be strong and flexible to resist forces encountered during activities such as walking and stair climbing, resulting in minimized stress on the hip joint.

As individuals age into late adulthood, muscle strength declines. Due to decreased strength in older individuals, the forces on the hip joint once taken up by the surrounding musculature are now placed more on the weight-bearing surface of the hip. **Osteoarthritis (OA)** and **osteoporosis** further compromise the hip joint. Both diseases are common in the elderly adult. As the aging process continues the effects of decreased strength, OA and osteoporosis can lead to a less stable hip joint. With decreased stability, an individual can be at an increased risk for falling. Unfortunately, **fractures** are a possible outcome of falling in older adults. Hip fractures are one of the most common fractures associated with falling.

Purpose

The hip joint is a very stable **ball and socket joint**. Because of this inherent stability, the hip rarely dislocates. There are also numerous muscles around the hip that move the lower limb forward, backward, and to the side. These muscles aid in stabilizing the hip by further compressing or “holding” the femoral head in place. As stated previously, as the age of an individual increases, the stability of the hip joint can decrease. This decreased stability can lead to **gait and balance problems**, thus increasing the risk for falling. Moreover, other factors such as **dementia**, medication, and **vision** can also increase the risk for falling. Barriers in the environment can also make a surrounding place unsafe for the elderly. It becomes quite clear that older adults are at risk for falling, and a serious complication can be fracture.

Precautions

There are disorders that effect the hip, and one of the most common in older adults is hip fracture. There is an area in the hip joint that is located approximately mid-way between the femoral head and the shaft of the femur.

KEY TERMS

Acetabulum—The cup-shaped socket in the pelvis.

Dementia—A deterioration of mentality usually with marked apathy.

Flex—To bend.

Isometric exercises—A mode of exercise where there is contraction of muscle fibers, yet there is no movement of the limb.

Lumbar—Pertaining to the vertebrae in the lower back.

Pelvis—A basin-shaped group of bones that form the pelvic girdle.

Osteoarthritis—Degeneration of cartilage and bone of joints.

Osteoporosis—A condition that is characterized by decrease in bone mass with decreased density and enlargement of bone spaces.

Progressive resistive exercises—The mode of training that involves increasing intensity of exercise over time.

Prosthesis—An artificial implant or device that replaces a part of the body.

This area is called the femoral neck. Within the femoral neck there is a zone of weakness that is inherent to the bony structure. Unfortunately, as aging occurs and OA progresses, this area (or zone of weakness) becomes weaker and loses the ability to handle stress. There is a greater risk for fracture secondary to trauma or degeneration particularly in the area of the femoral neck.

There are many factors that can lead to falling and subsequent hip fracture. There are ways in which older adults can minimize the risk of falling and thus, decrease the possibility of fracturing the hip. Steps that can be taken by the older adult to minimize the risk of falling are:

- Removing slippery or tiled surfaces in the home.
- Improve the lighting in a home.
- Removing small or loose rugs.
- Minimize height differential between rooms; use ramps when necessary.
- Make sure floor is free from small objects.
- Have vision checked.

- Have a physician evaluate medicines for side-effects such as dizziness.
- Use handrails when needed, especially in toilet and shower areas.
- **Exercise** regularly to promote wellness, increase strength, and improve balance.

Description

A hip fracture usually refers to a disruption of either the proximal femoral shaft or femoral neck. If a femoral fracture were to occur, it usually happens in the area of the zone of weakness. Hip fractures in young athletes are not common and usually occur secondary to large forces due to trauma. The older individual who has hip osteoarthritis or osteoporosis is at risk for hip fracture.

Two common fractures in the elderly are intertrochanteric and femoral neck. Intertrochanteric fractures usually occur in the elderly. These fractures occur between the greater and lesser trochanters of the proximal femur, thus the term intertrochanteric (inter: between) and trochanteric, referring to trochanters. When there is a fracture between the trochanters, the most common procedure is an open reduction with internal fixation or more commonly known as ORIF. The goal of the ORIF is to provide a strong and stable fixture for the proximal femur. Femoral neck fractures usually occur in the zone of weakness described previously in the area between the femoral head and the trochanters and are also common in the elderly. Usually the age of an individual determines the mode of treatment. For example, in a displaced fracture in a younger individual, the mode of treatment may be an open reduction with internal fixation. In an elderly individual, a displaced fracture usually results in either a partial or total hip replacement. In non-displaced fractures of the femoral neck, internal fixation with pins and/or screws is the treatment of choice.

Preparation

Hip fracture can lead to impaired function and disability. Therefore, rehabilitation is important to minimize impairment and restore function. Rehabilitation should include early ambulation (walking), stabilizing the individual medically, breathing exercises to minimize risk of pulmonary embolisms, frequent changes in position to minimize formation of pressure ulcers, and regular walking.

Aftercare

Specific **physical therapy** treatments include range of motion, resistive exercises, flexibility, transfer training, balance exercises, bed mobility, and walking.

Depending on the weight-bearing status set by the physician, a patient with ORIF or arthroplasty can either ambulate with toe-touch weight-bearing (TTWB) or weight-bearing as tolerated (WBAT). Usually, the patient will ambulate with a standard walker or rolling walker. By the first week after surgery the patient should be able to do active range of motion of the hip and perform isometric exercises of the knee and hip. Usually, the hip patient is trained on proper transfer techniques and toileting during the initial weeks of rehabilitation. The patient can ambulate with an assistive device and with assistance from a therapist. Strengthening exercises continue into the twelfth week that includes isometric and isotonic exercises to both the hip and knee. Again, weight-bearing continues from WBAT to full weight-bearing depending on the procedure and whether the fracture is stable.

Complications

Complications after hip fracture can be related to the fracture, effects of bed rest, and the internal hardware. In a femoral neck fracture a serious complication is avascular necrosis. In either type of fracture (femoral or intertrochanteric) there could be poor reduction or possible re-fracturing. Extended bed rest could lead to muscle wasting, development of pressure ulcers, lung problems such as **pneumonia**, and other medical anomalies. Complications of hip arthroplasty may include **infection**, dislocation, and loosening of the prosthesis. Usually, a standard protocol for individuals with total hip replacement are no hip internal rotation, adduction past midline, and no hip flexion beyond ninety degrees (no leaning trunk over hips while sitting). Passive range of motion should be avoided if there was a reduced fracture. Hip fractures occurring in older adults often results in deteriorating health due to compounding complications. There is a statistically high rate of mortality due to complications directly resulting from hip fractures in patients over the age of seventy.

Results

After hip fracture most individuals are full weight-bearing and independent in activities of daily living, i.e. walking, by four to six months post-surgery. Full passive and active range of motion exercise can be done; progressive resistive exercises should be continued to strengthen the hip and surrounding musculature.

Health care team roles

Unfortunately, individuals in their mid-80s and older who have a hip fracture are at a much higher risk of not

regaining prior level of function. Furthermore, almost 20% of individuals with hip fracture will require nursing **home care**. Thus, the cost of hip fracture for the individual, family, and society is quite high. Considering the aging of the United States population, it would seem reasonable to assume that the incidence of hip fracture and complications associated with this condition will increase over time. Thus, the importance of prevention and education in our society.

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Histocompatibility testing see **Human leukocyte antigen test**

HIV infection see **AIDS**

HIV preventative measures

Definition

Human **immunodeficiency** virus (HIV) is a systemic viral **infection** that weakens the body's ability to fight infection and can cause acquired immune deficiency syndrome (**AIDS**, the last stage of HIV disease). HIV preventative measures are a set of procedures that lower the risk of health care professionals being exposed to the virus.

Description

HIV is the most dangerous sexually transmitted disease (STD), affecting people of all ages. In 1999, HIV was considered the fifth cause of death among American men and women between 25 and 44 years of age. It is

believed that 40,000 Americans are infected every year. There have already been 700,000 cases reported in the United States. Globally, over 36 million people have been infected with the AIDS virus.

Most HIV-positive people are men. According to a 2001 survey by the United States Centers for Disease Control and Prevention (CDC) (www.cdc.gov), of 3,000 gay and bisexual men in six major U.S. cities (interviewed in public places, such as gay clubs and bars), 4.4% of gay and bisexual men, ages 23 to 29, are infected with HIV every year. Another study in 2001, also conducted by the CDC, reported that HIV infections among gay men of all races in their 20s were common in large American cities. Thirty percent of blacks, 15% of Hispanics, 7% of whites, and 3% of Asians were affected with HIV. In the general population, one in seven blacks becomes HIV-positive each year.

The incidence of the HIV and AIDS is rapidly increasing in women and children, too. Like many other **viruses**, HIV remains in the body for life. As of 2001, there is no vaccine against HIV.

Causes and symptoms

HIV infection can present no clinical symptoms, cause a spectrum of conditions, or appear as full-blown AIDS. A unique virus, HIV continually reproduces after it enters the body, eventually overwhelming the **immune system** and weakening the body's ability to fight lethal infections and cancers.

Most people infected with HIV are not ill. Some are without symptoms for more than 10 years. A "carrier" can host the virus and pass it on to other people without knowing it. Once the virus is established in the body, the chances of getting AIDS increase.

Some of the frequently reported symptoms of HIV/AIDS infections are:

- constant or rapid unexplained weight loss of more than 10 pounds in two months; lack of appetite
- unexplained long-lasting **diarrhea** or bloody stools
- constant fatigue that is not associated with physical activity or mental depression
- persistent fevers, night sweats, dry cough, or difficulty breathing for more than two weeks
- lightheadedness, dizziness, headaches, mental disorders
- a thick, whitish coating of yeast on the tongue or mouth that cannot be scraped off (This is called "thrush.")
- severe or recurring vaginal yeast infections and chronic pelvic inflammatory disease (PID)

- purplish growths or blotches on or under the skin, inside the mouth, or on the nose, eyelids, or rectum
- swollen glands or enlarged lymph nodes in the neck, armpits, or groin for more than a month

Many HIV/AIDS symptoms are similar to those of **tuberculosis, influenza, pneumonia**, minor yeast infections, and other STDs. Basically healthy people tend to ignore their symptoms until they are ill enough to seek medical care.

HIV is found in bodily fluids. It is most prevalent in **blood**, semen, vaginal secretions, and breast milk. HIV infection cannot be transmitted through casual contact. Rather, HIV is transmitted by sexual contact with an infected person, exposure to contaminated blood (e.g., by sharing needles or accidental exposure to contaminated needles) and maternal-fetal transfer.

Activities that spread HIV/AIDS to others are:

- anal and vaginal intercourse (It is less commonly transmitted through oral sex.)
- sharing contaminated needles for injecting illicit drugs
- transfusion of contaminated blood products
- **childbirth** and breast feeding
- accidental pricks with contaminated needles while providing health care to infected patients

Diagnosis

Blood tests are used to detect the presence of HIV antibodies in the blood. Antibodies are developed two weeks to three months after infection. Other bodily secretions may also provide evidence of HIV infection. Even before the antibody test is positive, a person can pass the virus to others.

AIDS is the final stage of the HIV infection. The diagnosis is supported by the presence of a variety of conditions and opportunistic infections (i.e., conditions caused by a microorganism that does not ordinarily cause disease, but which becomes pathogenic under certain circumstances) related to HIV. During the disease process, the AIDS virus attacks certain white blood cells (T-lymphocytes). AIDS destroys the body's immune (defense) system and allows otherwise controllable infections to invade the body and cause additional diseases. These opportunistic diseases gain strength in the body and may eventually cause death.

The AIDS virus may also attack the nervous system and cause **brain** damage. It may take years for symptoms of brain damage to occur, manifesting as **memory** loss, loss of coordination, partial **paralysis**, or mental disorder.

These symptoms may occur alone or in combination with any of the other symptoms associated with the disease.

HIV/AIDS can only be diagnosed by physicians or qualified health professionals. While AIDS patients are treated by physicians using established protocols for care, patients are often referred to medical specialists, known as epidemiologists, for consultation and monitoring the course of their disease. These specialists study the factors that influence the frequency and distribution of infectious diseases among populations of human beings. The physician specializing in epidemiology concentrates on research and management of infectious diseases.

Medical specialists utilize the support of pathologists in the diagnosis, management, and treatment of patients with the AIDS virus. The scientific study of bodily changes produced by AIDS, pathology is concerned with conducting research. This research is accomplished using comparative analyses of disease processes. Other research may include the practice of experimental pathology, whereby pathologic processes are artificially induced in the laboratory setting. Both methods, however, provide pathologists with the opportunity to learn about the fatal impact of AIDS.

Treatment

As of mid-2001, there is no known cure for, or vaccine against, HIV/AIDS. However, using new drug combination therapy can allow infected persons to remain symptom-free for longer periods, provided the disease is detected early. When HIV is detected early in **pregnancy**, its treatment with **antiretroviral drugs** might reduce the risk of transmitting the virus to the child. However, the an HIV-positive, pregnant woman's doctor will frequently advise delivery by cesarean section (cs) to eliminate the chance of transmitting the virus during childbirth.

Success with new, highly active antiretroviral therapy (i.e., HAART, also known as a drug "cocktail") and the decline in the number AIDS cases newly reported, as well as the number of deaths, are good news. A number of HIV-infected people who are still alive due to HAART, and that number is growing.

Drug therapies include TMP-SMX (trimethoprim-sulfamethoxazole [tri-METH-o-prim-sul-fa-meth-OX-uh-zole]). Brand names for these drugs are Bactrim, Septra, and Cotrim. The long-term effectiveness of HAART is unknown; HIV may develop resistance to these drugs. Further, this combination drug therapy is very expensive, and a vast number of HIV-infected persons do not have health insurance or the financial means to purchase medication.

Patients also have difficulty maintaining a complicated drug treatment schedule that involves taking a large numbers of pills. Many of these drugs have unpleasant or intolerable side effects, interact with other medications, and cause serious medical problems. Patients might even forget to take all of their medications, or skip doses.

Patients who feel healthy have been known to take "drug holidays," by not taking their medications for days or weeks. Treatment regimes are less effective in the overall population when there is an increased possibility of developing a drug-resistant strain of HIV. If drug resistance is developed by the evolving virus and is coupled with a relaxation in treatment regimens, resistant strains may be transmitted to others, and thus spread widely. Prevention remains the best and most cost-effective approach to controlling the HIV/AIDS epidemic and saving lives.

Prognosis

HIV infections and many AIDS-related conditions, such as pneumonias, cancers, and a variety of infections that take advantage of weakened immune systems, can be managed to some extent with different treatments. Improved treatment options are continually being developed by scientists and pharmaceutical companies. However, no one has ever recovered from full-blown AIDS. As of 2001, the disease is still considered fatal.

Health care team roles

Assessment

Nurses and allied health professionals are likely to be the first medical contact for HIV-infected patients. Information obtained about the patient's signs and symptoms, lifestyle, and social behavior must be documented by the medical staff.

Surveillance

There has been recognition by researchers that behavior that places an individual at risk for other STDs increases the risk of HIV infection. Sexually-transmitted disease (STD) surveillance can provide important indicators of sites to which HIV infection may spread, as well as point to targets to which efforts to promote safe sexual behavior should be aimed.

Monitoring

Patient care activities, patient progress, and response to symptomatic or preventive therapies need to be documented by nurses. Medical record information is vital to

KEY TERMS

Acquired immune deficiency syndrome (AIDS)—The final stage of a series of health problems caused by the human immunodeficiency virus (HIV).

Epidemiological studies—Medical research that deals with the incidence, distribution, and control of disease in a population; the sum of factors controlling the presence or absence of a disease, or pathogens.

Highly active antiretroviral therapy (HAART)—Also known as drug “cocktail,” this is a combination of powerful drugs prescribed to arrest HIV infection and delay the onset of AIDS. It is not a cure for HIV/AIDS.

Human immunodeficiency virus (HIV)—The virus that causes AIDS. HIV weakens the body’s ability to fight infections.

Opportunistic infection (OI)—Condition caused by a microorganism that does not ordinarily cause disease, but which becomes pathogenic under certain circumstances.

Sexually transmitted disease (STD)—Also called venereal disease; any disease transmitted through sexual contact.

continued research in the field. All information must be kept confidential and maintained in compliance with state and federal laws.

Education

Education about HIV prevention has been proven cost-effective when compared with the rising cost of lifetime medical management of people with AIDS. Different types of preventive messages, skills, and support are needed to help reduce sexual and drug-related risks.

Drug injectors should be educated about their high-risk behavior. Drug counseling may help them stop using drugs or sharing needles. These individuals need to be taught how to protect themselves from sexual transmission if their partners have ever been IV drug users and may have shared needles.

Substance abuse is a major problem. The combination of substance abuse and sexual HIV transmission must be given serious attention. Substance abuse prevention and intervention are sorely lacking for users of mor-

phine, cocaine, **marijuana**, and alcohol. These substances not only alter users’ behavior, but weaken their immune systems. This weakening may make them more susceptible to infection with HIV. Counseling and treatment should be available to those who abuse drugs and alcohol. They, too, are in need of assistance in helping them stop using drugs and to help them prevent HIV infection.

Comprehensive health education programs need to be directed toward generation-specific behavior and epidemiology. Programs for children and young adults should involve parents and educators. The most effective programs begin educating young people at an early age and are designed to promote healthy behaviors—such as exercising, eating healthy food, avoiding drug use, excessive alcohol consumption, smoking, and premature sexual activity.

Occupational HIV transmission

Although it is not a primary means of transmitting the spread of HIV, there are documented cases of HIV seroconversion among health workers. Responsibility for preventing occupational exposure to HIV and other bloodborne pathogens is that of the nurse. Precautions include the routine use of gloves for one-time use, goggles, and disposable protective clothing. These function as preventive barriers when there is the possibility of coming in contact with infectious materials. Good hand-washing practices are essential. It is necessary that sharp instruments and contaminated materials are handled and disposed of in a proper manner.

Prevention

Sustained, comprehensive efforts of the 1980s have had a significant impact on slowing the spread of HIV/AIDS in the United States. Although it is difficult to determine exactly how many thousands of infections were prevented as a result of deliberate effort, the mid-1980s witnessed an epidemic growing at an annual rate greater than 80%. As of mid-2001, this rate has stabilized. Nationally, 30 of every 100,000 men and nine of every 100,000 women have AIDS. Despite the occurrence of 40,000 new cases per year, fewer people are dying from AIDS and AIDS-related complications. This is indicative of tremendous progress. In general, previous preventive efforts resulted in many behavioral changes, thereby helping to slow the epidemic overall.

The decline in the number of deaths from AIDS and the effectiveness of antiretroviral therapies increase the number of HIV infected people in the general population. These successes may contribute to a person’s false sense of security when he or she believes and behaves as if pre-

venting the spread of HIV is no longer important. Complacency about the need for prevention adds a complex dimension to disease management for health care professionals and the at-risk population. The complicated nature of HIV/AIDS strongly supports valuable opportunities for prevention and intervention.

Primary HIV prevention means keeping people from becoming infected with HIV in the first place. Intervention must focus on preventing the spread of HIV by infected individuals as well as on acquisition by uninfected populations. Infected individuals need to develop skills to reduce the risk of infecting others. It is essential that there be easy access to voluntary blood testing; this will enable early detection of HIV infection.

Comprehensive school-based HIV and sex education programs are suspected to delay initiation of sexual activity in teenagers, reduce the frequency of intercourse for those who are sexually active, decrease the number of sexual partners they have, and increase the use of condoms and other contraceptives.

Stringent screening of donor blood supply for HIV antibodies, and heat-treating blood products used to treat **hemophilia** have nearly eliminated HIV transmission through transfusions.

Secondary HIV prevention is keeping HIV-infected people safe and healthy by helping them avoid opportunistic infections and stopping the infection from progressing to AIDS.

Scientists are exploring the possibility that combination drug therapies may reduce the infectious nature of the disease. With the lines between prevention and treatment beginning to merge, ongoing services for people who are HIV positive must balance medical advances with the behavioral and social support needed to preserve their quality of life and prevent the spread of infection.

A focus on behavioral change is paramount. Vaccines are not able to prevent disease if people are not vaccinated. No vaccine for lifelong immunity has yet been developed. Further, medical advances are unsuccessful unless their implementation parallels that of effective prevention strategies. People must be receptive to both in order for HIV rates to be reduced.

Pregnant women who may not know they are infected with HIV cannot reduce the risk of transmitting the disease to their unborn children unless that they get **pre-natal care**, routine HIV counseling, and submit to voluntary testing. Infected patients must have access to anti-retroviral drugs. Programs that identify and treat HIV-infected pregnant women have shown dramatic success in reducing HIV transmission to their babies. A woman who is HIV-positive and pregnant may be

advised by her doctor to deliver by cesarean section (cs) to eliminate the chance of transmitting the virus during childbirth.

Efforts to reduce the risk for HIV infection of injection drug users through public attitudes and policies have been very effective. State health departments have reported significant reductions in the sharing of drug injection equipment after implementing programs to increase access to sterile injection equipment.

Infected individuals need assistance developing skills to use the new medical treatments. Highly active antiretroviral therapy (HAART) involves complex treatment regimens and requires compliance-related skills. Patients need to learn how to deal with the side effects of medications and **drug interactions**. They must learn how to decrease the risk of developing drug resistance by taking their medications as recommended and also learn how to work with complicated medication schedules. HIV-positive individuals also depend on the support of family and friends to continue their drug regimens and to encourage prevention of transmission to others.

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HIV tests see **AIDS tests**

Hives

Definition

Hives is an allergic skin reaction causing localized redness, swelling, and itching.

Description

Hives is a reaction of the body's **immune system** that causes areas on the surface of the skin to swell, itch, and become reddened (wheals). These lesions are elevated, can be blanched with pressure applied from a finger, and are oval in shape. When the reaction is limited to small areas of the skin, it is called urticaria. Involvement of larger areas, such as whole sections of a limb, is called angioedema.

Causes and symptoms

Causes

Hives is an allergic reaction. The body's immune system is normally responsible for protection from foreign invaders. When it becomes sensitized to normally harmless substances, the resulting reaction is called an allergy. An attack of hives is set off when such a substance, called an allergen, is ingested, inhaled, or otherwise contacted. It interacts with immune cells called mast cells, which reside in the skin, airways, and **digestive system**. When mast cells encounter an allergen, they release histamine and other chemicals, both locally and into the bloodstream. These chemicals cause **blood vessels** to become more porous, allowing fluid to accumulate in tissue and leading to the swollen and reddish appearance of hives. Some of the chemicals released sensitize pain-nerve endings, causing the affected area to become itchy (pruritic) and sensitive.

A wide variety of substances may cause hives in sensitive people, including food, drugs, insect or stings, and common household items. Common culprits include:

- nuts, especially peanuts, walnuts, and Brazil nuts
- fish, mollusks, and shellfish
- eggs
- wheat
- milk
- strawberries
- food additives and preservatives
- penicillin or other antibiotics
- flu vaccines
- tetanus toxoid vaccine



Hives on the back of a young woman's legs. The accompanying inflammation develops as an allergic reaction which ranges in size from small spots to patches measuring several inches across. (Photograph by John Radcliffe, Custom Medical Stock Photo. Reproduced by permission.)

- gamma globulin
- bee, wasp, and hornet stings
- bites of mosquitoes, fleas, and scabies.
- dander from house pets
- new fragrances, laundry soaps, hand lotions, or articles of clothing
- certain plants, molds, chemicals, or dust particles

Symptoms

Urticaria is characterized by redness, swelling, and itching of small areas of the skin. These patches usually grow and recede in less than a day, but may recur in other locations, and complete resolution can take four to six weeks. Angioedema is characterized by more diffuse swelling. Swelling of the airways may cause wheezing and respiratory distress. In severe cases, airway obstruction may occur.

Diagnosis

Hives are easily diagnosed by visual inspection. The cause is usually more difficult to diagnose and requires a thorough medical history in order to determine the allergen.

Treatment

Mild cases of hives are treated with **antihistamines**, such as diphenhydramine (Benadryl). The major side effect of diphenhydramine is drowsiness. Newer antihistamines, such as loratadine (Claritin), are non sedating and are used more frequently with chronic hives management. More severe cases may require oral **corticosteroids**, such as prednisone. Prednisone helps block the release of mast cells and decreases the leakiness of **blood vessel walls**. Gradual tapering doses of prednisone are the most common way to take this medication. Topical corticosteroids are not effective. Airway swelling may require an emergency injection of epinephrine (adrenaline). Epinephrine constricts the blood vessels of the skin and immediately combats the histamine release.

An alternative practitioner will try to determine what allergic substance is causing the reaction and help the patient eliminate or minimize its effects. To deal with the symptoms of hives, an oatmeal bath may help to relieve itching. Chickweed (*Stellaria media*), applied as a poultice (crushed or chopped herbs applied directly to the skin) or added to bath water, may also help relieve itching. Several homeopathic remedies, including *Urtica urens* and *Apis* (*Apis mellifica*), may help relieve the itch, redness, or swelling associated with hives.

Prognosis

Most cases of hives clear up within one to seven days without treatment, providing the cause (allergen) is found and avoided. Some bouts of hives can persist up to six weeks and can be frustrating for the sufferer.

Health care team roles

The health care professional (R.N., L.P.N.) completing the history of a person presenting with hives should focus on specific information to determine the patient's allergen. Important information to include:

- Broad aspects about urticaria (when it started, how long and how often do episodes happen, where on the body do they usually appear, at what point do symptoms start to abate, and if there is a link with seasonal changes).
- Work and leisure activities (questions specific to possible exposure).
- Recent management of hives (previously prescribed medication, OTC medication or herbal supplements).
- Dietary review (a thorough review of the person's diet can help identify potential food substances that are common allergens).

KEY TERMS

Allergen—A substance capable of producing an immediate type of hypersensitivity or allergy.

Pruritic—Itchy.

Wheal—A smooth, slightly elevated area on the body surface, which is redder or paler than the surrounding skin.

Patient education

Patient education should focus on teaching the significance of avoiding allergens and the identification of the early signs of a hives outbreak. The patient should be made aware of the fact that diphenhydramine (Benadryl) causes sedation and should *not* be taken when driving or operating heavy machinery. If urticaria becomes a chronic problem, the patient should be made aware of the many new drugs that can help manage the condition.

Prevention

Preventing hives is only possible by avoiding the allergens causing them. Analysis of new items in the diet, new drugs taken, or new products at home may reveal the likely source of the allergen. Chronic hives can also be aggravated by **stress**, **caffeine**, alcohol, or tobacco; avoiding these may reduce the frequency of reactions. For people with chronic hives, referral to a doctor who specializes in **allergies**, skin disorders, immune disorders, or rheumatology may be helpful.

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HLA test see **Human leukocyte antigen test**

HMOs see **Managed care plans**

Hoarseness see **Voice disorders**

Holter monitoring see **Ambulatory electrocardiography**

Home care

Definition

Home care is a form of health care service provided wherever a patient lives. Patients can receive home care services whether they live in their own homes with family members or in an assisted living facility. The purpose of home care is to promote, maintain, or restore a patient's health and reduce the effects of diseases or disabilities.

Description

The goal of home care is the provision of whatever a patient needs in order to remain living in his or her home, regardless of age or disability. The services provided may range from such homemaking services as cooking or cleaning to skilled medical care for patients on **ventilators** or dialysis machines or those receiving infusion therapies. Some patients require home-health aides or personal care attendants to help them with activities of daily living (ADL).

Medical, dental, and nursing care may all be delivered in the patient's home, which allows him or her to feel more comfortable and less anxious. Therapists from speech-language pathology, **physical therapy**, and **respiratory therapy** departments often make regular home visits, depending on the patient's specific needs. General nursing care is provided by both registered and licensed practical nurses; however, there are also nurses who are clinical specialists in psychiatry, obstetrics, and cardiology who provide care in these areas when prescribed. Home-health aides provide what is called custodial care in domestic settings; their duties are similar to those of nurses' aides in the hospital. Professionals who deliver care to patients in their homes are employed either by independent for-profit home-care agencies or by hospital agencies or departments. Personal care attendants can also be hired privately by patients; however, not only is it more difficult to evaluate an employee's specific background and credentials when he or she is not associated with a certified agency or hospital, but medical insurance may not cover the expense of an employee who does not come from an approved source.

Viewpoints

Often, patients are more comfortable in their own homes, rather than a hospital settings. Depending on the patient's living status and relationships with others in the home, however, the home is not always the best place for caregiving. Nevertheless, home care continues to grow in popularity. Hospital stays have been shortened considerably, starting in the 1980s with the advent of the diagnosis-related group (DRG) reimbursement system as part of a continuing effort to reduce healthcare costs. But as a result, many patients come home "quicker and sicker," and in need of some form of care or help that family or friends may not be able to offer. Community-based healthcare services are expanding, giving patients more options for assistance at home.

History

It is helpful to have some basic information about the evolution of home care in order to understand the public's demand for quality health care, cost containment, and the benefits of advances in both medical and communication technologies. The first home care was delivered by members of Roman Catholic religious orders in Europe in the late seventeenth century. This form of care giving was later performed by registered nurses who "visited" people in their homes. Visiting Nurse Associations (VNAs) were formed toward the close of the nineteenth century. Today there are many home-care agencies and VNAs that continue to deliver a wide range of home-care services to meet the specific needs of patients throughout the United States and Canada.

Social factors have historically influenced home-care delivery and continue to do so today. Before the 1960s, home care was a community-based delivery system that provided care to patients whether they could pay for the services or not. Agencies relied on charitable contributions from private citizens or charitable organizations, as well as some limited government funding. But as the life expectancy of the United States population began to rise, advances in medical science saved patients who might have died in years past. As a result, more and more elderly or disabled people required medical care in their homes as well as in institutions. Consequently, the federal government put **Medicare** and **Medicaid** into place (1965) to help fund and regulate health-care delivery for this population.

Funding and regulation

Government involvement resulted in regulations that changed the focus of home care from a nursing-care delivery service to care delivery under the direction of a

physician. Home-care delivery is paid for either by the government through Medicare and/or Medicaid; by private insurance or health maintenance organizations (HMOs); by patients themselves; or provided without cost by certain non-profit community, charitable disease advocacy organizations (e.g., ACS), or faith-based organizations.

Home-care delivery services provided by Medicare-certified agencies are tightly regulated. For example, a patient must be home-bound in order to receive Medicare-reimbursed home-care services. The home-bound requirement—one of many—means that the patient who receives home-care services from a Medicare-certified agency must be physically unable to leave his or her home (other than for infrequent trips to the doctor or hospital), thereby restricting the number of persons eligible for home-care services. Private insurance companies and HMOs also have certain criteria for the number of visits that will be covered for specific conditions and services. Restrictions on the payment source, the physician's orders, and the patient's specific needs determine the length and scope of services.

Assessment and implementation

Since home-care nursing services are provided on a part-time basis, patients, family members, or other caregivers are encouraged and taught to do as much of the care as possible. This approach goes beyond payment boundaries; it extends to the amount of responsibility the patient and his or her family or caregivers are willing or able to assume in order to reach that expected outcome. Nurses who have received special training as case managers visit the patient's home and draw up a plan of care based on assessing the patient, listing the diagnoses, planning the care delivery, implementing specific interventions, and evaluating outcomes or the efficacy of the implementation phase. Planning the care delivery includes assessing the care resources within the circle of the patient's family and friends.

At the time of the initial assessment, the visiting nurse, who is working under a physician's orders, enlists professionals in other disciplines who might be involved in achieving expected outcomes, whether those outcomes include helping the patient return to a certain level of health and independence or maintaining the existing level of health and mobility. The nurse provides instruction to the patient and caregiver(s) regarding the patient's particular disease(s) or condition(s) in order to help the patient achieve an agreed-upon level of independence. Home-care nurses are committed to helping patients make good decisions about their care by providing them with reliable information about their conditions. Since



A home care nurse checks a patient's blood pressure.

(Photograph by Jose L. Pelaez. The Stock Market. Reproduced by permission.)

home care relies heavily on a holistic approach, care delivery includes teaching coping mechanisms and promoting a positive attitude to help motivate patients to help themselves to the extent that they are able. Unless the patient is paying for home-care services out-of-pocket and has unlimited resources or a specific private long-term care insurance policy, home-care services are scheduled to end at some point. Therefore, the goal of most home-care delivery is to move both the patient and the caregivers toward becoming as independent as possible during that time.

Professional implications

Home-care delivery is influenced by a number of variables. Political, social, and economic factors place significant constraints on care delivery. Differences among nurses, including their level of education, years of work experience, type of work experience, and level of cultural competence (cross-cultural sensitivity) all influence care delivery to some extent.

The following list identifies some of the professional issues confronting home-care nurses at the turn of the twenty-first century. They include:

KEY TERMS

Activities of daily living (ADLs)—The activities performed during the course of a normal day, for example, eating, bathing, dressing, toileting, etc.

Home health aide—An employee of a home-care agency who provides the same services to a patient in their home as nurses aides perform in hospitals and nursing homes. Home-care agencies differ according to state regulations and agency policy regarding the scope of duties provided by home health aides.

Licensed practical nurse (LPN)—A person who is licensed to provide basic nursing care under the supervision of a physician or a registered nurse.

Medicaid—The United States' federally-funded program for state-operated programs that provide medical assistance to permanently disabled patients and to low-income people.

Medicare—The federally-funded national health insurance program in the United States for all people over the age of 65.

Personal care attendant—An employee hired either through a healthcare facility, home-care agency, or private agency to assist a patient in performing ADLs.

Psychiatric nursing—The nursing specialty concerned with the prevention and treatment of mental disorders and their consequences.

Registered nurse—A graduate nurse who has passed a state nursing board examination and been registered and licensed to practice nursing.

Respiratory therapy—The department of any healthcare facility or agency that provides treatment to patients to maintain or improve their breathing function.

Speech-language pathology—Formerly known as speech therapy, speech-language pathology includes the study and treatment of human communication—its development and disorders.

- legal issues
- ethical concerns
- safety issues
- nursing skills and professional education

Legal issues

The legal considerations connected with delivering care in a patient's private residence are similar to those of care delivered in healthcare facilities, but have additional aspects. For example, what would a home care nurse do if she or he had heard the patient repeatedly express the desire not to be resuscitated in case of a **heart** attack or other catastrophic event, yet during a home visit, the nurse finds the patient unresponsive and cannot find the orders not to resuscitate in the patient's chart anywhere? What happens if the patient falls during home-care delivery? While processes, protocols, and standards of practice cannot be written to address every situation that may arise in a domestic setting, timely communication and strong policy are essential to keep both patients and home care staff free of legal liability.

Ethical concerns

Ethical implications are closely tied to legal implications in home care—as in the case of missing DNR (do not resuscitate) orders. For example, what measures are appropriate if a home-care nurse finds a severe diabetic and recovered alcoholic washing down a candy bar with a glass of bourbon? The patient is in his or her own residence and has the legal right to do as he or she chooses. Or what about the family member who has a bad fall while the nurse is in the home providing care? Should the nurse care for that family member as well? What is the nurse's responsibility to the patient when he or she notices that a family member is taking money from an unsuspecting patient? Complex ethical issues are not always addressed in policy statements. Ongoing communication between the home-care agency and the nurse in the field is essential to address problematic situations.

Safety issues

Safety issues in home care require attention and vigilance. The home-care nurse does not have security officers readily available if a family member becomes violent either toward the health-care worker or the patient. Sometimes home-care staff are required to visit patients in high-crime areas or after dark. All agencies should have some type of supervisory personnel available 24 hours a day, seven days a week, so that field staff can reach them with any concerns. Also, clear policy statements that cover issues of personal safety must be documented and communicated regularly and effectively.

With advances in technology and the increased effort to control cost, home care is beginning to involve telecare in the delivery services. Telecare uses communications technology to transmit medical information between the patient and the health care provider.

Providing care to patients without being in their immediate presence is a relatively new form of home nursing, and is not without its problems. While some uncertainty exists regarding legal responsibilities and the potential for liability, much has been done to make telecare an effective way to hold costs down for some patients. Home-care nurses who are required to make telecare visits should know what regulations exist in that state before providing care. The chief danger lies in diagnosing and prescribing over the phone without seeing the patient.

Implications for nursing education

While there is no specific degree program required for delivery of home-care services, providing nursing care in a patient's home differs significantly from hospital care. Home-care nurses provide care for patients of every age, economic class, and level of disability. Some nurses provide specialized hospice, mental health, or pediatric care. Home-care nurses, on the average, spend more time teaching patients and caregivers than in an institutional setting, since the emphasis in home care is to foster independence and to improvise with the tools at hand. And while all nurses are patient advocates, home-care nurses must respect social and cultural values as part of the impact that the family and the home environment have on the patient's overall health. Home-care nurses are case managers, since they apply the entire nursing process to each of their patients. They must implement their own quality improvement during care delivery. Home care nursing often involves more than biomedically-based care, depending on the patient's religious or spiritual background. Nurses who visit patients in their homes often spend more time with them and encounter situations and opportunities where each communicate on a higher level of understanding and sensitivity. Finally, home care delivery demands that employees exercise a high level of flexibility, creativity, and the ability to work without constant supervision.

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- National Association for Home Care. 519 C Street, NE, Washington, DC 20002. (202) 547-7424.
- Visiting Nurse Associations of America. 3801 East Florida Avenue, Suite 900, Denver, CO 80210. (800) 426-2547.

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- Senior Housing Net. <<http://www.seniorhousing.net>>.

Susan Joanne Cadwallader

Homeopathy

Definition

Homeopathy, or homeopathic medicine, is a holistic system of treatment that originated in the late eighteenth century. The name homeopathy is derived from two Greek words that mean "like disease." The system is based on the idea that substances that produce symptoms of sickness in healthy people will have a curative effect when given in very dilute quantities to sick people who exhibit those same symptoms. Homeopathic remedies are believed to stimulate the body's own healing processes. Homeopaths use the term "allopathy," or "different than disease," to describe the use of drugs used in conventional medicine to oppose or counteract the symptom being treated.

Origins

Homeopathy was founded by German physician Samuel Hahnemann (1755-1843), who was much disturbed by the medical system of his time, believing that its cures were crude and some of its strong drugs and

treatments did more harm than good to patients. Hahnemann performed experiments on himself using Peruvian bark, which contains quinine, a **malaria** remedy. He concluded that in a healthy person, quinine creates the same symptoms as malaria, including fevers and chills, which is the reason why it is effective as a remedy. He then began to analyze the remedies available in nature by what he called provings. Provings of homeopathic remedies are still compiled by dosing healthy adults with various substances and documenting the results, in terms of the dose needed to produce the symptoms and the length of the dose's effectiveness. The provings are collected in large homeopathic references called *materia medica* or materials of medicine.

Hahnemann formulated these principles of homeopathy:

- Law of Similars (like cures like).
- Law of the Infinitesimal Dose. (The more diluted a remedy is, the more potent it is.)
- Illness is specific to the individual.

Hahnemann's Law of Similars was based on thinking that dated back to Hippocrates in the fourth century B.C. It is the same thinking that provided the basis for vaccinations created by Edward Jenner and Louis Pasteur. These vaccines provoke a reaction in the individual that protects against the actual disease. Allergy treatments work the same way. By exposing a person to minute quantities of the allergen, the person's tolerance levels are elevated.

The Law of the Infinitesimal Dose has always caused controversy among those outside the field of homeopathy. Hahnemann contended that as he diluted his remedies with water and alcohol and succussed, or shook, them, the remedies actually worked more effectively. In fact, diluted homeopathic remedies may have no chemical trace of the original substance. Practitioners believe that the electromagnetic energy of the original substance is retained in the dilution, but toxic side effects of the remedy are not. It is this electrochemical "message" that stimulates the body to heal itself.

Homeopathic practitioners believe that illness is specific to an individual. In other words, two people with severe headaches may not receive the same remedies. The practitioner will ask the patient questions about lifestyle, dietary habits, and personality traits, as well as specific questions about the nature of the headache and when it occurs. This information gathering is called profiling or case-taking.

In the early 1900s, homeopathy was popular in America, with over 15 percent of all doctors being homeopathic. There were 22 major homeopathic medical

schools, including Boston University and the University of Michigan. However, with the formation of the American Medical Association, which restricted and closed down alternative practices, homeopathy declined for half a century. When the 1960s invigorated back-to-nature trends and distrust of artificial drugs and treatments, homeopathy began to grow again dramatically through the next decades. In 1993, *The New England Journal of Medicine* reported that 2.5 million Americans used homeopathic remedies and 800,000 patients visited homeopaths in 1990, and it has continued to grow. Homeopathy is much more popular in Europe than in the United States. French pharmacies are required to make homeopathic remedies available along with conventional medications. Homeopathic hospitals and clinics are part of the national health system in Britain. It is also practiced in India and Israel, among other countries.

Benefits

Homeopathic physicians seek to cure their patients on the physical, mental and emotional levels, and each treatment is tailored to a patient's individual needs. Homeopathy is generally a safe treatment, as it uses medicines in extremely diluted quantities, and there are usually minimal side effects. Its non-toxicity makes it a good choice for the treatment of children. Another benefit of homeopathy is the cost of treatments; homeopathic remedies are inexpensive, often a fraction of the cost of conventional drugs.

Homeopathic treatment has been shown effective in treating many conditions. Colds and flu may be effectively treated with aconite and bryonia. **Influenza** sufferers in a double-blind study found that they were twice as likely to recover in 48 hours when they took homeopathic remedies. Studies have been published in British medical journals confirming the efficacy of homeopathic treatment for rheumatoid arthritis. Homeopathic remedies are effective in treating infections, circulatory problems, respiratory problems, **heart** disease, depression and nervous disorders, migraine headaches, **allergies**, arthritis, and diabetes. Homeopathy is a good treatment to explore for acute and chronic illnesses, particularly if these are found in the early stages and where there is not severe damage. Homeopathy can be used to assist the healing process after surgery or **chemotherapy**.

Description

A visit to a homeopath can be a different experience than a visit to a regular physician. Surveys have shown that homeopathic doctors spend much more time during initial consultations than conventional doctors spend. This is because a homeopath does a complete case-taking

to get a complete picture of a person's general health and lifestyle, as well as particular symptoms, on the physical, mental, and emotional levels. Some symptoms can be so subtle that the patient is not always completely aware of them, and the doctor must spend time getting to know the patient.

The initial visit often includes a long questionnaire about a patient's medical and family history, and then a long interview with the doctor, who prompts the patient with many questions. Sometimes a homeopathic doctor will use lab tests to establish a patient's general level of health. The initial interview usually lasts between one and two hours.

The purpose of homeopathy is the restoration of the body to homeostasis, or healthy balance, which is its natural state. The symptoms of a disease are regarded as the body's own defensive attempt to correct its imbalance, rather than as enemies to be defeated. Because a homeopath regards symptoms as positive evidence of the body's inner intelligence, he or she will prescribe a remedy designed to stimulate this internal curative process, rather than suppress the symptoms.

In homeopathy, the curative process extends beyond the relief of immediate symptoms of illness. Healing may come in many stages, as the practitioner treats layers of symptoms that are remnants of traumas or chronic disease in the patient's past. This is part of Hering's Laws of Cure, named for Constantine Hering, the father of homeopathy in America. Hering believed that healing starts from the deepest parts of the body to the extremities, and from the upper parts of the body to the lower parts. Hering's Laws also state that homeopaths should treat disease symptoms in reverse chronological order, from the most recent to the oldest, restoring health in stages. Sometimes, the patient may feel worse before feeling better. This is called a healing crisis.

When prescribing a remedy, homeopaths will match a patient's symptoms with the proper remedy in a repertory or *materia medica* that has been compiled throughout the history of homeopathy. Classical homeopaths prescribe only one remedy at a time. However, it is becoming more common, especially in Europe, to use combination formulas of several remedies for the treatment of some combinations of symptoms.

The cost of homeopathic care can vary. The cost of visits will be comparable to conventional medicine, with initial visits ranging from \$50 to \$300. Non-M.D. homeopaths can charge from \$50 to \$250. Follow-up visits are less, at about \$35 to \$100. Homeopathic medicine is significantly cheaper than pharmaceuticals, and most remedies cost between \$2 and \$10. Some doctors provide remedies without charge. Homeopaths rarely use lab

tests, which reduces the cost of treatment further. In general, homeopathy is much more economical than conventional medicine. In 1991, the French government did a study on the cost of homeopathic medicine, and found that it costs half as much to treat patients, considering all costs involved.

When homeopaths are licensed professionals, most insurance companies will pay for their fees. Consumers should consult their insurance policies to determine individual regulations. Insurance usually will not cover homeopathic medicine, because it is sold over-the-counter.

Precautions

Although homeopathic remedies sometimes use substances that are toxic, they are diluted and prescribed in non-toxic doses. Remedies should be prescribed by a homeopathic practitioner. Those preparing to take homeopathic remedies should also avoid taking *antidotes*, substances which homeopathic doctors believe cancel the effects of their remedies. These substances include alcohol, coffee, prescription drugs, peppermint (in toothpaste and mouthwash), camphor (in salves and lotions), and very spicy foods. Homeopathic medicine should also be handled with care, and should not be touched with the hands or fingers, which can contaminate it.

Side effects

A homeopathic *aggravation* sometimes occurs during initial treatment with homeopathic remedies. This means that symptoms can temporarily worsen during the process of healing. Although this is usually mild, the aggravation can sometimes be severe. Homeopaths see aggravation as a positive sign that the remedy is a good match for the patient's symptoms. The healing crisis, which happens when the patient is undergoing treatment for layers of symptoms, may also cause the patient to feel worse before feeling better. Some patients can experience emotional disturbances like weeping or depression, if suppressed emotional problems led to the illness in the first place.

Research and general acceptance

Since the early 1900s, when the American Medical Association and pharmacists waged a battle against it, homeopathy has been neglected and sometimes ridiculed by mainstream medicine. Aside from politics, part of the reason for this is that there are some aspects of homeopathy which have not been completely explained scientifically. For instance, homeopaths have found that the more they dilute and succuss a remedy, the greater effect it seems to have on the body. Some homeopathic reme-

KEY TERMS

Aggravation—Temporary increase in symptoms due to homeopathic remedy.

Antidote—Substance which cancels the effect of homeopathic remedies.

Homeopath—A homeopathic physician.

Proving—Case study of the effect of a homeopathic medicine.

Repertory—Reference manual of homeopathic remedies.

Vital force—Innate wisdom and energy of the body.

dies are so diluted that not even a single molecule of the active agent remains in a solution, yet it still works; studies have demonstrated this paradox, yet can't explain it. Also, homeopathy puts an emphasis on analyzing symptoms and then applying remedies to these symptoms, rather than working by classifying diseases. Thus, some people with the same disease may require different homeopathic medicines and treatments. Furthermore, conventional medicine strives to find out how medicines work in the body before they use them; homeopathy is less concerned with the intricate biochemistry involved than with whether a remedy ultimately works and heals holistically. For all these reasons, conventional medicine claims that homeopathy is not scientific, but homeopaths are quick to reply that homeopathy has been scientifically developed and studied for centuries, with much documentation and success.

There continue to be many studies that affirm the effectiveness of homeopathic treatments. Among the most celebrated, the *British Medical Journal* in 1991 published a large analysis of homeopathic treatments that were given over the course of 25 years. This project involved over 100 studies of patients with problems ranging from vascular diseases, respiratory problems, infections, **stomach** problems, allergies, recovery from surgeries, arthritis, trauma, psychological problems, diabetes, and others. The study found improvement with homeopathic treatment in most categories of problems, and concluded that the evidence was "sufficient for establishing homeopathy as a regular treatment for certain indications."

Training and certification

The Council on Homeopathic Education is the only organization that accredits training programs in classical

homeopathy. To date, it has accredited five institutions: Bastyr University of Natural Health Sciences in Seattle, Ontario College of Naturopathic Medicine in Toronto, Hahnemann Medical Clinic in Albany, California, the National College of Naturopathic Medicine in Portland, and the International Foundation for Homeopathy, also in Seattle. Other well-known training programs include the Pacific Academy of Homeopathic Medicine in Berkeley, California, and the New England School of Homeopathy in Amherst, Massachusetts.

There are several organizations that certify homeopathic practitioners:

- The National Center for Homeopathy is the largest homeopathic organization, with over 7,000 members. It also runs the Council on Homeopathic Education, and provides a listing of all its members and their credentials. Address: 801 N. Fairfax St., #306, Alexandria, VA 22314, phone (703) 548-7790.
- The American Institute of Homeopathy is the oldest national medical body. It provides a list of D.Ht.s (Diplomate in Homeopathy) certified by the American Board of Homeotherapeutics. Address: 1585 Glencoe, Denver, CO 80220, phone (303) 898-5477.
- The Council for Homeopathic Certification was created in 1992 to establish a certification exam and a code of ethics. It confers upon qualified practitioners a C.C.H. (Certification in Classical Homeopathy). Address: P.O. Box 157, Corte Madera, CA 94976.
- The Homeopathic Academy of Naturopathic Physicians offers a certification based on a competency exam, the "Diplomate in the Homeopathic Academy of Naturopathic Physicians" (D.H.A.N.P.).
- The North American Society of Homeopaths certifies non-physician homeopaths. Address: 10700 Old County Rd. 15, #350, Minneapolis, MN 55441, phone (612) 593-9458.

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Homocysteine test see **Cardiac marker tests**

Hormones see **Endocrine system**

Hospices

Definition

The term *hospice* refers to an approach to end-of-life care as well as to a type of facility for supportive care of terminally ill patients. Hospice programs provide palliative (care that relieves discomfort but does not improve the patient's condition or cure the disease), patient-centered care, and other services. The goal of hospice care, whether delivered in the patient's home or in a health-care facility, is the provision of humane and compassionate medical, emotional, and spiritual care to the dying.

Description

History

The hospice movement began in the United Kingdom during the middle of the nineteenth century. In Dublin, the Roman Catholic Sisters of Charity undertook to provide a clean, supportive environment for care for the terminally ill. Their approach spread throughout England and as far as Asia, Australia, and Africa; but until the early 1970s, it had not been accepted on any wide scale in the United States.

Two physicians, Drs. Cicely Saunders and Elisabeth Kübler-Ross, are credited with introducing the hospice concept in the United States. Dame Saunders had originally trained as a nurse in England and afterward attended medical school. She founded St. Christopher's Hospice just outside of London in 1962. St. Christopher's pioneered an interdisciplinary team approach to the care of the dying. This approach made great strides in **pain management** and symptom control. Dr. Saunders also developed the basic tenets of hospice philosophy. These include:

- acceptance of death as the natural conclusion of life
- delivery of care by a highly trained, interdisciplinary team of health professionals who communicate among themselves regularly
- an emphasis on effective **pain** management and comprehensive **home care** services
- counseling for the patient and bereavement counseling for the family after the patient's death
- ongoing research and education as essential features of hospice programs

During this same period, Dr. Kübler-Ross, a psychiatrist working in Illinois, published results from her ground-breaking studies of dying patients. Her books about the psychological stages of response to catastrophe and her lectures to health professionals helped to pave the way for the development and acceptance of hospice programs in the United States. The merit of the five stages of acceptance that Dr. Kübler-Ross outlines is that they are not limited to use in counseling the dying. Many patients who become disabled—especially those whose disability and physical impairment are sudden occurrences—go through the same stages of “grieving” for the loss of their previous physical health or quality of life. Paraplegics, quadriplegics, amputees, and patients with brain-stem injuries all progress through these same stages of “acceptance”—and they are not dying.

The first hospice programs in North America opened during the 1970s. In New Haven, Connecticut, the Yale University School of Medicine started a hospice home care program in 1974, adding inpatient facilities in 1979. In 1976, another hospice/home-care program, the Hospice of Marin, began in northern California. After a slow start, interest in and enthusiasm for the hospice concept grew. Health professionals as well as the public at large embraced the idea of death with dignity. The notion of quality care at the end of life combined with grief counseling and bereavement care (counseling and support for families and friends of dying persons) gained widespread acceptance. The hospice movement also benefited from government efforts to contain health-care costs when reimbursement for inpatient hospital services was sharply reduced. Home-based hospice care is a cost-effective alternative to end-of-life care in a hospital or skilled nursing facility.

Present models of hospice care

According to the Hospice Foundation of America, there are presently about 3,100 hospice programs operating in the United States, including Puerto Rico and Guam. During 1998, hospice programs in the United States cared for nearly 540,000 people.

KEY TERMS

Hospice—An approach for providing compassionate, palliative care to terminally ill patients and counseling or assistance for their families. The term may also refer to a hospital unit or freestanding facility devoted to the care of terminally ill patients.

Palliative—A type of care that is intended to relieve pain and suffering, but not to cure.

Patient-controlled analgesia (PCA)—An approach to pain management that allows the patient to control the timing of intravenous doses of analgesic drugs.

Today, there are several successful hospice models. As of 2001, about 80% of hospice care is delivered in patients' homes, although the hospice programs that direct the care may be based in medical facilities. Home health agency programs care for patients at home, while hospital-based programs may devote a special wing, unit, or floor to hospice patients. Freestanding independent for-profit hospices devoted exclusively to care of the terminally ill also exist. Most hospice programs offer a combination of services, both inpatient and home-care programs, allowing patients and families to use both as needed.

One limitation of present hospice models is that most require physicians to estimate that the patient is not likely to live longer than six months. This requirement is related to criteria for **Medicare** eligibility. Unfortunately, it means that terminal patients with uncertain prognoses are often excluded from hospice care, as well as homeless and isolated patients.

Viewpoints

Although the hospice movement has gained widespread acceptance, it is often easier for health professionals to accept hospice theory as opposed to practice. For example, most American health professionals are trained to fight disease with the goal of cure. The hospice concept, on the other hand, requires that physicians, nurses, and other caregivers accept **death and dying** as the natural, inevitable conclusion to life, rather than viewing death as a battle lost. Some health professionals continue to view death as a personal defeat, however, and they remain uncomfortable with hospice care.

Along with acceptance of death as a natural part of the life cycle, health professionals who refer patients to

or work in hospice programs must become especially well informed about pain management and symptom control. This knowledge is necessary because about 80% of hospice patients are dying of end-stage **cancer**. In traditional medical settings, pain medication is often administered when the patient requests it. Hospice care approaches pain control quite differently. By administering pain medication regularly, before it is needed, hospice caregivers hope to prevent pain from recurring. Since addiction and other long-term consequences of narcotic **analgesics** are not a concern for the terminally ill, hospice caregivers focus on relieving pain as completely and effectively as possible. Hospice patients often have **patient-controlled analgesia (PCA)** pumps that allow them to control their pain medication.

Symptom relief often requires more than simply using narcotic analgesia. Hospices consider the patient and family as the unit of care; "family" is broadly defined as embracing all persons who are close to the patient as well as blood relatives. Seeking to relieve physical, psychological, emotional, and spiritual discomfort, hospice teams rely on members of the clergy, pastoral counselors, social workers, psychiatrists, massage therapists, and trained volunteers to comfort patients and family members, in addition to the solace offered by nurses and physicians.

In addition to mainstream medicine, many hospices offer patients and families the opportunity to use complementary and alternative approaches to control symptoms and improve well being. Acupuncture, bodywork, **massage therapy**, aromatherapy, Reiki (energy healing), Native American ceremonies, herbal treatments, and other non-Western practices may be used to calm and soothe patients and their families.

The goal of freestanding hospices and even hospital-based programs is the creation and maintenance of warm, comfortable, home-like environments. Rather than the direct overhead lights found in hospitals, these hospices use floor and table lamps along with natural light to convey a sense of brightness and uplift. Some hospices offer music or pet therapy and fill patient rooms with original artwork and fresh flowers.

Since the patient and his or her family members are considered the unit of care, hospice programs continue to support families and loved ones after the patient's death. Grief and bereavement counseling as well as support groups offer opportunities to express and resolve emotional concerns and share them with others.

Professional implications

The hospice approach emphasizes caring instead of curing, and some health professionals find this practice inconsistent with their previous education, experiences, beliefs, and traditions. Moreover, the involvement of complementary and alternative medicine practitioners may be unsettling for health professionals unaccustomed to interacting with these practitioners.

The hospice approach also requires health professionals to collaborate; they must work together as a team to identify and meet the needs of patients and family members. A hospice team is different from the traditional health-care team because the physician is not necessarily the team leader. In hospice programs, patients and families receive more of their care from nurse specialists with advanced coursework and education, nursing assistants, social workers, pastoral counselors, and volunteers than they do from physicians. Hospice team members support, encourage, and rely on one another as they work together toward the shared goal of assisting patients and families through life's final passage.

Health professionals and volunteers who work in hospice programs have special needs related to professional and emotional support. Since they work so closely with patients and families, they often experience grief and depression when patients die. Sympathy and empathy, the qualities that enable them to perform effectively in their hospice roles, may also hinder their abilities to maintain the emotional distance needed to successfully perform their work, or may lead to premature burnout.

Professional associations, support groups, and counselors provide forums in which hospice workers may share their challenges, frustrations, and losses. Many hospice programs teach workers and volunteers a variety of ways to reduce work-related **stress** and prevent burnout. In addition to teaching various **relaxation** techniques and the healing power of laughter, these programs help health professionals concentrate on the unique satisfactions of their work, their shared values, and their important contributions to the lives of patients and families.

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<<http://www.hospicefoundation.org>>.
- International Association of Hospice and Palliative Care. UT MD Anderson Cancer Center, 1515 Holcombe Blvd., Box 08, Houston, TX 77030.
<<http://www.hospicecare.com>>.

Barbara Wexler

Hospital-acquired infections *see* **Cross infection**

Hospital administration

Definition

Hospital administration is a phrase used to describe those professionals who choose to be a part of upper management in organized hospitals.

Description

In addition to traditional hospitals and medical centers, hospital administrators provide leadership for psychiatric and mental health facilities, alcohol and/or drug rehabilitation centers, and long term care and nursing-home-type agencies. Job qualifications for a career in hospital administration include a college degree and often a master's degree in either business, public administration, or in organizational administration/management. Occasionally a physician, **registered nurse**, pharmacist, social worker, or an individual in another health-related profession employed within the hospital setting will choose the upward mobility route of the hospital administrator. Job titles for individuals in these roles include Administrator, Director, Executive Director, Chief Operating Officer, and Chief Executive Officer. Hospital administrators tend to be at the top of the organizational pay scale and are often considered to be the top-level leaders within the facility, answering to the Board of Directors or the Board of Trustees. The salary

range varies with the region but tends to be higher than that of most other hospital employees, except for physicians who maintain private practices.

There are multiple skills needed for effective hospital administration. Knowledge of basic leadership skills and organizational management is required along with an understanding of organizational culture, i.e., the unwritten rules that determine how an organization operates as a separate system. The hospital administrator provides leadership and strategic directions within the organization to insure continuity and targeted growth over time. People-skills is a phrase used to describe someone who interacts positively with others at all levels. Administrators use people-skills along with an effective communication style to deal with issues in human resources, negotiation, and conflict resolution. Ability to interact positively with the Board of Directors/Trustees, the varied specialty physician groups, allied health care providers, paid staff in general, and the public is essential. Intermixed with the above skills, an administrator uses marketing expertise to ensure that the organization is meeting its market share in providing care. Administrators often interact with patients and families to determine if the organization is meeting patient/family expectations. Also, the administrator must be concerned with maintaining a positive image for the organization and must be able to maintain effective public relations within the community.

Practical business skills are a strong asset for the hospital administrator. Being able to deal with concepts such as overhead, costs, charges, fund asset replacement, capital availability, joint ventures, and how group purchasing arrangements benefit the organization are often a requirement for effective administrators. Financial management skills are critical. The use of financial systems, computer applications, consolidation of services, and network development are needed to achieve positive outcomes and insure quality of care and optimal performance of all employees. Job expectations for hospital administrators demand current knowledge of reimbursement policy within the state as well as an in depth understanding of the way the hospital is reimbursed for services under **Medicare**, **Medicaid**, managed care organizations, and other insurance carriers such as Blue Cross and Blue Shield. The ability to articulate the role the institution plays in the delivery of charity care and more importantly implementing corrective measures as needed for the percentage of charity care provided is crucial to overall organizational outcomes. Hospital administrators spend a significant amount of time addressing legal issues including contracts, partnerships, joint ventures, joint operating agreements, group purchasing, and management contracts.

A working knowledge of health care policy such as the balanced budget act and new regulations dealing with medical record confidentiality are beneficial to the hospital administrator. Administrators should possess a comprehensive view of regulatory requirements mandated by the city, regional, and/or state health departments. A cursory understanding that each specialty group within the hospital setting has its own national board with an accompanying set of requirements that divisions or departments within hospitals are required to meet is also an expectation. A specific example is the National Voluntary Laboratory Accreditation Program that visits hospitals to evaluate the standards in clinical laboratories. And finally inherent in this concept of policy is the hospital administrator's ability to understand what needs to be done for the facility to meet the requirements of the Joint Commission on Accreditation of Healthcare Organizations (JCAHO). All hospital administrators should have a working knowledge of coding requirements of **medical records**, national patient classification systems in common use, and the use of diagnostic related groups (DRGs), which is a classification system used to identify specific medical diagnoses. These varied systems are used to report all sorts of data to the regulatory agencies and must be understood to use the data provided by state or federal agencies when communicating with the hospital about things like patient mix or staffing ratios.

Perhaps one unique aspect of role expectations for hospital administrators is learning to identify and keep current with health care issues of regional and national interest. Access to information about changes in reimbursement and managed care regulations, as well as new laws effecting the hospital, is needed. Awareness that many large hospitals are difficult to manage is important. Knowing that the Baby Boomers will shortly be demanding care in hospitals and that this will increase the demand for senior services and put pressure on already scarce resources is beneficial to the administrator. And finally, understanding the impact a nursing shortage has on the hospital is vital to survival.

Effective strategies for success within the role are multifaceted. Management-by-walking-around is a phrase that describes the principle that effective leadership and management is best achieved by directly observing and seeing for oneself the services provided and the overall milieu of the organization. Future outlook includes consideration and understanding of the pros and cons of developing an Internet site for the hospital that provides health information for patients and interested visitors to the web address is an emerging reality. Being able to change with time, evaluating the evolution of the hospital organization, and avoiding the overflow of new

initiatives is crucial to personal survival. Most importantly, successful administrators demonstrate a code of ethics within the organization and demand the same of employees. And finally a basic understanding of mechanisms used to deliver patient care is very helpful. Knowing that practice guidelines, national standards for outcomes, **patient education**, and risk management are all intertwined remains an asset for the effective hospital administrator.

Readers interested in the field of hospital administration are encouraged to explore the web site of the American Hospital Association or related sites listed below to increase personal knowledge about issues that are current and highly significant for hospitals.

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Carole Birdsall, R.N., A.N.P., Ed.D.

Hot packs see **Heat treatments**

Hoyer lift usage see **Total body hydraulic lift usage**

Human anatomy

Definition

Human anatomy is the study of the structure of the human body and the relationship between its parts.

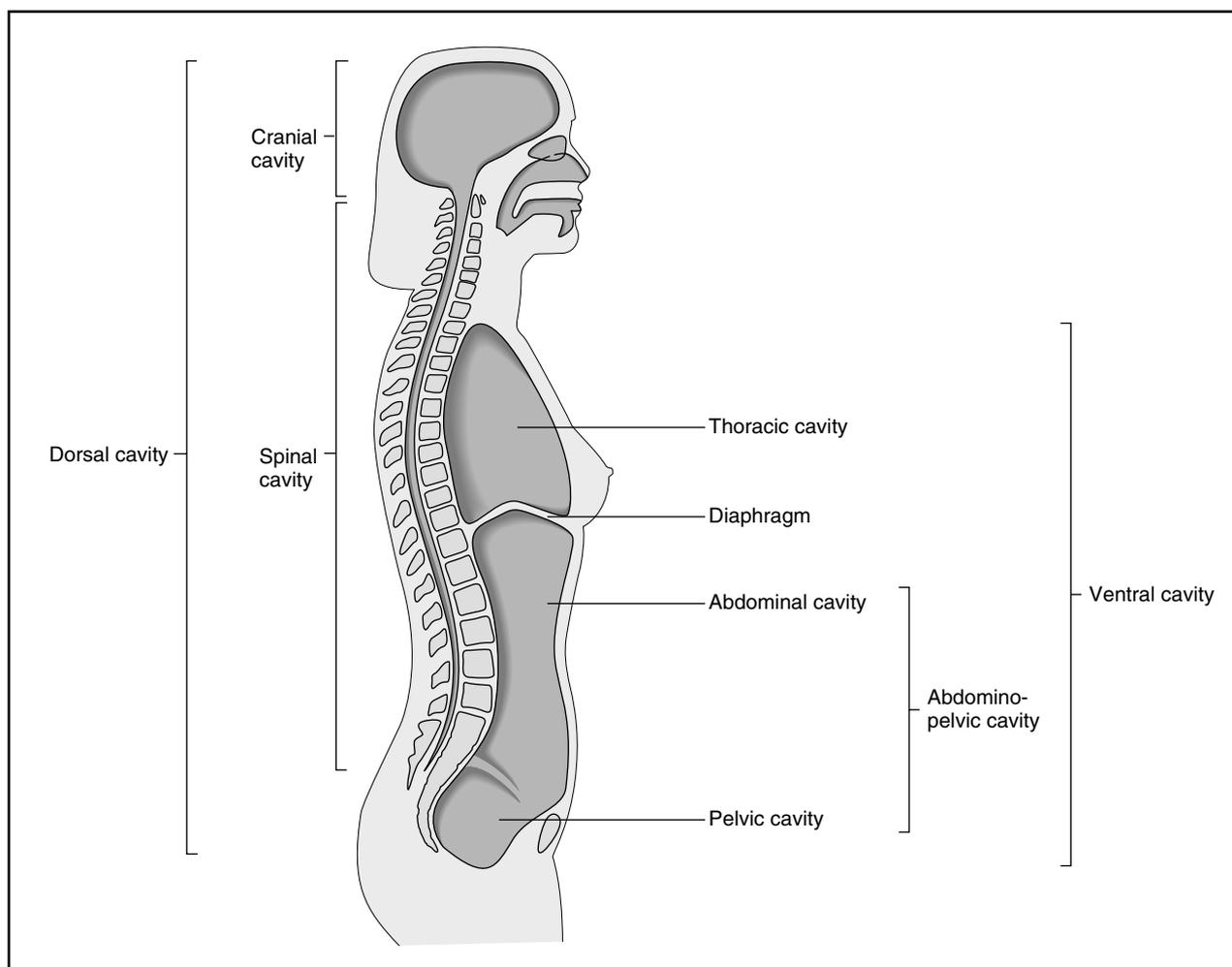
Description

Anatomic position

Discussions on the subject of human anatomy assume that the person is standing erect, feet slightly apart, arms by the side with palms facing forward, thumbs pointing away from the body. This is referred to as the anatomic position and acts as a common reference point for anatomists (an expert or student of anatomy). If the body is lying face up, it is referred to as supine, if it is lying face down, the body is in a prone position.

Various structures can be described in relation to any number of imaginary flat surfaces or planes that bisect the body. The median sagittal plane is a vertical plane that passes through the center of the body, dividing it into right and left sides. The coronal plane, on the other hand, is a vertical plane that is perpendicular to the sagittal plane and divides the body into front and back halves. A paramedian plane passes vertically through the body at any point parallel to the median sagittal plane, while a horizontal or transverse plane is perpendicular to both the sagittal and coronal planes. A plane on an angle to the transverse plane is called an oblique plane.

A number of terms can be used to describe the location of body structures in relation to the above planes. One structure that is closer to the sagittal plane than another is said to be medial, while one that is farther from the sagittal plane is lateral (e.g. the **heart** is medial to the left lung). Structures found on the same side of the median sagittal plane are referred to as ipsilateral, while those on opposite sides of the body are called contralateral. A structure is anterior or ventral if it is before or in front of



The major body cavities. (Delmar Publishers, Inc. Reproduced by permission.)

another structure, and posterior or dorsal if it found after or behind (e.g. the trachea or windpipe is anterior to the esophagus). Superior or cranial structures are found closer to the top or crown of the head than inferior or caudal structures (e.g. the heart is superior to the **stomach**). It is important to remember that the terms left and right are used from the perspective of the person being viewed, not the observer; for instance, the right lung would be on the left hand side of a body as viewed by an observer.

The head, neck, and trunk (the main axis) make up the axial portion of the body while the appendages or limbs compose the appendicular portion. To describe the limbs, the term proximal refers to a structure that is closer to the limb origin; a distal structure is farther from the limb origin (e.g. the wrist is distal to the elbow). The hand has a palmar surface (the anterior side) and a dorsal surface (the posterior side). The upper surface of the foot is called the dorsal surface, while the bottom side is called the plantar surface. Superficial structures are locat-

ed nearer to the surface of the body; those found farther from the surface are referred to as deep structures (e.g. the skin is superficial to the **skeletal muscles**). Internal structures are found inside of an organ or cavity, in contrast to external surfaces which are found outside (e.g. alveoli are internal to the **lungs**).

Terms of movement

A joint is a site where two or more bones come together. Some joints allow no movement between bones (e.g. the bones of the **skull**); others allow only slight movement (e.g. the joints between bones of the **vertebral column**). Still other joints allow free movement (e.g. the hip joint). There are subsequently numerous terms to describe the various movements that joints can make.

Flexion is the bending of a joint, typically in the anterior direction; an example is the bending of the arm at the elbow. In contrast, the term extension describes the

straightening of a joint; an example is the straightening of the leg at the knee. Abduction is the movement of a joint away from the midline along the coronal plane, while adduction is the movement toward the midline along the same plane; the arm, for example, abducts at the shoulder if it moves away from the torso in the same plane. Rotation occurs when a body part moves around its axis; medial rotation results in the anterior surface facing medially and lateral rotation results in the anterior surface facing laterally. The term pronation describes movement of the hand so that it faces posteriorly; supination causes the hand to face anteriorly. Circumduction is a movement that combines flexion, extension, abduction, and adduction; circling the arm around the shoulder joint is an example.

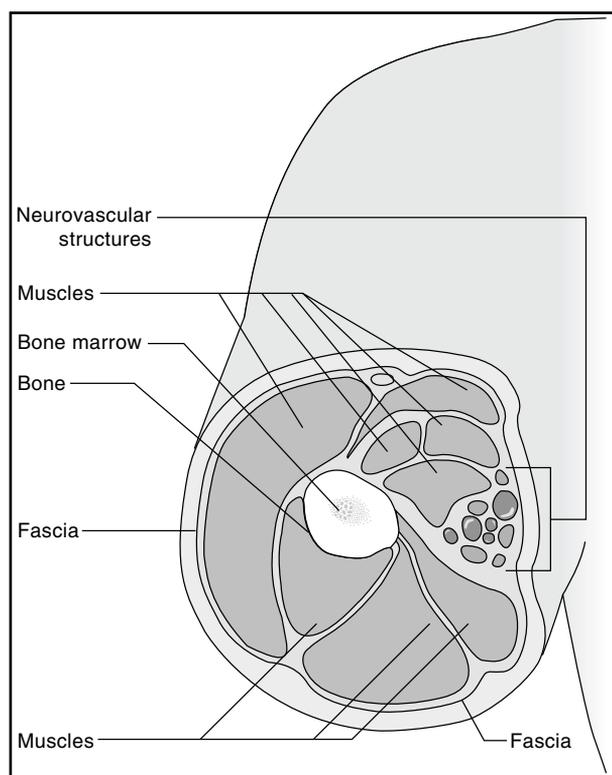
The term protraction describes a motion forward and retraction a motion backward; these describe the movement of the mandible (jaw) at the temporomandibular joints. Inversion occurs when the sole of the foot is turned to face the median (this would happen if you tried to stand on the outer side of your foot); eversion is movement that causes the sole of the foot to face laterally.

Cavities of the body

Within the axial portion of the body lie two major cavities: the dorsal and ventral body cavities. The dorsal body cavity lies posterior to the ventral body cavity and protects the organs of the **central nervous system**. It is composed of the cranial cavity (enclosing the **brain**) and the vertebral cavity (containing the **spinal cord**).

The ventral body cavity is the larger of the two and encloses the viscera or visceral organs (internal organs). It also has two major subdivisions: the thoracic cavity and the abdominopelvic cavity. The thoracic cavity is surrounded anteriorly by the ribs and chest muscles. It encloses two pleural cavities, each encasing a lung, and the mediastinum. The pericardial cavity is located inside of the mediastinum and encloses the heart. The mediastinum also surrounds the esophagus, trachea, and other thoracic organs. The abdominopelvic cavity is separated from the thoracic cavity by the diaphragm, a thin muscle below the lungs and heart that is important for breathing. The abdominopelvic cavity contains the abdominal cavity (enclosing the stomach, **liver**, spleen, intestines, and other digestive organs) and the pelvic cavity (containing the bladder, reproductive organs, and rectum).

There are also smaller body cavities that exist throughout the axial portion of the body. The oral cavity (mouth) contains the teeth and tongue. The digestive cavity includes the oral cavity and extends down to the anus, including all digestive organs. The nasal cavity is found posterior to the nose and is part of the **respiratory sys-**



The anatomic relationship between the skin, muscles, fascia, and bone. (Delmar Publishers, Inc. Reproduced by permission.)

tem. The middle ear cavity is medial to the external ear and contains three small bones (the malleus, the incus, and the stapes) that are essential to normal **hearing**. The orbital cavities are found in the skull and contain the eyes, as well as skeletal muscles and nerves. The freely movable joints of bones are found in synovial cavities, where synovial fluid is secreted that helps lubricate joints and reduce friction between bones.

VENTRAL BODY CAVITY MEMBRANES. The ventral body cavity is lined with a thin membrane called the parietal serosa; internal organs are covered with a similar membrane called the visceral serosa. These membranes secrete a small amount of fluid called serous fluid that separates and lubricates them. Different parietal and visceral membranes have different names for the cavities and organs that they protect. The parietal pericardium lines the cavity that contains the heart and the visceral pericardium covers the surface of the heart. Likewise, the parietal pleura lines the thoracic cavity and the visceral pleura covers the surface of the lungs.

Regions and quadrants

The abdominopelvic region is often further divided into regions or quadrants for reference in study or clinical

cal examination. The abdomen may be partitioned into nine regions, with two transverse planes and two parasagittal planes positioned in a grid. The central grid surrounds the umbilicus (navel) and is subsequently called the umbilical region; the left and right lumbar regions are found lateral to the umbilical region. The epigastric region is located superior to the umbilical region and includes the area of the stomach; the left and right hypochondriac regions are found to each side. Inferior to the umbilical region is the hypogastric or pubic region in which the urinary bladder is found; to each side are the left and right iliac or inguinal regions.

The quadrant system is often used by health care workers during examinations to localize **pain**, tumors, or abdominal structures. The median sagittal plane marks the vertical division while a transverse plane across the umbilicus marks the horizontal division. The subsequent four divisions are named the left upper quadrant (LUQ), right upper quadrant (RUQ), left lower quadrant (LLQ), and right lower quadrant (RLQ).

Different regional terms exist that help to specifically identify different regions or parts of the body. The following are some of the more common regional terms: nasal (nose), oral (mouth), otic (ear), cervical (neck), sternal (sternum or breastbone), axillary (armpit), thoracic (chest), mammary (breast), brachial (arm), abdominal (abdomen), olecranal (elbow), carpal (wrist), digital (fingers and toes), manus (hand), pubic (genitals), patellar (kneecap), crural (leg), femoral (thigh), tarsal (ankle), pedal (foot), vertebral (spinal column), dorsal (back), and gluteal (buttock). If an individual broke a bone in or near the elbow, for example, he or she would experience pain in the olecranal region.

Organization of the body

The complex structures of the human body are organized into numerous hierarchies. The chemical level is the most basic level and is the foundation on which life is based. Many different chemicals are essential to sustain life; these include carbon (C), oxygen (O), nitrogen (N), potassium (K), sodium (Na), and **calcium** (Ca). Atoms (single particles of an element) combine to form molecules that in turn combine to form various structures that are the building blocks of cells. The cell is the basic functional unit of life; on the cellular level, however, it is evident that it is an extremely complex structure. Different types of cells found in the human body include muscle cells, nerve cells, **blood** cells, and epithelial cells.

Similar cells may unite to perform a specific function; these groups of cells are called tissues. These are organized on the tissue level into four major groups: epithelial tissue that covers the internal and external sur-

faces of the body, nervous tissue that transmits electrical signals, muscle tissue that is specialized for contraction, and connective tissue that provides a structural matrix for other tissues. At the organ level, different tissues (at least two types) combine to form an organ, a structure that is capable of performing specialized tasks. Examples of organs are the stomach, lungs, **kidneys**, and liver.

A system consists of groups of organs that have a common function. This next level of organization includes systems such as the respiratory system, reproductive system, and **endocrine system**. The organs of the respiratory system, for example, work together to accomplish the intake of oxygen and the output of carbon dioxide. The organ systems together make up the organism, the individual human being. The organismic level is the highest level in the structural hierarchy; it represents the unification of all body structures and their complex interaction.

ORGAN SYSTEMS. Numerous organ systems are found in the human body. Each corresponds to a group of specialized organs that perform related activities. The following list represents the major organ systems of the human body and their key functions:

- **Integumentary system:** This includes the skin, nails, hair, and sweat and sebaceous glands. The integumentary system provides an external protective covering for the body; helps to regulate body temperature; protects internal organs from injury; excretes sebum, a oily substance with antimicrobial activity; synthesizes **vitamin D**; and has sensory receptors that are sensitive to pain, pressure, temperature, and touch.
- **Skeletal system:** Bones, cartilage, and ligaments make up the skeletal system. It provides a point of attachment for muscles and a framework that supports them. Blood cells are produced in bone marrow (the spongy material found in the center of most large bones); bones also store essential **minerals** such as calcium.
- **Muscular system:** Muscles are the organs of the muscular system. They provide the force necessary for body movement, support organs or body parts, help to maintain posture, provide the main source of body heat, and help in breathing.
- **Nervous system:** This includes the brain, spinal cord, nerves, and sense organs. Nervous impulses are the means by which organs and tissues communicate with the brain; nerve tissues carry impulses from various structures to the brain and vice versa. The nervous system can quickly respond to changes in the internal or external environment.
- **Endocrine system:** The hormone-secreting glands (**pituitary gland**, pineal gland, **thyroid gland**, thymus,

KEY TERMS

Abduction—Movement away from the midline along the coronal plane.

Adduction—Movement toward the midline along the coronal plane.

Anatomic position—Standing erect with feet slightly apart, arms at the side with palms facing forward, thumbs pointing away from the body.

Anterior—Situating before or in front of.

Circumduction—Movement that combines flexion, extension, abduction, and adduction.

Deep—Situating farther from the surface of the body.

Distal—Situating farther from the origin of a limb.

Eversion—Movement that turns the sole of the foot laterally.

Extension—Movement that straightens a joint.

Flexion—Movement that bends a joint.

Inferior—Situating farther from the crown of the head.

Inversion—Movement that turns the sole of the foot medially.

Lateral—Situating farther from the midline.

Medial—Situating closer to the midline.

Organ—A structure composed of different tissues that is capable of performing specialized tasks.

Plane—An imaginary line or surface that passes through the body.

Posterior—Situating after or behind.

Pronation—Movement that turns the hand so that it faces posteriorly.

Prone—The body lying face down.

Proximal—Situating closer to the origin of a limb.

Superficial—Situating closer to the surface of the body.

Superior—Situating closer to the crown of the head.

Supine—The body lying face up.

Tissue—Groups of similar cells that unite to perform a specific function.

adrenal gland, **pancreas**, testis, ovary, and parathyroid gland) make up the endocrine system. They are important in the regulation of different processes such as growth, **metabolism**, reproduction, and milk production in nursing women.

- **Cardiovascular system:** This is composed of the heart, **blood vessels** (arteries and veins), and the blood. The cardiovascular system is the means by which gases, nutrients, and wastes are transported throughout the body; it is also responsible for disseminating hormones, maintaining the **acid-base balance** in blood, and preventing extensive blood loss by the formation of clots.
- **Lymphatic system:** The lymphatic vessels, thymus, spleen, lymph nodes, and red bone marrow are all components of the lymphatic system. It is important in activating the **immune response** against foreign substances, returning tissue fluid to the blood, and supporting the maturation and proliferation of white blood cells.
- **Digestive system:** This includes the oral cavity (mouth, tongue, and teeth), salivary glands, pharynx, esophagus, stomach, liver, **gallbladder**, pancreas, small and large intestines, rectum, and anus. The purpose of the digestive system is to break down food and

absorb necessary nutrients. It is also important in the process of detoxification.

- **Respiratory system:** The nasal cavity, pharynx, larynx, trachea, bronchi, and lungs together make up the respiratory system. It is responsible for the intake of oxygen and the output of carbon dioxide, the exchange of gases through the walls of alveoli (air sacs), and the vocalization of sounds.
- **Urinary system:** The kidneys, ureters, urinary bladder, and urethra are the major components of the urinary system. It is important for removing wastes from the body; maintaining a balance of water and electrolytes in the blood; and producing, storing, and transporting urine (a fluid made up of water, electrolytes, and nitrogenous wastes such as urea, uric acid, and creatinine).
- **Reproductive system:** In males, the reproductive system is made up of the testes, scrotum, penis, epididymes, vas deferens, seminal vesicles, prostate gland, and urethra. Its purpose is to produce the male sex cell (sperm) and transfer sperm to the female reproductive tract. The reproductive system in females is composed of the ovaries, uterus, fallopian tubes, vagina, vulva, and mammary glands. Its purpose is to produce the female sex cell (egg), provide an environment for

sperm to fertilize an egg, support a developing fetus, and produce milk to nourish a newborn baby.

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Stéphanie Islane Dionne

Human chorionic gonadotropin test see
Pregnancy test

Human growth and development

Definition

In the context of the physical development of children, growth refers to the increase in the size of a child, and development refers to the process by which the child develops his or her psychomotor skills.

Description

Growth

The period of human growth from birth to adolescence is commonly divided into the following stages:

- **Infancy:** From birth to weaning.
- **Childhood:** From weaning to the end of **brain** growth.

- **Juvenile:** From the end of childhood to adolescence.
- **Adolescence:** From the start of growth spurt at **puberty** until sexual maturity.

Growth curves are used to measure growth. The distance curve is a measure of size over time; it records height as a function of age and gets higher with age. The velocity curve measures the rate of growth at a given time for a particular body feature (such as height or weight). The height velocity curve is highest in infancy, up to two years of age, with more consistent annual growth afterwards and increases again at puberty. The height of the average infant increases by 30% by the age of five months and by 50% by the age of one year. The height of a five-year-old usually doubles relative to that at birth. The limbs and arms grow faster than the trunk, so that body proportions undergo marked variation as an infant grows into an adolescent. Different body systems grow and develop at different rates. For example, if infants grew in height as quickly as they do in weight, the average one-year-old would be approximately 5 ft (1.5 m) tall. Thus, weight increases faster than height—an average infant doubles his birth weight by the age of five months and triples it by the age of one year. At two years of age, the weight is usually four times the weight at birth.

Physical development

During the growth period, all major body systems also mature. The major changes occur in the following systems:

- **Skeletal system.** At birth, there is very little bone mass in the infant body, the bones are softer (cartilagenous) and much more flexible than in the adult. The adult skeleton consists of 206 bones joined to ligaments and tendons. It provides support for the attached muscles and the soft tissues of the body. Babies are born with 270 soft bones that eventually fuse together by the age of 20 into the 206 hard, adult bones.
- **Lymphatic system.** The lymphatic system has several functions. It acts as the body's defense mechanism by producing white **blood** cells and specialized cells (antibodies) that destroy foreign organisms that cause disease. It grows at a constant and rapid rate throughout childhood, reaching maturity just before puberty. The amount of lymphatic tissue then decreases so that an adult has approximately 50% less than a child.
- **Central nervous system (CNS).** The CNS consists of the brain, the cranial nerves, and the **spinal cord**. It develops mostly during the first years of life. Although brain cell formation is almost complete before birth, brain maturation continues after birth. The brain of the

newborn is not yet fully developed. It contains about 100 billion brain cells that have yet to be connected into functioning networks. But brain development up to age one is more rapid and extensive than was previously realized. At birth, the brain of the infant is 25% of the adult size. At the age of one year, the brain has grown to 75% of its adult size and to 80% by age three, reaching 90% by age seven. The influence of the early environment on brain development is crucial. Infants exposed to good **nutrition**, toys, and playmates have better brain function at age 12 than those raised in a less stimulating environment.

Psychomotor development

During the first year of life, a baby goes through a series of crucial stages to develop physical coordination. This development usually proceeds cephalocaudally, that is from head to toe. For example, the visual system reaches maturity earlier than do the legs. First, the infant develops control of the head, then of the trunk (sitting up), then of the body (standing), and, finally, of the legs (walking). Development also proceeds proximodistally, that is from the center of the body outward. For example, the head and trunk of the body develop before the arms and legs, and infants learn to control their neck muscles before they learn to direct their limbs. This development of physical coordination is also referred to as motor development and it occurs together with cognitive development, meaning the development of processes such as knowing, learning, thinking, and judging.

The stages of motor development in children are as follows:

- First year. The baby develops good head balance and can see objects directly in his line of **vision**. He learns how to reach for objects and how to transfer them from one hand to the other. Sitting occurs at six months of age. Between nine and 10 months, the infant is able to pull himself to standing and takes his first steps. By the age of eight to 24 months, the baby can perform a variety of tasks such as opening a small box, making marks with a pencil, and correctly inserting squares and circles in a formboard. He is able to seat himself in small chair, he can point at objects of interest, and can feed himself with a spoon.
- Second year. At 24-36 months, the child can turn the pages of a book, scribble with a pencil, build towers with blocks up to a height of about seven layers, and complete a formboard with pieces that are more complex than circles or squares. He can kick a ball, and walks and runs fairly well, with a good sense of balance. Toilet training can be started.

- Third year. The child can now draw circles, squares, and crosses. He can build 10-block towers and imitate the building of trains and bridges. He is also achieving toilet independence. Hand movements are well coordinated and he can stand on one foot.
- Four years. At that age, a child can stand heel to toe for a good 15 seconds with his eyes closed. He can perform the finger-to-nose test very well, also with eyes closed. He can jump in place on both feet.
- Five years. The child can balance on tiptoe for a 10-second period, he can hop on one foot, and can part his lips and clench his teeth.
- Six years. The child can balance on one foot for a 10-second period, he can hit a target with a ball from 5 ft (1.5 m), and jumps over a rope 8 in (20 cm) high.
- Seven years. He can now balance on tiptoes for a 10-second period, bend at the hips sideways, and walk a straight line, heel-to-toe for a distance of 6 ft (1.8 m).
- Eight years. The child can maintain a crouched position on tiptoes for a 10-second period, with arms extended and eyes closed. He is able to touch the fingertips of one hand with his thumb, starting with the little finger and repeating in reverse order.

The development of motor skills in the child goes hand in hand with the development of cognitive skills, a process called cognitive development. Cognitive development can be divided into four stages:

- Sensorimotor stage. At this stage, infants discover their environment using a combination of sensory impressions (sight, **smell**, **hearing**, **taste**, and touch) and motor activities.
- Preoperational stage. At this stage, children are not able to use information in rational and logical ways, rather they use images and symbols. They learn how to associate cause and effect and to represent something with something else. Speech development begins.
- Concrete operational stage. At this stage, children understand elementary logical principles that apply to concrete external objects. They learn to sort things into categories, reverse the direction of their thinking, and think about two concepts (such as length and width) simultaneously.
- Formal operational stage. This stage is reached at adolescence. The individual can think in the abstract and speculate about probabilities and possibilities as well as reflect on their own thinking activities.

The simultaneous development of motor skills and cognitive skills is commonly referred to as psychomotor development and it occurs with the maturation of the central nervous system (CNS).

KEY TERMS

Bilirubin—A pigment produced as the liver processes waste products. Fetal bilirubin is eliminated from the fetus by placental transfer into the mother's plasma. At birth, the infant's liver takes over the elimination of bilirubin.

Central nervous system (CNS)—In humans, the system that consists of the brain, the cranial nerves, and the spinal cord.

Cognitive skills—Skills required to perform higher cognitive processes, such as knowing, learning, thinking, and judging.

Endocrine system—The endocrine system is the collection of glands that produce hormones. Endocrine glands release hormones directly into the bloodstream, where they are transported to organs and tissues throughout the entire body.

Frontal lobes—The frontal lobes of the brain are responsible for higher cognitive processes, meaning the mental processes of knowing, learning, thinking, and judging.

Hormone—Specialized substances required for normal body functions and produced by the glands of the endocrine system. Hormones regulate metabolism, growth, and sexual development.

Human growth hormone (hGH)—Hormone produced by the pituitary gland in the brain. It is usually released during sleep in response to positive and negative signals from the hypothalamus. Also known as the master hormone of the body, hGH affects growth, development, immunity, and metabolism.

Hypothalamus—The hypothalamus is located in the brain, connected to the cerebral cortex, thalamus, and other parts of the brain stem so that it can receive impulses from them and send impulses to

them. It thus functions as a link between the nervous and endocrine systems, being controlled by the central nervous system and controlling, in turn, the pituitary gland.

Immune system—The system that defends the body against infection, disease, and foreign substances.

Motor activity—The physical activity of an individual.

Motor cortex—The area of the frontal lobes of the brain concerned with primary motor control.

Motor skills—Skills required to perform complex motor acts, meaning acts that produce physical movement.

Nervous system—The nervous system is the entire system of nerve tissue in the body. It includes the brain, the brainstem, the spinal cord, the nerves, and the ganglia.

Placenta—An organ that joins the mother to the fetus and provides endocrine secretions as well as the capacity to exchange bloodborne substances, such as nutrients and waste products.

Psychomotor skills—Skills that develop with the maturation of the central nervous system and include both motor and cognitive skills.

Puberty—The period during which the secondary sexual characteristics begin to develop and at which the individual becomes capable of sexual reproduction.

Sense—A perception by the sensory organs of the body. The major senses are sight, smell, hearing, taste, and touch.

Sensory organs—Organs that allow the body to see, smell, hear, taste, and touch.

Function

The function of postnatal growth and development is to bring the individual to the stage of healthy adulthood, physically characterized by the end of growth with full sexual maturity and fertility for the individual.

Role in human health

Successful growth and development promotes health, providing not only physical but also emotional and psychological well-being.

Common diseases and disorders

There are many possible reasons for the impairment of growth and development in a child. Growth and development depend on the interplay of several factors, such as the genetic make-up of the child, the completion of normal **fetal development**, the diet from time of birth, the normal development of the central nervous system, and the quality of the psychological and physical environment, to name but a few. Any disturbance in any of the factors required for growth and development will accordingly affect the successful outcome of the process.

Specific disorders affecting growth and development include:

- Neonatal disorders. During the nine months of gestation, life sustaining functions, such as supplying of oxygen and nutrients, the elimination of waste, and the regulation of body temperature, are all taken care of by the mother. At the moment of birth, the newborn must abruptly take over the performance of all these tasks. Neonatal disorders include all conditions resulting from the unsuccessful transition from fetus to newborn. They cover the wide range of all body systems that undergo significant change at birth. For example, the inability to change from placental to lung-based respiration may include **respiratory distress syndrome** (RDS), which can occur in **premature infants**, and several other breathing disorders. Problems with the blood circulation transition may, for example, result in inadequate oxygen intake (asphyxia) and/or in the decrease of oxygen supply to the tissues (hypoxia). Bilirubin excretion problems may also occur (**jaundice**) if the infant's **liver** can not adequately replace the mother's placenta. Immunological disorders or infections may also result due to the immaturity of the newborn's immune system.
- Feeding and gastrointestinal disorders. Infant feeding disorders include milk regurgitation, overfeeding, underfeeding, vomiting, **diarrhea**, constipation, colic, and adverse effects due to the presence of drugs, if any, in the mother's milk. There are also a number of gastrointestinal disorders that may lead to poor absorption and utilization of food by the body. Failure to absorb nutrients and energy from food then leads to growth deficiencies.
- Inadequate nutrition. Nutritional deficiencies will cause poor growth and development. A balanced diet with adequate calories and protein intake is essential for optimal growth. Children who do not eat proper food-stuffs (malnutrition) develop growth disorders accompanied by intellectual underachievement.
- Attention deficit disorder (ADD). ADD is characterized by the inability to concentrate, hyperactivity, irritability, and impulsivity. As of 2001, 3–10% of the nation's school-age children were diagnosed with the disorder.
- Human growth hormone (hGH) deficiencies. hGH, also known as the master hormone of the body, is responsible for regulating growth, development, immunity, and **metabolism**. It affects the growth of tissues, bones, cartilage, muscles, skin, liver, and **kidneys**. hGH deficiency results in increased body weight and abdominal **obesity**, decreased lean body mass and decreased muscle mass, decreased strength, poor sleep, decreased

physical performance capacity, and lower cardiac performance.

- Diseases affecting the kidneys. Diseases of the kidneys may also impair growth and development as a result of buildup of waste products and undesirable substances in the body. For example, diabetic children grow slowly if their blood sugar is not maintained in the normal range.
- Disorders of the nervous system. Disorders affecting the nervous system can occur before or after birth with diagnosis usually made before one year of age. Some of the conditions that may affect growth and development include partial **paralysis** (spastic paresis), seizures (often infantile spasms), and abnormally large head (macrocephaly) or small head (microcephaly). Infants with nervous system disorders may have poor or absent speech development, epilepsy, abnormal fluid accumulation in the brain and **skull** (hydrocephalus), shrinkage or shortening of muscle tissue (spastic contractures), and mental retardation.
- Genetic or chromosomal abnormalities. There are many genetic disorders that may cause growth failure in children or affect it more or less seriously. They include hereditary defects incompatible with long-term development and survival, as well as hereditary conditions that are seriously life-threatening or that impair some aspect of growth and development.
- Severe **stress** or emotional deprivation. The child's psychological environment also affects physical development. A child requires care, affection, and stimulation for the normal growth and development of his body, brain, and nervous system. A striking example is provided by failure-to-thrive syndrome, in which children suffering from prolonged neglect or abuse simply stop growing. In these children, the psychological stress produced by their social environment causes the **endocrine system** to stop secreting growth hormones.

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Human Growth Foundation, 997 Glen Cove Ave., Glen Head, NY 11545. hgf1@hgfound.org.

National Institute of Child Health and Human Development, Building 31, Room B2B15, 9000 Rockville Pike, Bethesda, MD 20892.

OTHER

The National Parenting Center. "Physical Aspects of Infancy." <<http://www.tnpc.com/parentalk/infancy.html>>.

Monique Laberge, PhD

Human immunodeficiency virus infection
see **AIDS**

Human leukocyte antigen test

Definition

The human leukocyte antigen test, also known as HLA or tissue typing, identifies antigens on the white **blood** cells that determine tissue compatibility for organ transplantation (i.e., histocompatibility testing). There are six loci on chromosome 6 where the genes that produce HLA antigens are inherited: HLA-A, HLA-B, HLA-C, HLA-DR, HLA-DQ, and HLA-DP.

Unlike most blood group antigens which are inherited as products of two alleles (alternative genes), many different alleles can be inherited at each of the HLA loci. These are defined by antibodies (antisera) that recognize specific HLA antigens, or by DNA probes that recognize specific oligonucleotide sequences within the HLA allele. Using specific antibodies, 26 HLA-A alleles, 59 HLA-B alleles, 10 HLA-C alleles, 26 HLA-D alleles, 22 HLA-DR alleles, nine HLA-DQ alleles, and six HLA-DP alleles can be recognized. This high degree of genetic variability (polymorphism) makes finding compatible organs more difficult than finding compatible blood for transfusion.

Purpose

HLA typing, along with ABO grouping, is used to provide evidence of tissue compatibility. The HLA antigens expressed on the surface of the lymphocytes of the recipient are matched against those from various donors. HLA typing is performed for kidney, bone marrow, **liver**, **pancreas** or **heart** transplants. The probability that a transplant will be successful increases with the number of identical HLA antigens. HLA typing is not performed

for blood transfusion or corneal transplants, or for a graft of autologous tissue such as skin or bone.

Graft rejection occurs when the immune cells (T lymphocytes) of the recipient recognize specific HLA antigens on the donor's organ as foreign. These antigens are referred to as Class II histocompatibility antigens. The T lymphocytes initiate a cellular **immune response** characterized by release of cytotoxins and other cytokines that result in graft rejection. The cytotoxic reaction of the T lymphocytes is directed against the Class I histocompatibility antigens on the surface of the organ. Alternatively, T lymphocytes present in the grafted tissue may recognize the host tissues as foreign and produce a cell mediated immune response against the recipient. This is called graft versus host disease (GVHD), and it can lead to life-threatening systemic damage in the recipient. HLA testing is performed in order to reduce the probability of both allograft rejection and GVHD.

HLA typing is also used along with blood typing and DNA tests to determine parentage (i.e., for paternity testing). The HLA antigens of the mother, child, and alleged father can be compared. When an HLA antigen of the child cannot be attributed to the mother or the alleged father, then the latter is excluded as the father of the child.

A third use of HLA testing called linkage analysis is based upon the fact that the region where the HLA loci are positioned, the major histocompatibility complex (MHC), contains many other genes located very close to the HLA loci. The incidence of crossing-over between HLA genes during gamete formation is generally less than 1%. Consequently, the HLA antigens from all six loci are inherited together and segregate with many other genes located within the same region of chromosome 6. Many of the MHC region genes are involved in immunological processes. Consequently, alleles that are known to increase the chance of developing various autoimmune diseases have remained associated with specific HLA alleles. For example, 2% of people who have the HLA-B27 allele develop an arthritic condition of the vertebrae called ankylosing spondylitis. However, approximately nine out of 10 white persons who have ankylosing spondylitis are positive for HLA-B27. Because of this association the disease and this HLA type are linked. Family members of a person with ankylosing spondylitis who are HLA-B27 positive have a much higher likelihood of developing this condition than those who are not. Some notable autoimmune diseases that have a strong association with HLA antigens include Hashimoto's thyroiditis (an autoimmune disorder involving underproduction by the **thyroid gland**) associated with HLA-DR5; Graves' disease (an autoimmune disorder associated with

overproduction by the thyroid gland) associated with HLA-B8 and Dw3; and hereditary hemochromatosis (excess **iron** stores) associated with HLA-A3, B7, and B14.

Precautions

HLA testing is performed using white blood cells harvested from peripheral blood collected by venipuncture. The blood should be collected using either heparin or ACD anticoagulant. The nurse or phlebotomist performing the venipuncture should observe **universal precautions** for the prevention of transmission of blood-borne pathogens. If possible, this test should be postponed if the patient has recently undergone a transfusion. Any white blood cells from the transfusion may interfere with the tissue typing of the patient's lymphocytes.

Description

The HLA gene products can be grouped into three classes. Class I consists of the products of the genes located on the HLA-A, HLA-B, and HLA-C loci. These HLA antigens are found on all nucleated cells. Class II molecules consist of antigens inherited as genes from the HLA-DR, HLA-DQ, and HLA-DP loci. These HLA antigens are normally found only on B lymphocytes, macrophages, monocytes, dendritic cells, endothelial cells, and activated T lymphocytes. Class III molecules consist of several **proteins** belonging to the complement system and cytokines produced by lymphocytes such as tumor necrosis factor. Class III molecules are not evaluated in histocompatibility testing.

Because the HLA loci are closely linked, the HLA antigens are inherited as a group of six antigens called a haplotype. Each person receives one haplotype from each parent. HLA antigens, like blood group antigens, are codominant, and a person expresses both the alleles when two different genes are inherited from each parent. Since crossing-over does not often occur, the probability of siblings having an identical haplotypes is one in four. Therefore, siblings provide the opportunity for the best matches. Unfortunately, they can donate bone marrow, a kidney, and a section of their liver, but cannot donate other solid organs. Approximately 85% of transplants are organs from cadavers, and because the HLA antigens are so highly polymorphic, the chance of identical haplotypes falls precipitously.

Histocompatibility testing consists of three tests, HLA antigen typing (tissue typing), screening of the recipient for anti-HLA antibodies (antibody screen), and the lymphocyte crossmatch (compatibility test). HLA

antigen typing may be performed by serological or DNA methods. In the serological method, called the microcytotoxicity assay, lymphocytes are harvested from the blood by density gradient centrifugation. A solution of Ficoll-Hypaque is layered underneath the whole blood and the tube is centrifuged. Red blood cells and granulocytes are denser than the gradient and are forced to the bottom. The mononuclear cells are less dense than the gradient and are found at the top just underneath the platelets. The mononuclear cell layer is removed and washed. T-cells are removed by one of several methods, for example by binding to magnetic beads coated with T-cell antibodies. The B-cell enriched suspension is tested against a panel of specific antibodies to HLA antigens. The cells are added to wells of a microtiter tray each containing a different antibody. After incubating, rabbit complement is added to each well. Following a second incubation, a dye, Eosin Y, is added. Next, a formalin solution is added to fix the cells and stop any further immunological destruction. If the specific antibodies in the well recognize the HLA antigen on the lymphocytes, they will bind to the cells forming antigen-antibody complexes. The antigen-antibody complexes activate the complement proteins causing partial lysis of the cells. Eosin Y stains only those cells that are dead (i.e., unable to exclude the dye). The cells coated with antibodies can be identified by examining each well with an inverted phase contrast **microscope**. Cells that are stained pink are positive. The percentage of stained cells in each well is used to determine whether the cells are positive or negative for the HLA antigen. In general, when 60% or more of the cells are stained they are considered positive for the HLA antigen defined by the antibody in the well.

The alternative approach to HLA typing is DNA testing. In this method, white blood cells (granulocytes and lymphocytes) are separated from peripheral blood by lysis of the red blood cells and centrifugation. The DNA is extracted from the white cells and added to the wells of a microtiter tray. Each well contains an oligonucleotide primer complementary to a small segment of DNA. Each primer will hybridize with the DNA belonging to only one HLA allele. Therefore, if the primer attaches to the DNA, the corresponding HLA antigen coded by that allele was present on the cells. A master mix containing DNA polymerase and oligonucleotide triphosphates is added to each well and the plate is incubated in a thermal cycler that causes the DNA sequence framed by the primers to be amplified. The amplified products are detected by electrophoresis. The presence of a DNA band in the gel indicates a positive test for the respective HLA antigen.

A laboratory will perform HLA typing by either the serological or DNA method. In either case, HLA typing

KEY TERMS

Antibody—A protein (immunoglobulin) produced by B-lymphocytes in response to stimulation by a specific antigen.

Antigen—A molecule, usually a protein, that elicits the production of a specific antibody or immune response.

Autoimmune disorders—A disorder caused by a reaction of an individual's immune system against the organs or tissues of one's own body.

Cornea—The transparent outer layer of the eye. It covers the iris and lens.

Haplotype—A set of alleles of a group of closely linked genes which are usually inherited as a unit from one parent.

Lymphocyte—A class of white blood cell that is responsible for the immune response to antigens.

Phenotype—A trait produced by a gene. For example, the specific HLA antigen(s) inherited for the HLA-A locus is the phenotype for that gene.

of HLA-A, HLA-B, HLA-DR, and HLA-DQ antigens is performed for solid organ transplants. HLA typing of HLA-C antigens is also included when tissue typing is performed for bone marrow transplants.

The antibody screen is performed in order to detect antibodies in the recipient's serum that react with HLA antigens. The most commonly used method of HLA antibody screening is the microcytotoxicity test with an antiglobulin phase. Leukocytes harvested from the blood of donors of known HLA types are added to the wells of a microtiter plate. Serum from the recipient is added to each well and incubated. The cells are washed to remove any unbound proteins, and antihuman immunoglobulin (AHG) and rabbit complement are added. If an antibody against an HLA antigen is present, it will bind to the cells. The antigen-antibody complexes will bind the antihuman immunoglobulin resulting in partial lysis by the complement. Eosin Y is added and the cells are examined under the microscope. The presence of pink-stained cells indicates the presence of anti-HLA antibodies. As for HLA typing, the percentage of cells stained in each well is used to determine whether the serum is positive or negative for HLA antibody. The antibody screen is reported as the percentage of panel reactive antibodies (PRA). For example, if 50 cells are tested and 10 wells show a positive test, then the PRA is 20%. The higher the number of different HLA antibodies the lower the probability of

finding a compatible match. ELISA test kits that use HLA antigens bound to the wells of a commercially prepared microtiter tray are also available for HLA antibody screening.

The third component of a histocompatibility study is the crossmatch test. In this test peripheral blood lymphocytes from the donor are separated into B and T lymphocyte populations. Purified T cells are prepared by mixing the lymphocyte suspension with magnetic beads coated with monoclonal antibodies to the B lymphocytes. The B-cells bind to the beads that are then pulled to the bottom of the tube by a magnet. The supernatant cell suspension can be used for the T-cell crossmatch. Purified B lymphocytes are produced in like manner except that an antibody to the T-cells is used. In the crossmatch serum from the recipient is mixed with T-cells or B-cells from the donor. The T-cell crossmatch is performed by the same microcytotoxicity method as described above for the antibody screen (i.e., an AHG reagent is used). The B-cell crossmatch is performed by the same microcytotoxicity method as described previously for HLA typing. A positive finding indicates the presence of preformed antibodies in the recipient that are reactive against the donor tissues. An incompatible T-cell crossmatch contraindicates transplantation of a tissue from the T-cell donor.

Preparation

The HLA test requires a blood sample collected in heparin or acid-citrate-dextrose (ACD). There is no need for the patient to fast before the test.

Aftercare

The patient may feel discomfort when blood is drawn from a vein. Bruising may occur at the puncture site or the person may feel dizzy or faint. Pressure should be applied to the puncture site until the bleeding stops to reduce bruising. Warm packs can also be placed over the puncture site to relieve discomfort.

Complications

Risks for this test are minimal, but may include slight bleeding from the puncture site, fainting or feeling lightheaded after venipuncture, or hematoma (blood accumulating under the puncture site).

Results

HLA typing either by serological or DNA methods is reported as the phenotype for each HLA loci tested. The antibody screen test is reported as the percentage of panel

reactive antibodies (PRA). The percent PRA is the number of wells reactive with the patient's serum expressed in percent. The crossmatch is reported as compatible or incompatible.

Tissue typing results for both donors and recipients and antibody screen results for recipients are submitted to the United Network for Organ Sharing (UNOS) database. The database searches all regional donors that are ABO compatible for an HLA identical match. If none is found, the database searches the national database for ABO compatible donors and scores the match. A point system is used based upon several parameters including the number of matching HLA loci, the length of time the recipient has been waiting, the recipient's age, and the PRA score.

Health care team roles

A physician specializing in transplantation medicine orders HLA typing tests. A nurse or phlebotomist draws the blood sample. Histocompatibility tests are performed by clinical laboratory scientists/medical technologists with specialized training in cellular immunology and **DNA typing** procedures. Results are interpreted by a physician who specializes in transplantation immunology.

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Mark A. Best

Hyaline membrane disease see **Respiratory distress syndrome**

Hydrocortisone see **Corticosteroids**

Hydrogen peroxide see **Antiseptics**

Hydrotherapy

Definition

Hydrotherapy, or water therapy, is the use of water (hot, cold, steam, or ice) to relieve discomfort and promote physical well-being.

Purpose

Hydrotherapy is intended to relieve **pain**, increase mobility, and promote a feeling of well-being. Various methods are used to apply heat or cold to different body parts. Water is a non-toxic substance that is also used for cleansing and irrigating selected body cavities.

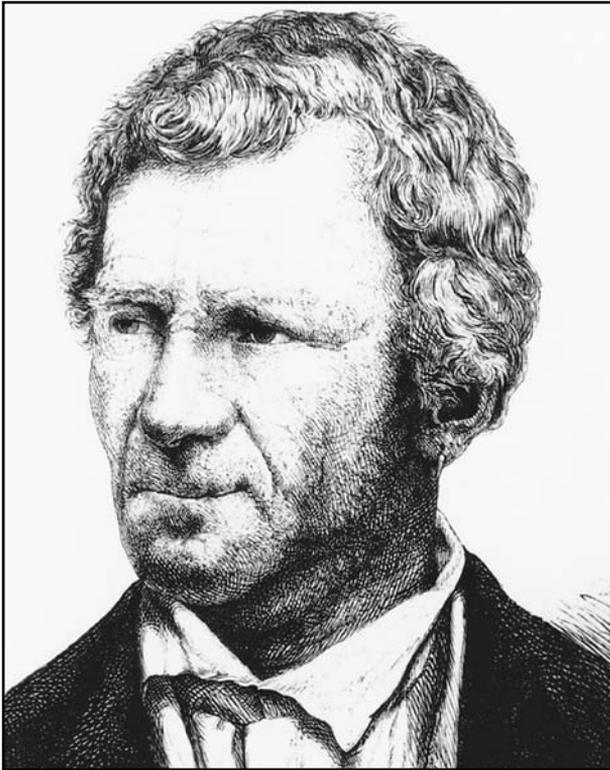
Hydrotherapy is an ancient technique. Historical and archeological evidence has shown that it has been used for several thousand years in both the east and west. Naturally occurring hot or mineral springs have long been used for therapeutic purposes. Herbs and scented oils have been added to heated water for almost as long a period of time.

Hydrotherapy treatments are used by both allopathic and complementary medicine to treat a wide variety of discomforts and disorders. Not as well accepted are invasive hydrotherapy techniques, such as colonic irrigation, **enemas**, and douching. These internal cleansing techniques can actually harm an individual by upsetting the natural balance of the digestive tract and the vagina. Most conventional medical professionals agree that vaginal douches are not necessary to promote hygiene in most women, and can actually do more harm than good.

Precautions

Water should not be hot enough to cause **burns**. Ice should not be left in contact with the skin for prolonged periods of time. Time in a sauna should be limited to avoid hypotension. Persons receiving whirlpool or Jacuzzi treatment should be monitored to avoid accidental drowning or loss of consciousness. Water in whirlpool baths or Jacuzzis should be changed after each use or regularly sanitized and tested. Long hair should be covered when a person is immersed in a whirlpool or Jacuzzi bath. Jewelry should be removed before any hydrotherapy treatment.

Individuals with **paralysis**, frostbite, or other conditions that impair the nerve endings and cause reduced sensation should only take hydrotherapy treatments under the guidance of a trained hydrotherapist, physical therapist, or other appropriate healthcare professional. Because these individuals cannot accurately sense temperature changes, they run the risk of being seriously



Vincenz Priessnitz (1799–1851), an early proponent of hydrotherapy. (Betmann/CORBIS. Reproduced by permission.)

burned. Diabetics and people with **hypertension** should also consult their healthcare professional before using hot tubs or other heat hydrotherapies.

Hot tubs, Jacuzzis, and pools can become breeding grounds for **bacteria** and other infectious organisms if they are not cleaned regularly, maintained properly, kept at the appropriate temperatures, and treated with the proper chemicals. Individuals should check with their healthcare provider to ensure that the hydrotherapy equipment they are using is sanitary. Those who are using hot tubs and other hydrotherapy equipment in their homes should follow the directions for use and maintenance provided by the equipment manufacturer.

Certain essential oils should not be used by pregnant or nursing women or by people with specific illnesses or physical conditions. Individuals suffering from any chronic or acute health condition should inform their healthcare provider before starting treatment with any essential oil.

Essential oils such as cinnamon leaf, juniper, lemon, eucalyptus blue gum, peppermint, and thyme can be extremely irritating to the skin if applied in full concentration. Oils used in hydrotherapy should always be diluted in water before they are applied to the skin.

Individuals should never apply essential oils directly to the skin unless directed to do so by a trained healthcare professional or aromatherapist.

Colonic irrigation should only be performed by a healthcare professional. Pregnant women should never douche, as the practice can introduce bacteria into the vagina and uterus. They should also avoid using hot tubs without the consent of their healthcare provider.

The benefit of vaginal douching for all women is questionable. The vagina is self-cleansing, and douches have been known to upset the balance of vaginal pH and flora, promoting vaginitis and other infections. Some studies have linked excessive vaginal douching to increased incidence of pelvic inflammatory disease (PID).

Description

Water can be used therapeutically in a number of ways. Common forms of hydrotherapy include:

- Whirlpools, Jacuzzis, and hot tubs. These soaking tubs use jet streams to massage the body. They are frequently used by physical therapists to help injured persons regain muscle strength and to soothe joint and muscle pain. Some midwives and obstetricians also approve of the use of hot tubs to soothe the pain of labor.
- Pools and Hubbard tanks. Physical therapists and rehabilitation specialists may prescribe underwater pool exercises as a low-impact method of rebuilding muscle strength in injured people. The buoyancy experienced during pool immersion also helps ease pain in conditions such as arthritis.
- Baths. Tepid baths are prescribed to reduce a **fever**. Baths are also one of the oldest forms of **relaxation** therapy. Adding Epsom salts (magnesium sulfate) or Dead Sea salts to a bath can promote relaxation and soothe rheumatism and arthritis.
- Showers. Showers are often prescribed to stimulate the circulation. Water jets from a shower head are also used to massage sore muscles.
- Moist compresses. Cold, moist compresses can reduce swelling and inflammation of an injury. They can also be used to cool a fever and treat a headache. Hot or warm compresses are useful for soothing muscle aches and treating abscesses.
- Steam treatments and saunas. Steam rooms and saunas are recommended to open the skin pores and cleanse the body of toxins. Steam inhalation is prescribed to treat respiratory infections.
- Internal hydrotherapy. Colonic irrigation is an enema that is designed to cleanse the entire bowel. Douching,

another form of internal hydrotherapy, directs a stream of water into the vagina for cleansing purposes. The water may or may not contain medications or other substances. Douches can be self-administered with kits available at most drug stores.

Preparation

Because of the expense of the equipment and the expertise required to administer effective treatment, hydrotherapy with pools, whirlpools, Hubbard tanks, and saunas is best taken in a professional healthcare facility under the supervision of a healthcare professional. However, baths, steam inhalation treatments, and compresses can be easily administered at home.

Bath preparations

Warm-to-hot bath water should be used for relaxation purposes, and a tepid bath is recommended for reducing fevers. To prepare salts for the bath, add one or two handfuls of Epsom salts or Dead Sea salts to boiling water until they are dissolved, and then add them to the tub.

A sitz bath, or hip bath, can be taken at home to treat hemorrhoids and promote healing of an episiotomy. A special apparatus is available for taking a seated sitz bath, but one can also have a sitz bath in a regular tub partially filled with warm water.

Steam inhalation

Steam inhalation treatments can be easily administered by holding one's head over a bowl of steaming water and using a large towel as a tent.

Compresses

A cold compress is prepared by soaking a cloth or cotton pad in cold water and then applying it to the area of injury or distress. When the cloth reaches room temperature, it should be resoaked and reapplied. Gentle pressure can be applied with the hand to the compress. Cold compresses are generally used to reduce swelling, minimize bruising, and to treat headaches and sprains.

Warm or hot compresses are used to treat abscesses and muscle aches. A warm compress is prepared in the same manner as a cold compress, except steaming water is used to wet the cloth instead of cold water. Warm compresses should be refreshed and reapplied after they cool to room temperature.

Aftercare

Typically, no special care is required after receiving hydrotherapy.

Complications

Most forms of hydrotherapy are well-tolerated and complications are unusual. Water that is too hot may cause burns. Contact with cold temperatures may cause transient hypothermia to the treated portion of the body. The effects of hydrotherapy typically wear off with time, so additional treatments are required if the problem persists. Repeated use of colonic hydrotherapy, however, may impair function of the **large intestine**, leading to dependence on the hydrotherapy to maintain normal bowel function.

There is a risk of allergic reaction (also known as contact dermatitis) for some people using essential oils and herbs in their bath water. These individuals may want to test for allergic sensitization to herbs by performing a skin patch test (i.e., rubbing a small amount of diluted herb on the inside of their elbow and observing the spot for redness and irritation). People who experience an allergic reaction to an essential oil should discontinue its use and contact their healthcare professional for further guidance.

The most serious possible side effect of hydrotherapy is overheating, which may occur when an individual spends too much time in a hot tub or Jacuzzi. However, this is a minimal risk when the patient is properly supervised.

Results

Relief from pain or discomfort is the usual result of hydrotherapy. Increased mobility, especially in joints, also frequently occurs. Many persons receiving hydrotherapy report having higher levels of energy.

Hydrotherapy can soothe sore or inflamed muscles and joints, rehabilitate injured limbs, lower fevers, soothe headaches, promote relaxation, treat burns and frostbite, ease labor pains, and clear up skin problems. The temperature of water used affects the therapeutic properties of the treatment. Hot water is chosen for its relaxing properties. It is also thought to stimulate the **immune system**. Tepid water can also be used for **stress** reduction and may be particularly relaxing in hot weather. Cold water is used to reduce inflammation. Alternating hot and cold water can stimulate the circulatory system and improve the immune system.

Health care team roles

A variety of doctors, such as orthopedic surgeons, sports medicine doctors, and rheumatologists may make an initial referral for some forms of hydrotherapy.

KEY TERMS

Contact dermatitis—Skin irritation as a result of contact with a foreign substance.

Episiotomy—An incision made in the perineum during labor to assist in delivery and to avoid tearing of the perineum.

Essential oil—A volatile oil extracted from the leaves, fruit, flowers, roots, or other components of a plant and used in aromatherapy, perfumes, foods and beverages.

Hubbard tank—A large water tank or tub used for underwater exercises.

Individuals also sometimes initiate visits themselves. A hydrotherapist provides the requested services.

Hydrotherapy is practiced by a number of physical therapists, medical doctors (especially those specializing in rehabilitation), nurses, and naturopathic physicians. Naturopaths are licensed in a number of states. Aromatherapists, who frequently recommend water-based treatments with herbs and essential oils, are not licensed, although there are certification programs available for practitioners.

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ORGANIZATIONS

- American Academy of Physical Medicine and Rehabilitation, One IBM Plaza, Suite 2500, Chicago, IL 60611-3604. (312) 464-9700. Fax (312) 464-0227. <<http://www.aapmr.org/consumers/public/amputations.info@aapmr.org>>.
- American Association of Naturopathic Physicians, 8201 Greensboro Drive, Suite 300, McLean, Virginia 22102. (703) 610-9037. Fax (703) 610-9005. <<http://naturopathic.org>>. info@naturopathic.org.
- American College of Sports Medicine, 401 W. Michigan St., Indianapolis, IN 46202-3233. (317) 637-9200. Fax (317) 634-7817. <<http://www.acsm.org>>. mkeckhaver@acsm.org.

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L. Fleming Fallon, Jr., MD, DrPH

Hyperbilirubinemia see **Neonatal jaundice**

Hypercoagulability tests

Definition

Hypercoagulability tests measure three **proteins** produced by the **liver** that when deficient increase the risk of thrombosis. These proteins are antithrombin III, protein C, and protein S.

Purpose

The **blood coagulation** process prevents people from bleeding excessively. Normally, this process occurs whenever the **blood** vessel wall incurs damage, and the resulting clot keeps the blood from escaping from the damaged vessel. The coagulation factors responsible for clot formation are mainly enzymes, and their activity is down regulated by other proteins that inactivate them. Abnormal clot formation will occur when one of these proteins is defective or diminished in concentration. The purpose of hypercoagulability tests is to determine whether a person is at increased risk for abnormal clot formation. A person with a deficiency of antithrombin III, protein C, or protein S is at increased risk for thrombus formation. This can result in occlusion of a vessel and diminished blood flow to dependent tissues.

Precautions

When functional activity is being measured for protein S or C, anticoagulant therapy with warfarin (Coumadin) will interfere with the results. Heparin therapy will interfere with functional assays for antithrombin III. Blood for these tests must be collected in sodium citrate. The nurse or phlebotomist collecting blood for this test should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. Shaking the tube vigorously, collecting an insufficient sample, or using the wrong tube required for hypercoagulability tests are not acceptable and will require a second venipuncture.

Description

Hypercoagulable conditions that allow the blood to clot inappropriately pose a life-threatening risk to patients. A thrombus that forms in the absence of bleeding can obstruct the normal flow of blood to tissues beyond the clot site. If a portion of the mass breaks off and travels to another body site or organ, it is called an embolus. A thrombus or embolus can be fatal if it lodges in a vital area like the **heart** or **lungs**. When antithrombin III, protein C, or protein S is deficient or defective,

there will be an increased risk of thrombus or embolus formation.

Deficiencies of antithrombin III, protein C, and protein S may be either inherited or acquired. All three deficiencies are inherited as an autosomal dominant condition. The heterozygote (one defective gene) generally has 40-50% of the normal level of functional protein. Such persons usually have a history of thrombotic events such as deep or superficial vein thrombosis, pulmonary or cerebral embolism, ischemic heart disease or coronary thrombosis. Since the liver is the site of synthesis, a deficiency of each of these proteins can result from liver disease. Antithrombin III deficiency may also be caused by oral contraceptives, nephrotic syndrome, and disseminated intravascular coagulation. Acquired protein S deficiency is also associated with the lupus anticoagulant (an antibody to phospholipid), **pregnancy**, oral contraceptives, and **vitamin K** deficiency.

Hypercoagulability testing is performed when a patient has risk factors that increase the chance of thrombosis. These factors include:

- repeated episodes of thrombosis in the past
- family history of thrombosis
- vascular damage
- severely decreased mobility, bed rest, or paralysis
- heart disease
- severe liver disease
- severe kidney disease
- cancer
- obesity
- surgery
- pregnancy

Antithrombin III

Antithrombin III binds to factor Xa and thrombin (serine proteases involved in coagulation) and prevents them from acting on their natural substrates. Antithrombin III requires heparin for its activity. The heparin is released from the vessel wall cells and complexes the antithrombin III. This causes changes in the conformation of antithrombin III that allow it to bind to the active sites of Xa and thrombin. Two types of assays are available for measuring antithrombin III. Immunoassays such as nephelometry determine the mass of antithrombin III in the plasma based upon its reaction with specific antibody. Functional assays are usually based upon its activity against a chromogenic substrate. The plasma is incubated with excess factor Xa and heparin. The factor Xa that remains active is measured by

KEY TERMS

Immunoassay—A laboratory analysis that uses an antibody-antigen reaction. A specific antibody is used that will react with the protein of interest, for example antithrombin III. In this reaction, the antithrombin III functions as the antigen.

Nephelometry—A laboratory technique used to measure light scattering by small immune complexes suspended in the reaction solution. Light scattering is proportional to the antigen concentration with the antibody is present in excess.

its ability to split a synthetic analide substrate. This produces aniline, which is yellow in color and can be measured at 405 nm. The amount of aniline produced is inversely proportional to antithrombin III activity. Results are expressed as the percentage of a normal control plasma. It is important to note that immunoassays and functional assays may give different results. When the quantity of antithrombin III is decreased, both tests will be abnormal. However, when the protein is defective, the immunoassay result will be normal, but the functional assay will be abnormal. Some functional deficiencies are heparin dependent. When the assay is performed without heparin, the activity is equal to that of the normal control. These persons have an antithrombin III with a defective heparin binding site, and their condition is usually milder.

Protein C

Protein C is a serine protease that enzymatically inactivates both factor Va and factor VIIIa. Protein C is activated when a receptor on the blood vessel cell surface called thrombomodulin binds to and neutralizes the coagulating activity of thrombin. The activity of protein C requires phospholipids from platelets adhering to the vessel wall and also protein S. As with antithrombin III, protein C may be measured by immunoassay or by a functional assay. When immunoassay is used, only a quantitative deficiency of protein C will be detected. Two types of functional assays are used, the chromogenic substrate assay and the clot formation (activated partial thromboplastin) test. In the clot formation test, plasma is mixed with an activator of protein C, usually *Agkistrodon* snake venom. After incubation, **calcium** chloride and activated thromboplastin are added and the time required for a clot to form is measured. The time required for the clot to form is proportional to protein C activity. Results are expressed as the percentage activity of the normal

control. All forms of protein C deficiency are detected by this method. In the chromogenic substrate assay, plasma is mixed with *Agkistrodon* snake venom and incubated. A synthetic analide substrate is added. The activated protein C splits the substrate liberating aniline. The concentration of aniline is measured at 405 nm and is proportional to protein C activity. This assay detects quantitative deficiencies of protein C and some functional defects, but it does not detect defective binding of protein C by protein S.

Protein S

Protein S is a cofactor necessary for protein C activity. Approximately 60% of the circulating protein S is bound to complement and the remainder is free. Only the free protein S is physiologically active. Protein S can be measured by immunoassay or by a clot formation test. The immunoassay measures total protein S unless the protein-bound fraction has been removed prior to assay. Some persons with protein S deficiency have low levels of free protein S but normal levels of the protein-bound form. Others have a decreased concentration of both free and bound protein S. The functional assay will be abnormal in both types. The assay is performed by mixing the patient's plasma with protein S deficient plasma, activated protein C, and activated factor V. After incubation, calcium chloride is added. The time required for a clot to form is proportional to the protein S activity of the sample. The result for the patient is compared to normal plasma to determine the percentage of protein S activity.

Preparation

The reason for testing should be explained by the health care provider. If the patient is taking an anticoagulant medication, the physician may require that the medication be discontinued for a specific time period prior to hypercoagulability testing.

Aftercare

Discomfort or bruising may occur at the puncture site, or the person may feel dizzy or faint. Pressure to the puncture site until the bleeding stops reduces bruising. Applying warm packs to the puncture site relieves discomfort.

Complications

Minor temporary discomfort may occur with any blood test, but there are no complications specific to hypercoagulability testing. In normal circumstances, a blood draw for these tests takes only a few minutes, and the patient experiences only minor discomfort.

Results

The results of tests for antithrombin III, protein C, and protein S depend upon the method used. Some representative normal ranges are shown below:

- Antithrombin III activity assessed by immunoassay: 20–30 mg/dL or 0.85–1.22 U/mL.
- Antithrombin III antigen assessed by chromogenic substrate assay: 80–120% of normal activity.
- Protein C activity assessed by photo-optical clot detection: 70–140% of normal activity.
- Protein C antigen assessed by immunoassay: 0.8–2.3 U/mL.
- Protein S activity assessed by photo-optical clot detection: (Male) 70–150% of normal activity; (Female) 58–130% of normal activity.
- Protein S antigen assessed by immunoassay: 0.6–1.8 U/mL.

If the level of any of these regulatory proteins is below normal, the patient has an increased risk of developing serious blood clots.

Health care team roles

A physician orders the tests and interprets the results. Usually a nurse or phlebotomist performs the venipuncture procedure. Clinical laboratory scientists/medical technologists perform the assays for antithrombin III, protein C, and protein S. Persons with family history of thrombosis and abnormal test results may be referred for **genetic testing**. A genetic counselor will explain the genetic findings and the chance of passing the abnormal gene to an offspring.

Patient education

The health care team must provide clear and accurate information for patients who require hypercoagulability testing. The medical implications of having a blood clotting abnormality are serious and the patient must understand the importance of treatment. If an abnormal gene is responsible he or she will require anticoagulant medication for life. Since these deficiencies are inherited as autosomal dominant traits an affected person has a 50% chance of passing the condition to their offspring. Additional members of the patient's family will also require testing.

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Hypernasality see **Voice disorders**

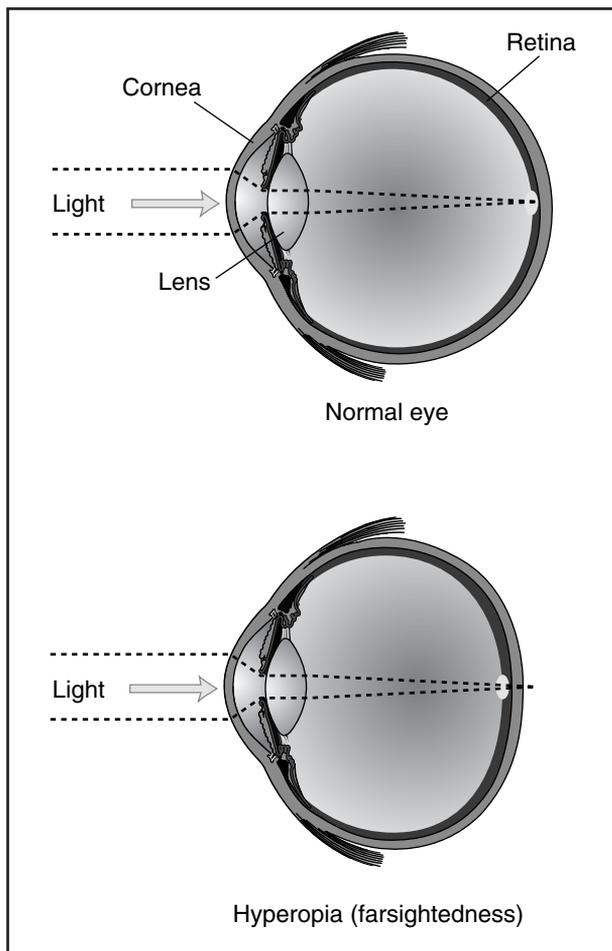
Hyperopia

Definition

Hyperopia, also known as hypermetropia or farsightedness, is the condition of the eye in which incoming rays of light reach the retina before they converge into a focused image.

Description

When light goes through the lens and cornea, its velocity decreases. The greater the curvature of the lens system, the greater the change in the direction of the light. When parallel light rays from an object go through the lens system, they are bent so they converge at a point some distance behind the lens. With perfect **vision** this



Hyperopia, or farsightedness, is a condition of the eye in which incoming rays of light impinge on the retina before converging into a focused image, resulting in difficulty seeing nearby objects clearly. (Illustration by Electronic Illustrators Group.)

point of convergence is on the retina. Hyperopia is the condition in which the point of focus of parallel light rays from an object is behind the retina. This condition exists when the combined curvature of the lens and cornea is insufficient (e.g., flatter than needed for the length of the eyeball).

There is a connection between the focusing of the lens of the eye (accommodation) and convergence of the eyes (the two eyes turning in to point at a close object). The best example is during reading. The lens accommodates to bring close-up material into focus and the eyes turn in to view the print and keep it single. Because of this connection between accommodation and convergence, the eyes may appear to turn in if the lens needs to accommodate to focus, even on distant objects. This can result in a condition known as accommodative esotropia. The eyes turn in and the cause is accommodation because of hyperopia.

Causes and symptoms

Most babies are born slightly hyperopic. This tends to decrease with age. In some eyes the cornea is too flat for the distance between the cornea and the retina. If the hyperopia is not too severe the lens may accommodate and focus the image onto the retina. This results in clear distance vision, also potential headaches or eyestrain. If the lens cannot accommodate for the full amount of the hyperopia, the distance image would be blurry.

If the eyes are focusing for distance and the patient shifts his or her gaze to a near object, the eyes need to accommodate further. This may result in nearby objects appearing blurry, or the patient may experience headaches while performing work on objects that are close to the eyes.

Symptoms can range widely depending on the severity of hyperopia. There may be no noticeable symptoms, distance vision may be clear but near vision blurry, or both distance and near vision may be blurry. Headaches and eyestrain may occur, particularly when performing near tasks. An eye turned in (esotropia) may be a result of hyperopia, particularly in children.

Diagnosis

To determine hyperopia, a complete eye exam should be performed by an ophthalmologist (M.D.) or optometrist (O.D.). The exam should begin by the physician or ophthalmic assistant taking a detailed medical history from the patient. Then the physician, or in some cases a highly trained ophthalmic assistant, will begin the ocular examination by measuring the visual acuity and performing a refraction.

During the exam the physician will also determine ocular motility and alignment, nearpoint of convergence, near fusional vergence amplitudes, relative accommodation measurements, accommodative amplitude, and facility of accommodation. Additional ocular health assessment and screenings should rule out other accommodative dysfunctional disorders such as Graves' disease.

Treatment

The usual treatment for hyperopia is corrective lenses (eyeglasses or **contact lenses**). Plus-powered spherical or spherocylindrical lenses are prescribed. In some instances, physicians will choose pharmaceuticals to reduce a high accommodative convergence to accommodation.

In June 2000, the Food and Drug Administration (FDA) approved the first laser treatment for hyperopia. Laser thermal keratoplasty (LTK), performed by an

M.D., takes three seconds per eye and involves no cutting or removal of corneal eye tissue. The holium:YAG laser uses a process for shrinking collagen and applies two concentric rings of eight simultaneous spots of laser energy to the periphery of the cornea. The laser heats the corneal collagen and steepens its shape, improving refractive (focusing) power.

LTK patients must be at least 40 years old; have stable vision for at least six months; fall in the low-to-moderate range of hyperopia (+0.75 diopters to +2.50 diopters); and have no more than 0.75 diopters of **astigmatism**. A complete medical history must be taken before the procedure is performed. Patients who fall into any of the following categories should not have LTK performed are:

- pregnant or nursing women
- patients with clinically significant corneal dystrophy or scarring in the 6 mm or 7 mm central zone
- patients with a history of herpetic keratitis
- patients with an autoimmune disease, collagen vascular disease, clinically significant atopic syndrome, insulin dependent diabetes or an immune compromised status

Investigation of phakic intraocular lenses to treat hyperopia continues. As of early 2001, there were three separate FDA clinical trials in progress. The most promising is an implantable contact lens to treat hyperopia that is injected through a clear corneal incision.

In conjunction with these treatments, physicians may also want to address environmental factors to treat hyperopia, and advise patients to reduce glare and improve lighting and ergonomic conditions in their work stations.

Prognosis

Patients with low to moderate amounts of hyperopia have an excellent opportunity to receive fully corrected vision with eyeglasses, contact lenses or refractive surgery. Patients with very high hyperopia (+10.00D or more) may not achieve full correction.

Hyperopia increases the chances of chronic **glaucoma**, but vision loss from glaucoma is preventable.

Health care team roles

Nursing and allied health professionals perform an important role in the examination to determine hyperopia. They take a detailed patient history, insert eyedrops, and ready the physician's instruments. Skilled technicians also can perform the first level of refraction in the general eye exam. Depending on the technician's skill level, the physician may check these findings.

KEY TERMS

Accommodation—The ability of the eyes to focus clearly at various distances.

Cornea—The clear, dome-shaped outer covering of the front of the eye. It lies in front of the iris and pupil.

Iris—The colored ring just behind the cornea and in front of the lens that controls the amount of light sent to the retina.

Pupil—The black hole in the center of the iris. Light enters here on the way to the lens and retina.

Refraction—Method of determining the optical status of the eyes. Lenses are placed before the patient's eyes while reading from an eye chart. The result is the eyeglass prescription.

Retina—The inner, light-sensitive layer of the eye containing rods and cones; transforms the image it receives into electrical messages sent to the brain via the optic nerve.

Technology also allows technicians to perform parts of the exam previously only completed by the eye doctor, including corneal topography, retinal photography, and automated keratometry.

Ophthalmic assistants and nurses also assist in the screening of LTK patients. They prep the patients for surgery and may insert anesthetic eyedrops.

Prevention

Hyperopia is usually present at birth, and there is no known way to prevent it.

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Hypersomnia see **Sleep disorders**

Hypertension

Definition

Hypertension is high **blood pressure**. **Blood pressure** is the force of blood pushing against the walls of arteries as it flows through them.

Description

As blood flows through arteries it pushes against the inside of the artery walls. The more pressure the blood exerts on the artery walls, the higher the blood pressure will be. The size of small arteries also affects the blood pressure. When the muscular walls of arteries are relaxed, or dilated, the pressure of the blood flowing through them is lower than when the artery walls narrow, or constrict.

Blood pressure is highest when the **heart** beats to pump blood out into the arteries. Between beats, when the heart relaxes to refill with blood, the pressure drops to its lowest point. The blood pressure peak, when the heart pumps, is called systolic pressure. The blood pressure trough, when the heart is filling, is called diastolic pressure. When blood pressure is measured, the systolic pressure is stated first and the diastolic pressure second. Blood pressure is measured in millimeters of mercury (mm Hg). For example, if a person’s systolic pressure is 120 and diastolic pressure is 80, it is written as 120/80 mm Hg. The American Heart Association considers systolic blood pressure less than 140 and diastolic blood pressure less than 90 normal for adults.

Hypertension is a significant **public health** problem. Since it has no symptoms, many people are unaware that they have hypertension. In the United States, about 50 million people age six and older have high blood pressure. Hypertension occurs more frequently in men than women and in people over the age of 65 than in younger persons. More than half of all Americans over the age of 65 have hypertension. It is also more prevalent in African-Americans than in white Americans.

Hypertension is serious because it places patients at higher risk for heart disease and other medical problems than people with normal blood pressure. Serious complications may be prevented by encouraging patients to check their blood pressure regularly, and by treating hypertension once it is diagnosed.

If left untreated, hypertension can lead to the following medical conditions:

- arteriosclerosis, also called atherosclerosis
- **myocardial infarction** (heart attack)
- cerebrovascular accident (stroke)
- left ventricular hypertrophy leading to congestive **heart failure**
- chronic renal failure (kidney damage)

Arteriosclerosis is hardening of the arteries. The walls of arteries have a layer of muscle and elastic tissue that makes them flexible and able to dilate and constrict as needed. High blood pressure can cause artery walls to thicken and harden. When artery walls thicken, the lumen (hollow center of the blood vessel) narrows. Cholesterol and fatty plaques are more likely to build up on the walls of damaged arteries, further narrowing them. Blood clots can also become trapped in narrowed arteries, blocking the flow of blood.

Arteries narrowed by arteriosclerosis may restrict blood flow to organs and other tissues. Reduced or blocked blood flow to the heart can cause myocardial infarction (a heart attack). Similarly, if an artery to the **brain** is blocked, a stroke can result.

Hypertension forces the heart muscle to work harder to pump blood through the body. The extra workload can cause the heart muscle to thicken and stretch. When the heart becomes too enlarged, it cannot pump enough blood. If hypertension continues and is not treated, the heart may fail.

The **kidneys** remove waste from the blood. Chronic hypertension thickens the arteries to the kidneys and impairs renal (kidney) function. As the condition progresses, the kidneys eventually fail and hemodialysis or kidney transplant will be needed. About 25% of people

who receive hemodialysis have kidney failure caused by hypertension.

Causes and symptoms

Blood pressure varies in response to physical and emotional stimuli. Many different actions or situations normally raise blood pressure. Physical activity can temporarily raise blood pressure. Emotionally stressful situations also can increase blood pressure. When the **stress** subsides or disappears, blood pressure usually returns to normal. These temporary increases in blood pressure are not considered hypertension. A diagnosis of hypertension is made only when a patient has multiple high blood pressure readings over a period of time.

For 90–95% of patients with hypertension, the cause is unknown. Hypertension without a known cause is called primary or essential hypertension.

When a patient has hypertension caused by another medical condition, it is considered secondary hypertension. Secondary hypertension may be caused by a variety of disorders. Many patients with kidney diseases have secondary hypertension because the kidneys regulate the balance of salt and water in the body. If the kidneys cannot rid the body of excess salt and water, blood pressure rises. Chronic pyelonephritis (kidney infections), renal artery stenosis, and glomerulonephritis are examples of kidney diseases that may cause secondary hypertension.

Cushing's syndrome and tumors of the pituitary and **adrenal glands** often increase levels of the adrenal gland hormones—cortisol, adrenaline and aldosterone—which can cause hypertension. Other conditions that may cause secondary hypertension are vasculitis, thyroid disorders, some prescription and over-the-counter medications, **alcoholism**, and **pregnancy**.

Although the cause of most hypertension is not known, some individuals have greater risk of developing hypertension. Many lifestyle-associated risk factors may be modified or eliminated to reduce the chance of developing hypertension or to reduce blood pressure in patients with hypertension.

Risk factors for hypertension include:

- Age; persons over 60 are at greater risk.
- Gender; males are more often affected.
- Race; African Americans are more often affected.
- Heredity; persons with a family history of hypertension are at greater risk.
- Salt sensitivity.
- Obesity.
- Inactive, sedentary lifestyle.

- Heavy alcohol consumption.
- Use of oral contraceptives.

Some risk factors for getting hypertension can be changed, while others cannot. Age, gender, heredity, and race are risk factors that cannot be influenced. An individual with any of these non-modifiable risk factors should avoid or eliminate other, controllable risk factors to reduce the chance of developing hypertension.

Diagnosis

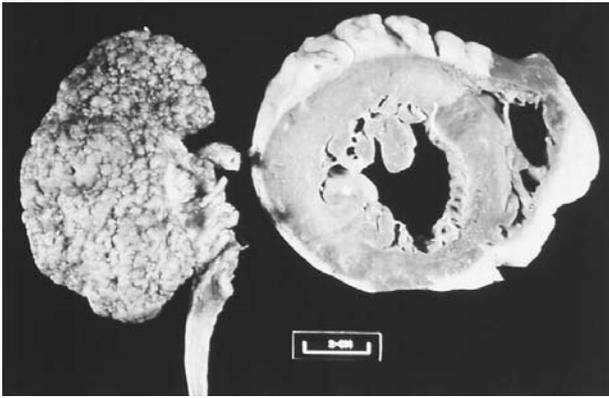
Since hypertension is asymptomatic (does not cause symptoms), it is important for patients to have regular blood pressure checks. Conventionally, blood pressure is measured with an instrument called a **sphygmomanometer**. When the cuff is inflated, an artery in the arm is squeezed to momentarily stop the flow of blood. Then, the air is let out of the cuff while a **stethoscope** placed over the artery is used to detect the sound of the blood spurting back through the artery. This first sound is the systolic pressure, the pressure when the heart beats. The last sound heard as the air is being released is the diastolic blood pressure.

Normal blood pressure is defined by a range of values. Systolic blood pressure lower than 140 mm Hg and diastolic blood pressure lower than 90 mm Hg is considered normal. A number of factors such as **pain**, stress, or **anxiety** can cause a temporary increase in blood pressure. For this reason, hypertension is not diagnosed on the basis of a single elevated blood pressure reading. If a blood pressure reading is 140/90 or higher, the physician or mid-level practitioner (physician assistant or nurse practitioner) will have the patient return for another blood pressure check or instruct the patient to check their blood pressure at home using an inexpensive, automated device. Diagnosis of hypertension usually is made based on two or more readings after the first visit.

Isolated systolic hypertension is common among older adults and is diagnosed when diastolic pressure is normal or low, but the systolic is elevated, e.g. 170/70 mm Hg. This condition usually co-exists with atherosclerosis (hardening of the arteries).

Blood pressure measurements are classified in stages, according to severity:

- Normal blood pressure: less than 130/85 mm Hg.
- High normal: 130–139/85–89 mm Hg.
- Mild hypertension: 140–159/90–99 mm Hg.
- Moderate hypertension: 160–179/100–109 mm Hg.
- Severe hypertension: 180–209/110–119.
- Very severe hypertension: 210/120 or higher.



The effects of hypertension on the heart and kidney. Hypertension has caused renal atrophy and scarring, and left ventricular hypertrophy in the sectioned heart (at right). (Photograph by Dr. E. Walker, Photo Researchers, Inc. Reproduced by permission.)

A typical **physical examination** to evaluate hypertension includes:

- medical and family history
- physical examination
- ophthalmoscopy: examination of the **blood vessels** in the eye
- **chest x ray**
- electrocardiogram (ECG)
- blood and urine tests, including electrolytes, creatinine, protein, **calcium**, random blood sugar, thyroid stimulating hormone (TSH), routine and microscopic **urinalysis** and urine for culture and sensitivity

The medical and family history help the physician or mid-level practitioner to determine if the patient has any conditions or disorders that might contribute to or cause the hypertension. A family history of hypertension may suggest a genetic predisposition for hypertension.

The physical exam may include several blood pressure readings at different times and in different postural positions. The physician or mid-level practitioner uses a stethoscope to listen to sounds made by the heart and for abdominal bruits (blood flowing through partially obstructed arteries). The pulse, **reflexes**, and height and weight are checked and recorded. Internal organs are palpated to determine if they are enlarged.

Since hypertension may cause damage to the blood vessels in the eyes, the eyes may be examined with an ophthalmoscope to detect thickening, narrowing, or hemorrhages in the blood vessels.

A chest x ray can detect an enlarged heart, other vascular abnormalities, or pulmonary (lung) disease.

An electrocardiogram (ECG) measures the electrical activity of the heart. It can detect if the heart muscle is enlarged and if there is damage to the heart muscle from blocked arteries.

Urine and blood tests may be performed to determine whether the hypertension has already caused kidney damage and to detect the presence of disorders that might cause secondary hypertension.

Treatment

There is no cure for primary hypertension, but blood pressure can almost always be lowered with appropriate treatment. The goal of treatment is to lower blood pressure to levels that will prevent heart disease and other complications of hypertension. In secondary hypertension, the underlying disease responsible for the hypertension is treated along with the hypertension itself. Successful treatment of the underlying disorder may entirely eliminate the secondary hypertension.

Treatment to lower blood pressure usually includes changes in diet, regular **exercise**, and antihypertensive medications. Patients with mild or moderate hypertension who do not have damage to the heart or kidneys may initially be treated with lifestyle changes.

Lifestyle changes that may reduce blood pressure by about 5–10 mm Hg include:

- Reducing salt intake.
- Reducing fat intake.
- Losing weight.
- Getting regular exercise.
- Quitting smoking.
- Reducing alcohol consumption.
- Managing stress.

Patients whose blood pressure remains higher than 139/89 will most likely be advised to take antihypertensive medication. Numerous drugs have been developed to treat hypertension. The choice of medication will depend on the stage of hypertension, side effects, other medical conditions the patient may have, and other medicines the patient is taking.

Patients with mild or moderate hypertension are initially treated with monotherapy, a single antihypertensive medicine. If treatment with a single medicine fails to lower blood pressure sufficiently, a different medicine may be tried or another medicine may be added to the first. Patients with more severe hypertension may initially be given a combination of drugs to control hypertension. Combining antihypertensive medicines with different mechanisms of action often controls blood pressure

with smaller doses of each drug than would be needed for monotherapy. It is not uncommon to treat a patient with hypertension with three or more different anti-hypertensive drugs.

Antihypertensive medicines include several classes of drugs:

- diuretics
- beta-adrenergic blockers
- calcium channel blockers
- angiotensin converting enzyme inhibitors (ACE inhibitors)
- angiotensin receptor antagonists
- alpha-adrenergic blockers
- alpha-beta adrenergic blockers
- vasodilators
- selective alpha-adrenergic antagonists
- centrally acting adrenergic agonists

Diuretics, such as hydrochlorothiazide, help the kidneys eliminate excess salt and water, thereby reducing intravascular volume. This results in dilatation of arteries and lower blood pressure.

Beta-adrenergic blockers, such as metoprolol or atenolol, lower blood pressure by blocking the effects of adrenaline thereby slowing the heart rate and reducing the force of the heart's contraction. They are used with caution in patients with heart failure, **asthma**, diabetes, or peripheral arterial disease.

Calcium channel blockers, such as diltiazem, nifedipine, or verapamil, block the entry of calcium into muscle cells in artery walls. Muscle cells need calcium to contract, so reducing their calcium keeps them more relaxed and the arteries dilated. This action lowers blood pressure.

ACE inhibitors, such as lisinopril or captopril, block the effects of angiotensin converting enzyme, thus reducing the production of aldosterone. They are also used for treating congestive heart failure or diabetic nephropathy. ACE inhibitors may be used together with diuretics.

Angiotensin receptor antagonists, such as losartan or candesartan, block angiotensin II receptors in many tissues, allowing blood vessels to dilate and the kidneys to eliminate excess sodium and water.

Alpha-adrenergic blockers, such as phentolamine, act on the nervous system to dilate arteries and reduce the force of the heart's contractions.

Alpha-beta adrenergic blockers, such as labetalol, combine the actions of alpha and beta blockers.

Vasodilators, such as hydralazine, act directly on arteries to relax their walls so blood can move more easily through them. They lower blood pressure rapidly and are injected in hypertensive emergencies when patients have dangerously high blood pressure.

Selective alpha-adrenergic antagonists, such as prazosin or terazosin, act on the nervous system to relax arteries and reduce the force of the heart's contractions. They usually are prescribed together with a diuretic. Selective alpha-adrenergic antagonists may cause slowed mental function and lethargy.

Centrally acting adrenergic agonists, such as clonidine or methyldopa, also act on the nervous system to relax arteries and slow the heart rate. They are usually used with other antihypertensive medicines.

Health care team roles

The diagnosis of hypertension may be made by a primary care physician, mid-level practitioner, or nurse. Often, hypertension is identified during a routine medical visit or during screening at events such as health fairs. Laboratory technologists perform needed blood work and urinalysis; radiologic technologists conduct any ordered x rays, ECG, or imaging studies. Patients returning for follow-up blood pressure checks may be seen by nurses and may receive **nutrition** education from dietitians.

Patient education

Nurses, health educators, dietitians, physicians, mid-level practitioners, and other health professionals are involved in educating the community-at-large about the risks associated with untreated hypertension. Screening programs to detect hypertension also aim to identify individuals with hypertension and encourage them to seek treatment.

Since the condition is asymptomatic, many patients mistakenly believe that they can safely stop treating their hypertension. Health professionals should not only emphasize the importance of adherence, but also should educate patients about the long-term health risks and consequences of untreated hypertension.

Prognosis

There is no known cure for hypertension. However, it can be effectively controlled with proper treatment. Therapy with a combination of lifestyle changes and antihypertensive medicines usually can maintain blood pressure at levels that will not cause damage to the heart or other organs. The key to avoiding serious complica-

KEY TERMS

Arteries—Blood vessels that carry blood to organs and other tissues of the body.

Arteriosclerosis—Hardening and thickening of artery walls.

Cushing's syndrome—A disorder in which too much of the adrenal hormone, cortisol, is produced; it may be caused by a pituitary or adrenal gland tumor.

Diastolic blood pressure—Blood pressure when the heart is resting between beats.

Hypertension—High blood pressure.

Renal artery stenosis—Disorder in which the arteries that supply blood to the kidneys constrict.

Sphygmomanometer—An instrument used to measure blood pressure.

Systolic blood pressure—Blood pressure when the heart contracts (beats).

Vasodilator—Any drug that relaxes blood vessel walls.

Ventricle—One of the two lower chambers of the heart.

tions of hypertension is to detect and treat it before damage occurs. Because antihypertensive medicines control blood pressure, but do not cure it, patients must continue taking the medications to maintain reduced blood pressure levels and avoid complications.

Prevention

Prevention of hypertension centers on avoiding or eliminating known risk factors. Even persons at risk because of age, race, or gender or those who have an inherited risk can lower their chance of developing hypertension.

The risk of developing hypertension can be reduced by making the same changes recommended for treating hypertension:

- Reducing salt intake.
- Reducing fat intake.
- Losing weight.
- Getting regular exercise.
- Quitting smoking.
- Reducing alcohol consumption.

- Managing stress.

Resources

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ORGANIZATIONS

American Heart Association. 7272 Greenview Avenue, Dallas, TX 75231-4596. (800) AHS-USA1. <<http://www.amhrt.org/>>.

National Heart, Lung, and Blood Institute. Information Center. PO Box 30105, Bethesda, MD 20824-0105. (301) 251-1222.

Texas Heart Institute. Heart Information Service, PO Box 20345, Houston, TX 77225-0345. (800) 292-2221.

Barbara Wexler

Hypertensive retinopathy see **Retinopathies**

Hyperthermia/hypothermia unit management

Definition

Hyperthermia/hypothermia unit management is the use of special electronically regulated blankets or pads to adjust body temperature until it returns to normal levels.

Purpose

The human body operates at temperatures within a fairly narrow range. A body temperature of 98.6°F (Fahrenheit), or 37°C (Celsius), is considered to be normal for human beings. In reality, normal body temperature varies not only in different individuals, but also in the same person, depending upon activities engaged in or the time of day. **Exercise**, eating, and ovulation in women can raise body temperature, while sleeping,

drinking fluids, and (for women) menses can lower it. Body temperature is typically at its lowest level at 3 A.M., and at its highest level at 6 P.M. However, all of these variations do not normally extend beyond a range of 97.8°F (36.5°C) and 99°F (37.2°C).

The purpose of hyperthermia and hypothermia units is to correct aberrant temperature and prevent the complications that can occur when this narrow range of human body temperature is not maintained. Sometimes, body temperature is purposefully lowered to aid in certain surgical procedures. The lower body temperature allows vital organs such as the **heart** to survive with decreased **blood** supply, thus increasing the available time a surgeon has to operate. But the usual reason hyperthermia or hypothermia equipment is used is because the body has exceeded the extremes in temperature.

Normally, a section of the **brain** known as the hypothalamus acts to regulate temperature in a manner similar to the workings of a thermostat. Body temperature is constantly monitored by the hypothalamus, and mechanisms to compensate for any abnormality are set in motion. Classic examples of such mechanisms are shivering and perspiring. The hypothalamus reacts to low body temperature by sending neurological impulses that cause shivering. Shivering in turn produces heat from within the body through muscle activity. When the body temperature rises, the hypothalamus causes fluid to be excreted via the skin as perspiration. As the perspiration evaporates, it lowers the body temperature.

Both excessively high and low temperatures can be medical emergencies capable of causing death without immediate, appropriate medical intervention. Among the causes of abnormally elevated or lowered temperature are:

- exposure to extreme heat or cold
- infections
- glandular disorders, especially those that involve the thyroid gland
- certain tumors
- abnormal reaction to anesthesia
- dehydration

Artificially raising a person's body temperature, or inducing hyperthermia, has not been used as a **cancer** treatment in recent years. Usually, hyperthermia is a pathological condition. Patients whose temperature rises above 105.8°F (41°C) are considered to be at serious risk of brain damage, and those with a temperature above 109.4°F (43° C) will usually not survive. Mental confusion and delirium seizures (especially in young children

and infants) are some of the serious problems associated with high fevers.

Hypothermia is medically defined as a drop in body temperature to below 95°F (35°C). Hypothermia can lead to irregular heartbeat and, eventually, cardiac arrest. The elderly and very young children are the most vulnerable to extreme drops in body temperature. The *Merck Manual* recommends that health care staff consider people with radically low body temperature as viable and treatable until the body has been warmed, and there are still no signs of life such as heartbeat and respirations. Length of exposure to cold and general health are standard predictors of survival, but the National Institute on Aging gives the following guidelines regarding the chances of recovery for hypothermia victims:

- If body temperature has not fallen below 90°F (32.2°C), the likelihood of complete recovery is good.
- When body temperature is between 80°F (26.6°C) and 90°F (32.2°C), the majority of hypothermia victims survive, but are likely to have lasting damage such as brain damage.
- People with temperatures below 80°F (26.6°C) are not likely to live.

Precautions

Hypothermia/hyperthermia units should never be placed in direct contact with the patient's skin due to the risk of **burns**.

Description

For centuries, wrapping feverish people in cold, wet sheets and immersing them in cool baths helped to lower body temperature. Hot water bottles and blankets were used to warm hypothermia victims. Today, hyperthermia blankets or pads are special medical devices that have a built-in temperature regulator, or thermostat, capable of raising or lowering body temperature. Such blankets or pads circulate solution through them at pre-set temperature levels calculated to raise or lower body temperature. There are various kinds, and manufacturer's instructions for each type must be read and understood. Some utilize dry cold to lower temperature, and are used for just one patient and then discarded. Others have a special adapter to change from heat to cold, and can be used again and again. A K-Pad is one brand of pad used in some health care facilities to raise the temperature in hypothermia victims. K-Pads are composed of tubular forms that are filled with water, which is then heated and monitored by an electronic thermostat to keep it at the correct temperature.

KEY TERMS

Axillae—The medical term for the areas under both shoulders commonly called the armpits.

Dehydration—A condition in which a living being's water level within its body has fallen to dangerously low levels.

Hyperthermia—The medical term for abnormally high body temperature.

Hypothalamus—A cherry-sized portion of the brain located behind the eyes that is responsible for the regulation of body temperature, the sympathetic nervous system, and coordination between the nervous and endocrine systems.

Hypothermia—A decrease in body temperature below 95°F (35°C).

Preparation

Often, the patient with a radical alteration in temperature may be unconscious. But if the person is aware, providing a good explanation of what is being done and why will be very important. Although some brands of hyperthermia/hypothermia blankets are cloth-covered, patients should still always have a bath blanket beneath and over them so that their skin does not come in direct contact with the hyperthermia/hypothermia equipment. This is particularly important when the unit is being used to warm the body, as direct contact can result in burns. K-Pads are filled two-thirds full of water, and superfluous air is removed before use.

Most hyperthermia/hypothermia units have dual temperature monitors for both the temperature of the unit and that of the patient. This temperature probe for the person often involves a rectal probe, as that is the most accurate measure of body temperature. Regardless, it is imperative that the person's temperature be monitored constantly, and if the unit does not measure body temperature, then the temperature must be taken with a regular **thermometer**. (In the case of hypothermia, a special thermometer that registers below 94°F [34.4°C] will be necessary.)

Aftercare

In the case of hyperthermia, the cooling unit is removed while the body temperature is still slightly above normal, as the body will continue to cool after the unit is removed. The temperature continues to be monitored, and cold packs to axillae (the armpits) and the

groins may also be used. Often, fever-reducing medications such as acetaminophen are given once the person is conscious, or may be administered by suppository.

The **vital signs** (temperature, pulse, respirations, and **blood pressure**) continue to be monitored for hypothermia patients. The warming unit is not usually removed until the body temperature rises to normal. Warm liquids may be given once the person is conscious.

Complications

The major complication involved in the use of hypothermia/hyperthermia units is either the occurrence of burns from units used for heating or the discomfort from more direct contact with cooling units. Both can be prevented by following procedures, including the placement of bath blankets between the patient and the unit and reading the manufacturer's instructions.

Results

Optimum results from the use of these units are a return to normal bodily temperature without the person sustaining any permanent damage.

Health care team roles

Emergency personnel such as emergency room technicians (EMTs) and physicians are often involved as both hypothermia and hyperthermia are often accidental happenings, occurring due to exposure to heat or cold sustained from immersion in water or being exposed to the elements.

Also, registered nurses (RNs) and licensed practical nurses (LPNs) are responsible for setting up hypothermia/hyperthermia units and caring for the patient undergoing temperature-altering treatment.

Resources

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Joan M. Schonbeck

Hypervitaminosis see **Vitamin toxicity**

Hypopituitarism

Definition

Hypopituitarism, also known as the underactivity of the **pituitary gland** (an endocrine gland), is loss of function in the pituitary and the failure to secrete hormones that affect many of the body's functions. The pea-sized pituitary gland is located at the base of the **brain**, and is attached (by a stalk) to the hypothalamus. Patients diagnosed with hypopituitarism may be deficient in one or several hormones or have complete pituitary failure.

Description

The pituitary gland regulates many hormones that control various functions and organs within the body. Some of these regulatory substances and target glands that can be affected by hypopituitarism are those of the reproductive system, growth hormones, as well as the thyroid and pituitary glands. Hypopituitarism can affect both males and females of any age.

In hypopituitarism, interference with the production and release of some hormones affects the function of the target gland. Commonly affected hormones may include:

Reproductive hormones (i.e., gonadotropin deficiency)

Gonadotropin deficiency involves two distinct hormones affecting the reproductive system. Luteinizing hormone (LH) stimulates the testes in men and the ovaries in women. This deficiency can affect both male and female fertility, and menstruation. Follicle-stimulating hormone (FSH) has similar effects to LH.

Thyroid-stimulating hormone

Thyroid-stimulating hormone (TSH) is involved in stimulation of the **thyroid gland**. A lack of stimulation (deficiency) in the gland leads to hypothyroidism.

Adrenocorticotropic hormone

Also known as corticotropin, adrenocorticotropic hormone (ACTH) stimulates the adrenal gland to produce a hormone similar to cortisone, called cortisol. The loss of this hormone (deficiency) can lead to serious problems.

Growth hormone

Growth hormone (GH) regulates the body's growth. Patients who lose supply of this hormone before physical

maturity will suffer impaired growth. Loss of the hormone can also affect adults.

Other hormone deficiencies

Prolactin stimulates the female breast to produce milk. A hormone produced by the posterior pituitary, called anti-diuretic hormone (ADH), controls the function of the **kidneys**.

Multiple hormone deficiencies

Deficiency of a single pituitary hormone occurs less commonly than deficiency of more than one hormone. Sometimes referred to as progressive pituitary hormone deficiency, or partial hypopituitarism, there is usually a predictable order of hormone loss. Generally, growth hormone is lost first; luteinizing hormone (LH) deficiency follows. The loss of follicle-stimulating hormone (FSH), thyroid stimulating hormone (TSH), and adrenocorticotropic hormones (ACTH) follows. The progressive loss of pituitary hormone secretion is usually a slow process that can occur over a period from months to years. Hypopituitarism, however, occasionally starts suddenly, with rapid onset of symptoms.

Panhypopituitarism

This condition represents the loss of all hormones released by the anterior pituitary gland. Panhypopituitarism is also known as complete pituitary failure.

Causes and symptoms

There are several factors that can lead to the damage of the pituitary gland and the development of hypopituitarism. Causes can be congenital (from birth) or developed at a later stage in life. Interference in the interaction between the pituitary gland and the hypothalamus or other endocrine gland—such as tumors, inflammation, **infection**, lesions, or interruption of **blood** supply—can lead to an underactive pituitary gland. Interruption of the delivery of hormones may include certain tumors and aneurysms. Damage to the gland, from severe **head injury**, radiographic therapy (i.e., for cancers such as leukemia), or surgery can also lead to hypopituitarism.

Another cause of hypopituitarism can be damage to the pituitary gland cells. Destroyed cells cannot produce the pituitary hormones that would normally be secreted by the gland. Cells may be destroyed by a number of diseases and tumors.

Symptoms of hypopituitarism vary with the affected hormones and severity of hormone deficiency. Frequently, patients can have years of nonspecific symptoms that present when major illness or increased levels

of **stress** occur. Overall symptoms may include fatigue, sensitivity to cold, weakness, decreased appetite, weight loss, and abdominal **pain**. Low **blood pressure** (hypotension), headache, and visual disturbances are other associated symptoms.

Symptoms specific to individual hormone deficiencies are as follows:

Gonadotropin deficiency

Symptoms specific to this hormone deficiency include decreased interest in sex for women and **infertility** in women and men. Women may also have premature cessation of menstruation, hot flashes, vaginal dryness, and pain during intercourse. Women who are postmenopausal will not have such obvious symptoms, and may first present with headache or loss of **vision**. Men may also suffer **sexual dysfunction** as a result of gonadotropin deficiency. In acquired gonadotropin deficiency, both men and women may notice loss of body hair.

Thyroid stimulating hormone deficiency

A deficiency of TSH may produce intolerance to cold, fatigue, weight gain, constipation, and pale, waxy and dry skin. These symptoms can indicate thyroid hormone deficiency.

Adrenocorticotropic hormone deficiency

Symptoms of ACTH deficiency include fatigue, weakness, weight loss and low blood pressure. Nausea, pale skin, and loss of pubic and armpit hair in women may also indicate deficiency of ACTH.

Growth hormone deficiency

In children, growth hormone deficiency will result in short stature and growth retardation. Symptoms such as **obesity** and skin wrinkling may or may not show in adults; normal release of growth hormone normally declines with age.

Other hormone deficiencies

Prolactin deficiency is rare and is the result of partial or generalized anterior pituitary failure. When present, the symptom is absence of milk production in women. There are no known symptoms for men. Antidiuretic hormone deficiency may produce symptoms of diabetes insipidus, such as excessive thirst and frequent urination.

Multiple hormone deficiencies

Patients with multiple hormone deficiencies will show symptoms of one or more specific hormone deficiencies or some of the generalized symptoms listed above.

Diagnosis and testing

Once the diagnosis of a single hormone deficiency is made (usually through blood tests, history taking for symptoms, and **physical examination**), it is strongly recommended that tests be conducted to rule out other hormone deficiencies. Diagnostic testing varies between men and women, because of differences in hormone levels between the sexes.

Multiple and general hypopituitarism tests

Nonspecific symptoms can indicate deficiency of one or more hormones. A thorough clinical history should be conducted through questioning by medical support staff and the physician. In general, diagnosis of hypopituitarism can be accomplished with a combination of dynamic and simple blood tests, as well as imaging exams. Most of these tests can be conducted in an outpatient laboratory or radiology facility. The **magnetic resonance imaging (MRI)** exam is the preferred imaging scan to study the suspicious region of the hypothalamus and pituitary glands, and is conducted by a radiographic technician. When MRI is not available, a carefully conducted computed tomography (CT)—also known as a computed axial tomography, or CAT scan—can be performed. Examination of the images produced by a CT can reveal a tumor or other mass that may be interfering with pituitary function. Tests for specific hormone deficiencies are as follows:

Gonadotropin deficiency

The detection of low levels of gonadotropin can be accomplished through simple blood tests that measure LH and FSH simultaneously with gonadal steroid levels. The combination of results can indicate to a physician if the cause of decreased hormone levels or function is attributable to hypopituitarism or some kind of primary gonadal failure.

Thyroid-stimulating hormone (TSH) deficiency

Laboratory tests measuring thyroid function can help the doctor to determine a diagnosis of TSH deficiency. The commonly used tests are T4 and TSH measurement, conducted simultaneously to determine the reserve, or pool, of TSH.

Adrenocorticotropic hormone deficiency

An insulin tolerance test (ITT) may be administered by laboratory technicians to determine if cortisol levels rise when hypoglycemia is induced. If they do not rise, there is insufficient reserve of cortisol, indicating an ACTH deficiency. If the ITT is not safe for a particular patient, a glucagon test offers similar results. A CRH (corticotropin-releasing hormone) test may also be given. It involves injection of CRH to measure, through regularly drawn blood samples, a resulting rise in ACTH and cortisol. Other tests that stimulate ACTH may be ordered.

Growth hormone deficiency

Growth hormone deficiency is measured through the use of insulin-like growth factor tests that measure growth factors that are dependent on growth hormones. Sleep and **exercise** studies may also be used to test for growth hormone deficiency, since these activities are known to stimulate growth hormone secretion. Several drugs can also induce secretion of growth hormone, and may be given in order to measure hormone response. The standard test for growth hormone deficiency is the insulin-induced hypoglycemia test. This test, however, does carry some risk from the induced hypoglycemia. Other tests include an arginine infusion test, clonidine test, and growth-hormone-releasing hormone test.

Other hormone deficiencies

If a test calculates normal levels of prolactin, deficiency of the hormone is eliminated as a diagnosis. A thyrotropin-releasing hormone (TRH) simulation test can determine prolactin levels. A number of tests are available to detect ADH levels.

Panhypopituitarism

The insulin-induced hypoglycemia, or ITT that is used to determine specific hormone deficiencies, is an excellent test to diagnose panhypopituitarism. This test can reveal levels of growth hormone, ACTH (cortisol) and prolactin deficiency. The presence of insufficient levels of all of these hormones is a good indicator of complete pituitary failure. Imaging studies and clinical history are also important.

Treatment

Treatment differs widely, depending on the age and sex of the patient, severity of the deficiency, the number of hormones involved, and the investigation of the underlying cause of the hypopituitarism. Immediate hormone replacement is generally administered to replace the spe-

cific deficient hormone. **Patient education** regarding the medical implications of the diagnosed hormone deficiency is encouraged to help patients manage the impact of their hormone deficiency on daily life. For instance, certain illnesses, accidents, or surgical procedures may elicit adverse complications or lesser outcomes, due to hypopituitarism. Treatment options for each of the hormone deficiencies are outlined below:

Gonadotropin deficiency

Replacement of gonadal steroids is common treatment for LH and FSH deficiency. Estrogen for women and testosterone for men will be prescribed in the lowest effective dosing regimens possible, since there can be complications to this therapy. To correct women's loss of libido, small doses of androgens may be prescribed. To restore fertility in men, regular hormone injections may be required. Male and female patients whose hypopituitarism results from hypothalamic disease may be successfully treated with a hypothalamic-releasing hormone (GnRH), which can restore gonadal function and fertility.

Thyroid stimulating hormone deficiency

In patients who have hypothyroidism, the function of the **adrenal glands** will be tested and treated with steroids before thyroid hormone replacement is administered.

Adrenocorticotropic hormone deficiency

Hydrocortisone, or cortisone, may be given to compensate for this hormone deficiency. Most patients require 20 mg or less of hydrocortisone per day.

Growth hormone deficiency

It is essential to treat children suffering from growth hormone deficiency. The effectiveness of growth hormone therapy in adults, particularly elderly adults, is not as well documented. It is thought to help restore normal muscle to fat ratios. Growth hormone is an expensive and cautiously prescribed treatment.

Treatment of multiple deficiencies and panhypopituitarism

The treatment of hypopituitarism is usually very straightforward, but must normally continue for the remainder of the patient's life. Some patients may receive treatment with GnRH, the hypothalamic hormone. In most cases, treatment will be based on the specific hormone deficiency. Patients with hypopituitarism should be regularly monitored to measure treatment effectiveness and to avoid overtreatment with hormone therapy.

KEY TERMS

Adenoma—A benign (not threatening or cancerous) tumor that originates in a gland.

Androgen—A hormone that usually stimulates the sex hormones of the male.

Congenital—Present at birth.

Endocrine—Refers to the system of internal secretion of substances into the body system from glands.

Hypothyroidism—Deficient activity of the thyroid gland and resulting loss of energy.

Radiation or surgical removal are options for treatment if the disorder is caused by a tumor or lesion. Successful removal of the mass may reverse the hypopituitarism. Even after its removal, however, hormone replacement therapy may still be necessary.

Prognosis

The prognosis for most patients with hypopituitarism is positive. As long as therapy is continued, many experience normal life spans. However, hypopituitarism is usually a permanent condition, and prognosis depends on the primary cause of the disorder. It can be potentially life threatening, particularly when acute hypopituitarism occurs as a result of a large pituitary tumor. The cause is not known. It is possible that increased morbidity and death are due to overtreatment with hormones. Recovery of pituitary function without medical intervention is preferred to lifelong hormone therapy.

Health care team roles

As with all conditions and diseases, patient education is critical and provided by medical support staff (i.e., nurses, nurse practitioners, physician assistants). Because of the delicate nature of several of the hormone deficiencies (e.g., growth and reproductive hormones), patients may experience low self-esteem and depression. Staff members who are in personal contact with patients during visits record any symptoms of stress or depression/anxiety, and should alert the physician. Patients should be advised on the benefits of mental health consultations or participation in support groups.

Coordination of care between mental health care providers, specialists and, in the instance of a surgical consult, surgical and hospital staff, may be required. This necessitates follow-up calls to the various health care

providers who may become involved in the case. In some instances, patients will need to learn how to give themselves subcutaneous hormone injections, which requires teaching assistance from nursing staff or laboratory technicians. Alternatively, these patients may be required to make frequent office visits that require chart monitoring and assistance by office personnel. In this case, nursing and scheduling staff support is imperative to the avoidance of additional stress on the patient.

When the patient first presents with symptoms of hypopituitarism, explanation of testing can ease the frustration of finding the diagnosis. The importance of patient compliance with a hormone regimen should be emphasized. In the case of deficiencies of more than one hormone, a daily treatment timetable may be needed (e.g., what time of day to take each hormone supplement). Thorough knowledge of the regimen is required by support staff members, and monitoring the regimen is important. Family members may be recruited to assist the health care team in making sure that compliance is optimal. Detailed chart management, thorough history taking at each subsequent visit, and the recording of notes on the smallest changes in a patient's symptoms are vital to a positive outcome.

Prevention

There is no known means of prevention of hypopituitarism apart from the prevention of damage/injury to the pituitary/hypothalamic areas of the head.

Resources

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<<http://www.medhelp.org/geneticalliance/>>.

Human Growth Foundation. 7777 Leesburg Pike, Suite 202-South, Falls Church, VA 22043. 1-800-451-6434.

<<http://www.genetic.org>>.

OTHER

Health Answers. <<http://www.healthanswers.com>>.

Michele R. Webb

Hypothermia blanket see **Hyperthermia/Hypothermia unit management**

Hypovolemic shock see **Shock**

Hysterosalpingography

Definition

Hysterosalpingography is a procedure where x rays are taken of a woman's reproductive anatomy after a contrast dye is injected into the cervix. *Hystero* means uterus and *salpingo* means tubes, so hysterosalpingography literally means to take pictures of the uterus and fallopian tubes. This procedure may also be called HSG or hystero-graphy.

Purpose

Hysterosalpingography is used to determine if the fallopian tubes are open, or if there are any apparent abnormalities or defects in the uterus. It can be used to detect tumors, scar tissue, or tears in the lining of the uterus. This procedure is often used to help in diagnosing any physical abnormalities causing **infertility** in women. The fallopian tubes are the location where an egg from the ovary joins with sperm to produce a fertilized ovum. If the fallopian tubes are blocked or deformed, the egg may not be able to descend or the sperm may be blocked from moving up to meet the egg. Up to 30% of all cases of infertility are due to damaged or blocked fallopian tubes.

Precautions

This procedure should not be done on women who suspect they might be pregnant or who may have a pelvic **infection**. The exam is usually timed within a few days after a period to minimize the chance of performing the procedure while the patient is pregnant. If a woman has a history of **heart** abnormalities, she should consult with her doctor prior to the exam. Women who have had an allergic reaction to the contrast dye used in previous x-ray procedures should inform their doctor.

Description

As with other types of pelvic examinations, the woman will lie on her back on an examination table with her legs sometimes raised in stirrups. The x-ray equipment is placed above the abdomen.

A speculum is inserted into the vagina by the radiologist. The cervix is numbed with a local anesthetic such as Xylocaine 1%, and sometimes an instrument called a tenaculum, is gently clamped onto the cervix to hold it steady. This is mostly painless, although the patient will feel some pressure from the clamp. A catheter (a thin tube) is inserted into the uterus through the cervix (the opening to the uterus). A tiny balloon in the catheter is



A hysterosalpingogram of the abdomen of a woman whose fallopian tubes are blocked. The right fallopian tube (left on image) is blocked near the uterus, the triangular shape at center. The left fallopian tube is obstructed at a point further from the uterus where dilatation has occurred.
(Photo Researchers, Inc. Reproduced by permission.)

inflated to hold it in place. A liquid water-based or oil-based dye is then injected through the catheter into the uterus. As the contrast spills into and out of the fallopian tubes, some cramping, **pain**, and spasms usually occur. The patient might also feel a burning sensation in her pelvic cavity.

As the contrast spreads through the reproductive tract, the doctor will watch for blockages or abnormalities on an x-ray monitor. Several x rays will also be taken. The procedure takes approximately 15–30 minutes. The x rays will be developed while the patient waits, but the final reading and interpretation of the x rays by a radiologist (a doctor who specializes in x rays) may not be available for a few days. Typically, the radiologist can give the patient their impression, as they watch the progress of the contrast.

Interestingly, sometimes the hysterosalpingography procedure itself can be considered a treatment. The contrast used can sometimes open up small blockages in the fallopian tubes. This happens due to the pressure created in the injection of the contrast, and it is not uncommon for the patient to become pregnant in the month or two after the exam. The need for additional test procedures or surgical treatments to deal with infertility should be discussed with the doctor.

KEY TERMS

Catheter—A thin tube, usually made of plastic, that is inserted into the body to allow the passage of fluid into or out of a site.

Fallopian tubes—The narrow ducts leading from a woman's ovaries to the uterus. After an egg is released from the ovary during ovulation, fertilization (the union of sperm and egg) normally occurs in the fallopian tubes.

Hystero-graphy—Another term for the x-ray procedure of the uterus and fallopian tubes.

Hysterosalpingogram—The term for the x ray taken during a hysterosalpingography procedure.

Speculum—A plastic or stainless steel instrument that is inserted into the opening of the vagina so the cervix (the opening of the uterus) and interior of the vagina can be examined.

Tenaculum—An instrument used to hold onto the cervix to render it immobile.

Preparation

This procedure is generally done in the x-ray department of a hospital or large clinic. **General anesthesia** is not needed. A non-aspirin based pain reliever may be taken prior to the procedure to lessen the severity of cramping.

Aftercare

No special aftercare is required after a hysterosalpingography. There may be a small amount of spotty bleeding for a few hours after the procedure, as well as some contrast that may flow out of the vaginal opening therefore a sanitary napkin may be worn after the procedure. If a blockage is seen in a tube, the patient may be given an antibiotic. A woman should notify her doctor if she experiences excessive bleeding, extensive pelvic pain, **fever**, or an unpleasant vaginal odor after the procedure. These symptoms may indicate a pelvic infection. Counseling may be necessary to interpret the results of the x rays, and to discuss any additional procedures to treat tubal blockages or uterine abnormalities found.

Complications

Cramps during the procedure are common. It is important that the radiologist inject the contrast very slowly as a blockage might cause extensive pain if the

blockage doesn't resolve from the force of the injection. The radiologist can observe this on the x-ray monitor, and adjust their technique accordingly. Rare complications associated with hysterosalpingography include pelvic infection and allergic reactions. If a patient notices a vaginal odor or unusual discharge, she should contact her own physician for treatment immediately. Although this test is relatively accurate, in some circumstances, abnormalities will not be seen on the films.

Results

A normal hysterosalpingography will show a normally shaped uterus and unblocked fallopian tubes.

Blockage of one or both of the fallopian tubes or abnormalities of the uterus may be detected. In addition, any pelvic scarring might also be observed.

Health care team roles

The technologist plays a large role in the comfort and cooperation of the patient in this exam. Being prepared with all equipment and supplies is very critical as well. It is important that the technologist be informative, gentle, and calm, as most women having this exam are stressed as a result of their infertility. The technologist can share any unusual concerns regarding the patient, with the radiologist prior to the beginning of the exam.

Training

The technologist doing the HSG is highly trained in this procedure, and must be organized and confident in his or her abilities. The technologist has often observed and assisted in numerous HSG exams, both as a student radiographer and a technologist, prior to performing them with only the physician present.

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Hysteroscopy

Definition

Hysteroscopy enables a physician to look through the vagina and neck of the uterus (cervix) to inspect the cavity of the uterus with an instrument called a hysteroscope. Hysteroscopy is used as both a diagnostic and a treatment tool.

Purpose

Diagnostic hysteroscopy can be used to help determine the cause of **infertility**, dysfunctional uterine bleeding, and repeated miscarriages. It can also help locate polyps and fibroids, as well as intrauterine devices (IUDs).

The procedure is also used to investigate and treat gynecological conditions, often instead of or in addition to dilation and curettage (D&C). A D&C is a surgical procedure that expands the cervical canal (dilation) so that the lining of the uterus can be scraped (curettage). A D&C can be used to take a sample of the lining of the uterus for analysis. Hysteroscopy has advantages over a D&C because the doctor can take tissue samples of specific areas and view any fibroids, polyps, or structural abnormalities. In addition, small fibroids and polyps may be removed via the hysteroscope (in combination with other extremely small instruments that are inserted through canals in the hysteroscope), thus avoiding more invasive and complicated open surgery. This approach is also used to remove IUDs that have become embedded in the wall of the uterus.

Precautions

The procedure is not performed on women with acute pelvic inflammatory disease (PID) due to the potential for exacerbation. A hysteroscopy should be scheduled after menstrual bleeding has ended and before

ovulation to avoid a potential interruption of a new **pregnancy**.

Description

Diagnostic hysteroscopy is performed in either a doctor's office or hospital. Uterine size and potential diagnosis and complexity of treatment determine the setting. The hysteroscope itself is an extremely thin telescope-like instrument that looks like a lighted tube. The modern hysteroscope is so thin that it can fit through the cervix with only minimal or no dilation.

Before inserting the hysteroscope, the doctor administers an anesthetic. Once it has taken effect, the doctor dilates the cervix slightly, then inserts the hysteroscope through the cervix to reveal the inside of the uterus. Ordinarily, the walls of the uterus are touching each other. In order to get a better view, the uterus may be inflated with carbon dioxide gas or fluid. Hysteroscopy takes approximately 30 minutes.

Treatment involving the use of hysteroscopy is usually performed as a short-stay hospital procedure with regional or **general anesthesia**. Tiny **surgical instruments** may be inserted through the hysteroscope to remove polyps or fibroids. A small sample of tissue lining the uterus is often removed for examination, especially if the patient has any abnormal bleeding.

Preparation

If the procedure is performed under general anesthesia, the patient should have nothing to eat or drink after midnight the night before the procedure. Routine lab tests may be ordered if the procedure is performed in a hospital. Occasionally, a mild sedative is administered to help the patient relax. The patient is asked to empty her bladder. She is then placed in position (usually in a special chair that tilts back), and the vagina is cleansed. Usually a local anesthetic, like a dentist may use, is administered around the cervix. However, a regional anesthetic that blocks nerves connected to the pelvic region or a general anesthetic may be required for some patients.

Aftercare

It is normal to experience light bleeding for one to two days after surgical hysteroscopy. Mild cramping or **pain** is common after operative hysteroscopy but usually diminishes within eight hours. If carbon dioxide gas was used, the resulting discomfort usually subsides within 24 hours.

KEY TERMS

Dilation and curettage (D&C)—A surgical procedure that expands the cervical canal (dilation) so that the lining of the uterus can be scraped (curettage).

Fibroid—A benign tumor of the uterus.

Polyp—A growth that projects from the lining of the cervix or any other mucus membrane.

Septum—An extra fold of tissue down the center of the uterus. This tissue can be removed with a wire electrode and a hysteroscope.

Complications

Diagnostic hysteroscopy rarely causes complications. The primary risk is for **infection**. Prolonged bleeding may follow a surgical hysteroscopy to remove a growth.

Other complications include perforation of the uterus, bowel, or bladder caused by too forceful advancement of the hysteroscope. An infrequent but dangerous complication is increased fluid absorption from the uterus into the **blood** stream. Keeping track of the amount of fluid used during the procedure can minimize this complication. Surgery under general anesthesia poses the additional risks typically associated with this type of anesthesia.

Patients should notify their health care provider if, after the hysteroscopy, they develop any of these symptoms:

- abnormal discharge
- heavy bleeding
- fever over 101°F (38.3°C)

- severe lower abdominal pain

Results

A normal hysteroscopy reveals a healthy uterus with no fibroids or other growths. Abnormal results include uterine fibroids, polyps, or a septum (an extra fold of tissue down the center of the uterus). Sometimes, precancerous or malignant growths are discovered.

Health care team roles

The test is usually performed by a gynecologist. Nursing staff assist with providing education, positioning the patient, and specimen collection.

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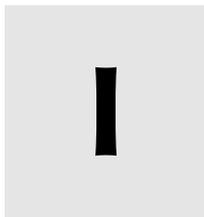
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Ibuprofen see **Nonsteroidal anti-inflammatory drugs**

Ice packs see **Cooling treatments**

Icterus see **Jaundice**

Ileostomy see **Enterostomy**

IM injection see **Intramuscular injection**

I Immovable joint

Definition

An immovable joint is an articulation between bones in which no movement occurs. It is also referred to as synarthrotic (meaning immovable).

Description

An immovable joint can be either one of two types of joints, fibrous or cartilaginous. In a fibrous joint, there are two types of articulations that are considered immovable, suture and gomphosis.

A suture is a type of articulation in which the bones that make up the joint are close together. An analogy to this is the interlocking fashion exhibited by placing puzzle pieces together. In a suture, the union of bones is bound by connective tissue.

A gomphosis is a type of joint in which one bone fits into another bone. The articulating edges are bound together by connective tissue. Similar to the suture, the bony surfaces in the articulation are close together. An analogy to this is a wooden dowel fitting into a hole and held together by glue, with the dowel and hole representing the bony structures and the glue representing the connective tissue.

In a cartilaginous type of joint, there is one type of articulation that is considered immovable, the synchondrosis.



The immovable joints of the skull are joined by sutures. The coronal suture is along the top of the skull, and the lambdoidal suture is seen toward the back of the skull.
(Photograph by Simon Brown. Science Source/Photo Researchers. Reproduced by permission.)

A synchondrosis is a joint in which the articulating surfaces are close together but are bound by hyaline cartilage. In a synchondrosis, the hyaline cartilage eventually converts to either bone or fibrocartilage.

Function

The function of the immovable or synarthrotic joint is to provide a stable union between bony surfaces. The suture and synchondrosis actually become more stable when ossification of the joint takes place.

KEY TERMS

Cartilaginous joint—A joint that represents the connection of two bones bound by either hyaline fibro or elastic cartilage.

Connective tissue—Tissue that has pliable fibers, which provide strength to the tissue.

Diaphysis—The center or shaft of a bone that is ossified.

Epiphysis—Considered a secondary center of ossification. This secondary center of ossification appears at the ends of long bone.

Fibrocartilage—Connective tissue made up of collagen fibers with less ground substance compared to hyaline cartilage.

Fibrous joint—Surfaces of two bones that are connected by fibrous tissue, which consists mainly of collagen fibers.

Hyaline cartilage—A mesh of collagen fibers and ground substance.

Proximal—The closest portion of a bone, structure, or other element that is close to the head of the body.

Synarthrosis—An immovable joint.

Role in human health

An example of a suture in the human body is the fibrous joints between the bones of the **skull**. Before birth the suture is fibrous tissue that forms soft spots on the skull. The common medical term is fontanelle. The fibrous joint between the bones of the skull allows the skull to be more pliable during birth as the head passes through the vagina. During infancy the pliable nature of the skull, secondary to fibrous sutures, allows for growth of the **brain**. As growth and development occurs the sutures become ossified.

An example of a gomphosis in the human body is the joining of the root of a tooth with the mandible or jaw bone. The fibrous union between the tooth and the bone secures the tooth in its position. This allows the teeth to function as grinders during chewing.

An example of synchondrosis in the human body is two distinct portions of long bone that are separated by a hyaline cartilaginous plate. This typically occurs at the ends of long bones where a cartilaginous plate separates the diaphysis from the epiphysis. This plate allows the

end of bones to grow throughout early human development. As growth and development continue, the hyaline cartilage ossifies. By adulthood the joint is gone. Another example of a synchondrosis in the human body is the articulation between the first rib and the manubrium or the upper portion of the sternum. Initially, the connection between the manubrium and first rib is hyaline cartilage. Through adulthood the hyaline cartilage is replaced by fibrocartilage. This process allows the superior portion of the thorax to be more secure and stable.

Common diseases and disorders

The most common disorder of sutures or fontanelles of the skull is the disruption of the bony components, thus compromising the integrity of the fibrous attachment. This could occur as a result of **head injury** from a blow to the head or a fall. Common disorders of the teeth that compromise the integrity of the fibrous attachment of tooth to bone are: fracture of the jaw bone, fracture of the tooth, avulsion of the tooth, loosening of the tooth secondary to decay, or a blow to the head or jaw. The most common disorder associated with a synchondrosis is a disruption of the epiphyseal hyaline cartilage plate. This is particularly evident in the proximal femur, specifically related to the hip. This disorder occurs mainly in young children as a result of a fall or other trauma. This disruption to the plate can lead to fracture, disruption of **blood** supply, and, if not treated appropriately, deformity of the hip. The medical term for this disorder is slipped capital femoral epiphysis.

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Immune response

Definition

The action taken by the body to defend itself from pathogens or abnormalities is called the immune response. With the aid of the **immune system**, the body monitors constant exposure to harmful elements in the external and internal environment and provides a means of defense. Pathogens that are able to cause immune responses included **bacteria**, **viruses**, and parasites. The immune system must be able to determine what is a normal part of the body or “self,” as opposed to that which is foreign or “non-self.” The development of cancers, for example, represents a part of “self” that has been abnormally changed such that it is recognized as foreign to the immune system.

Description

The immune response can be roughly divided into two broad categories, innate (natural) immunity and adaptive (acquired) immunity. Innate immunity is the first line of defense against invasion by pathogens. This response is not directed against any one particular pathogen but is capable of destroying many different invaders. If the pathogen is able to conquer this initial protection, an adaptive immune response will follow. In this response, lymphocytes arise that can specifically kill the invader and prevent re-infection. These lymphocytes recognize specific antigens on pathogens (substances that are foreign to the host cell and cause the production of antibodies to fight the disease).

Innate (natural) immunity

Innate immunity refers to those parts of the immune system that are normally present and do not given an elevated response upon a second exposure to a pathogen (without immunological **memory**). This immunity is non-specific and is not directed against one type of pathogen. It is more generalized to allow the recognition of common elements that may be shared among pathogenic microorganisms.

Anatomical or physical barriers provide innate protection. The skin provides a protective barrier and contains substances that are antimicrobial (against bacterial growth) such as lactic acid, ammonia, and uric acid. The bacteria (microflora) that normally inhabit the skin do not cause disease under normal conditions. These organisms also contribute to innate immunity. The competition of the microflora with pathogens for resources and nutrients limits the growth of pathogens. If the skin is broken due to **wounds** or **burns**, pathogenic bacteria may enter

to cause disease. In the urinary and biliary tracts, the increased flow of secretions provides protection against the establishment of harmful organisms.

Physiologic barriers are also a part of the innate immune system. **Stomach** acid can kill and inhibit the growth of many microorganisms and degrade potentially harmful **proteins**. A rise in body temperature can create an environment that is no longer suitable for the growth of some bacteria. Saliva, nasal secretions, tears, and mucus also contain substances that block viruses and help in the destruction of harmful bacteria.

Some cells of the immune system are able to attack and engulf pathogens, molecules, or particles by a process known as phagocytosis. The Russian immunologist Eli Metchnikoff observed that some pathogenic microorganisms were destroyed by phagocytic cells he called macrophages. These phagocytic cells originate in the bone marrow, are called monocytes in the bloodstream, and become macrophages in the tissue. These phagocytic macrophages in the tissue are able to ingest and destroy some pathogens even though they have not previously encountered them. These cells are capable of migration and are found in many sites throughout the body, including the lymph nodes, spleen, **liver**, **lungs**, as well as the peritoneal lining that surrounds the organs and the lungs. Macrophages in the bone are called osteoclasts, in the **central nervous system** they are called microglia, and in the connective tissue they are known as histiocytes. The neutrophils (polymorphonuclear leukocytes or PMNs) are another type of phagocytic cell that is critically important for innate immunity. These cells are found in great numbers and are one of the most important types of white **blood** cells found in the bloodstream. They are quickly recruited to the site of **infection** to engulf pathogens. Both neutrophils and macrophages contain enzymes that break down the engulfed material.

Natural killer (NK) cells are a type of lymphocyte in the blood that can detect and destroy cells infected by certain viruses. Viruses attack host cells and use them to facilitate viral replication and production of more viruses. Infected host cells must be rapidly destroyed to prevent this replication and spread of disease. It has been observed that natural killer cells play an especially important role in the early defense against herpes viruses. They also are involved in the killing of some tumors. Natural killer cells may kill by activating a process called apoptosis, the programmed cell death that is present in all cells and is responsible for their self-destruction.

The plasma contains a group of proteins called complements that act in a coordinated manner to attack pathogens. When some pathogens bind with a complement protein called C3b, a series of reactions in the alter-

native complement pathway occur. The surface of the pathogen is changed so that phagocytic cells can ingest them, a process called opsinization.

If the pathogen is able to effectively cross the barriers of innate immunity, an early induced, non-adaptive response will occur. This response serves to stop pathogens or slow them down until the body can initiate an adaptive immune response. Additional phagocytic cells and molecules are summoned to the site of infection by cytokines, a group of proteins that affect the actions of other cells. Some cytokines can cause an increase in the number of neutrophils in the circulation and **fever**, an elevation in body temperature. As most pathogenic bacteria have optimal growth at lower temperatures, this temperature rise helps to inhibit their growth. The fever also enhances the adaptive immune responses that follow. Local effects from injury or infection give rise to inflammation as white blood cells, fluid, and plasma proteins gather at the site. This is evident clinically at the site by redness, **pain**, heat, and swelling. The **blood vessels** in the site of injury or infection increase in diameter and allow more blood to flow into the area at a slower rate. Immune cells arrive quickly to the site and move into the tissue from the bloodstream. Small proteins called chemokines assist in this process and enhance the migration and activation of cells. Other special proteins called interferons are produced by virally infected cells and may stop the virus from multiplying within other cells, preventing the spread of infection.

Adaptive (acquired) immunity

In adaptive immunity, the immune response is specific for a particular antigen, causes lymphocytes that recognize the antigen to multiply (clonal expansion), and imparts the quality of immunological memory of prior encounters with the antigen. Specificity is an essential component of adaptive immunity as many organisms have evolved to evade the innate immune system. A system of defense is needed to specifically eliminate these elusive invaders, of which there are countless numbers. Two parts of adaptive immunity meet this challenge: cellular-mediated immunity and humoral (antibody-mediated immunity).

CELL-MEDIATED IMMUNITY. Once a pathogen has evaded the innate immune system, the cellular immune response mechanisms are initiated. In the lymphoid tissues, naive lymphocytes that have not been exposed to the pathogen encounter pathogen antigens for the first time. Dendritic cells, macrophages, and B cells take up the antigens that have been trapped in the lymphoid tissue and present them to naive T cells. These T cells become activated, recognizing specific antigens from the

pathogen and become effector cells; helper T cells (TH1 or TH2) and cytotoxic T cells. The TH1 cells produce interferons and cytokines that assist in the activation of macrophages that have ingested pathogens. They also help B cells make antibodies that are used to opsinize pathogens and secrete cytokines that draw phagocytic cells to the site of infection. The TH2 cells produce B cell growth factors that activate the B cells, causing them to multiply and produce antibodies that give rise to a humoral (antibody) response. A delicate balance exists between the TH1 and TH2 cells and is directed by cytokines. Cytotoxic T cells are involved in the killing of pathogens that live inside host cells (cytosolic pathogens) such as viruses and some bacteria. These pathogens hide within cells, and cannot be reached with antibodies. Cytotoxic T cells cause infected cells to undergo programmed cell death or apoptosis and also secrete cytokines that assist in the immune response.

HUMORAL (ANTIBODY-MEDIATED) IMMUNITY. The humoral immune response uses antibodies produced by B cells to destroy pathogens. Pathogens travel in the extracellular fluid (outside of the cell) during the spread of infection. Antibodies specific for foreign pathogen antigens combine with them and neutralize the pathogen, preventing the spread of infection. Toxins secreted by bacteria, such as those from diphtheria and tetanus, are harmful to the body may also be neutralized by antibodies. Bacterial surfaces may be coated with antibody such that phagocytic cells can recognize them and ingest them (opsinization). When antibodies bind with pathogen antigens, the complement system of plasma proteins is activated. This results in opsinization and draws phagocytes to the site of infection.

The B cells are activated upon exposure to antigen, such as that which occurs in the lymphoid tissue. B cell surfaces contain immunoglobulin proteins (antibody) that bind with antigens from pathogens. With the aid of antigen-specific helper T cells, the B cells begin to multiply and produce cells that make antibody (plasma cells). This antibody is directed against the same specific antigen that was recognized by the helper T cell. Memory B cells are also produced and are involved in the protection of the body upon a second exposure to the pathogen at another time. Some pathogens can also cause the B cells to become activated without the help of T cells.

Role in human health

Pathogens have evolved over time such that they can avoid detection by the immune system. Bacteria may change their antigens to escape recognition by immune cells. Such mechanisms occur in the case of bacteria that cause **pneumonia**, **food poisoning**, and gonorrhea. The

influenza virus may undergo a similar process, hence the reason that new flu vaccines are continually under development. The protozoans that cause **malaria** and sleeping sickness also use such methods to escape detection. Epstein-Barr and herpes simplex viruses enter a period of latency within the cells in which the virus does not multiply. The disease is “hidden” from immune surveillance, yet persists in the system to become active at a later time.

In opportunistic infections, a microorganism that is normally present as part of the microflora is no longer controlled by the host and seizes an opportunity to establish infection. This occurs in HIV infection due to suppressed immunity in the body. Opportunistic infections may arise following medical or surgical treatments. Such is the case with urinary tract infections when *Esherichia coli* that are normally found on the gut enter the urinary tract during catheterization or yeast infections following the administration of **antibiotics**.

Immune responses are particularly important during the process of organ transplantation where the recipient may perceive donor antigens as “non-self.” Careful matching of donor and recipient tissues and the use of immunosuppressive agents that diminish the immune response minimize rejection. Graft-vs-host disease occurs during bone marrow transplants when the T cells of the donor recognize antigens in the recipient as “foreign.”

Directions in immunotherapy

Humans have tried to understand the immune response and prevent the spread of disease throughout history. In ancient China and Asia Minor, attempts were made to inoculate against the smallpox virus by a process called variolization. In 1774 a farmer, Benjamin Jesty, used the cowpox virus to protect his children from smallpox. Edward Jenner began studies using cowpox virus in 1796 and demonstrated that immunization with cowpox protected a child from developing a smallpox infection. He published his results, calling this process **vaccination**. Efforts to refine this process ultimately lead to the declaration by the World Health Organization 1979 that the disease had been eradicated. Research directions for 2000 and beyond include vaccine development for HIV, tumors, schistosomiasis (a parasitic disease), and malaria.

Advances in cytokine therapy are another promising area of research and development. This approach involves boosting the body’s own immune modulators to initiate an increased response. The use of cytokines has been explored in bone marrow transplantation, sepsis trials, and treatment of leprosy.

KEY TERMS

Adaptive immunity—The immune response is specific for a particular antigen, causes lymphocytes that recognize the antigen to multiply (clonal expansion), and imparts the quality of immunological memory of prior encounters with the antigen.

Apoptosis—The programmed cell death that is present in all cells and is responsible for their self-destruction.

Innate immunity—Parts of the immune system that are normally present, non-specific, and do not given an elevated response upon a second exposure.

Phagocytosis—The process whereby a cell engulfs particles or materials.

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Immune system

Definition

The immune system is composed of cells, organs, tissues, and molecules that protect the body from disease. The term “immunity” comes from the Latin word *immunitas*.

Description

Physical barriers

Anatomic barriers provide protection against invading bacterial and viral pathogens. The skin is composed primarily of keratin, which cannot be digested by most microorganisms. The skin is usually dry with a high salt concentration due to sweat. These conditions are not favorable for bacterial growth. Sweat and sebaceous skin secretions also contain substances that kill **bacteria**. Some types of bacteria inhabit the skin surface and do not cause disease under normal conditions (microflora). These bacteria may produce substances that kill other more pathogenic bacteria. The microflora may also consume nutrients required by pathogens. This gives rise to a competitive relationship that limits the growth of the pathogens. If the skin is broken, due to injuries or **burns**, harmful bacteria may enter and give rise to **infection**. The cilia of the **lungs** protect this organ from inhaled pathogens, transporting secretions to the throat so that they can be swallowed and destroyed by **stomach** acid. Secretions in the nose, saliva, and components of tears also contain substances that protect against bacteria and **viruses**.

Cells of the immune system

Lymphocytes. There are two major types of lymphocytes, the T-cells and B-cells, which comprise 20–50% of the white **blood** cells in normal adult human circulation. T-cells mature and differentiate in the thymus gland and assist in cellular immune responses. These cells are responsible for the recognition of antigens (materials that give rise to an **immune response**, such as components of pathogenic bacteria). There are three major types of T-cells that are classified according to their function: cytotoxic T cells (T_c) that kill abnormal cells, helper T cells (T_h) that enhance an immune response, and suppressor T-cells (T_s) that diminish the immune response. The B-cells mature in the bone marrow and recognize antigens with the help of T-cells. Upon activation, these cells give rise to plasma cells, which produce antibodies (immunoglobulins). Antibodies bind with toxic pathogen **proteins** or antigens and interact with other cells to remove the invader

from the system. Plasma cells are found in the lymph nodes, spleen and bone marrow. B-cells also give rise to **memory** cells that remain alive for long periods of time and assist in a more effective immune response upon the next exposure to the same antigen.

The natural killer cells (NK) are a third type of lymphocyte and comprise approximately 3% of normal blood circulation. These large cells are responsible for the killing of some tumors and virus-infected cells. Additionally, some cells can be induced to kill their targets in a non-specific manner under the appropriate conditions. These cells are called lymphokine activated killer (LAK) cells.

Granulocytes. The granulocytes or polymorphonuclear leukocytes (PMNs) are a group of cells that display a characteristic staining of granules in blood smears, hence their name. These cells have a short life span in the blood (about two or three days), and make up the majority of the white blood cells under normal conditions. They are usually found in greater numbers during an immune response to injury or infection. The neutrophils are a very important type of granulocyte and demonstrate phagocytosis (ingestion of particles by cells, such as particles of bacteria, with ultimate destruction by lysosomal enzymes). These cells are critical in the development of the immune response to pathogens and can migrate from the blood to the tissues during infection by a process known as chemotaxis (the movement of cells in response to and external chemical stimulation). They comprise approximately 40–75% of the blood. The eosinophils are mainly involved in an immune response to parasitic infection and also play a role in the allergic response, and comprise only 1–6% of the blood. The basophils, normally present in low numbers in the circulation (less than 1% of the blood), are thought to play a role in the inflammation and damage to tissue associated with allergic reactions.

Monocytes, Macrophages, and Mast Cells. Monocytes are a type of cell that circulates in the bloodstream, comprising 2–10% of the blood. Upon migration into the tissues, these cells differentiate into macrophages that are capable of ingesting microorganisms by phagocytosis and have a critical role in the host defense to pathogens. They also produce substances called monokines that are a type of secreted protein (cytokine) that affects the actions of other cells.

Mast cells are distributed in the connective tissues, especially in the skin and mucosal surfaces of the respiratory, gastrointestinal, and urogenital tracts as well as the eye. These cells are also involved in the allergic response.

Platelets. Platelets are cell fragments in the blood that are involved in blood clotting and inflammation.

DENDRITIC CELLS. Dendritic cells are potent stimulators of immune responses. These cells play an important role in the increased immune response upon a second exposure to an antigen. Dendritic cells are distributed throughout the body, especially in the T-cell areas of lymphoid organs. In the lymphoid tissue, dendritic cells are involved in the stimulation of T-cell responses.

Central lymphoid tissues

The central lymphoid organs include the bone marrow and thymus. At these sites, the lymphocytes interact with other cells to enhance their development or increase their ability to assist in an immune response. They also acquire the ability to recognize specific antigens before they actually become exposed to them, and are antigen-independent. At this stage the lymphocytes are called naïve lymphocytes because they have not yet been exposed to antigens. The bone marrow is the site of hematopoiesis. Both B-lymphocytes and T-lymphocytes come from this site, but only the B cells undergo maturation in this area (hence the name *B-cell T-cell*).

Peripheral lymphoid tissues

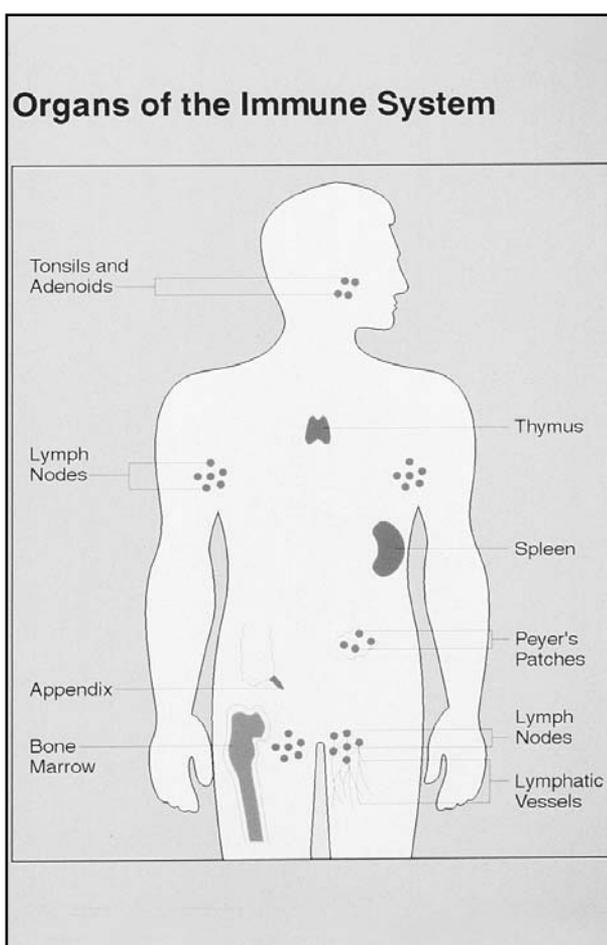
The peripheral lymphoid tissues include the lymphatic vessels, lymph nodes, various lymphoid tissues, and spleen. The events that occur in these areas require exposure to an antigen, and are called antigen-dependent events.

Lymphatic vessels

The filtration of the blood results in the production of extracellular fluid called lymph. The lymphatic vessels that carry the fluid back to the bloodstream also carries cells with antigens. These antigens come from other sites within the body where infection may be present. The fluid passes through the lymph nodes. This fluid is eventually returned to the blood via lymphatic vessels. All the lymph from the body is carried back to the **heart** by way of the thoracic duct.

Lymph nodes and lymphoid tissue

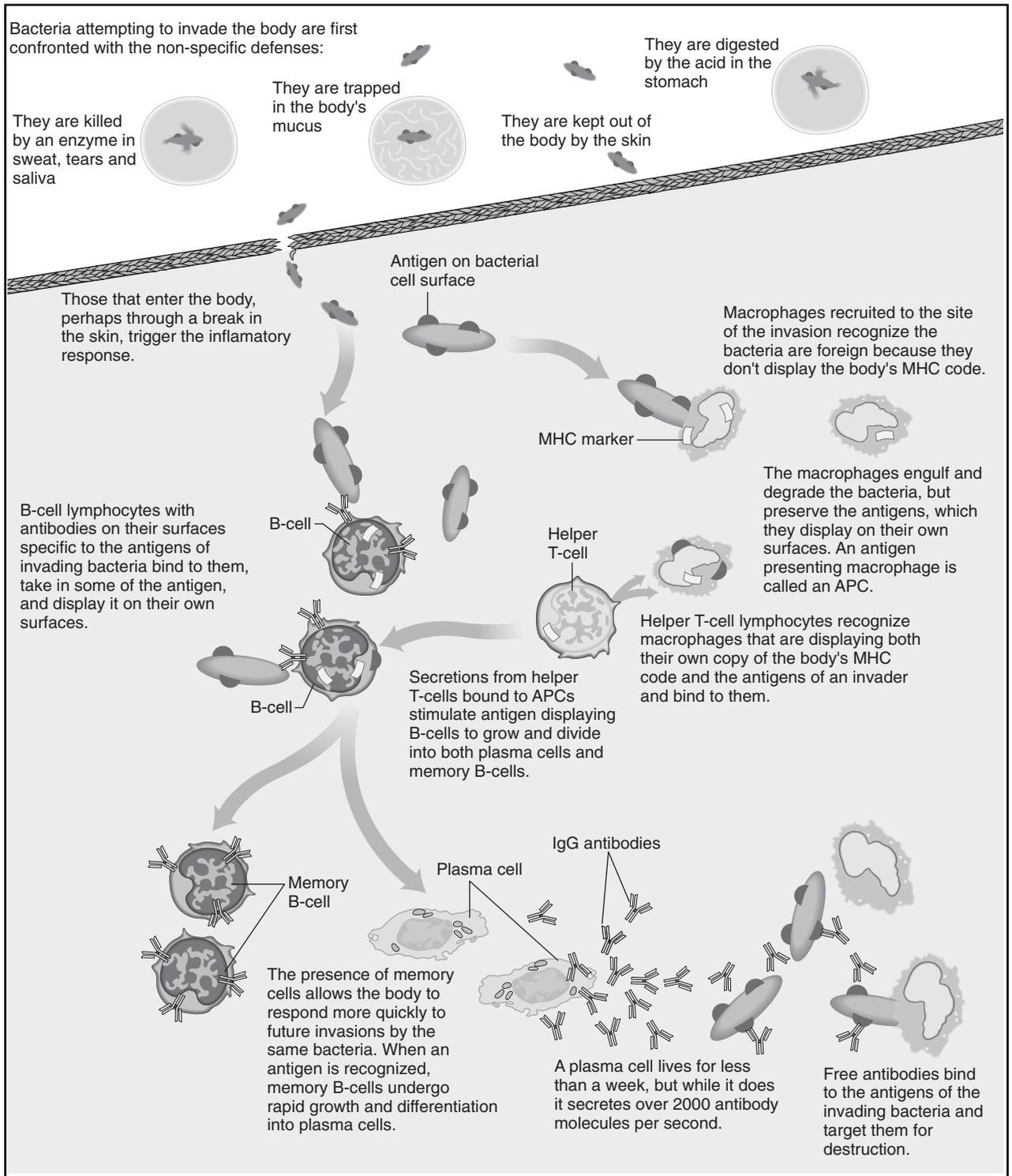
Lymph nodes are distributed along lymphatic vessel pathways and act as a filter for the lymph. The lymph nodes are distributed throughout the **lymphatic system**, and are especially prominent in the neck, axilla (underarm), and groin. These fibrous nodes contain immune cells such as lymphocytes, macrophages, and dendritic cells. Dendritic cells have long, filamentous cytoplasmic processes. These processes have the ability to bind antibodies such that the antibodies can also bind with their specific antigens. This creates a web that traps antigens. The macrophages in the lymph nodes degrade debris and



The organs of the immune system are located throughout the body. (National Institutes of Health. Reproduced by permission.)

extract material that contains antigens, such as those from pathogenic bacteria. The structure of the lymph nodes is such that both T- and B-cells are exposed to this antigenic material. The cells that recognize this material are held in the lymphoid nodes and tissues where they multiply and differentiate. These cells become effector cells that are capable of fighting disease. The node may enlarge during this process, giving rise to the clinical observation of swollen glands.

Lymphocytes can also be found in several other areas throughout the body. The gut-associated lymphoid tissue is a broad term that describes lymphoid tissue found in the Peyer's patches of the intestine, appendix, adenoids, and tonsils. Cells that protect the respiratory tract are called bronchial-associated lymphoid tissue (BALT). Other mucosal areas are protected as well, and are collectively known as mucosal-associated lymphoid tissue (MALT).



Immune system. (Illustration by Hans & Cassidy. Courtesy of Gale Group.)

Spleen

Blood is filtered in the spleen, where damaged or dead red blood cells are removed from the blood as well as antigens. This organ also serves as a site for storage of

erythrocytes and platelets. In the fetus, it is the site of erythropoiesis (formation of red blood cells). Within this organ reside B-cells, T-cells, macrophages, and dendritic cells. As in the lymph nodes, lymphocytes are trapped in

this organ. Antibodies and effector cells are produced in the spleen.

Common disorders and diseases

Hypersensitivity reactions result from an immune-mediated inflammatory response to an antigen that would normally be innocuous (causing no harm to the body). Examples include allergic reactions, such as hay **fever**, **asthma**, reactions to insect bites, and the systemic anaphylactic **shock** that occurs in response to bee stings, **allergies** to **antibiotics**, and foods.

Delayed-type hypersensitivity reactions are due to the release of lymphokines. These lymphokines are small polypeptides produced by lymphocytes that have been stimulated by an antigen, affecting other cells. This hypersensitivity reaction may occur as part of the normal immune response to infection by bacteria and viruses. This effect is responsible for the tissue damage in the lungs due to **tuberculosis**, the skin lesions that occur in leprosy and herpes, and rashes associated with chicken pox and measles. This may also occur via skin exposure to cosmetics, poison ivy, and allergy to metals in jewelry, resulting in contact dermatitis.

Autoimmune diseases occur when the immune system begins to attack the body or “self.” In Grave’s disease, antibodies are produced against the thyroid-stimulating hormone (TSH) receptor. In **multiple sclerosis** (MS), antibodies are produced against elements of the myelin sheaths in the **brain** and **spinal cord**. The effects of myasthenia gravis are traced to antibodies directed against the acetylcholine receptor. Following a heart attack, antibodies may form against heart muscle antigens resulting in autoimmune myocarditis. Rheumatoid arthritis (RA) develops from complexes of antibodies to immunoglobulin G (IgG) in the joints and connective tissue. In systemic lupus erythematosus, the body produces antibodies directed against nuclear antigens and DNA.

In acquired **immunodeficiency** syndrome (AIDS), the HIV retrovirus attacks T-cells (CD4), dendritic cells, and macrophages. The number of CD4 T-cell in the blood eventually declines and the body can no longer resist the HIV infection. With the immune system compromised, constitutional disease can develop with fever, weight loss, or **diarrhea**. Neurological disease can occur, resulting in **dementia** and effects to the peripheral nervous system. Pathogenic microorganisms may cause opportunistic infections in this compromised immune state, such as **pneumonia**, diarrhea, skin and mucous membrane infections, and **central nervous system** infections. Cancers may also arise, such as lymphomas. Death from HIV is due to one of these complications or a combination of effects.

KEY TERMS

Antibodies (immunoglobulins)—Proteins that bind to their corresponding specific antigen.

Antigen—A material that gives rise to an immune response.

Autoimmune disease—An immune response that occurs when the immune system begins to attack the body or self.

B lymphocyte—A lymphocyte that contains an immunoglobulin on the surface (the B-cell receptor). B cells mature in the bone marrow.

Effector cells—Mature lymphocytes that assist in the removal of pathogens from the system and do not require further differentiation to perform this function.

Hypersensitivity—An immune reaction that results from an immune mediated inflammatory response to an antigen that would normally be innocuous.

Macrophages—Cells that are capable of ingesting microorganisms by phagocytosis and have a critical role in the host defense to pathogens.

Pathogen—A microorganism that has the potential to cause a disease.

T cytotoxic cells (Tc)—T lymphocytes that kill abnormal cells.

T helper cells (Th)—T lymphocytes that enhance an immune response.

T lymphocyte—A lymphocyte that matures in the thymus and has receptors related to CD3 complex proteins.

T suppressor cells (Ts)—T lymphocytes that diminish the immune response.

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Jill Ilene Granger, M.S.

Immunoassay tests

Definition

Immunoassays are chemical tests used to detect or quantify a specific substance, the analyte, in a **blood** or body fluid sample using an immunological reaction. Immunoassays are highly sensitive and specific assays. Their high specificity results from the use of antibodies and purified antigens as reagents. An antibody is a protein (immunoglobulin) produced by B lymphocytes in response to stimulation by an antigen. Immunoassays measure the formation of antibody-antigen complexes and detect them via an indicator reaction. This may be done by precipitation of the immune complexes and measurement of turbidity or light scattering or by labeling either the antibody or antigen with a radioactive tag, enzyme, fluorescent, or chemiluminescent molecule. High sensitivity is achieved by using an indicator system (e.g. enzyme label) that results in amplification of the measured product.

Immunoassays may be qualitative or quantitative. An example of a qualitative assay is an immunoassay test for **pregnancy**. Pregnancy tests detect the presence of human chorionic gonadotropin (hCG) in urine or serum. In a typical **pregnancy test**, two antibodies are used. The hCG molecule, a protein hormone produced by the trophoblast, is the antigen. One antibody is directed against the alpha polypeptide chain of hCG and the other against the beta polypeptide chain. The sample is added to a support medium containing immobilized antibody to the alpha subunit of hCG. If hCG is present in the sample, it will bind to the antibody. The support is washed to remove all unbound molecules, and an antibody to the beta subunit is added. This second antibody is conjugat-

ed to an enzyme. After washing away any unbound antibody-conjugate, a substrate is added that changes color when acted on by the enzyme. Therefore, the presence of color at the end of the test indicates that hCG was present in the sample. With the use of highly purified antibodies and the enzyme indicator system, pregnancy can be detected within two days after fertilization.

Quantitative immunoassays are performed by measuring the signal produced by the indicator reaction. This same test for pregnancy can be made into a quantitative assay of hCG by measuring the concentration of product formed using a spectrophotometer. A calibration curve is produced by measuring several standards of known hCG concentration, and the curve is used to calculate the concentration of hCG in the sample after measuring the amount of product formed.

Purpose

The purpose of an immunoassay is to measure (or in a qualitative assay detect) an analyte. Immunoassay is the method of choice for measuring analytes normally present at very low concentrations which cannot be determined accurately by less expensive colorimetric tests. Common uses include measurement of drugs, hormones, specific **proteins**, tumor markers, and markers of cardiac injury. Qualitative immunoassays are often used to detect antigens on infectious agents and antibodies produced against them. For example, immunoassays are used to detect antigens on *Hemophilus*, *Cryptococcus*, and *Streptococcus* organisms in the cerebrospinal fluid of **meningitis** patients. They are also used to detect antigens associated with organisms that are difficult to culture such as hepatitis B virus and *Chlamydia trichomatis*. Immunoassays for antibodies produced in viral hepatitis, HIV, and Lyme disease are commonly used to identify patients with these diseases.

Immunoassay methods

Immunoprecipitation

The reaction of antibodies with protein antigens is a two-phase reaction. The first phase results in the formation of an antibody-antigen complex and takes place within seconds. This is followed by cross linking of individual immune complexes to form a macromolecular aggregate which precipitates out of the solution or gel. This second reaction is slow and often requires overnight incubation to reach completion. The simplest immunoassay method measures the quantity of precipitate which forms after the reagent antibody (precipitin) has incubated with the sample and reacted with its respective antigen to form an insoluble aggregate. Immunoprecipitation reactions may be qualitative or quantitative. In quantita-

tive assays, the immune complexes can be measured by turbidimetry or by performing the reaction in an agarose gel. In gel assays, an excess of the specific antibody is usually poured into the gel. The sample is placed in a well cut into the gel and is allowed to diffuse into the gel. The result will be a ring of precipitated immune complexes which grows larger with time until the endpoint is reached. At the endpoint, the diameter of the ring is proportional to antigen concentration. There will be insufficient antigen beyond the ring to form a visible reaction. Inside the ring, antigen concentration is in excess resulting in small invisible antibody-antigen complexes. The ring position represents the equivalence point or optimal molar ratio of antibody to antigen for the visible reaction. An alternative and more rapid immunoprecipitation method is the Laurel rocket electrophoresis or electroimmunoassay method. In this procedure the antigen is added to wells on one side of the gel which contains a specific antibody throughout. The gel is electrophoresed, and the antigen migrates toward the anodal side of the gel (see Electrophoresis tests). This results in an immunoprecipitation reaction in the shape of a rocket (peak). The height of the peak is logarithmically proportional to antigen concentration.

Particle immunoassays

Immunoprecipitation reactions can be direct or indirect. In direct assays the union of antibody with antigen occurs without attaching the antibody or antigen to a solid phase. In passive or indirect assays, the visible phase of the reaction is enhanced by binding one of the reactants to a solid phase such as latex, red blood cells, or suspension of colloidal gold particles. Particle immunoassays add sensitivity by enhancing surface area and visibility. By linking several antibodies to the particle, the particle is able to bind many antigen molecules simultaneously. This greatly accelerates the speed of the visible reaction. Particle assays may also be performed using antigens bound to the particle. This allows rapid and sensitive detection of antibodies that are markers of diseases such as infectious mononucleosis and rheumatoid arthritis.

Immunonephelometry

The immediate union of antibody and antigen forms immune complexes that are too small to precipitate. However, these complexes will scatter incident light and can be measured using an instrument called a nephelometer. These instruments measure the rate at which the immune complexes form. Incident light from a high intensity monochromatic light source is passed through the reaction cuvet. A photomultiplier tube is placed at an angle (e.g. 70 degrees) to the incident light beam. The

amount of light striking the tube is proportional to antigen concentration. The antigen concentration can be determined within minutes of the reaction. A calibration curve based on a nonlinear model such as a cubic spline plot is used to calculate the antigen concentration from the reaction rate.

Radioimmunoassay (RIA)

RIA is a method employing radioactive isotopes to label either the antigen or antibody. Isotopes are atoms that have unstable nuclei and emit radiation in order to transform into stable atoms. Most RIA methods employ 125 iodine (^{125}I) as the radiolabel. This isotope emits gamma rays. It has a high specific activity so that a very small mass of isotope is needed, and a short half-life (60 days). These properties result in minimal disposal problems with leftover or spent reagents. Gamma rays emitted by the immune complexes are usually measured following removal of unbound (free) radiolabel. Since background radiation is very low and the counting time can be extended if needed to generate more counts, RIA is the most sensitive of all immunoassay methods.

There are two types of RIA, competitive and immunoradiometric (sandwich) assays. Competitive assays use radiolabeled antigen. The labeled antigen “competes” with non-radioactive antigen in the sample for a limited number of binding sites on the reagent antibody. Following incubation, the free radiolabeled antigens are removed by decanting or washing and the radioactivity of the antibody-bound antigens is measured. The radioactivity of the antibody-antigen complexes is inversely proportional to antigen concentration. In the immunoradiometric (IRMA) or sandwich assay, two antibodies are used and one is radiolabeled. In the test system, the sample is incubated with a specific antibody usually attached to a solid phase such as a plastic bead or the wall of a plastic test tube. After washing to remove unbound sample components, a radioactively labeled antibody is added. The second antibody may be directed against a different part of the antigen molecule, or it may be directed against the first antibody (e.g. anti-human immunoglobulin). The second antibody binds to the immune complexes making an antibody-antigen-antibody “sandwich.” After washing to remove the unbound radiolabeled antibody, the radioactivity is measured. The amount of radioactivity is directly proportional to antigen concentration.

As with immunonephelometric assays, the calibration curve for RIA is nonlinear. The reagent antibodies reacting with different parts of the antigen have different binding affinities causing the curve to be hyperbolic. Various methods are used to transform the plot so that

result can be more accurately determined. Concentration is plotted on the x-axis and radioactivity on the y-axis. In competitive assays, radioactivity is usually expressed as %B/Bo where B is the count per minute of the sample and Bo is the count per minute of the zero calibrator. This keeps the slope of the curve from changing each day as the amount of radioactivity of the reagent decreases naturally. The most common plotting method converts the concentration (x-axis) to \log_{10} and the %B/Bo to $\text{logit } B/Bo$ (the natural log of B/Bo divided by $1-B/Bo$). This produces a linear plot from which the concentration of unknown can be easily determined.

The major advantages of RIA when compared to other immunoassays are higher sensitivity, easy signal detection, and well-established, rapid assays. The major disadvantages are the health and safety risks posed by use of radiation and the time and expense associated with maintaining a licensed radiation safety and disposal program. For this reason, RIA has been largely replaced in routine clinical laboratory practice by enzyme immunoassay. It is still the gold standard to which other immunochemical methods are compared and is still performed in reference laboratories for analytes such as 11-deoxycortisol, which are not available by other methods.

Enzyme immunoassay (EIA)

Enzyme immunoassay was developed as an alternative to RIA. These methods use an enzyme to label either the antibody or antigen. As for RIA, the EIA methods may be divided into competitive or sandwich type assays. Competitive assays use enzyme labeled antigen, and sandwich assays use an enzyme labeled antibody. The steps performed in RIA and EIA are similar. However, EIA requires an additional step, the addition of substrate which follows the immunological reaction. The sensitivity of EIA approaches that for RIA because a single enzyme molecule can catalyze the conversion of many molecules of substrate to product. Therefore, the enzyme label amplifies the reaction by producing many colored, fluorescent, or chemiluminescent molecules for each antibody-antigen reaction. As with RIA, the relationship between enzyme activity and concentration is nonlinear, and curve-fitting methods such as the cubic spline plot or the four-parameter logistic curve are used to calculate concentration. Many EIA assays use monoclonal antibodies as reagents to increase the sensitivity and lot to lot reproducibility of the assay. Monoclonal antibodies are made by fusing the immunoglobulin genes from a B lymphocyte, which produces the desired antibody specificity with a malignant plasmacytoma cell line. This results in a malignant cell line called a hybridoma that secretes large quantities of the desired antibody. Since the antibodies are derived from identical cells, the antibody mol-

ecules are identical and all have the same binding affinity for the antigen.

In addition to safety, another advantage of EIA is that light (versus) radiation is measured. This obviates the need for a scintillation counter that is more expensive than a light measuring instrument. In addition, some competitive EIA methods do not require the separation of antibody-bound and free antigen. These methods are called homogenous assays. Examples of homogenous EIAs are the enzyme multiplied immunoassay technique (EMIT), fluorescence polarization immunoassay (FPIA), and cloned enzyme donor immunoassay (CEDIA).

One of the most widely used EIA methods for detection of infectious diseases is the enzyme-linked immunosorbent assay (ELISA). The ELISA method is a heterogenous sandwich immunoassay, which means that separation of bound and free enzyme label is required. The term ELISA refers to the use of a solid phase to which the antibody (or antigen) is bound in order to facilitate the separation. ELISA methods are usually performed using a microtiter plate containing 96 wells rather than in test tubes. Incubation, washing, and signal reading steps are performed as with EIA sandwich assays described above.

Fluorescent immunoassay (FIA)

FIA refers to immunoassays that utilize a fluorescent label or an enzyme label that acts on the substrate to form a fluorescent product. In fluorescence measurements short wavelength light (usually near ultraviolet light) is used to excite the molecules. Fluorescent molecules stabilize by losing part of the absorbed light energy as heat and part as longer wavelength (visible) light. Fluorescent measurements are inherently more sensitive than colorimetric (spectrophotometric) measurements. Therefore, FIA methods have greater analytical sensitivity than EIA methods which employ absorbance (optical density) measurement.

Chemiluminescent immunoassay

Chemiluminescent immunoassays utilize a chemiluminescent label. Chemiluminescent molecules produce light when they are excited by chemical energy. The energy usually comes from an oxidation-reduction reaction. These molecules can be conjugated directly to antigens, or they can be used as substrates for enzyme labels. The most commonly used chemiluminescent labels are acroдинium, luminol, and dioxetane. Acroдинium and luminol are excited by peroxidase enzyme reactions and can be used with EIAs that employ a horseradish peroxidase label. Dioxetane-phosphate can be excited by hydrolysis of the phosphate bond using the enzyme alka-

line phosphatase as the label. Consider this example of a competitive binding assay for thyroxine (T4) based on chemiluminescence. The sample is mixed with T4 labeled with alkaline phosphatase (ALP) in a plastic tube containing anti-T4 conjugated to the tube wall. T4 in the sample competes with the ALP-labeled T4 for the antibody. After the reaction, the tube is washed to remove any unbound T4 and dioxetane-phosphate is added. The enzyme hydrolyzes the phosphate ester bond exciting the dioxetane which releases flashes of light. These emissions are measured by a light detector and are inversely proportional to the T4 concentration of the sample.

Precautions

Blood samples are collected by venipuncture using standard precautions for reducing exposure to blood-borne pathogens. It is not necessary to restrict fluids or food prior to collection. Blood should be collected in tubes containing no additive. Risks of venipuncture include bruising of the skin or bleeding into the skin. Random urine samples are acceptable for drug assays; however, 24-hour urine samples are preferred for hormones and other substances which show diurnal or pulse variation.

Special safety precautions must be observed when performing radioimmunoassay (RIA) methods. RIA tests use radioactive isotopes to label antigens or antibodies. Pregnant females should not work in the area where RIA tests are being performed. Personnel handling isotope reagents must wear badges which monitor their exposure to radiation. Special sinks and waste disposal containers are required for disposal of radioactive waste. The amount of radioisotope discarded must be documented for both liquid and solid waste. Leakage or spills of radioactive reagents must be measured for radioactivity; the amount of radiation and containment and disposal processes must be documented.

Results

Immunoassays that are qualitative are reported as positive or negative. Quantitative immunoassays are reported in mass units along with reference intervals (normal ranges) for the test. Normal ranges may be age and gender dependent. Immunoassays that measure antibody concentration may be reported as an antibody titre. The titre is the reciprocal of the highest dilution of sample that gives a positive (detectable) result. Positive immunoassay test results for HIV and drugs of abuse generally require confirmatory testing.

Although immunoassays are both highly sensitive and specific, false positive and negative results may

KEY TERMS

Antibody—A protein produced by B lymphocytes in response to stimulation by an antigen.

Antigen—Any substance which induces an immune response.

Chemiluminescent immunoassay—An immunoassay in which the label is a molecule that emits light when excited by a chemical reaction.

Enzyme immunoassay—An immunoassay using an enzyme as the label. The enzymatic reaction product is measured to determine the concentration of the analyte in the sample.

Fluorescent immunoassay—An immunoassay that uses a fluorescent label or produces a fluorescent product.

Immunoassay—A method that measures antibody-antigen complexes formed by reacting purified antibody or antigen with the sample.

Nephelometry—A method for measuring the light scattering properties of a sample.

Radioimmunoassay—A method that uses a radioisotope label in an immunoassay.

occur. False negative results may be caused by improper sample storage or treatment, reagent deterioration, or improper washing technique. False positive results are sometimes seen in persons who have heterophile antibodies, especially to mouse immunoglobulins that may be used in the test. False positive results have been reported for samples containing small fibrin strands that adhere to the solid phase matrix. False positives may also be caused by substances in the blood or urine that cross react or bind to the antibody used in the test.

Preparation

Generally, no special instructions need be given to patients for immunoassay testing. Some assays require a timed specimen collection while others may have special dietary restrictions.

Aftercare

When blood testing is used for the immunoassay, the venipuncture site will require a bandage or light dressing to accomplish hemostasis.

Complications

Immunoassay is an *in vitro* procedure, and therefore not associated with complications. When blood is collected slight bleeding into the skin and subsequent bruising may occur. The patient may become lightheaded or queasy from the sight of blood.

Health care team roles

Immunoassay tests are ordered by physicians and samples may be collected by a physician, physician assistant, nurse, or phlebotomist. Simple immunoassay tests (e.g. pregnancy tests and rapid Strep tests) may be performed by medical personnel without special laboratory training. More complex testing is performed by clinical laboratory scientists CLS(NCA) or medical technologists, MT(ASCP) or by clinical laboratory technicians, CLT(NCA) or medical laboratory technicians, MLT(ASCP).

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Robert Harr
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Immunodeficiency

Definition

Immunodeficiency disorders are characterized by an **immune system** that is lacking, impaired, or defective. As a result, patients with immunodeficiency disorders have increased susceptibility to **infection** and neoplasia (**cancer** development). They have more frequent infections that are generally more severe and last longer than

those experienced by persons with healthy, functioning immune systems. Patients with immunodeficiency disorders also are susceptible to infection with organisms that do not normally infect healthy people.

Description

The immune system is the body's primary defense against infections. Any defect in the immune system decreases the body's ability to combat infections. Patients with immunodeficiency disorders may suffer more frequent infections, heal more slowly, and have a higher incidence of some cancers.

The normal immune system involves a complex interaction of cells and molecules that can recognize and attack invaders such as **bacteria**, **viruses**, and **fungi**. It also plays a role in fighting cancer. The immune system has both innate and adaptive components. Innate immunity is the immune protection present at birth. Adaptive immunity develops throughout life and has two components, humoral immunity and cellular immunity.

The innate immune system consists of the skin (which serves as a barrier to prevent organisms from entering the body), white **blood** cells called phagocytes, a system of **proteins** called the complement system, and chemicals called interferon. When phagocytes encounter an invading organism, they surround and engulf it to destroy it. The complement system attacks bacteria. The elements of the complement system create a hole in the outer layer of the target cell, which leads to the death of the cell.

The adaptive component of the immune system is extremely complex and is still not entirely understood. Basically, it has the ability to recognize a foreign organism, tumor cell, or foreign chemical as an invader, and to develop a response to attempt to eliminate it.

The humoral response of adaptive immunity involves a type of cell called B lymphocytes that manufacture proteins called antibodies (also called immunoglobulins). Antibodies attach themselves to the foreign substance allowing phagocytes to begin engulfing and destroying the invading organism. The action of antibodies also activates the complement system. The humoral response is particularly useful for attacking bacteria.

The cellular response of adaptive immunity is useful for attacking viruses, some parasites, and possibly cancer cells. The main type of cell in the cellular response is the T lymphocyte. There are helper T lymphocytes and killer T lymphocytes. Helper T lymphocytes play a role in recognizing invading organisms and help killer T lympho-



A nurse holds a baby with immunodeficiency, who must be treated in a sterile environment. (Science Source/Photo Researchers. Reproduced by permission.)

cytes to multiply. As the name suggests, killer T lymphocytes destroy the target cell or organism.

Defects can occur in any component of the immune system. They can also occur in several components simultaneously, and are then referred to as combined immunodeficiency. Defects can be congenital or acquired.

Congenital immunodeficiency disorders

Congenital immunodeficiency is present at the time of birth and is the result of genetic defects. Though more than 70 different types of congenital immunodeficiency disorders have been identified, they are rare. They may be caused by defects in either B lymphocytes or T lymphocytes, or both, and can also occur in the innate immune system.

B LYMPHOCYTE DEFICIENCY. If there is an abnormality in either the development or function of B lymphocytes, then the ability to make antibodies is impaired. Impaired antibody production results in increased susceptibility to recurrent infections. Bruton's agammaglobulinemia, also known as X-linked agammaglobulinemia, is one of the most common congenital immunodeficiency

disorders. The defect results in a decrease or absence of B lymphocytes and therefore a decreased ability to produce antibodies. Patients with this disorder are particularly susceptible to infections of the throat, skin, middle ear, and **lungs**. It is seen only in males because it is caused by a genetic defect on the X chromosome. Since males have only one X chromosome, they always have the disorder if the defective gene is present. Females may have the defective gene; however, since they have two X chromosomes, only one will have the defective gene and the other will have a normal gene to counter the defective gene. Women may pass the defective gene to their male offspring.

Another type of B lymphocyte deficiency involves a group of disorders called selective immunoglobulin deficiency syndromes. There are five different types of immunoglobulins—IgA, IgG, IgM, IgD, and IgE. The most common type of immunoglobulin deficiency is selective IgA deficiency. Some patients with selective IgA deficiency experience no symptoms while others have occasional lung infections and **diarrhea**. In another immunoglobulin disorder, IgG and IgA antibodies are deficient and there is increased IgM. Patients with this disorder tend to develop severe bacterial infections.

Common variable immunodeficiency is another type of B lymphocyte deficiency. In this disorder production of one or more of the immunoglobulin types is decreased and the antibody response to infections is impaired. This disorder generally develops between the ages of 10 and 20 years. Symptoms vary among affected patients, however, most suffer frequent infections and some also experience anemia and rheumatoid arthritis. Many patients with common variable immunodeficiency develop cancer.

T LYMPHOCYTE DEFICIENCIES. Severe defects in the ability of T lymphocytes to mature results in impaired immune responses to infection with viruses, fungi, and certain types of bacteria. These infections are often severe and can be fatal. DiGeorge syndrome is a T lymphocyte deficiency that begins during **fetal development**, although it is not inherited. Children with DiGeorge syndrome either have no thymus or have an underdeveloped thymus. Since the thymus directs the production of T lymphocytes, people with this immunodeficiency have very low numbers of T lymphocytes. They are susceptible to recurrent infections and usually have physical abnormalities as well, which may include low-set ears, a small receding jawbone, and widely spaced eyes. In some cases no treatment is required for DiGeorge syndrome because T lymphocyte production spontaneously improves. Either an underdeveloped thymus begins to produce more T lymphocytes or organ sites other than the thymus compensate by producing more T lymphocytes.

COMBINED IMMUNODEFICIENCIES. Some types of immunodeficiency disorders affect both B lymphocytes and T lymphocytes. For example, severe combined immunodeficiency disease (SCID) is caused by defective development or function of both of these types of lymphocytes. It results in impaired humoral and cellular immune responses. SCID is usually recognized during the first year of life. It tends to cause thrush (a fungal infection of the mouth), diarrhea, failure to thrive, and other serious infections. Treatment requires bone marrow transplant and, if left untreated, children with SCID generally die from infections before the age of two years.

DISORDERS OF INNATE IMMUNITY. Disorders of innate immunity affect phagocytes or the complement system. These disorders also result in recurrent infections.

Acquired immunodeficiency disorders

Acquired immunodeficiency is more common than congenital immunodeficiency. It is the result of an infectious process or other disease. For example, the human immunodeficiency virus (HIV) is the virus that causes acquired immunodeficiency syndrome (**AIDS**). It is not,

however, the most common cause of acquired immunodeficiency.

Acquired immunodeficiency often occurs as a complication of other conditions and diseases. For example, the most common causes of acquired immunodeficiency are malnutrition, some types of cancer, and infections such as chickenpox, cytomegalovirus, German measles, measles, **tuberculosis**, infectious mononucleosis (Epstein-Barr virus), chronic hepatitis, lupus, and bacterial and fungal infections.

Sometimes, acquired immunodeficiency is a side effect or consequence of drugs used to treat another condition. For example, organ transplant patients are given drugs to suppress the immune system so the body will not reject the transplanted organ. Some **chemotherapy** drugs, given to combat cancer, have the side effect of killing immune system cells. The risk of infection increases significantly while these drugs are being taken and usually returns to normal one the patient is off the drugs.

Causes and symptoms

Congenital immunodeficiency is caused by genetic defects, which generally occur while the fetus is developing in the womb. These defects affect the development and/or function of one or more components of the immune system. Acquired immunodeficiency is the result of a disease process and occurs later in life. The causes can be disease, infection, or side effects of drugs given to treat other conditions.

Patients with an immunodeficiency disorder tend to become infected by organisms that do not usually cause disease in healthy people and they suffer repeated infections that resolve slowly and cause symptoms that persist for long periods of time. Patients with chronic infections tend to be pale and thin and may have skin rashes. Their lymph nodes tend to be larger than normal and their **liver** and spleen may also be enlarged. Broken **blood vessels**, especially near the surface of the skin, may be apparent and they may develop alopecia (hair loss) and/or conjunctivitis (inflammation of the lining of the eye).

Diagnosis

One of the first signs that a patient may have an immunodeficiency disorder is failure to improve rapidly when given **antibiotics** to treat an infection. Another strong indicator is if a person becomes ill from organisms that do not normally cause diseases. When this occurs in very young children, it may indicate a genetic defect responsible for the immunodeficiency disorder. Among older children or young adults, their medical history

helps determine if childhood diseases may have caused an immunodeficiency disorder. Other possibilities to consider are recently acquired infections such as HIV, hepatitis, or tuberculosis.

Laboratory tests are used to determine the exact nature of an immunodeficiency. Most tests are performed on blood samples. A blood cell count will determine if the number of phagocytic cells or lymphocytes is below normal. Lower-than-normal counts of either of these cell types indicate the presence of immunodeficiency. The blood cells are also examined for their appearance. Some patients may have normal cell counts but their blood cells may be structurally defective. If the lymphocyte cell count is low, further testing is performed to determine whether any particular type of lymphocyte is lower than normal. A lymphocyte proliferation test determines if the lymphocytes can respond to stimuli. The failure to respond to stimulants correlates with immunodeficiency. Antibody levels may be measured by a process known as electrophoresis, while complement levels can be determined by immunodiagnostic tests.

Treatment

There is no cure for congenital or most acquired immunodeficiency disorders. Therapy is aimed at controlling infections and, for some disorders, replacing defective or absent cellular components. Patients with Bruton's agammaglobulinemia must be given periodic injections of gamma globulin throughout their lives to compensate for their decreased ability to produce antibodies. The gamma globulin preparation contains antibodies against common invading bacteria. Untreated, the disease is usually fatal.

Common variable immunodeficiency also is treated with periodic injections of gamma globulin throughout life. Additionally, antibiotics are given when necessary to treat infections.

Patients with selective IgA deficiency usually do not require any treatment for the deficiency. Instead, antibiotics are given for infections.

In some cases, no treatment is required for DiGeorge syndrome because T lymphocyte production increases spontaneously. However, in some severe cases, bone marrow transplant or thymus transplant may be performed.

For patients with SCID, bone marrow transplantation is essential. In this procedure, healthy bone marrow is removed from a compatible donor (one with a similar tissue type, usually a brother or sister). The bone marrow of the patient receiving the transplant is destroyed and replaced with the bone marrow from the donor.

Treatment of the HIV infection that causes AIDS consists of drugs called antiretrovirals. Several of these drugs, used in various combinations, can prolong the period of time before the disease becomes symptomatic. However, these drugs do not produce a cure. Other treatments for patients with AIDS are aimed at the particular infections that arise as a result of the impaired immune system. In most cases immunodeficiency caused by malnutrition is reversible. The health of the immune system is directly linked to the nutritional status of the patient. Among the essential nutrients required by the immune system are proteins, **vitamins**, **iron**, and **zinc**. Among cancer patients, periodic relief from chemotherapy drugs can restore the function of the immune system.

In general, patients with immunodeficiency disorders should be counseled to maintain a healthy diet. This is because malnutrition can aggravate immunodeficiencies. Patients should also be advised to avoid exposures to sick people because they can easily acquire new infections. For the same reason, patients should be instructed to practice good personal hygiene, especially dental care. Patients with immunodeficiency disorders should also avoid eating undercooked food because it might contain bacteria that could cause infection. Also, they should be given antibiotics at the first indication of an infection.

Prognosis

Prognosis for individuals with immunodeficiency disorders depends upon the type of disorder. Patients with Bruton's agammaglobulinemia who are given injections of gamma globulin generally live into their 30s or 40s and death is usually from chronic pulmonary infections. Patients with selective IgA deficiency generally live normal lives. They may experience allergic reactions to a blood transfusion, however, and should therefore wear a Medic Alert bracelet or have some other way to alert healthcare professionals about their disorder.

SCID is a serious immunodeficiency disorder. Without successful bone marrow transplant, a child with this disorder usually will not live beyond two years of age.

Although people with HIV/AIDS are living longer than in the past because of **antiretroviral drugs**, AIDS remains a fatal disease. AIDS patients usually die of opportunistic infections—viral and bacterial infections that occur because the impaired immune system is unable to fight them.

Health care team roles

Diagnosis and effective management of immunodeficiency disorders involves cooperation and collaboration between the patient and an interdisciplinary team of

KEY TERMS

Agammaglobulinemia—The lack of gamma globulins in the blood. Antibodies are the main gamma globulins of interest, so this term means a lack of antibodies.

Humoral immune response—Immune system response to antigens found in body fluids. This response is mediated by antibodies, which are secreted by B lymphocytes circulating in the blood.

Lymphocytes—White blood cells that fight infection and disease.

health care professionals. The patient's primary care physician or pediatrician, immunologist, nurses, laboratory technologists, respiratory therapists, pharmacists, pharmacy assistants, and health educators are involved in helping patients and families gain an understanding of how to prevent infections and effectively manage them when they occur or recur.

Patient education

Nurses and health educators help patients learn how to prevent infection. They teach patients how to identify early symptoms of infection that require prompt medical attention. Pharmacists and pharmacy assistants may offer additional instruction about antibiotic therapy and the importance of adhering to prescribed treatment.

Prevention

There is no way to prevent a congenital immunodeficiency disorder. Physicians and health care providers should recognize symptoms as early warning signs and implement appropriate treatment as soon as possible. People with congenital immunodeficiency disorders may want to consider **genetic counseling** before having children to determine if there is a chance they will pass the defect on to their children.

Some infections associated with acquired immunodeficiency can be prevented or treated before they cause problems. For example, there are effective treatments for tuberculosis and most bacterial and fungal infections. HIV infection can be prevented by practicing "safe sex," and by not using illegal intravenous drugs. These are the primary routes of transmitting the virus.

Malnutrition can be prevented by obtaining adequate **nutrition**. Although it does exist in the United States,

malnutrition is considered a problem of greater magnitude in developing countries.

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Barbara Wexler

Impacted stool removal see **Fecal impaction removal**

Impacted tooth

Definition

An impacted tooth is a dental disorder in which a tooth fails to fully emerge through the gums.

Description

Teeth emerge through the gums during infancy and also when primary (baby) teeth are replaced by the permanent teeth. If a tooth fails to emerge or emerges only partially, it is considered impacted. The teeth most commonly impacted are the wisdom teeth (or third molars). These teeth are the last to develop, but don't begin breaking through the bone and gum tissue until the later teen years. By this time, the upper and lower jaws have stopped growing and may be too small to accommodate these four additional teeth. As the wisdom teeth continue to grow, one or more may become impacted. If there is not enough room in the mouth to accommodate these teeth, they will remain trapped in the jawbone.

Impacted teeth can take many positions in the bone as they attempt to find a pathway that will allow them to erupt. According to the American Board of Oral and Maxillary Surgeons nine out of every ten people have an impacted tooth. Impacted tooth surgery is the leading surgical problem faced by general dentists and oral surgeons.

Causes and symptoms

An impacted tooth may be caused by overcrowding of the teeth often because the jaw is too small. Teeth may also become twisted, tilted, or displaced as they try to emerge. Less common symptoms of an impacted tooth may be:

- **pain** and tenderness of the gums
- visible gap where a tooth has not emerged
- redness and swelling of the gums around the impacted tooth area
- swollen lymph nodes of the neck
- difficulty opening the mouth
- prolonged headaches or jaw ache
- unpleasant **taste** when biting down on or near the impacted area
- raised gum tissue where impacted tooth lies under the gum tissue

Diagnosis

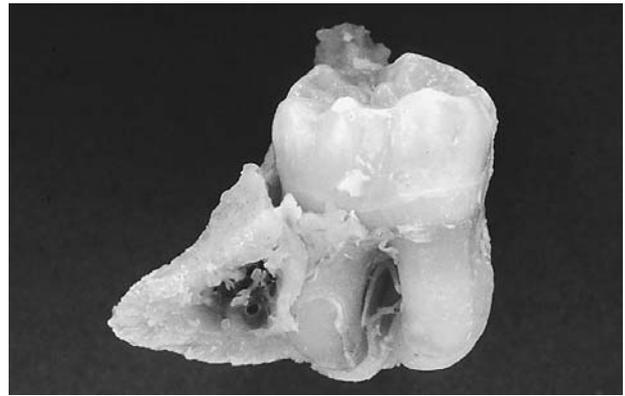
Upon visual examination, the dentist may find signs of **infection** or swelling in the area where the tooth is absent or only partially erupted. **Dental x rays** are essential in diagnosing an impacted tooth. The dentist may also see signs of enlargement of the tissue over the area where a tooth has not emerged, or has emerged only partially. The impacted tooth may also be pressing on an adjacent tooth causing pain.

Treatment

The goal of treatment is to relieve irritation of the mouth and remove pain caused by the impacted tooth. If the impacted tooth is not causing infection or inflammation, or is not affecting the alignment of the other teeth, no treatment may be necessary. Warm, salt-water rinses may be advised to aid in soothing the swollen gums.

A dentist may perform an extraction with forceps and local anesthetic agent if the tooth is exposed and appears to be easily removable. Extracting an impacted tooth typically requires making an incision through gum tissue to expose the tooth and may require removing portions of bone to free the tooth. The tooth may have to be removed in pieces to minimize destruction to the surrounding bone and tissue. The extraction site may require one or more stitches to aid healing.

Another type of treatment called ligation is performed on impacted teeth in conjunction with orthodontics. A small portion of the crown of an impacted tooth is exposed through the gum tissue and a small orthodontic



This impacted wisdom tooth, attached to part of the jaw bone, was broken during extraction. (Photograph by James Stevenson, Photo Researchers, Inc. Reproduced by permission.)

bracket is attached to the exposed area so that the tooth can be brought into alignment with the rest of the teeth while the patient is being orthodontically treated. An oral and maxillofacial surgeon commonly performs this type of treatment.

Antibiotics may be required after the extraction or ligation if the area is infected or there is a risk of infection. Over the counter pain medications, such as Tylenol, Advil, or Motrin may be taken to lessen the pain of the treated area. This pain will gradually decrease over two to three days.

Prognosis

The prognosis is very good for the removal or ligation of an impacted tooth. Potential complications include postoperative infection, temporary numbness from nerve irritation, jaw fracture, and jaw joint pain. A painful condition, which may develop after an extraction, is known as a dry socket, when a **blood** clot does not completely fill the empty tooth socket, or is disturbed by an oral vacuum, by drinking through a straw, or by smoking. The bone beneath the socket is painfully exposed to air. The general dentist will pack the socket with medication to allow healing to take place. One complication of the ligation process is that the bracket and chain may come off and will need to be replaced by the oral and maxillofacial surgeon.

Health care team roles

Extraction of a symptomatic impacted tooth is often treated in a general dental office. If the tooth is deeply impacted or more difficult to remove than expected the general dentist may refer the patient to an oral and maxillofacial surgeon.

KEY TERMS

Dry socket—A painful condition following tooth extraction in which a blood clot does not properly fill the empty socket, leaving the bone underneath exposed to air and food.

Eruption—The process of a tooth breaking through the hard and soft oral tissue to grow into place in the mouth.

Extraction—The surgical removal of a tooth from its socket in the bone.

Ligated—Where a small chain and wire are glued to the impacted tooth by an oral and maxillofacial surgeon. The wire is tightened during monthly visits with an orthodontist. This brings the tooth out of the bone and gum tissue and into alignment with the other teeth.

Oral and maxillofacial surgeon—A dentist specializing in oral and maxillofacial surgical procedures of the mouth.

Wisdom teeth—Also called third molars, the last teeth to erupt in the upper and lower jawbone.

Prevention

There is no way to prevent an impacted tooth. Heredity plays a role in the growth and development of the jaw, making it hard to prevent an impacted tooth from happening. Complications with an impacted tooth can be prevented by **patient education**, good **oral hygiene**, and proper care of the extraction area.

Resources

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American Board of Oral and Maxillofacial Surgeons, 625 North Michigan Avenue, Suite 1820, Chicago, Illinois 60611. (312) 642-0070. <<http://www.aaoms.org>>.

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Impedance plethysmography see **Impedance plethysmography**

Impedance plethysmography

Definition

Impedance plethysmography, also called impedance test or **blood flow** or impedance **phlebography**, is a non-invasive test that uses electrical monitoring in the form of resistance (impedance) changes to measure blood flow in veins of the leg. Information from this test helps doctors detect deep vein thrombosis (blood clots or thrombophlebitis).

Purpose

Impedance plethysmography may be done in order to:

- detect blood clots lodged in the deep veins of the leg
- screen patients who are likely to have blood clots in the leg
- detect the source of blood clots in the **lungs** (pulmonary emboli)

Accurate diagnosis of deep vein thrombosis (DVT) is critical because blood clots in the legs can lead to more serious problems. If a clot breaks loose from a leg vein, it may travel to the lungs and lodge in a blood vessel in the lungs. Blood clots are more likely to occur in people who have recently had leg injuries, surgery, **cancer**, or a long period of bed rest.

Precautions

Because this test is not invasive, it can be done on all patients and is easy to perform. However, the accuracy of the results is affected if the patient does not breathe normally or keep the leg muscles relaxed. Compression of the veins because of pelvic tumors or decreased blood

flow, due to **shock** or any condition that reduces the amount of blood the **heart** pumps, may also change the test results. Both false-positives (e.g. when thrombi are non-occlusive) and false-negatives have been reported using this technique, which justifies repeated testing over a period of seven to ten days for patients with initial negative results. Success rates for this test have been estimated at anywhere from 65–66% to 92–98%.

Description

Using conductive jelly, the examiner strategically places two to four electrodes on the patient's calf (the four-electrode configuration yields a more uniform and precise current density and consequent measurement result). These electrodes are connected to an instrument called a plethysmograph, which records the changes in electrical resistance that occur during the test and produces a graph of the results.

The patient must lie down and raise one leg at a 30° angle so that the calf is above the level of the heart. The examiner then wraps a pressure cuff around the patient's thigh and inflates it to a pressure of 45–60 cm of water for 45 seconds. The plethysmograph records the electrical impedance changes that correspond to changes in the volume of blood in the vein at the time the pressure is exerted and again three seconds after the cuff is deflated. This procedure is repeated several times in both legs.

This test takes 30–45 minutes, costs an estimated \$50–\$100 (as of 2001), and results can be available within a few minutes.

Impedance plethysmography works by measuring the resistance to the transmission of electrical energy (impedance). This resistance is dependent upon the volume of blood flowing through the veins. By graphing the impedance, the doctor or technician can tell whether a clot is obstructing blood flow.

Preparation

Patients undergoing this test do not need to alter their diet, change their normal activities, or stop taking any medications. They will wear a surgical gown during the test and should be asked to urinate before the test starts. If keeping the legs elevated causes discomfort, mild **pain** medication can be given.

Aftercare

The patient may resume normal or postoperative activities after the test.

KEY TERMS

False negative—A test result that wrongly indicates a disease or condition is not present, when, in fact, it is.

False positive—A test result that wrongly indicates the a disease or condition is present, when, in fact, it is not.

Impedance—Denoted by Z, it is an expression of the opposition that an electronic component, circuit, or system presents to an alternating current (or direct current, in which case impedance equals resistance). Included in impedance are resistance, capacitance, and inductance. Impedance thus has both a real (resistance) and imaginary (phase) part.

Thrombophlebitis—Inflammation of a vein, associated with the formation of a blood clot.

Complications

Impedance plethysmography is painless and safe. It presents no risk to the patient.

Results

Normally, inflating the pressure cuff will cause a sharp rise in the pressure in the veins of the calf because blood flow is blocked. When the cuff is released, the pressure decreases rapidly as the blood flows away.

If a clot is present, the pressure in the calf veins will already be high. It does not become sharply higher when the pressure cuff is tightened. When the pressure cuff is deflated, the clot blocks the flow of blood out of the calf vein. The decrease in pressure is not as rapid as when no clot is present and the shape of the resulting graph is different, all of which is indicative of obstruction of major deep veins.

Health care team roles

Doctors, nurses, or well-trained technicians may perform all or part of the procedure, which includes application of electrodes and placement of cuffs as well as handling of the electronic equipment and analysis of results.

Training

Training for the procedure includes instruction on placement of electrodes and cuffs, facility with the electronic equipment, correct patient positioning during the

procedure, and capability for accurate interpretation of resulting impedance graphs.

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Bryan Ronain Smith

Implantable cardioverter-defibrillator

Definition

The implantable cardioverter-defibrillator (ICD) is a surgically implanted electronic device that directs an electric charge directly into the **heart** to treat life-threatening heartbeat irregularities.

Purpose

The implantable cardioverter-defibrillator is used to detect and stop serious arrhythmias and restore a normal heartbeat. The exact indications for the implantation of the device are controversial, but patients suffering from ventricular fibrillation (unproductive heartbeat), ventricular tachycardia (abnormally fast heartbeat), long QT syndrome (an inherited heart disease), or others at risk for sudden cardiac death are potential candidates for this device. A study by the National Institute for Heart, Lung, and Blood of the National Institutes of Health indicated a significant increase in survival for patients suffering from ventricular arrhythmias when ICD implant is compared to medication. Several follow-up studies indicate that this may be due to the marked increase in survival for the sickest patients, generally defined as those having a heart weakened to less than 50% of normal, as measured by the ability of the left side of the heart to pump blood. Overall,

studies have documented a very low mortality rate of 1–2% annually for persons implanted with the device, compared to approximately 15–25% for patients on drug therapy.

Description

Similar in structure to a pacemaker, an ICD has three main components: a generator, leads, and an electrode. The generator is encased in a small rectangular container, usually about 2 in (5 cm) wide and around 3 oz (85 g) in weight. Even smaller generators have been developed, measuring 1 in (2.54 cm) in diameter and weighing about half an ounce (14.17 g). The generator is powered by lithium batteries and is responsible for generating the electric shock. The generator is controlled by a computer chip that can be programmed to follow specific steps according to the input gathered from the heart. The programming is initially set and can be changed using a device (called a wand programmer) that communicates by radio waves through the chest of the patient after implantation.

One or two leads, or wires, are attached to the generator. These wires are generally made of platinum with an insulating coating of either silicone or polyurethane. The leads carry the electric shock from the generator. At the tip of each lead is a tiny device called an electrode that delivers the necessary electrical shock to the heart. Thus, the electric shock is created by the generator, carried by the leads and delivered by the electrodes to the heart. The decision of where to put the leads depends on the needs of the patient, but they can be located in the left ventricle, the left atrium, or both.

According to the American College of Cardiology, more than 100,000 persons worldwide currently have an ICD. The battery-powered device rescues the patient from a life-threatening arrhythmia by performing a number of functions in order to reestablish normal heart rhythm, which varies with the particular problem of the patient. Specifically, if encountered with ventricular tachycardia, many devices will begin treatment with a pacing regimen. If the tachycardia isn't too fast, the ICD can deliver several pacing signals in a row. When those signals stop, the heart may go back to a normal rhythm. If the pacing treatment is not successful, many devices will move onto cardioversion. With cardioversion, a mild shock is sent to the heart to stop the fast heartbeat. If the problem detected is ventricular fibrillation, a stronger shock called a defibrillation is sent. This stronger shock can stop the fast rhythm and help the heartbeat go back to normal. Finally, many ICDs can also detect heartbeats that are too slow. It can act like a pacemaker and bring the heart rate up to normal.

ICDs that defibrillate both the ventricles and the atria have also been developed. Such devices not only provide dual-chamber pacing but also can distinguish ventricular from atrial fibrillation. Patients that experience both atrial and ventricle fibrillation or atrial fibrillation alone that would not be controlled with a single chamber device are candidates for this kind of ICD.

Operation

ICD insertion is considered minor surgery and can be performed in either an operating room or an electrophysiology laboratory. The insertion site, in the chest, will be cleaned, shaved and numbed with the injection of a medication (local anesthetic). Generally, left handed persons have ICDs implanted on the right side and visa versa, to speed return to normal activities. Two small cuts (incisions) are made, one in the chest wall and one in a vein just under the collarbone. The wires of the ICD are passed through the vein and attached to the inner surface of the heart. The other ends of the wires are connected to the main box of the ICD, which is inserted into the tissue under the collarbone and above the breast. Once the ICD is implanted, the physician will test it several times before the anesthesia wears off by causing the heart to fibrillate and making sure the ICD responds properly. The doctor then closes the incision with sutures (stitches), staples or surgical glue. The entire procedure takes about an hour.

Immediately following the procedure, a **chest x ray** will be taken to confirm the proper placement of the wires in the heart. The ICD's programming may be adjusted by passing the programming wand over the chest. After the initial operation, the physician may induce ventricular fibrillation or ventricular tachycardia one more time prior to the patient's discharge, although recent studies suggest that this final test is not generally necessary.

A short stay in the hospital is usually required following ICD insertion but this varies with the patient's age and condition. If there are no complications, complete recovery from the procedure will take about four weeks. During that time, the wires will firmly take hold where they were placed. In the meantime, the patient should avoid heavy lifting or vigorous movements of the arm on the side of the ICD, or else the wires may become dislodged.

After implantation, the implantable cardioverter-defibrillator is programmed to respond to rhythms above the patient's **exercise** heart rate. Once the device is in place, many tests will be conducted to ensure that the device is sensing and defibrillating properly. About 50%

of patients with ICDs require a combination of drug therapy and the ICD.

Safety

Environmental conditions that can affect the functioning of the ICD after installation include:

- strong electromagnetic fields, such as those used in arc-welding
- contact sports
- shooting a rifle from the shoulder nearest the installation site
- cell phones used on that side of the body
- magnetic mattress pads, such as those believed to treat arthritis
- some medical tests such as **magnetic resonance imaging (MRI)**

Environmental conditions often erroneously thought to affect ICDs include:

- microwave ovens (the waves only affect old, unshielded **pacemakers** and do not affect ICDs)
- airport security (although metal detector alarms could be set off, so patients should carry a card stating they have an ICD implanted)
- anti-theft devices in stores (although patients should avoid standing near the devices for prolonged periods)

Patients should also be instructed to memorize the manufacturer and make of their ICD. Although manufacturing defects and recalls are rare, they do occur and a patient should be prepared for that possibility.

Maintenance

In general, if the condition of the patient's heart, drug intake, and metabolic condition remain the same, the ICD requires only periodic checking every two months or so for battery strength and function. This is done by placing a special device over the ICD that allows signals to be sent over the telephone to the doctor, a process called trans-telephonic monitoring.

If changes in medications or physical condition occur, the doctor can adjust the ICD settings using a programmer, which involves placing the wand above the pacemaker and remotely changing the internal settings. One relatively common problem is the so-called "ICD storm," where the machine inappropriately interprets an arrhythmia and gives a series of shocks. Reprogramming can sometimes help alleviate that problem.

When the periodic testing indicates that the battery is getting low, an elective ICD replacement operation is

KEY TERMS

Arrhythmia—A variation of the normal rhythm of the heartbeat.

Cardioverter—A device to apply electric shock to the chest to convert an abnormal heartbeat into a normal heartbeat.

Defibrillation—An electronic process which helps re-establish a normal heart rhythm.

Ventricles—The two large lower chambers of the heart which pump blood to the lungs and the rest of the human body.

Ventricular fibrillation—An arrhythmia in which the heart beats very fast but blood is not pumped out to the body that can become fatal if not corrected.

Ventricular tachycardia—An arrhythmia in which the heart rate is more than 100 beats per minute.

scheduled. The entire signal generator is replaced because the batteries are sealed within the case. The leads can often be left in place and reattached to the new generator. Batteries usually last about four to eight years.

Health care team roles

Electrophysiologists are specially trained cardiologists or thoracic surgeons who study and treat problems with the heart conduction system. They often implant the ICD system and oversee the programming or reprogramming of the device. They are assisted in the operating room by specially trained nurses, who can help with the testing of the ICD, and the anesthesiologist, who is responsible for numbing the area of the incision and keeping the patient comfortable. ICD manufacturers often send representatives to be present for the implantation and initial programming.

The maintenance of the ICD can be overseen by the electrophysiologist or cardiologist and associated staff, which can include specially trained cardiac medical assistants as well as nurses.

Training

The training for implantation of ICDs and their use occurs during medical training (medical or nursing school) and on the job. Physicians, nurses, and other allied health professionals can also receive training about ICDs as part of their continuing education courses.

Continuing education concerning ICD tends to be in specific subject areas, such as the psychological effects of ICD firing, the interpretation of clinical trials in the area, or comparisons between appropriate and inappropriate firing rates.

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Michelle L. Johnson, M.S., J.D.

Incentive spirometry see **Ventilation assistance**

Incontinence, fecal see **Fecal incontinence**

Infant nutrition

Definition

Infant **nutrition** is the feeding behavior of an infant during the first year after birth.

Purpose

Due to the tremendous amount of growth during infancy, adequate nutrition after birth is essential for the development and nourishment of children. Proper nutrition can be obtained from the use of breast milk, infant formulas, and adequate diet related to age.

Precautions

When assessing the nutritional status of infants, it is important to consider the differences in the bodily functions of infants. The gastrointestinal functions of newborns are much slower than that of older infants, especially gastric emptying, which may account for the regurgitation, or spitting up, in newborns.

Passage through the **small intestine** is slower for infants, which helps ensure proper absorption and digestion of nutrients. However, the **large intestine** has a much faster transit time, which puts infants at an increased risk of **dehydration** if resorption of water and electrolytes is compromised.

The digestion of fat is also limited in infancy due to the decreased amount of pancreatic lipase, an enzyme secreted by the **pancreas** to digest fat. However, other lipases present in breast milk compensate for the lack of this enzyme and aid in fat digestion. Thus, the fat in human milk is more readily absorbed than the fat in prepared formulas.

Renal function is also limited in newborns because their **kidneys** are not fully developed until one month of age. The immature kidneys and other factors limit the newborns' ability to cope with fluid and electrolyte loads. Infants fed breast milk or properly prepared formulas normally do not have problems with renal solute load, although problems may occur with **fever**, **diarrhea**, or a reduction in the volume of fluids consumed.

Infants who sleep through the night may need to be woken up mid-way through the night to feed if they are underweight or not consuming enough. It is important to have routine check-ups with the doctor or dietitian to ensure that infants are eating adequately. Honey should also not be given to infants because it may contain spores that cause botulism.

Description

During the first six months of life, infants can receive adequate nutrition through either breast milk or fortified formula. An infant who is breastfeeding will need to nurse on demand or usually about eight to 12 times per day, while babies who are formula fed need to eat about six to eight times per day. In both breastfed and

formula-fed infants, the number of feedings decreases as they get older, but the amount of milk the baby consumes at each feeding increases.

Prior to four months of age, an infant's **digestive system** has not developed well enough to tolerate solid foods. But at about four to six months of age, solid foods can start to be introduced into the infant's diet. It is important to look for signs that an infant is developmentally ready to handle solid foods. Once infants can hold their head up, sit up with minimal support, and begin to show an interest in food, solid feedings of iron-fortified baby cereal can be started. Mixing it with breast milk or formula to get a thin consistency is recommended until the infant can control its mouth better to handle a thicker consistency.

At six to eight months of age, the introduction of fruit juices and strained fruits and vegetables can begin. Use unsweetened juices that contain large amounts of **vitamin C**, such as orange, apple, or grape, but avoid putting an infant to sleep with a bottle of juice as this can lead to tooth decay. Introduce fruits and vegetables one at a time and wait a few days in between introductions to make sure the infant has no allergic reactions. Use plain fruits and vegetables such as carrots, squash, beans, bananas, applesauce, and pears. Introducing vegetables into the diet before fruits is often recommended because the sweet **taste** of fruit may make vegetables less appealing to the infant. Finger foods may also be introduced at this time, but avoid foods that may cause choking, such as grapes, hotdogs, nuts, and seeds. Breast milk or fortified formula should still be given about three to five times a day.

At eight to 12 months of age, an infant should still be receiving breast milk or formula three to four times a day, but also should start eating strained or finely chopped meat. Introduce different meat every week and include strained and ground meats and hotdogs. If eggs are given, only the yolk should be used until one year of age in case the infant is sensitive to egg whites.

If an infant still uses a bottle at one year of age, the bottle should only contain water, or whole (**vitamin D**) milk can be used instead of breast milk or formula. Low-fat milk should not be used until at least two years of age because infants need the extra calories for adequate development. Thereafter, no less than 2% milk should be fed to a young child.

Breastfeeding versus formula feeding

During the first year of life, breast milk is the best source of nutrition for infants. Breast milk provides several health benefits for both the mother and infant beyond the benefits of adequate nutrition. Nutritionally, breast

KEY TERMS

Antibodies—A naturally occurring protein in the blood that is produced in response to the toxicity of an antigen.

Botulism—A disease of the nervous system caused by eating spoiled foods.

Colostrum—Milk secreted for a few days after parturition that is characterized by high protein and antibody content.

Electrolytes—Compounds that form ions when they dissociate in water, such as potassium and chloride.

Enzyme—A protein catalyst that facilitates a reaction in the body without itself being altered.

Essential amino acids—Amino acids that cannot be made by the body.

Galactose—Monosaccharide that is part of the disaccharide lactose.

Glucose—Monosaccharide used for energy; also known as blood sugar.

Lactose—Disaccharide known as milk sugar.

Renal solute load—Amount of solution carried by the blood to the kidneys which is to be excreted through the urine.

Resorption—Absorb again.

Spores—Reproductive body of an organism that is capable of producing new individuals.

milk provides the appropriate amounts of carbohydrate, protein, and fat for infants, along with essential **vitamins**, **minerals**, and digestive enzymes. It also provides antibodies that help increase the infant's **immune system**, decrease gastrointestinal distress, reduce the risk of allergy, and promote the development of the jaws and teeth. Colostrum is the milk secreted from the mother's breasts during the first few days after giving birth. This milk adequately provides the infant's needs during its first week of life as it is characterized by high protein and antibody content. For the mother, breastfeeding facilitates a faster recovery from labor, allows the mother to rest more often, and saves money that would have been spent on formula.

If breastfeeding is not the chosen method of feeding, iron-fortified formulas can be used to provide adequate nutrition. Infant formula has more protein and more **iron** than human milk, but it lacks antibodies. The American

Academy of Pediatrics recommends that all formula-fed infants be given iron-fortified formula. Formula feeding also allows the mother to receive help with feedings and sleep more during the night. Formulas are available for infants who may have **allergies** to milk protein or are lactose intolerant. There are also formulas available for **premature infants** and those who have **metabolism** disorders.

Preparation

Improperly prepared formulas can be a very common cause of infant illnesses. When preparing formula, it is recommended that it not be mixed with warm tap water as this can increase the amount of lead in the formula, which can be very harmful to the infant. Bottles should also not be heated in a microwave because this could cause the milk to scald or the bottle to explode. Lastly, adding sweetened beverages or cereals to bottles should also be avoided because they will only displace the more nutrient-dense formula.

Complications

Most women are capable of breastfeeding as long as they allow their infant to nurse, although there are special circumstances when formula must be used instead of breast milk. Galactosemia is a rare genetic disease in which newborns lack the enzyme needed to convert galactose to glucose. Galactose is a component of lactose, which is very abundant in breast milk. Without the enzyme to convert it to glucose, galactose accumulates in the **blood** causing tissue damage and possibly death. Therefore, it is essential that these infants receive a lactose-free soy-based formula.

Phenylketonuria is another genetic disorder in which newborns lack the enzyme needed to convert the essential amino acid phenylalanine to the amino acid tyrosine. Accumulation of phenylalanine in the blood can cause severe mental retardation. Therefore, it is necessary to start a low phenylalanine diet with a low phenylalanine formula.

Health care team roles

The dietitian plays a very important role in educating parents on the importance of adequate infant nutrition and proper feeding methods. Dietitians are also responsible for informing people of the proper preparation of formula and the advantages and disadvantages of both breastfeeding and formula feeding. While caring for an infant, it is important to have routine check-ups with the doctor to check the infant's height and weight to ensure

that the infant is at the right stage of growth and receiving adequate nutrition.

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Lisa M. Gourley

Infant respiratory distress syndrome see **Respiratory distress syndrome**

Infarct avid imaging see **Technetium heart scan**

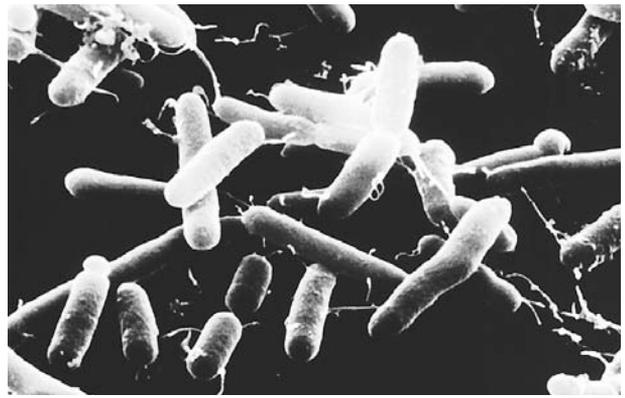
Infection

Definition

Infection is the invasion and replication of microorganisms—**viruses**, **bacteria**, protozoa, or **fungi**—in body tissues.

Description

There are thousands of infectious agents that can cause human disease. Although the body is extraordinarily adaptive in its responses to such agents, sometimes its



Salmonella bacteria often cause infection through food contamination. (Photograph by Oliver Meckes. Photo Researchers, Inc. Reproduced by permission.)

preventative measures fail, resulting in disease. A sub-clinical infection occurs when the body's defensive mechanisms are effective, resulting in no apparent clinical symptoms. When infection persists to cause disease, it is called an acute or chronic infection.

Infectious agents

There are four major classes of organisms that infect the human body:

- **Viruses:** microscopic agents that consist of genetic material coding for the virus's reproduction enclosed in a protective protein coat or lipid membrane. Viruses are obligate intracellular parasites; they cannot replicate without first infecting a cell and exploiting its reproductive capabilities.
- **Bacteria:** microscopic prokaryotic organisms (lacking a nuclear membrane, mitochondria, and other organelles). Two major classes include gram-positive bacteria (surrounded by a protective cell wall) and gram-negative bacteria (surrounded by an outer lipid membrane).
- **Fungi:** eukaryotic organisms (containing distinct organelles and a nucleus enclosed by a nuclear membrane). Fungi can be unicellular (e.g., yeast) or multicellular (e.g., mold).
- **Parasites:** eukaryotic organisms ranging from microscopic, unicellular protozoa to macroscopic arthropods and worms.

Infectious organisms are found everywhere on Earth—in extremes of hot and cold; in acidic and alkaline environments; in air, soil, and water; in our bodies, and on our skin. The human body is colonized by numerous types of bacteria (called normal flora) that reside in the **stomach**, intestines, colon, upper respiratory tract, and

KEY TERMS

B cells—White blood cells responsible for the production of antibodies.

Ciliated cells—Cells with hair-like structures that help flush out foreign particles from the human body.

Complement system—Proteins that activate inflammation response and recruit white blood cells to the site of infection.

Endogenous infection—Infection caused by the normal flora of the human body.

Eukaryote—An organism whose cells contain a true nucleus bound by a membrane.

Exogenous infection—Infection caused by microbes found external to the human body.

Normal flora—Types of bacteria and other organisms that colonize the human body without normally causing disease.

Obligate intracellular parasites—Microbes that must remain inside of a cell in order to survive and replicate.

Phagocytosis—Engulfment and digestion of foreign particles and cells by phagocytic cells such as neutrophils and macrophages.

Prokaryote—A cell that contains no true nucleus or membrane-bound organelles.

T cells—White blood cells responsible for activating and controlling immune response.

on the skin. Ordinarily, normal flora aids in food digestion, protection against disease, and various other functions. Exogenous infections occur when organisms found outside of the body cause disease, while endogenous infections are caused by the normal flora colonizing sterile tissue sites.

Transmission

There are countless ways in which an individual can become infected with an infectious organism. The mode of transmission depends largely on the type of organism, its size, its structure, its vector (who transmitted it), and other factors. Some common ways that infectious agents are transmitted (and examples of such agents) are:

- inhalation (*Mycobacterium tuberculosis*; **influenza** viruses; *Histoplasma capsulatum*, a fungus that causes pneumonia)

- ingestion (*Salmonella*, *Vibrio*, *Giardia* and *Listeria* species; *Escherichia coli*)
- penetration of skin (*Clostridium tetani*, causative agent of tetanus; *Staphylococcus aureus*; hepatitis C virus [HCV])
- sexual transmission (human **immunodeficiency** virus [HIV]; *Neisseria gonorrhoeae*; *Chlamydia trachomatis*)
- zoonoses or animal contact (flaviviruses; rabies virus; *Yersinia pestis*, causative agent of bubonic plague)
- mother-to-child (Rubella virus or German measles; herpes simplex virus [HSV]; varicella-zoster virus or chicken pox)

Role in human health

Response to infection

The human body has three basic means of defense against invading microorganisms: natural barriers, innate non-specific immunity, and antigen-specific immunity. Each protective measure acts at a different time point in infection and varies according to the type of infectious agent.

NATURAL BARRIERS. The first barriers against infection are the skin and mucous membranes (the inner lining of the mouth, nose, vagina, urethra, and upper respiratory tract). Besides providing a physical barrier against the entry of infectious agents, these tissues are inhospitable environments for invading microbes. For example, mucus (a secretion made of protein and sugar molecules) in the upper respiratory tract can trap infectious particles before they go on to colonize the lung; ciliated cells (with hair-like structures on their surface) help flush the particles out of the respiratory tract to be expelled. The gastrointestinal tract (including the stomach and intestines) and the urinary tract (including the bladder and **kidneys**) secrete fluids such as gastric juice and bile that create hostile conditions for infectious agents.

The temperature of the human body (normally 98.6°F or 37°C) is itself a mechanism of evading infection. A major elevation of body temperature (i.e., **fever**) can slow or prevent the colonization and spread of many microbes and increase the efficiency of **immune response**.

INNATE NON-SPECIFIC IMMUNE RESPONSE. When an infectious agent is able to evade natural barriers and enter the body, the first responses to its presence are non-specific protective responses. For example, the presence of certain microbial surface molecules activates the complement system (**proteins** that activate inflammation response and recruit white **blood** cells to the site of infec-

tion). The complement system attracts phagocytic cells such as neutrophils and macrophages, which engulf foreign particles and digest them. (Neutrophils circulate primarily in the blood stream, while macrophages reside in tissues.) Activation of the complement system leads to the classic symptoms of inflammation: **pain**, fever, erythema (redness), and **edema** (swelling).

ANTIGEN-SPECIFIC IMMUNE RESPONSE. If non-specific immunity fails to slow or prevent the spread of a microorganism, another line of defense may be used: antigen-specific immunity. Two classes of white blood cells have a large role in specific immune response; these are B cells (or B lymphocytes) and T cells (or T lymphocytes).

B cells are responsible for the production of antibodies, also called immunoglobulins. Antibodies bind specifically to a foreign particle (called an antigen) so that once antibodies have been produced against a particular invader, the **immune system** can react more rapidly if that invader enters the body again. Antibodies can also enhance phagocytosis, neutralize toxins, inhibit the binding of microorganisms to human cells, and activate the complement system.

There are two main types of T cells: helper T cells (CD4 type) and cytolytic and suppressor T cells (CD8 type). Helper T cells activate and control immune response by stimulating B cells to produce antibodies. Receptors on the surface of cytolytic T cells recognize cells with surface antigens; the cell is then killed. Suppressor T cells help regulate immune response.

In some cases immune response is over-stimulated, resulting in extensive tissue damage and systemic effects. An example is toxic shock syndrome (TSS), a disease that results from infection with *Staphylococcus aureus*. Upon infection the bacteria produces a toxin that over-stimulates immune response. The result is a proliferation of T cells and over-secretion of cytokines (small proteins that act as signals between cells of the immune system). The clinical manifestations of this disease are devastating: symptoms start with fever and hypotension (low **blood pressure**) and may progress to multiple organ failure and desquamation of the skin (extensive peeling or scaling).

Infection control

In the brochure “An Ounce of Prevention: Keeps the Germs Away,” (2000) the Centers for Disease Control and Prevention (CDC) identified some simple and inexpensive means of preventing the spread of infectious diseases. These include:

- Wash hands frequently.

- Clean and disinfect.
- Handle and prepare foods safely.
- Get immunized.
- Do not take unnecessary **antibiotics** (e.g., for viral infections).
- Keep pets healthy.
- Avoid contact with wild animals.

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Infection control

Definition

Infection control is the protection of patients and health care workers by the prevention of **infection** in the health care setting in a cost-efficient manner.

Standard precautions for infection control

Environmental control	Follow hospital procedures for routine care, cleaning, and disinfection of all surfaces, beds, bedrails, bedside equipment, and other frequently touched surfaces.
Linen	Handle, transport, and process used linen soiled with blood, body fluids, secretions, or excretions in a manner that prevents exposures and contamination of clothing, and avoids transferring microorganisms to other patients and environments.
Occupational health and bloodborne pathogens	Prevent injuries when using needles, scalpels, and other sharp instruments or devices; when handling sharp instruments after procedures; when cleaning used instruments; and when disposing of used needles. Never recap used needles using both hands or any other technique that involves pointing the needle toward any part of the body; instead, use a one-handed "scoop" technique or a mechanical device designed for holding the needle sheath. Do not remove used needles from disposable syringes by hand, and do not bend, break, or otherwise manipulate used needles by hand. Place used disposable syringes and needles, scalpel blades, and other sharp items in puncture-resistant sharps containers located as close as practical to the area in which the items were used, and place reusable syringes and needles in a puncture-resistant container for transport to the processing area. Use resuscitation devices as an alternative to mouth-to-mouth resuscitation.
Patient-care equipment	Handle used patient-care equipment soiled with blood, body fluids, secretions, or excretions in a manner that prevents skin and mucous membrane exposures and contamination of other patients and environments. Ensure that reusable equipment is not used for the care of another patient until it has been appropriately cleaned and reprocessed and single use items are properly discarded.
Patient placement	Use a private room for a patient who contaminates the environment or who does not (or cannot be expected to) assist in maintaining appropriate hygiene or environmental control. Consult Infection Control if a private room is not available.
Wash hands (plain soap)	Wash after touching blood, body fluids, secretions, excretions, and contaminated items. Wash immediately after gloves are removed and between patient contacts. Avoid transfer of microorganisms to other patients or environments.
Wear gloves	Wear when touching blood, body fluids, secretions, excretions, and contaminated items. Put on clean gloves just before touching mucous membranes and nonintact skin. Change gloves between tasks and procedures on the same patient after contact with material that may contain high concentrations of microorganisms. Remove gloves promptly after use, before touching non-contaminated items and other surfaces, and before going to another patient, and wash hands immediately to avoid transfer of microorganisms to other patients or environments.
Wear gown	Protect skin and prevent soiling of clothing during procedures that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions. Remove a soiled gown as promptly as possible and wash hands to avoid transferring microorganisms to other patients or environments.
Wear mask and eye protection or face shield	Protect mucous membranes of the eyes, nose, and mouth during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions.

SOURCE: CDC, 1996.

Purpose

The purpose of infection control is to reduce the risk of health care worker exposure and infection and nosocomial (hospital-acquired) infections, which can complicate existing diseases or injuries.

Description

Organized efforts at infection control began in the United States in the 1950s, along with the increase in intensive care units to care for critically ill patients and the emergence of nosocomial **staphylococcal infections**. Many hospitals implemented programs in the 1960s and 1970s at the insistence of various organizations. In the 1980s, state and federal agencies, along with professional organizations, began to make recommendations for infection control and require adherence to regulations.

Infection control procedures are followed in hospitals, long term care facilities, rehabilitation units, outpatient facilities, and **home care**. All infection control programs should encourage actions that limit the spread of nosocomial infections. All healthcare institutions are mandated by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) to "develop specific objectives and outcome measures to determine whether or not its infection control goals have been achieved" (AJIC, 1998). Infection control programs must include the means to measure the effectiveness of procedures, policies, or programs to protect patients and health care providers and to determine if these activities are cost-effective.

Health care organizations must be in compliance with regulations and accreditation requirements by various federal and state agencies and governing bodies. JCAHO, for instance, has standards that are incorporated

into many state licensing, as well as **Medicare** and **Medicaid**, regulations. The facility's administration is responsible for ensuring compliance. Ongoing education and training are an important part of an effective infection control program. Also, the monitoring of patient-care activities can identify areas of concern, and the data obtained is vital to improving the program and ensuring successes.

The Hospital Infections Program (HIP) of the National Center for Infectious Diseases, Centers for Disease Control and Prevention (CDC), is the focus for information, surveillance, investigation, prevention, and control of nosocomial infections for the U.S. Public Health Service, state and local health departments, hospitals, and professional organizations in the United States and around the world. Studies indicate that one-third of nosocomial infections can be prevented by well-organized infection control programs, yet only 6-9% are actually prevented. The Study of Efficacy of Nosocomial Infection Control (SENIC) carried out by HIP over ten years showed that, to be effective, nosocomial infection programs must include the following: 1) organized surveillance and control activities, 2) a ratio of one infection control practitioner for every 250 acute care beds, 3) a trained hospital epidemiologist, and 4) a system for reporting surgical wound infection rates back to surgeons (NNIS, 1996). The National Nosocomial Infections Surveillance (NNIS) System has been gathering information for 20 years regarding nosocomial infections. This information is being used to assist hospitals in conducting successful surveillance of these infections.

In 1987, the Centers for Disease Control (CDC) expanded previous recommendations to prevent the spread of human **immunodeficiency** virus (HIV), hepatitis B virus (HBV), and other bloodborne pathogens. Previously, certain isolation precautions were recommended only for those patients who were known or suspected to have bloodborne infectious diseases. Because of the growing number of persons infected with HIV and the high mortality rates associated with **AIDS**, Universal Blood and Body Fluids Precautions were developed. Under these new recommendations, all patients are considered potentially infectious for bloodborne infections. In 1991, the Occupational Safety and Health Administration's (OSHA) Bloodborne Pathogen Standard required the use of **universal precautions** and dictated that all staff must be trained annually on the risk of exposure to bloodborne pathogens. Preventing exposure is the best and safest way to reduce infection.

The effectiveness of infection control programs are evaluated in several ways: lower rates of infection for the patient, shorter periods of hospital stays, decreased morbidity, and reduction of on-the-job exposure of health

Methods of disinfection

Method	Use
Alcohols	Skin degerming.
Autoclaving	Sterilize instruments not harmed by heat and water pressure.
Boiling water	Kill non-spore-forming pathogenic organisms.
Chlorines	Water disinfection; food surface sanitization.
Ethylene oxide gas	Sterilization of heat-sensitive materials or those that must be kept dry.
Fiberglass filters	Air disinfection.
Formaldehyde (formalin)	Drastic disinfection.
Formaldehyde gas	Fumigation; sterilization of heat-sensitive materials.
Germicidal soaps (hexachlorophene)	Skin degerming.
Iodines, tincture	Skin degerming.
Iodines, iodophors	General disinfectant.
Ionizing	Sterilize medicines, some plastics, sutures, and biologicals.
Membrane filtration	Water purification.
Mercurials	Skin degerming.
Phenols	General disinfectant.
Quaternary ammonia compounds, tincture	Skin degerming.
Quaternary ammonia compounds, aqueous	General disinfectant.
Ultrasonic	Disinfect instruments.
Ultraviolet light	Air and surface disinfection.
Washing	Disinfect hands and surfaces.

SOURCE: Benarde, M.A., ed. *Disinfection: A Treatise*. New York: Marcel Dekker, 1970.

care workers to infection and contamination from patients. To do this, infection control policies focus on strategies for isolation, barrier precautions, case investigation, health care worker education, immunization services, and employee health programs. When healthcare institutions are successful in their infection control programs, it decreases the cost of care and has a positive impact on the institution's image within the community.

It is the responsibility of infection control to identify problems, collect and analyze data, change policies and procedures when necessary, and monitor data. The specific functions of an infection control program should be based on the needs of the individual healthcare institution. It is most important to monitor infection activity. Data is collected and disseminated based on the principles of epidemiology to implement quality-improvement activities and improve patient outcomes. Policies and procedures of the facility must be based on scientific and valid infection control prevention and be reviewed and updated frequently to reflect practice guidelines and standards.

SELECTED INFECTIOUS DISEASES AND CORRESPONDING TREATMENT

<i>Disease</i>	<i>Symptoms</i>	<i>Transmittal</i>	<i>Treatment</i>
Chicken pox	Rash, low-grade fever	Person to person	None
Common cold/ Influenza	Runny nose, sore throat, cough, fever, headache, muscle aches	Person to person	None
Hepatitis	Jaundice, flu-like symptoms	Sexual contact with an infected person, contaminated blood, food, or water	None
Legionnaire's Disease	Flu symptoms, pneumonia, diarrhea, vomiting, kidney failure, respiratory failure	Air conditioning or water systems	Antibiotics
Measles	Skin rash, runny nose and eyes, fever, cough	Person to person	None
Meningitis	Neck pain, headache, pain caused by exposure to light, fever, nausea, drowsiness	Person to person	Antibiotics for bacterial meningitis, hospital care for viral meningitis
Mumps	Swelling of salivary glands	Person to person	Anti-inflammatory drugs
Ringworm	Skin rash	Contact with infected animal or person	Antifungal drugs applied topically
Tetanus	Lockjaw, other spasms	Soil infection of wounds	Antibiotics, antitoxins, muscle relaxers

(Public Domain.)

Transmission of infection within a health care organization requires three elements: a source of infecting microorganisms, a susceptible host, and a means of transmission for the microorganism. The skin of patients and personnel can function as a reservoir for infectious agents and as a vehicle for transfer of infectious agents to susceptible persons. The microbial flora of the skin consists of resident and transient microorganisms. Resident microorganisms persist and multiply on the skin. Transient microorganisms are contaminants that can survive for only a limited period of time. Most resident microorganisms are found in superficial skin layers, but about 10-20% inhabit deep epidermal layers. Handwashing with plain soaps is effective in removing many transient microorganisms. Resident microorganisms in the deep layers may not be removed by hand-

washing with plain soaps, but usually can be killed or inhibited by antimicrobial products. *Handwashing is the single most important measure for preventing nosocomial infections.*

Hand-washing indications

Health care workers should wash their hands:

- after removing gloves
- when coming on duty
- when hands are soiled, including after sneezing, coughing, or blowing the nose
- between patient contacts
- before medication preparation
- after personal use of the toilet

- before performing invasive procedures
- before taking care of particularly susceptible patients, such as those who are severely immunocompromised and newborns
- before and after touching wounds
- before and after eating
- after touching inanimate objects that are likely to be contaminated with pathogenic microorganisms, such as urine-measuring devices and secretion collection apparatuses
- after taking care of infected patients or patients who are likely to be colonized with microorganisms of special clinical or epidemiologic significance; for example, **bacteria** that are resistant to multiple antibiotics

Preparation

Routine hand-washing is accomplished by vigorously rubbing together all surfaces of lathered hands followed by thorough rinsing under a stream of water. This should take 10-15 seconds to complete. The hands should be dried with a paper towel. Immediate recontamination of the hands by touching sink fixtures may be avoided by using a paper towel to turn off faucets.

Universal precautions recommend that all health care workers who come into contact with a patient's blood or body fluids that contain visible blood should wear an appropriate type of barrier to prevent the spread of blood-borne pathogens. Other body fluids for which barrier protection is recommended include semen, vaginal secretions, cerebrospinal fluid (CSF), synovial fluid, pleural fluid, pericardial fluid, and amniotic fluid. The type of exposure determines the specific barrier that should be used. Universal precautions are designed to augment, not replace, standard infection control procedures such as hand washing and the use of gloves when touching obviously infected materials.

Adequate routine cleaning and removal of soil should be the environmental sanitation procedure for all healthcare facilities. Microorganisms are normal contaminants of the environment. A healthcare facility's environmental services department should maintain schedules for routine cleaning in all rooms and include equipment and working surfaces. General and infectious wastes are disposed of on a regular schedule. All departments, though, are responsible for implementing infection control policies.

Complications

Health care workers must not be complacent about implementing their facility's infection control policies.

Perhaps due to long-time exposure to occupationally acquired infections, they have the tendency to minimize or ignore the ramifications. Infections oftentimes go undetected, underreported, or overlooked by health care workers.

Results

If infection control programs are successful, the result will be a reduction in the risk of infection and related adverse outcomes in the healthcare setting, achieved in a cost-efficient manner.

Health care team roles

Much of the responsibility for infection control rests on the shoulders of the clinical staff providing care at the bedside. Because nurses are close to the patient physically, they are able to prevent the spread of infection, but they can also be a means of transmitting infection. Therefore they need to foster compliance with infection control policies to ensure a high quality outcome for the patient. Infection control practices should have a positive effect on not only the clinical staff, but the patient as well.

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Infectious mononucleosis test

Definition

Infectious mononucleosis (IM) tests detect the presence or absence of antibodies in the **blood** stream directed against **proteins** of the Epstein-Barr Virus (EBV), the cause of IM.

Purpose

Infectious mononucleosis tests are used to diagnose infectious mononucleosis in patients with symptoms compatible with the disease. Initial testing is based on the demonstration of heterophile antibodies produced in infectious mononucleosis. Heterophile antibodies are those that react with the cells from a different (nonhuman) species. A positive result from a rapid slide (Monospot) test for IM specific heterophile antibodies is diagnostic, and no further testing is necessary. The Monospot test will be positive in more than 90% of adults or adolescents with IM, but is more frequently negative in young children. When the Monospot test results are negative, an EBV antibody panel may be needed to differentiate EBV infections from mononucleosis-like illnesses induced by cytomegalovirus, adenovirus, or *Toxoplasma gondii*. The EBV antibody panel can differentiate persons who have never been infected with EBV, acute infections, and past infections. EBV antibody tests are not needed when the doctor believes that a person has IM and the Monospot test is positive.

Precautions

Blood for this test is collected by venipuncture. The nurse or phlebotomist performing the procedure should observe **universal precautions** for the prevention of

transmission of bloodborne pathogens. False positive Monospot results occur in a small percentage of the patient population. False negative Monospot results occur in 10% to 15% of patients, primarily in children under the age of 10. With the EBV panel false positive results may occur in patients with rheumatoid arthritis, leukemia, lymphoma, or HIV.

Description

The Epstein-Barr Virus (EBV) is one of the most common human **viruses**, and most of the world's population is infected at sometime during their lives. According to the CDC, when an EBV **infection** occurs during adolescence or young adulthood, it causes infectious mononucleosis 35–50% of the time. The virus is believed to be transmitted primarily via salivary exchange, including intimate kissing, sharing toothbrushes, cups, or eating utensils..

Symptoms of infectious mononucleosis include **fever, sore throat**, swollen lymph glands lasting for two to three weeks, and fatigue and a swollen spleen or **liver** typically lasting for approximately one month. While the infection is rarely fatal and usually resolves in one or two months, the course is more chronic in some persons, and the virus may remain dormant in some throat and blood cells for the rest of the person's life.

The clinical diagnosis of infectious mononucleosis is suggested on the basis of the symptoms of fever, sore throat, swollen lymph glands, and the age of the patient. Laboratory tests are needed for confirmation. Laboratory findings suggestive of infectious mononucleosis include an elevated white blood cell count, an increased lymphocyte count, and the presence of a significant number of atypical lymphocytes (seen when viewing a stained blood smear under the **microscope**). Diagnosis is usually made by demonstrating a positive reaction to a rapid slide test (usually referred to as a Monospot test) for the specific heterophile antibodies seen in IM.

Heterophile antibodies may be of two types, called Forssman and nonForssman. Infectious mononucleosis causes production of nonForssman heterophile antibodies. Testing for heterophile antibodies must distinguish these from the Forssman type which are not produced by IM and are present in the blood of many persons without IM. The Monospot test is based upon the principle that IM heterophile antibodies will agglutinate horse red blood cells (because they are nonForssman). First, the serum is mixed with two different antigen suspensions, guinea pig kidney antigen and beef red blood cell stroma, prior to testing with the horse red cells. The guinea pig kidney antigen absorbs (removes) Forssman heterophile antibodies while the beef red cell stroma removes

nonForssman IM antibodies. After mixing the serum with these two suspensions, the serum is mixed with the horse red cells. In infectious mononucleosis, agglutination should be seen in the serum mixed with guinea pig antigen. Little or no agglutination should be seen in the serum mixed with the beef red cell stroma.

An EBV antibody panel can be used to confirm a negative Monospot result or rule out a false positive Monospot result. The panel includes four antibody measurements: IgM viral capsid antigen (VCA), IgG VCA, Early Antigen (EA), and Epstein-Barr nuclear antigen (EBNA), which help determine the stage of the patient's EBV infection.

Preparation

To obtain the 2 mLs of blood required for this test, a nurse or phlebotomist ties a tourniquet on the person's upper arm, locates a vein in the inner elbow region, and inserts a needle into that vein. Vacuum action draws the blood through the needle into an attached tube. Collection of the sample takes only a few minutes.

Aftercare

Discomfort or bruising may occur at the puncture site. Applying pressure to the puncture site until the bleeding stops reduces bruising; warm packs relieve discomfort. Some people feel dizzy or faint after blood has been drawn and should be treated accordingly.

Complications

There are no risks beyond those of having blood drawn for any other purpose.

Results

Results of the rapid slide test are determined as positive or negative. According to the CDC, the confirmatory diagnosis of EBV infection is summarized as follows:

- **Susceptibility:** If antibodies to the VCA are not detected.
- **Primary infection:** If IgM antibody to the VCA is present in the absence of antibody to EBNA. A rising or high IgG antibody titre to the viral capsid antigen and a negative antibody test to EBNA after at least four weeks of illness are strongly suggestive of primary infection.
- **Past infection:** If antibodies to both the VCA and EBNA are present, then past infection (from four to six months to years earlier) is indicated.
- **Reactivation:** In the presence of antibodies to EBNA, an elevation of antibodies to early antigen suggests reactivation.

KEY TERMS

Heterophile antibodies—Antibodies created against one species that cross react with another.

Lymphocyte—White blood cell that fights viral and some bacterial infections by direct attack or the production of antibodies.

- **Chronic EBV infection:** Reliable laboratory evidence for continued active EBV infection is very seldom found in patients who have been ill for more than four months.

If the results are difficult to interpret, it may be necessary to retest later, after waiting one to three weeks. The change in the amounts of antibody detected between the two tests can be particularly useful, at times, in helping to make a diagnosis.

The **complete blood count (CBC)** in a patient with infectious mononucleosis typically reveals:

- a white blood cell count (WBC) of 10,000 to 20,000 cells per microliter
- more than 4,500 lymphocytes per microliter and more than 50% lymphocytes in the differential
- atypical lymphocytes (Downey cells) accounting for more than 10% of total leukocytes

Health care team roles

Physicians order and interpret the IM tests. Nurses or phlebotomists usually draw the blood needed for these tests. Clinical laboratory scientists/medical technologists or clinical laboratory technicians/medical laboratory technicians perform the antibody tests in clinical laboratories. Interpretation of EBV antibody tests is somewhat complex and requires familiarity with EBV testing and access to all the patient's clinical information.

Resources

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Infertility

Definition

Infertility is the failure to conceive a **pregnancy** after attempting for at least one full year. In primary infertility, pregnancy has never occurred. In secondary infertility, one or both members of the couple have previously conceived, but are unable to conceive again after a full year of attempting.

Description

Currently, in the United States, about one in five couples struggles with infertility at any given time. Infertility has increased as a problem over the last 30 years. Some studies assign the blame for this increase on social phenomena, including the tendency for marriage to occur at a later age. Fertility in women decreases with increasing age, as illustrated by the following statistics. In one year of trying to become pregnant:

- Infertility in women at age 20 is 4%.
- Infertility in women at age 30 is 7%.
- Infertility in women at age 35 is 12%.
- Infertility in women over the age of 40 is 75%.

Many individuals have multiple sexual partners before marriage. This increase in numbers of sexual partners has led to a rise in sexually transmitted diseases. Scarring from these infections, especially from pelvic inflammatory disease (PID, a serious **infection** of the female reproductive organs, most commonly caused by chlamydia and gonorrhea), seems to be partially responsible for increases in infertility. Furthermore, use of some forms of a contraceptive called the intrauterine device (IUD) contributed to an increased rate of pelvic inflammatory disease. However, the newer IUDs do not cause infections.

To understand issues of infertility, it is first necessary to understand the basics of human reproduction. Fertilization occurs when a sperm from the male merges with an egg (ovum) from the female, creating a zygote that contains genetic material (DNA) from both the father and the mother. If pregnancy is then established, the zygote will develop into an embryo, then a fetus, and ultimately a baby will be born.

The male contribution to fertilization and the establishment of pregnancy is the sperm. Sperm are small cells that carry the father's genetic material, which is contained within the oval head of the sperm. The sperm are mixed into a fluid called semen that is discharged from the penis during sexual intercourse. The whip-like tail of sperm allows them to swim up the female reproductive tract in search of an egg (ovum).

The female makes many contributions to fertilization and the establishment of pregnancy. The ovum is the cell that carries the mother's genetic material; ova (plural of ovum) develop within the ovaries. Once a month, a single mature ovum is produced, and leaves the ovary in a process called ovulation. This ovum enters a tube leading to the uterus (the fallopian tube). If fertilization is to occur, the ovum must encounter the sperm in the fallopian tube.

When fertilization occurs, the resulting cell is called a zygote. This single cell will multiply within the fallopian tube, and the resulting cluster of cells, a blastocyst, will then move into the womb (uterus). The uterine lining (endometrium) has been preparing itself to receive a pregnancy by growing thicker. If the blastocyst successfully reaches the inside of the uterus and attaches itself to the wall of the uterus, then pregnancy has been achieved.

Causes and symptoms

Unlike most medical problems, infertility is an issue requiring the careful evaluation of two separate individuals, as well as an evaluation of their interactions with each other. In about 3–4% of couples, no cause for their infertility will be discovered.

The main factors involved in causing infertility, ranging from the most to the least common, include:

- male problems: 30-40%
- ovulation problems: 10-15%
- pelvic disease: 30-40%
- cervical factors: 10-15%
- undiagnosed: 5-10%

Diagnosis

Diagnosis of infertility involves examination of both male and female partners.

Male factors

Male infertility can be caused by a number of different characteristics of sperm. To check for these characteristics, a sample of semen is obtained and examined under a **microscope (semen analysis)**. Four basic characteristics are usually evaluated:

- Sperm count refers to the number of sperm present in a semen sample. The typical number of sperm present in just one milliliter (ml) of semen is more than 20 million. A male with only 5–20 million sperm per ml of semen is considered subfertile, while a male with less than 5 million sperm per ml of semen is considered to be infertile.
- Sperm are examined to determine how well they swim (sperm motility) and to ensure that most have normal structure (morphology). Not all sperm within a specimen of semen will be perfectly normal. Some may be immature, and others may have abnormalities of the head or tail. A typical semen sample will contain no more than 25% abnormal forms of sperm.
- Volume of the semen sample is important; an abnormal amount of semen could adversely affect the ability of the sperm to successfully fertilize an ovum.
- The ability of the sperm to penetrate the outer coat of the ovum is also evaluated. This is accomplished by observing whether sperm in a semen sample can penetrate the outer coat of a hamster ovum. Fertilization cannot occur, of course, but this test is useful in predicting the ability of an individual's sperm to penetrate a human ovum.

Any number of conditions result in abnormal findings in the semen analysis. Men can be born with testicles that have not descended properly from the abdominal cavity into the scrotal sac, or may be born with only one testicle, instead of the normal two. Testicle size might be smaller than normal. Past infection (including mumps) can affect testicular function, as can a past injury. The presence of abnormally large veins (varicocele) in the testicles can increase testicular temperature, which decreases sperm count.

History of having been exposed to various toxins, drug use, excessive alcohol use, use of anabolic steroids, certain medications, diabetes, thyroid problems, or other endocrine disturbances can have direct effects on the formation of sperm (spermatogenesis). Problems with the male anatomy can cause sperm to be ejaculated into the bladder, or scarring from past infections can interfere with ejaculation.

Female factors

OVULATORY PROBLEMS. The first step in diagnosing ovulatory problems is to make sure that an ovum is being produced each month. A woman's body temperature in the morning is slightly higher around the time of ovulation. A woman can measure and record her temperatures daily, and a chart can be drawn to show whether or not ovulation has occurred. Luteinizing hormone (LH) is released just before ovulation. A simple urine test can be done to check if LH has been released around the time that ovulation is expected.

PELVIC ADHESIONS AND ENDOMETRIOSIS. Pelvic adhesions and endometriosis can cause infertility by preventing the sperm from reaching the egg or interfering with fertilization.

Pelvic adhesions are fibrous scars. These scars can be the result of past infections, such as pelvic inflammatory disease, or infections following abortions or prior births. Previous surgeries can also leave behind scarring. Pelvic adhesions cause infertility by blocking the fallopian tubes. The ovum may be prevented from traveling down the fallopian tube from the ovary or the sperm may be prevented from traveling up the fallopian tube from the uterus.

A hysterosalpingogram (HSG) can show if the fallopian tubes are blocked. This is an x-ray exam that tests whether dye material can travel through a woman's fallopian tubes. Scarring also can be diagnosed by examining the pelvic area through the use of a scope that can be inserted into the abdomen through a tiny incision made near the navel. This technique is called **laparoscopy**.

Endometriosis may lead to pelvic adhesions. Endometriosis is the abnormal location of uterine tissue outside of the uterus. When uterine tissue is implanted elsewhere in the pelvis, it still bleeds on a monthly basis with the start of the normal menstrual period. This leads to irritation within the pelvis around the site of this abnormal tissue and bleeding, and may cause scarring.

CERVICAL FACTORS. The cervix is the opening from the vagina into the uterus through which the sperm must pass. Mucus produced by the cervix helps to transport the sperm into the uterus. Cervical mucus can be examined under a microscope to diagnose whether cervical factors are contributing to infertility. An injury to the cervix or scarring of the cervix after surgery or infection can result in a smaller than normal cervical opening, which would make it difficult for sperm to enter. Injury or infection can also decrease the number of glands in the cervix, leading to a smaller amount of cervical mucus. In other situations, the mucus produced might be the wrong consistency to allow sperm to travel through. In addition,

some women produce antibodies (immune cells) that identify sperm as foreign invaders and kill them. Finally, cervical stenosis is a rare cause of infertility.

Treatment

Treatment of infertility first involves addressing underlying conditions in the male and female partners. If these fail to produce a pregnancy, additional steps can be undertaken to assist pregnancy.

Treatment of male infertility includes first addressing known reversible factors such as discontinuing any medication known to have an effect on spermatogenesis or ejaculation, decreasing alcohol intake, or treating thyroid or other endocrine disease. Varicoceles can be treated surgically. Testosterone in low doses can improve sperm motility.

Other treatments of male infertility include collecting semen samples from multiple ejaculations, after which the semen is put through a process that allows the most motile sperm to be sorted out. These motile sperm are pooled together to create a concentrate that can be deposited into the female partner's uterus at ovulation. In cases where the male partner's sperm is proven unviable, with the consent of both partners, donor sperm may be used. Depositing the male partner's sperm or donor sperm by mechanical means into the female partner is a form of artificial insemination.

Treatment of ovulatory problems depends on the cause. If a thyroid or pituitary problem is responsible, treating that problem can restore fertility. Medication such as Clomid and Pergonal can be used to stimulate fertility. These drugs may increase the risk of multiple births (twins, triplets, etc.).

Pelvic adhesions can be excised with laparoscopy. Endometriosis can be treated with certain medications, but may also require surgery to repair any obstruction caused by adhesions.

Treatment of cervical factors includes **antibiotics** in the case of an infection, steroids to decrease production of anti-sperm antibodies, and artificial insemination techniques to completely bypass the cervical mucus.

Assisted reproductive techniques include in vitro fertilization (IVF), gamete intrafallopian transfer (GIFT), and zygote intrafallopian tube transfer (ZIFT). These are usually used after other techniques to treat infertility have failed.

IVF involves the use of a drug to induce the simultaneous release of many eggs from a female's ovaries. These are surgically retrieved. Meanwhile, several semen samples are obtained from the male partner, and a sperm

concentrate is prepared. The ova and sperm are then combined in a laboratory, where several of the ova may be fertilized. **Cell division** is allowed to take place up to the embryo stage. While this takes place, the female may be given drugs to prepare her uterus to receive an embryo. Three or four of the embryos are transferred to the female's uterus, and the wait begins to see if any or all of them implant and result in an actual pregnancy.

Success rates of IVF are still rather low. Most centers report pregnancy rates between 10–20%. Since most IVF procedures put more than one embryo into the uterus, the chance for a multiple birth is greatly increased in couples undergoing IVF.

GIFT involves retrieval of both multiple ova and semen, and the mechanical placement of both within the female partner's fallopian tubes. ZIFT involves the same retrieval of ova and semen and the fertilization and growth in the laboratory up to the zygote stage, at which point the zygotes are placed in the fallopian tubes. Both GIFT and ZIFT have higher success rates than IVF.

Prognosis

It is very difficult to obtain statistics regarding the prognosis of infertility because many different problems may exist within an individual or couple trying to conceive. In general, of all couples who undergo a complete evaluation of infertility followed by treatment, about half will ultimately have a successful pregnancy. Of those couples who do not choose to undergo evaluation or treatment, about 5% will go on to conceive after a year or more of infertility.

Health care team roles

Gynecologists who specialize in infertility lead most investigations. Registered nurses (RNs) assist throughout investigations and other associated procedures. Laboratory technicians conduct laboratory tests and evaluations of ova and sperm. Other technicians may assist in preparing eggs and sperm for IVF, or readying women for GIFT or ZIFT. Pharmacists dispense the many drugs that are required for GIFT, ZIFT, or IVF.

Prevention

Prevention of infertility involves avoiding many of the various problems that can cause infertility. Since sperm count declines with age, insemination is more likely to occur with younger men than older men. Males can preserve maximal fertility by maintaining optimal temperatures in their testicles by wearing non-binding undergarments. People should avoid exposure to coal-

based products such as tar and soot as they are associated with infertility. Protecting the testicles from trauma helps to preserve fertility. Immunization for mumps is important.

Women are maximally fertile in the beginning of their third decade of life. Thereafter, conception becomes more difficult. Avoiding or promptly treating sexually transmitted diseases lessens the possibility of endometriosis and pelvic adhesions. Limiting the number of male partners improves fertility as antibodies against sperm will not be formed. Hasty decisions to perform tubal ligations as a means of birth control may be regretted if marital arrangements change. Although tubal ligations can be reversed, subsequent pregnancy rates are not 100%.

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- American College of Obstetricians and Gynecologists. 409 12th St., S.W., P.O. Box 96920, Washington, D.C. 20090-6920. <<http://www.acog.org>>.
- American Infertility Association. 666 Fifth Avenue, Suite 278, New York, NY 10103. (718) 621-5083. <<http://www.americaninfertility.org>>. info@americaninfertility.org.
- American Society for Reproductive Medicine. 1209 Montgomery Highway, Birmingham, AL 35216-2809. (205) 978-5000. <<http://www.asrm.com>>.
- International Council on Infertility Information Dissemination, Inc. P.O. Box 6836, Arlington, Virginia 22206. (703) 379-9178. <<http://www.inciid.org>>.
- Resolve: The National Infertility Association. 1310 Broadway, Somerville, MA 02144. (617) 623-0744. <<http://www.resolve.org>> resolveinc@aol.com.

OTHER

- Internet Health Resources. <<http://www.ihr.com/infertility>>.
- IVF.com. <<http://www.ivf.com>>.

KEY TERMS

Blastocyst—A cluster of cells representing multiple cell divisions that have occurred in the fallopian tube after successful fertilization of an ovum by a sperm.

Cervix—The opening from the vagina that leads into the uterus.

Embryo—The stage of development of a baby between the second and eighth weeks after conception.

Endometrium—The lining of the uterus.

Fallopian tube—The tube leading from the ovary into the uterus; there are two fallopian tubes.

Fetus—A baby developing in the uterus from the third month to birth.

Ovary—The female organ in which eggs (ova) are stored and mature.

Ovum (plural: ova)—The reproductive cell of the female that contains genetic information and participates in the act of fertilization. Also popularly called the egg.

Semen—The fluid that contains sperm that is ejaculated by the male.

Sperm—The reproductive cell of the male that contains genetic information and participates in the act of fertilization of an ovum.

Spermatogenesis—The process by which sperm develop to become mature sperm, capable of fertilizing an ovum.

Zygote—The result of sperm successfully fertilizing an ovum, the zygote is a single cell that contains the genetic material of both the mother and the father.

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Infertility therapies see **Fertility treatments**

Influenza

Definition

Usually referred to as the flu or gripe, influenza is a highly infectious respiratory disease caused by certain strains of influenza virus. When the virus is inhaled it attacks cells in the upper respiratory tract causing typical flu symptoms such as fatigue, **fever** and chills, hacking cough, and body aches. Influenza victims are also susceptible to potentially life-threatening secondary infections. Although the **stomach** or intestinal upsets and **diarrhea** are commonly called “flu,” the influenza virus rarely causes gastrointestinal symptoms. Such symptoms are most likely due to other organisms such as rotavirus, *Salmonella*, *Shigella*, or *Escherichia coli*.

Description

Influenza is considerably more debilitating than the **common cold**. Influenza outbreaks occur suddenly and **infection** rapidly spreads. The annual death toll attributable to influenza and its complications averages 20,000 in the United States alone.

Influenza outbreaks occur on a regular basis. Pandemics, the most serious outbreaks, affect millions of people worldwide and last for several months. The 1918–1919 influenza outbreak serves as the primary example of an influenza pandemic. In that Spanish flu pandemic, the death toll reached a staggering 20–40 million people worldwide. Approximately 500,000 of these fatalities occurred in the United States. Pandemics also occurred in 1957 and 1968 with the Asian flu and Hong Kong flu, respectively. The Asian flu was responsible for 70,000 deaths in the United States, while the Hong Kong flu killed 34,000 people.

Epidemics are widespread regional outbreaks that occur every two to three years and affect 5–10% of the population. The Russian flu in the winter of 1977 is an example of an epidemic. A regional epidemic is shorter lived than a pandemic, lasting only several weeks. Finally, there are smaller outbreaks each winter that are confined to specific locales.

The earliest existing descriptions of influenza were written nearly 2,500 years ago by the ancient Greek physician, Hippocrates. Historically, influenza was ascribed to a number of different agents, including “bad air” and several different **bacteria**. It was not until 1933 that the causative agent was identified as a virus.

There are three types of influenza **viruses**, identified as A, B, and C. Influenza A can infect a range of species, including humans, pigs, horses, and birds, but only

humans are infected by types B and C. Influenza A is responsible for most flu cases, while infection with types B and C viruses are less common and cause a milder illness.

Causes and symptoms

Approximately one to four days after infection with the influenza virus, a person is hit with an array of symptoms. “Hit” is an appropriate term, because symptoms are sudden, harsh, and followed by overall bodily aches and a fever that may run as high as 104°F (40°C). As the fever subsides, nasal congestion and a **sore throat** become noticeable. Persons with the flu feel extremely tired and generally miserable. Typical influenza symptoms include the abrupt onset of a headache, dry cough, and chills, and a rapid onset of physical weakness. Normal energy levels typically do not return for several days, but this can extend up to two weeks.

Influenza complications usually arise from secondary bacterial infections of the lower respiratory tract. Signs of a secondary respiratory infection often appear just as a person seems to be recovering. These signs include high fever, intense chills, chest pains associated with breathing, and a productive cough with thick, yellowish-green sputum. If these symptoms appear, medical treatment is necessary. Other secondary infections, such as sinus or ear infections, may also require medical intervention. **Heart** and lung problems and other chronic diseases can be aggravated by influenza. This is a particular concern among elderly people.

With children and teenagers, it is advisable to be alert for symptoms of Reye’s syndrome, a rare but serious complication of the flu. Symptoms of Reye’s syndrome are nausea and vomiting, and—more seriously—neurological problems such as confusion or delirium. Among children Reye’s syndrome can be fatal. The syndrome has been associated with the use of aspirin to relieve flu symptoms.

Diagnosis

Although specific laboratory tests can be performed on respiratory samples to identify a flu virus strain, doctors typically rely on a set of symptoms and the presence of influenza in the community for diagnosis. Specific tests are useful to determine the type of flu in the community, but they do little to influence individual treatment. Doctors may administer tests, such as throat cultures, to identify and treat secondary bacterial infections.

Treatment

Essentially, little can be done for a case of influenza as it must simply run its course. Symptoms can be relieved with bed rest and by keeping well hydrated. A steam vaporizer may make breathing easier, and **pain** relievers such as ibuprofen and acetaminophen will relieve most aches and pains. Food may not seem appetizing, but an effort should be made to consume nourishing food. Returning to normal activities too quickly invites a possible relapse or complications.

Drugs

Since influenza is a viral infection, **antibiotics** are not an effective treatment. However, antibiotics are frequently used to treat secondary infections. Over-the-counter medications are used to treat symptoms, but it is not necessary to purchase a product marketed specifically for flu symptoms. Any medication designed to relieve pain and coughing will provide some relief. Products containing alcohol, however, should be avoided because of the dehydrating effects of alcohol. The best medicine for symptoms is simply an analgesic, such as acetaminophen or ibuprofen. Without a doctor's approval, aspirin is generally not recommended for people under the age of 18 years owing to its association with Reye's syndrome. As a precaution against the syndrome, children should receive acetaminophen or ibuprofen to treat their symptoms.

There are two **antiviral drugs** marketed for use in the United States against the influenza virus. These may be useful in treating individuals who have weakened immune systems or who are at risk for developing serious complications of influenza but may be allergic to the flu vaccine. The first is amantadine hydrochloride, which is marketed under the names Symmetrel (syrup), Symadine (capsule), and Amantadine-hydrochloride (capsule and syrup). The second antiviral is rimantadine hydrochloride, marketed under the trade name Flumandine (tablet and syrup). These two drugs are chemically related and are only effective against type A influenza viruses. Both drugs can cause side effects such as nervousness, **anxiety**, lightheadedness, and nausea. Side effects are more likely to occur with amantadine. Severe side effects include seizures, delirium, and hallucinations. These are rare and are nearly always limited to people who have kidney problems, seizure disorders, or psychiatric disorders.

Alternative treatment

There are several alternative treatments that may help in fighting off the virus, easing symptoms, and promoting recovery:



A transmission electron micrograph (TEM) of influenza viruses budding from the surface of an infected cell.

(Photo Researchers, Inc. Reproduced by permission.)

- **Acupuncture and acupressure.** Both are said to stimulate natural resistance, relieve nasal congestion and headaches, fight fever, and calm coughs, depending on the acupuncture and acupressure points used.
- **Aromatherapy.** Aromatherapists recommend gargling daily with one drop each of the essential oils of tea tree (*Melaleuca* spp.) and lemon mixed in a glass of warm water. If the patient is already suffering from the flu, two drops of tea tree oil in a hot bath may help ease the symptoms. Essential oils of eucalyptus (*Eucalyptus globulus*) or peppermint (*Mentha piperita*) added to a steam vaporizer may help clear chest and nasal congestion.
- **Herbal remedies.** Herbal remedies such as echinacea can be used to stimulate the **immune system**; as antivirals, goldenseal (*Hydrastis canadensis*) and garlic (*Allium sativum*) can be used. They can also be used to alleviate whatever symptoms arise as a result of the flu. For example, an infusion of boneset (*Eupatatorium perfoliatum*) may counteract aches and fever, and yarrow (*Achillea millefolium*) or elderflower tinctures may combat chills.
- **Homeopathy.** To prevent flu a homeopathic remedy called *Oscillocochinum* may be taken at the first sign of flu symptoms and repeated for a day or two. Other recommended homeopathic remedies vary according to the specific flu symptoms present. *Gelsemium* (*Gelsemium sempervirens*) is recommended to combat weakness accompanied by chills, headache, and nasal congestion. *Bryonia* (*Bryonia alba*) may be used to treat muscle aches, headaches, and a dry cough. For restlessness, chills, hoarseness, and achy joints, poison ivy (*Rhus toxicodendron*) is recommended. Finally, for bodily aches and a dry cough or chills, *Eupatorium perfoliatum* is suggested.

- **Hydrotherapy.** A hot bath to induce a fever will speed recovery from the flu by creating an environment in the body where the flu virus cannot survive. Taking a bath in water as hot as can be tolerated, and remain in the bath for 20–30 minutes, is recommended. While in the bath, drinking a cup of yarrow or elderflower tea helps induce sweating. However, a cold cloth should be held on the forehead or the nape of the neck to keep down the temperature of the **brain**. In case dizziness or weakness occurs, the patient should be assisted when getting out of the bath. The individual should then go to bed and cover up with layers of blankets to induce more sweating.
- **Vitamins.** For adults, 2–3 grams of **vitamin C** daily may help prevent the flu. Increasing the dose to 5–7 grams per day if infected by the flu can help overcome the infection. The dose of vitamin C should be reduced if diarrhea develops.

Prognosis

Following proper treatment guidelines, healthy people under the age of 65 years of age usually suffer no long-term consequences associated with influenza infections. While the elderly and the chronically ill are at greater risk for secondary infection and other complications, they can also recover completely. While most people fully recover from an influenza infection, the flu should not be viewed with complacency. Influenza is a serious disease. Approximately one in every 1,000 cases proves fatal.

Health care team roles

Family physicians, internists, and pediatricians most often diagnose influenza in people who seek medical attention. Nurse practitioners and physician assistants may also make such diagnoses. A physician usually prescribes over-the-counter products for symptomatic relief. Occasionally, antiviral products are prescribed for people at particular risk. Nurses administer vaccines to prevent influenza, providing education and information to those contemplating or receiving the vaccine.

Prevention

The Centers for Disease Control and Prevention recommend that people—particularly the at-risk population such as children, individuals with other diseases or disorders or a compromised immune system, and the elderly—get an influenza vaccine injection each year before the flu season starts. In the United States the flu season typically runs from late December to early March. Vaccines should be received two to six weeks prior to the

beginning of the flu season to allow people's bodies enough time to establish immunity. Adults need only one dose of the yearly vaccine, but children under nine years of age who have not previously been immunized should receive two doses with a month between each dose.

Each season's flu vaccine contains three virus strains that are the most likely to be encountered in the coming flu season. When there is a good match between the anticipated flu strains and the strains used in the vaccine, the vaccine is 70–90% effective in people younger than 65 years of age. Because **immune response** diminishes somewhat with age, people older than 65 years may not receive the same level of protection from the vaccine as do younger people. Even if they do contract the flu, the elderly benefit from vaccines, which diminish severity and help prevent complications.

The virus strains used to make the vaccine are inactivated and will not cause a case of influenza. In the past, flu symptoms following **vaccination** were associated with vaccine preparations that were not as highly purified as modern vaccines, not to the virus itself. In 1976 there was a slightly increased risk of developing Guillain-Barré syndrome, a very rare disorder associated with the swine flu vaccine. This association occurred only with the 1976 swine flu vaccine preparation and has never recurred.

Serious side effects with modern vaccines are extremely unusual. Some people experience a slight soreness at the point of injection, which resolves within a day or two. People who have never been exposed to influenza, particularly children, may experience one to two days of a slight fever, tiredness, and muscle aches. These symptoms start within 6 to 12 hours after vaccination.

It should be noted that certain people should not receive an influenza vaccine. Infants six months and younger have immature immune systems and will not benefit from the vaccine. Since the vaccines are prepared using hen eggs, people who have severe **allergies** to eggs or other vaccine components should not receive the influenza vaccine. As an alternative, they may receive a course of amantadine or rimantadine, which are also used as protective measures against influenza. Other people who might receive these drugs are those who have been immunized after the flu season has started or who are immunocompromised, such as people with advanced HIV disease. Amantadine and rimantadine are 70–90% effective in preventing influenza.

Members of certain groups are strongly advised to be vaccinated because they are at-risk for influenza-related complications:

- all people 65 years and older

- residents of **nursing homes** and chronic-care facilities, regardless of age
- adults and children who have chronic heart or lung problems, such as asthma
- adults and children who have chronic metabolic diseases, such as diabetes and renal dysfunction, as well as severe anemia or inherited hemoglobin disorders
- children and teenagers receiving long-term aspirin therapy
- pregnant women who will be in the second or third trimester during flu season, or women who are nursing
- anyone who is immunocompromised, including HIV-infected people with CD4 count over 200; people with **cancer**; organ transplant recipients; and people receiving steroids, **chemotherapy**, or radiation therapy
- anyone in contact with people in these groups, such as teachers, care givers, health-care personnel, and family members
- travelers to foreign countries

An individual need not be in one of the at-risk categories listed above, however, to receive a flu vaccination. Anyone who wants to avoid the discomfort and inconvenience of a case of influenza should receive the vaccine.

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KEY TERMS

Common cold—A mild illness caused by an upper respiratory virus. Usual symptoms include nasal congestion, coughing, sneezing, throat irritation, and a low-grade fever.

Epidemic—A widespread regional disease outbreak.

Guillain-Barré syndrome—Also called acute idiopathic polyneuritis, this condition is a neurologic syndrome that can cause numbness in the limbs and muscle weakness following certain viral infections.

Pandemic—Worldwide or multiregional outbreak of an infection afflicting millions of people.

Reye's syndrome—A syndrome of nausea, vomiting, and neurological problems such as confusion or delirium. It can be fatal in children.

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American Academy of Pediatrics. 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. <<http://www.aap.org/default.htm>>.

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Informed consent

Definition

Informed consent is a legal document in all 50 states, prepared as an agreement for treatment, nontreatment, or for an invasive procedure that requires physicians to disclose the benefits, risks, and alternatives to said treatment, nontreatment, or procedure. It is the method by which a fully informed, rational patient may be involved in choices about his or her health care.

Description

Informed consent stems from the legal and ethical right the patient has to decide what is done to his or her body, and from the physician's ethical duty to make sure that the patient is involved in decisions about his or her own health care. The process of securing informed consent has three phases, all of which involve information exchange between doctor and patient and are part of **patient education**. First, in words the patient can understand, the physician must convey the details of a planned procedure or treatment, its potential benefits and serious risks, and any feasible alternatives. The patient should be presented with information on the most likely outcomes of the treatment. Second, the physician must evaluate whether or not the person has understood what has been said, must ascertain that the risks have been accepted, and that the patient is giving consent to proceed with the procedure or treatment with full knowledge and forethought. Finally, the patient must sign the consent form, which documents in generic format the major points of

consideration. The only exception to this is securing informed consent during extreme emergencies.

It is critical that the patient receive enough information on which to base informed consent, and that the consent is wholly voluntary and has not been forced in any way. It is the responsibility of the physician who discusses the particulars with the patient to detail the conversation in the patient's record. A physician may, at his or her discretion, appoint another member of the health care team to obtain the patient's signature on the consent form, with the assurance that the physician has satisfied the requirements of informed consent.

Paul H. Ting, M.D., Assistant Professor of Anesthesiology at the University of Virginia and editor of the "About Anesthesiology" web site discusses why patients are apprehensive. "I think that people's greatest concerns are...whether they will live or die...whether they will feel any **pain** or be uncomfortable...whether they will be well taken care of (and I include in this whether their care will lead to a successful result and whether they will be treated with dignity)...."

"The boilerplate consent form has good intentions; it is comprehensive and therefore should reflect that a comprehensive discussion was completed," said Dr. Ting. "The actual form itself is in place to protect the hospital and the physician. Legally, it is proof that things have been covered and the patient agrees to the procedure, risks, benefits, options, etc. However, the informed consent process (which the form merely is supposed to document) is in place for the protection of the patient. The process is in place to make sure that everything is discussed with the patient—all of the options, all of the common risks, the worst thing that can happen, etc."

The law requires that a reasonable physician standard be applied when determining how much information is considered adequate when discussing a procedure or treatment with the patient. There are three approaches to making this discussion: what the typical physician would say about the intervention (the reasonable *physician* standard); what the average patient would need to know to be an informed participant in the decision (the reasonable *patient* standard); and what the patient would need to know/understand to make a decision that is informed (*subjective* standard).

Viewpoints

There is a theory that the practice of acquiring informed consent is rooted in the post-World War II Nuremberg Trials. At the war crimes tribunal in 1949, 10 standards were put forth regarding physicians' requirements for experimentation on human subjects. This

established a new standard of ethical medical behavior for the post-WW II human rights age, and the concept of voluntary informed consent was established. A number of rules accompanied voluntary informed consent. It could only be requested for experimentation for the gain of society, for the potential acquisition of knowledge of the pathology of disease, and for studies performed that avoided physical and mental suffering to the fullest extent possible.

As of 2001, most of the 50 United States had legislation that spells out the required standards for informed consent. For example, the State of Washington employs the second approach outlined as the *reasonable patient* standard. This ensures that the doctor fulfills all professional responsibilities and provides the best care possible and that the patient has a choice in decisions about his or her health care. However, the patient's competence in making a decision is considered. This points to the issue of the patient's "capacity." Anyone suffering from an illness, anticipating surgery, or undergoing treatment for a disease is under a great deal of **stress and anxiety**. It may be natural for a patient to be confused or indecisive. When the attending physician has serious doubts about the patient's understanding of the intervention and its risks, the patient may be referred for a psychiatric consultation. This is strictly a precaution to ensure that the patient understands what has been explained; declining to be treated or operated on does not necessarily mean the person is incompetent. It could mean that the person is exercising the right to make his or her own health care decisions.

Although it is the law to formally present the procedure or treatment to the patient, physicians do express doubt as to its wisdom. Some believe that informing patients of the risks of treatment might scare them into refusing it when the risks of non-treatment are even greater. But patients might have a different view. Without the complete story, for example, a patient might consent to beginning a particular course of **chemotherapy**. Convinced by the pressures from a pharmaceutical company, it is conceivable that a doctor will use an agent less effective than a newer treatment. By withholding information about treatment alternatives, the physician may be denying the patient a choice and a chance of an extended life of greater quality.

The international community has also had much to say in this regard. Martin Tattersall, professor at the Sydney University Cancer Medicine Department, and Alan Langslands, professor in Radiation Oncology at Westmead, said in the August 1995 issue of the *Medical Journal of Australia*, "Our findings indicate the extent of variation in the practice of providing information to **cancer** patients commencing treatment.... The current dou-

ble standard between former clinical trials (where ethics committees require that patients be given a 'plain language statement,' as well as giving their signed consent) and the 'usual' practice outside such trials, is apparently narrowing. The reasons for this may relate to the fear of litigation, rather than recognition of the need to provide full information." A litigious society such as the United States might be plagued by an even greater number of lawsuits than at present if informed consent were not legally mandated.

Professional implications

Undeniably, physicians in surgery, anesthesia, oncology, infectious disease—the list is endless—are faced with issues regarding Informed Consent. As the federal government takes a more active role in deciding the extent to which patients must be informed of treatments, procedures, and clinical trials in which they voluntarily become enrolled, more and more health care providers must become educated in what needs to be conveyed to patients. This is emphasized by the report of a case in which a federal court (Hutchinson vs. United States [91 F2d 560 (9th Cir. 1990)]) ruled in favor of the physician, despite his failure to advise his asthmatic patient (for whom he had prescribed the steroid, prednisone), of the well-known risk of developing aseptic necrosis (bone death), which did occur. The practitioner neglected to inform the patient that there were other drugs available with a much less serious side effect profile that could have treated the **asthma**. However, and despite this "neglect," a higher, appellate court reversed the ruling and found the physician guilty. Apparently the patient had used more conservative drugs in the past with good results. The court believed that if the physician had merely advised the patient of the more serious side effects of prednisone and offered the patient more conservative treatment, the physician would have avoided liability.

Nursing professionals have a greater role in evaluating whether the consent is informed or not than they might believe. When a nurse witnesses the signature of a patient for a procedure, or surgery, he or she is not responsible for providing its details. Rather, the role is to be the patient's advocate; to protect the patient's dignity; identify any fears; and determine his or her degree of comprehension and approval of care to be received. Each patient is an individual, and each one will have a different and unique response depending on his or her personality, level of education, emotions, and cognitive status. If the patient can restate the information that has been imparted to him or her, then that will help to confirm that he or she has received enough information and has understood it. The nurse is obligated to report any doubts about the patient's

understanding regarding what has been said, or any concerns about his or her capacity to make decisions.

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Inheritance, principles of

Definition

The patterns governing how genetic information is transmitted from generation to generation are collectively known as the principles of inheritance.

Description

Single-gene inheritance

Genes are composed of DNA (deoxyribonucleic acid), whose building blocks, the nucleotides, code for the multitude of **proteins** in the human body, including enzymes and structural proteins. In 2001, estimates place the number of human protein-coding genes between 25,000 and 35,000. A single-gene disorder is one caused by an alteration (mutation) in a specific gene that normally plays an important role in the human body. The protein product of a mutated gene is either abnormal in function, reduced in amount, or missing entirely.

Genes are passed down from parent to child in predictable patterns, discussed below. Knowledge of these patterns allows health care providers to explain to patients why a certain genetic disease is present in members of the family, and to predict the possibility that another family member will also be affected. As of 2001 more than 10,000 traits or diseases had been identified as following a single-gene pattern of inheritance. These are catalogued in the Online Mendelian Inheritance in Man (OMIM) at <<http://www.ncbi.nlm.nih.gov/omim/>>. In the following discussion, the MIM numbers associated with each disease example are the OMIM catalogue numbers.

In order to understand single-gene inheritance, it is necessary to be familiar with several terms and concepts. With some exceptions, discussed later, genes are present in pairs. Each member of the pair is termed an allele. An individual is said to be homozygous (a homozygote) at a certain gene locus if the two alleles of a pair are the same (i.e., if both alleles are either normal or carry the same mutation). In contrast, if the two alleles are different, the person is heterozygous (a heterozygote). For example, a person is heterozygous if he or she has one normal and one mutant allele; or if he or she has two abnormal alleles, each of which has a different mutation. The word "genotype" refers to an individual's allelic makeup at a gene. "Phenotype" refers to the observable result of having a certain genotype. Hair color is an example of a phenotype. Phenotype can be affected by other genes or by environmental influences.

Genetic traits caused by single genes are often referred to as Mendelian traits, in tribute to the Austrian monk Gregor Mendel, who in 1865 reported the results of his painstaking work on the transmission of traits such as color and shape in the garden pea. His three laws of heredity are:

- Unit inheritance. Prior to Mendel, many believed that traits were blended as they were passed from generation to generation. Although genes would not be "dis-

covered” until the next century, Mendel clearly spelled out that inheritance is a matter of passing on discrete traits.

- **Segregation.** The two alleles of a gene are never transmitted together from one parent to an offspring. This means that, in humans, an individual egg or sperm is formed with only one allele of each gene.
- **Independent assortment.** Alleles of different genes pass randomly to offspring. This law was later found to have important exceptions: If two genes are very close to each other on a chromosome, they tend to be passed down together.

Mendel’s laws went unnoticed until 35 years later, when they were simultaneously and independently discovered by Hugo De Vries in the Netherlands, Erich von Tschermak in Austria, and Carl Correns in Germany. These rediscoveries marked the real beginning of genetics as a science. Over the years many other scientists and physicians have contributed to our current understanding of inheritance in humans.

AUTOSOMAL INHERITANCE. The transmission of single-gene traits from generation to generation follows one of several basic patterns, depending on the location of the particular gene. A gene on one of the 22 pairs of autosomes—that is, the non-sex-determining chromosomes—is called an autosomal gene. Similarly, a trait or disease associated with that gene is an autosomal trait. Autosomal conditions are the most common and are equally likely to occur in males or females. Autosomal traits are further classified as either dominant or recessive.

Autosomal-dominant inheritance. Dominant conditions are those that are expressed in heterozygotes. For example, in a dominant disorder, if the two alleles of the gene are labeled A for the mutant (disease-producing) copy and B for the normal copy, an individual who is AB at that gene locus will have the disease, as will the individual who is AA. However, because a mutant allele is much less common than its normal counterpart, it is very unlikely that an affected individual would be AA.

The inheritance pattern of dominant traits is distinctive. If one parent has a particular dominant trait (e.g., an AB genotype), he or she has a 50% chance of passing the mutant allele (A) to each offspring, and, similarly, a 50% chance of passing the normal allele. Since most mutant alleles are very rare, there is usually little chance that the other parent would have the same mutant allele. Therefore, the total risk of having a child with the same disorder is 50% with each **pregnancy**. However, depending on the particular trait or disease, there are often circumstances in which the actual risk is less than 50%. For example, whether or not a person with the mutant gene



Gregor Mendel. (Archive Photos, Inc. Reproduced by permission.)

exhibits the trait may depend on a phenomenon called penetrance. If an autosomal-dominant disorder is fully penetrant, every individual with a mutant copy of the gene will have the disease. An allele is said to have reduced penetrance if only some individuals with the allele ever develop signs of the disorder. Similarly, expressivity refers to the degree to which someone who has inherited the mutant gene will be affected. For example, one person with a particular mutant allele might be severely affected, while another will have only mild features of the disease. The degree to which penetrance and expressivity play a role in autosomal-dominant disorders varies with the particular gene. In addition, some mutant alleles cause disease only later in life; these are the so-called adult-onset single-gene disorders.

Of the 10,000 genetic traits and diseases currently known, more than half are autosomal-dominant. When considered individually, the majority are rare, with the most common being present in only 1 in 500 to 1,000 individuals. However, taken together, they have an important impact on health. One of the most common is familial hypercholesterolemia (MIM 143890), a cause of early-onset **heart** disease. Mutations in the gene for this condition disrupt the normal **metabolism** of **fats** in the body and lead to a significant buildup of cholesterol

deposits in the arteries. Huntington disease (MIM 143100), a progressive neurological disorder affecting approximately 1 in 20,000 individuals, is an example of an autosomal-dominant disorder that does not usually appear until well into adulthood. Individuals with a mutant copy of this gene typically begin to show symptoms between ages 30 and 50, with death occurring approximately 15 years later. Neurofibromatosis (von Recklinghausen disease, MIM 162200), a commonly encountered autosomal-dominant condition (1 in 3,000 individuals), is a good example of a disease exhibiting variable expressivity. Signs and symptoms can vary from extremely mild ones such as pigmentary changes of the skin (cafe-au-lait spots) to more severe complications (including learning disabilities and multiple disfiguring tumors).

Autosomal-recessive inheritance. The genes for autosomal-recessive traits are also located on the autosomes, but the mutant, disease-causing alleles are recessive to the normal alleles; thus, if one normal allele is present, it is usually sufficient to prevent any expression of the disease. If the normal allele is designated A and the mutant allele is designated a, individuals who are AA or Aa will be phenotypically normal. Only those with an aa genotype will exhibit signs of the disease. Aa individuals are termed carriers, because they carry one mutant copy without showing symptoms themselves. Except for extremely rare cases of new mutations, both parents of an individual (aa) with an autosomal recessive disorder are carriers (Aa). Each time they make a germ cell (egg or sperm), that germ cell can receive only one allele. Thus, each parent always has a 50% (1 in 2) chance of passing on the mutant allele. If both parents pass the mutant allele to their germ cells, at fertilization the resulting embryo will have two mutant alleles (aa) and no normal allele. Thus, the chance that two parents who are both carriers of a mutant allele at the same gene locus will have a child with the disease is 25% (50% x 50%), or 1 in 4 with each pregnancy. Similarly, the probability of their having a child who is a carrier (Aa) is 50%, and the chance of having a child (AA) who did not inherit the disease allele from either parent is 25%.

Because an individual who carries one copy of a gene for an autosomal-recessive disorder is usually symptom-free, he or she can unknowingly transmit the disease allele to offspring. However, because of the rarity of most autosomal-recessive disorders, it is unlikely that both members of a couple will be carriers for the same disease gene and have a risk for producing children with the disorder. An exception to this is when parents are consanguineous (**blood** relatives), because they are both at risk of being carriers for the same disease allele present in their family. Consanguinity is a hallmark of

autosomal-recessive traits, and couples who are related may be at an increased risk over nonconsanguineous couples for an autosomal-recessive disorder in their offspring if a disease allele is carried in their family.

X-LINKED INHERITANCE. In addition to the 22 pairs of autosomes, humans have two sex chromosomes, X and Y, which determine an individual's sex (gender). Females have two X chromosomes (XX) and males have an X and a Y (XY). Because the smaller Y chromosome has only a very few genes as compared to the larger X, X-linked inheritance is often referred to as sex-linked inheritance. The pattern of inheritance of X-linked traits is very different from that of autosomal conditions. A distinguishing feature is the lack of male-to-male transmission, because a father transmits only his Y chromosome, not his X, to his sons. There are examples of both X-linked recessive and X-linked dominant diseases, although the former are far more common.

X-linked recessive inheritance. Another hallmark of X-linked recessive traits is that they are almost exclusively seen in males, while females are the carriers. This is explained by the fact that males only have one X chromosome and females have two Xs. The rarity of a particular mutant allele (X_m) in the general population means that a female's other allele at that gene locus is likely to be normal (X_n). Because the mutant allele is recessive, females with one mutant allele and one normal allele ($X_m X_n$) are rarely affected. However, on average, one half, or 50%, of the sons of a carrier female will have the particular disease as a result of inheriting the mother's X chromosome with the mutant allele ($X_m Y$). Similarly, half of a carrier female's daughters will be carriers. Since a male with an X-linked recessive trait has only one X chromosome and he transmits that X to all of his daughters, all of his daughters will be carriers.

X-linked dominant inheritance. An X-linked disease is considered dominant if it is expressed in heterozygotes ($X_m X_n$). All of the daughters of an affected male, but none of his sons, will have the disease. All offspring, female or male, of an affected female will be affected. However, because of a phenomenon called X-inactivation, some females may have a milder disease. In all females, one X in each cell is normally inactivated, and most genes on that X are nonfunctioning in that cell. The process is usually random, meaning that in females with one mutant and one normal allele, approximately half of the cells will have an active normal allele, which is often enough to ensure a milder course of the disease. In some severe X-linked disorders, most affected individuals are females, and it is rare to see a male with the disease. This is explained by the fact that males do not have another X with a normal allele. Rett syndrome (MIM 312750), a severe mental-retardation syndrome, is an X-linked dom-

inant disorder seen only in females. It is proposed that male fetuses with the abnormal Rett syndrome gene do not survive to birth.

MITOCHONDRIAL INHERITANCE. The above-described patterns of inheritance are applicable to genes present on the chromosomes in the nucleus of the cell. However, cells have additional genes in their mitochondria, the energy-producing organelles in the cytoplasm, the non-nuclear portion of the cell. Leber hereditary optic atrophy (MIM 535000), a severe type of midlife **vision** loss, is one of the rare disorders traced to mutations in mitochondrial DNA. Because mitochondria are almost exclusively passed from parent to child in the egg and not in the sperm, a hallmark of mitochondrial inheritance is transmission from an affected woman to all of her children. Although mitochondrial diseases are single-gene disorders, they are not considered Mendelian.

Chromosome abnormalities

In humans, the 35,000 or so nuclear genes are located on 46 chromosomes: 22 pairs of autosomes and 1 pair of sex chromosomes. Unlike single-gene diseases that are due to mutations in the DNA, chromosomal disorders are the result of too little or too much normal DNA. These disorders are usually divided into two types, numerical and structural.

NUMERICAL CHROMOSOME ABNORMALITIES. Numerical disorders are the result of either a missing or an extra whole chromosome. Although classified as genetic disorders, they are not transmitted through families. Rather, they are usually the result of an error in the specialized cell divisions (meiosis) that produce eggs and sperm. **Down syndrome**, a condition involving mental retardation and characteristic physical features, with an incidence of approximately 1 in 800 live births, is perhaps the most familiar example of a chromosome disorder. In 95% of individuals with Down syndrome, the condition is due to an extra, free-standing chromosome 21 (trisomy 21). More than 90% of trisomy 21 is due to an extra chromosome being packaged into the egg. In less than 10% of individuals, the sperm is the source of the extra 21. The only known risk factor for trisomy 21 is the age of the mother. Women have an increasingly greater risk for having a child with trisomy 21 as they get older. The reason for this is not known. Other examples of clinically important conditions that result from either a missing or an extra chromosome are Turner syndrome, Klinefelter syndrome, trisomy 13, and trisomy 18.

STRUCTURAL CHROMOSOME ABNORMALITIES. Structural chromosome abnormalities are caused by chromosome breakage and rearrangement. Among the more common types are inversions, translocations, dele-

tions, and duplications. If the rearrangement preserves all of the genetic material, it is called balanced. Individuals who carry balanced rearrangements are not affected themselves, but their altered chromosomes are at risk for further breakage and rearrangement during egg and sperm formation. This can result in offspring with extra or missing portions of chromosomes. In approximately 5% of individuals with Down syndrome, the extra chromosome 21 is not free-standing, as in trisomy 21, but is attached to another chromosome as the result of an unbalanced translocation. Often one parent will carry the balanced form of the translocation and be at risk for having other children with Down syndrome. Unbalanced structural chromosome abnormalities are found in about 1 in 17,000 live births. In the majority of cases, the resulting imbalance in the amount of genetic material results in serious physical and developmental abnormalities.

Multifactorial inheritance

Instead of one single gene being of paramount importance in producing disease, a multifactorial disorder results from the interaction of a number of genes plus influences in the environment. Despite the fact that multifactorial disorders are among the most common causes of disease in humans, the specific genes and environmental factors are still poorly understood. In contrast to single-gene disorders, multifactorial diseases do not exhibit a clear-cut pattern of inheritance within families. After one affected individual in the family, the risk of a second affected with the disorder may be somewhat increased, but that increase is more in the range of 2–10% percent than the 25–50% seen in single-gene disorders.

Nontraditional inheritance

In addition to the well-known patterns of inheritance described above, some important clinical disorders exhibit variations on these patterns. Several of these nontraditional types of inheritance are introduced briefly here. The reader is referred to other sources listed in the references for more detailed treatments.

- Triplet-repeat disorders. These are caused by genes that change in size and function from parent to child. Fragile X syndrome (MIM 309550), primarily affecting males, is caused by a gene on the X chromosome that can expand when passed from parent to child. The expansion disrupts gene function and results in mental retardation, characteristic facial features, and enlarged testes. There are a number of other triplet-repeat disorders, including the autosomal-dominant Huntington disease.

KEY TERMS

Allele—A member of a pair of genes.

Autosomes—Non-sex-determining chromosomes.

Chromosomes—Structures in the nucleus of a cell consisting of a thread of DNA containing the genetic information (genes). Humans have 46 chromosomes in 23 pairs.

Enzyme—A protein catalyst that promotes chemical reactions within the body.

Hemoglobin—The iron-containing protein of the red blood cells. Its function is to carry oxygen from the lungs to the tissues.

- **Imprinting disorders.** Most genes are expressed the same in an individual whether that gene was contributed by the mother or the father. However, there are exceptions in which the allele from one parent is normally imprinted and inactive. If the allele from the other parent is missing, for example, due to a deletion of a portion of the chromosome containing the gene, the individual is left with no functioning gene. Two very different conditions involving mental retardation, Prader-Willi syndrome (MIM 176270) and Angelman syndrome (MIM 105830), have been found to involve the phenomenon of imprinting.
- **Uniparental disomy.** This is the presence of both members of a chromosome pair from one parent and no copy from the other parent. The reader is referred to other sources for a more detailed treatment of this rare phenomenon. Uniparental disomy in combination with imprinting can also result in clinically important disorders, including some cases of Prader-Willi and Angelman syndromes.

Role in human health

Although genetics plays a role in the majority of human diseases, the contribution of genes may be primary or secondary in the pathophysiology of diseases. A British Columbian survey of more than one million individuals estimated that by age 25, at least 53 of 1,000 will have a disease with a significant genetic component.

Common diseases and disorders

Most genetic disorders fall into one of three main types; single gene, chromosomal, and multifactorial. Each type has its important hallmarks, and a basic knowl-

edge of the distinguishing factors of each is important for those who work in a clinical setting.

Single-gene disorders

Cystic fibrosis (CF, MIM 602421) is a typical autosomal-recessive disease. CF is often said to be the most common serious autosomal-recessive condition in the Caucasian population, with a frequency of about 1 in 2,000 children. Its clinical features include chronic respiratory disease, pancreatic insufficiency, and a decreased life expectancy. At present there is no cure, but because a great deal is being learned about the function of the CF gene, CF is a disease for which treatment at the gene level (also known as gene replacement or **gene therapy**) is being considered. Carrier parents who have had one child with CF have a 25% risk, with each subsequent pregnancy, of having another affected child. It is customary to offer these couples the option of prenatal diagnosis in future pregnancies to determine if the fetus is affected.

Sickle-cell anemia (MIM 603903), another autosomal-recessive disorder, is due to a specific mutation in one of the genes that codes for hemoglobin. The resulting abnormalities in the hemoglobin-rich red blood cells lead to multiple clinical symptoms in affected (aa) individuals, including increased risks for infections, blood clots, strokes, and painful swelling of the joints. Sickle cell is more common in those who can trace their ancestry to the African continent. About 1 in 500 African Americans is born with this disease. Approximately 8% are carriers (Aa) but remain symptom-free.

Perhaps the best-known example of an X-linked recessive disease is **hemophilia A** (MIM 306700). Seen almost exclusively in males, this is a failure of the blood to clot normally because of a mutation in the gene for one of the clotting factors, factor VIII. Affected males require life-long treatment with blood transfusions and factor VIII concentrates. In recent years research has been directed toward being able to offer gene therapy for males with this disorder. Duchenne **muscular dystrophy** (DMD, MIM 310200) is another X-linked recessive condition affecting the muscle fibers; it results in death usually by age 20. Since most males with DMD do not survive to reproduce, their abnormal genes are not passed on. Nevertheless, the frequency of DMD does not decline over time, because approximately one third of all cases are due to new mutations and not to the transmission of the gene from a carrier mother.

Multifactorial inherited disorders

Spina bifida, or open-spine defect, is a multifactorial birth defect, as are many cases of cleft lip/palate.

Recent studies have suggested that a deficiency of **folic acid**, one of the **B vitamins**, may play a role in causing spina bifida, and women who are planning a pregnancy are urged to take supplemental folic acid. Notwithstanding the important part that multifactorial inheritance plays in the etiology of birth defects, perhaps its greatest role is in the common diseases that are adult-onset. For example, most coronary heart disease is thought to be multifactorial, with genes plus dietary habits playing a part in determining an individual's risk for atherosclerosis, a narrowing of the arteries of heart caused by lipid (fat) deposits. A variety of cancers are also thought to be due to a combination of genetic and environmental factors. An enormous challenge awaits the next generation of geneticists as they attempt to unravel the complex interactions of genes and environment in these clinically important multifactorial disorders.

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Inlays *see* **Dental crowns, inlays, and bridges**

Insomnia *see* **Sleep disorders**

Instability tests *see* **Orthopedic tests**

Insulin *see* **Antidiabetic drugs**

Integumentary system

Definition

The integumentary system includes the skin and the related structures that cover and protect the body. The human integumentary system is composed of the skin, and includes glands, hair, and nails. The largest organ in the body, the skin protects the body, prevents water loss, regulates body temperature, and senses the external environment.

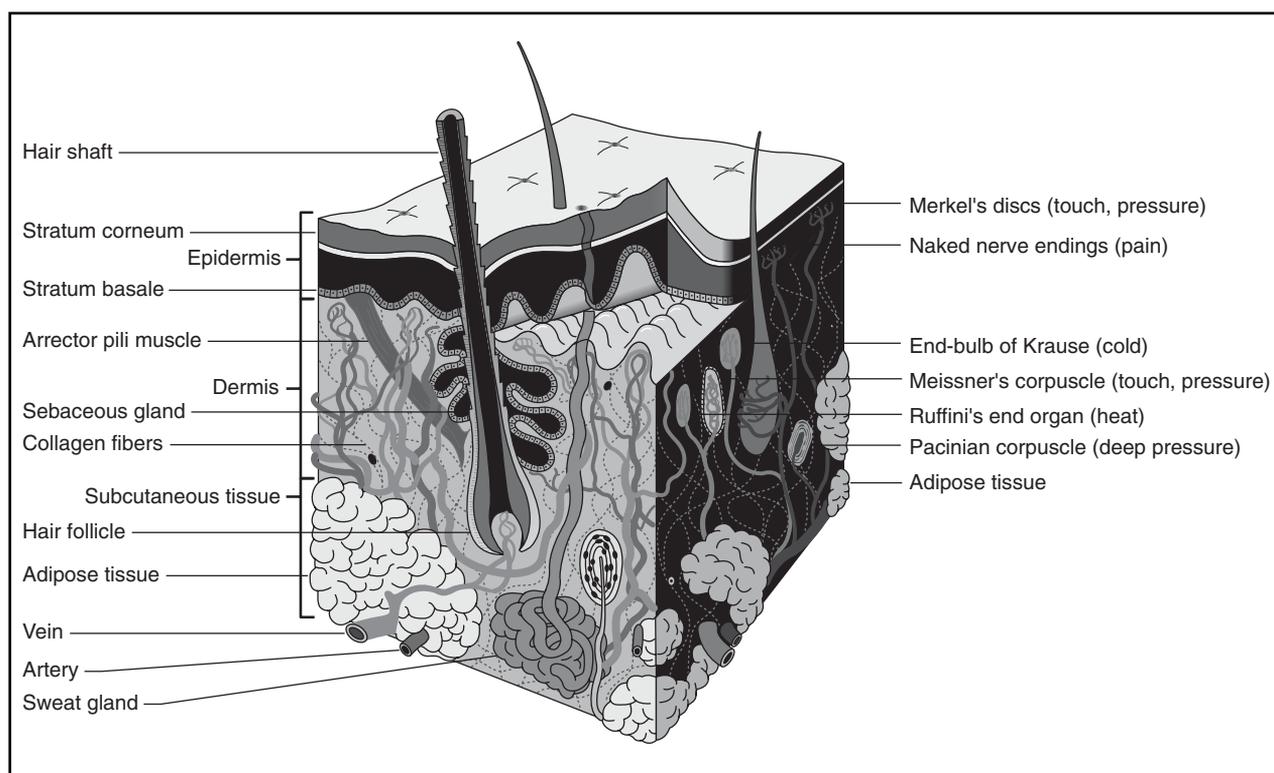
Description

The integumentary system serves many protective functions for the body. It acts as a mechanical barrier, simultaneously preventing water from entering the body and excessive water loss. It also limits access of microorganisms that could cause illness, and protects underlying tissues from mechanical damage. Pigments in the skin called melanin, give skin its color, and absorb and reflect the sun's harmful ultraviolet radiation.

Function

In addition to serving as a protective barrier, the skin helps to regulate the body temperature by several mechanisms. If heat builds up in the body, sweat glands in the skin produce more sweat that evaporates and cools the skin. When the body overheats, **blood vessels** in the skin dilate (expand), bringing more **blood** to the surface, and allowing body heat to dissipate. When the body is too cold, the blood vessels in the skin constrict, shunting blood away from the body surface, thus conserving heat. Along with temperature regulation, the skin serves as a minor excretory organ, since sweat removes small, clinically insignificant amounts of nitrogenous wastes produced by the body. The skin also functions as a sense organ since it contains millions of nerve endings that detect touch, heat, cold, **pain** and pressure. Finally, the skin produces **vitamin D** in the presence of sunlight, and renews and repairs damage to itself.

In an adult, the skin covers about 21.5 sq. ft (2 sq. m), and weighs about 11 lb. (5 kg). Depending on location, the skin thickness ranges from 0.02-0.16 in (0.5-4.0 mm). Skin is composed of an outer layer, or epidermis, and a thicker inner layer, the dermis. A subcutaneous layer of fatty or adipose tissue is immediately below the dermis. Fibers from the dermis attach the skin to the subcutaneous layer, and the underlying tissues and organs also connect to the subcutaneous layer.



Human skin. (Diagram by Hans & Cassidy. Courtesy of Gale Group.)

The epidermis

Ninety percent of the epidermis, including the outer layers, contains keratinocytes, cells that produce keratin, a protein that helps waterproof and protect the skin. Melanocytes are pigment cells that produce melanin, a brown-black pigment that adds to skin color and absorbs ultraviolet light, thereby shielding the genetic material in skin cells from damage. Merkel's cells disks are touch-sensitive cells found in the deepest layer of the epidermis of hairless skin.

In most areas of the body, the epidermis consists of four layers. On the soles of the feet and palms of the hands where there is considerable friction, the epidermis has five layers. Calluses, abnormal thickenings of the epidermis, occur on skin subject to constant friction. At the skin surface, the outer layer of the epidermis constantly sheds the dead cells containing keratin. The uppermost layer consists of about 25 rows of flat dead cells that contain keratin.

The dermis

The dermis is made up of connective tissue that contains protein, collagen, and elastic fibers. It also contains blood and lymph vessels, sensory receptors, related nerves, and glands. The outer part of the dermis has fin-

gerlike projections, called dermal papillae, that indent the lower layer of the epidermis. Dermal papillae cause ridges in the epidermis above it, which in the digits give rise to fingerprints. The ridge pattern of fingerprints is inherited, and is unique to each individual. The dermis is thick in the palms and soles, but very thin in other places, such as the eyelids.

The blood vessels in the dermis contain a volume of blood. When a part of the body, such as a working muscle, needs more blood, blood vessels in the dermis constrict, shifting blood from the skin to supply muscles and other body parts. Sweat glands with ducts that pass through the epidermis and open on the skin surface through pores are embedded in the deep layers of the dermis. Hair follicles and hair roots also originate in the dermis, and the hair shafts extend from the hair root through the skin layers to the surface. The dermis also contains sebaceous glands associated with hair follicles. Sebaceous glands produce an oily substance called sebum. Sebum softens the hair and prevents it from drying, but if sebum blocks a sebaceous gland, a whitehead appears on the skin. A blackhead results if the material oxidizes and dries. Acne pimples are caused by infections of the sebaceous glands.

The skin is an important sense organ and as such includes a number of types of nerves, which are mainly

in the dermis, with a few reaching the epidermis. Nerves carry impulses to and from hair muscles, sweat glands, and blood vessels, and receive messages from touch, temperature, and pain receptors. Some nerve endings are specialized such as sensory receptors that detect external stimuli. The nerve endings in the dermal papillae, known as Meissner's corpuscles, detect light touch, or the feel of clothing on the skin. Pacinian corpuscles, located in the deeper dermis, are stimulated by stronger pressure on the skin. Receptors near hair roots detect displacement of the skin hairs by stimuli such as touch or wind. Bare nerve endings throughout the skin supply information to the **brain** about temperature change (both heat and cold), texture, pressure, and trauma.

Role in human health

Along with its vital roles as shield against microorganisms and regulating body temperature, skin often provides information about overall health and a variety of medical conditions. The color, texture, temperature, and elasticity of skin can aid in diagnosing a variety of disorders. For example, patients with hepatitis may have a characteristic yellow tinge to their skin. Similarly, cold sores and **fever** blisters are indications of **infection** with herpes simplex virus, and warts (intraepidermal skin tumors) result from infection with human papilloma virus (HPV).

Skin testing is an important diagnostic tool in the evaluation of **allergies**. Skin testing involves a series of superficial injections of one or more suspected allergens. A positive response, such as redness, or inflammation, at the site of the skin test, helps to pinpoint the culprit.

Common diseases and disorders

Acne, caused by clogged pores and bacterial infection, is commonly diagnosed in teenagers and young adults. Acne may be mild, moderate, or severe and is characterized by blackheads, whiteheads, papules, pustules, and cysts on the face, shoulders, chest, and back. Mild acne may be treated with topical antimicrobial agents to kill the **bacteria** on the skin and topical retinoids to open the pores. Moderate and severe acne often respond to treatment with systemic **antibiotics** such as tetracycline or doxycycline.

Common bacterial skin infections are impetigo, folliculitis, and cellulitis. Impetigo is a contagious skin infection caused by streptococci or staphylococcus. It produces crusty patches on the skin. Local outbreaks may be treated with antibacterial ointment, and patients with widespread infections are given oral antibiotics. Infectious folliculitis produces erythema (redness) and pustules. It is caused by staphylococcus and treated with oral antibi-

otics. Cellulitis is swelling, erythema, warmth, and pain caused by infection of the dermis and subcutaneous tissue often near a wound site. Cellulitis is usually caused by Group A streptococci or staph aureus and is treated with a course of anti-strep or anti-staph antibiotics.

Common viral skin disorders include infection with herpes simplex or herpes zoster. Herpes simplex is responsible for cold sores, fever blisters, and lesions on the genitals and buttocks. Herpes zoster produces a painful rash characterized by vesicles. Both conditions are treated with acyclovir, or other orally administered anti-viral agent.

Skin reactions include eczema, allergic contact dermatitis (rashes), such as those resulting from contact with poison ivy, sumac, or oak, and **hives**. Contact dermatitis, an eruption of itchy skin vesicles, is an allergic skin reaction. Patients are advised to avoid contact with the suspected allergen, and mild cases may be treated with warm soaks and topical ointments to reduce inflammation and soothe inflamed skin.

Cosmetic damage as well as potentially fatal skin disorders may result from overexposure to the ultraviolet (UV) rays in sunlight. At first, overexposure to sunlight results in injury known as sunburn. UV rays damage skin cells, blood vessels, and other dermal structures. Continual overexposure produces leathery skin, wrinkles, and discoloration and may also lead to skin **cancer**. Anyone excessively exposed to UV rays runs a risk of skin cancer, regardless of the amount of pigmentation normally in the skin. Seventy-five percent of all skin cancers are basal cell carcinomas that arise in the epidermis and rarely metastasize (spread) to other parts of the body. Physicians can surgically remove basal cell cancers. Squamous cell carcinomas also occur in the epidermis, and these may metastasize. Malignant melanomas are life-threatening skin cancers that metastasize rapidly. There can be a 10 to 20 year delay between exposure to sunlight and the development of skin cancers.

Dermatology is the medical specialty devoted to the diagnosis and treatment of skin disorders. In addition to the disorders previously described, primary care physicians and dermatologists are frequently called upon to diagnose and treat the following conditions:

- alopecia (hair loss)
- athlete's foot (fungus infection)
- moles
- psoriasis (scaly skin on the scalp, trunk, arms and legs)
- rosacea (symmetrically distributed papules and pustules on the nose and cheeks)

KEY TERMS

Chitin—Polysaccharide that forms the exoskeleton of insects, crustaceans, and other invertebrates.

Dermis—Thicker layer of skin lying below the epidermis.

Epidermis—Thinner outermost layer of the skin.

Keratin—Insoluble protein found in hair, nails, and skin.

Melanin—Brown-black pigment found in skin and hair.

- scabies (skin infestation with mites that produces inflammatory papules in the wrists, web spaces, and sides of feet)
- seborrheic dermatitis (facial redness and scaling)
- spider veins, varicose veins
- vitiligo (loss of skin color on patches of skin, usually affects the face and extremities)

Today, many dermatologists also provide a range of cosmetic services to reduce the signs of aging, such as wrinkles, sagging skin and discoloration, and reverse some of the effects of sun damage to skin. Microdermabrasion, laser skin resurfacing, and injections of collagen are among the techniques used to improve the appearance of skin.

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Intensive care unit equipment

Definition

Intensive care unit (ICU) equipment includes patient monitoring, respiratory and cardiac support, **pain man-**

agement, emergency resuscitation devices, and other life support equipment designed to care for patients who are seriously injured, have a critical or life-threatening illness, or have undergone a major surgical procedure, thereby requiring 24-hour care and monitoring.

Purpose

An ICU may be designed and equipped to provide care to patients with a range of conditions, or it may be designed and equipped to provide specialized care to patients with specific conditions. For example, a neuromedical ICU would care for patients with acute conditions involving the nervous system or for patients who have just had neurosurgical procedures and would require equipment for monitoring and assessing the **brain and spinal cord**. A neonatal ICU is designed and equipped to care for infants who are ill, born prematurely, or have a condition requiring constant monitoring.

Patient monitoring equipment

Patient monitoring equipment includes the following:

- Acute care physiologic monitoring system—Continuously measures and displays data on **vital signs**, such as **heart rate**, **blood pressure**, cardiac output, and **blood oxygen levels**.
- Pulse oximeter—Monitors the oxygen saturation in the blood.
- Intracranial pressure monitor—Measures the pressure of fluid in the brain in patients with head trauma or other conditions affecting the brain (such as tumors, **edema**, or hemorrhaging).
- Apnea monitor—Continuously monitors breathing to detect cessation in infants and adults at risk of respiratory failure.

Life support and emergency resuscitative equipment

ICU equipment for life support and emergency resuscitation include the following:

- Ventilator (also called a respirator)—Assists with or controls pulmonary ventilation in patients who cannot breathe on their own.
- Infusion pump—Device that delivers fluids intravenously or epidurally, including continuous anesthesia, drugs, and blood infusions.
- Crash cart—Portable cart containing emergency resuscitation equipment for patients who are “coding” (that is, their vital signs are in a dangerous range), including

a defibrillator, airway intubation devices, resuscitation bag/mask, and medication box.

- **Intra-aortic balloon pump**—A device that helps reduce the heart's workload and helps blood flow to the coronary arteries for patients with unstable angina, **myocardial infarction**, or patients awaiting transplants.

The use of diagnostic equipment is also required in the ICU. Mobile x-ray units are used for bedside radiography, particularly of the chest. Portable clinical laboratory devices, called point-of-care analyzers, are used for blood analysis at the bedside to provide results much faster than if samples were sent to the central laboratory.

Disposable ICU equipment includes urinary (Foley) catheters, catheters used for arterial and central venous lines, Swan-Ganz catheters, chest and endotracheal tubes, gastrointestinal and nasogastric feeding tubes, and monitoring electrodes.

Description

ICU equipment includes patient monitoring, life support and emergency resuscitation devices, and diagnostic devices.

Patient monitoring equipment

- Acute care physiologic monitoring systems are comprehensive patient monitoring systems that can be configured to measure and display various parameters, such as an electrocardiogram (ECG), respiratory rate, blood pressure (noninvasive and invasive), body temperature, cardiac output, arterial hemoglobin oxygen saturation, mixed venous oxygenation, and end-tidal carbon dioxide, via electrodes and sensors connected to the patient. Each patient bed in an ICU has a physiologic monitor, and all monitors are networked to a central nurses' station.
- Pulse oximeters measure the arterial hemoglobin oxygen saturation of the patient's blood with a sensor clipped over the finger or toe. Pulse oximetry is usually a capability included in a physiologic monitoring system, but the ICU also uses dedicated pulse oximeters for some patients.
- Intracranial pressure monitors are connected to sensors inserted into the brain through a cannula or bur hole. These devices warn of elevated pressure and record or display pressure trends. Intracranial pressure monitoring may be a capability included in a physiologic monitor.
- Apnea monitors use electrodes or sensors placed on the patient to detect cessation of breathing, display respira-

tion parameters, and trigger an alarm if a certain amount of time passes without a patient's breath being detected. Apnea monitoring may be a capability included in a physiologic monitor.

Life support and emergency resuscitative equipment

- **Ventilators** consist of a flexible breathing circuit, gas supply, heating/humidification mechanism, monitors, and alarms. They are microprocessor-controlled and programmable, and regulate the volume, pressure, and flow of patient respiration. Ventilator monitors and alarms may be interfaced to a central monitoring system or information system.
- **Infusion pumps** employ automatic, programmable pumping mechanisms to supply the patient with fluids intravenously or epidurally through a catheter. The pump is hung on an intravenous pole, which is located next to the patient's bed.
- **Crash carts**, also called resuscitation carts or code carts, are strategically located in the ICU for immediate availability when a patient experiences cardiorespiratory failure. The cart holds a defibrillator, which is used to apply an electric shock to a patient in ventricular fibrillation. Two paddles are placed on the patient's chest and buttons are pressed to discharge an electrical shock of approximately 2,000 to 4,000 volts. The cart also holds a resuscitator, which is inserted into the patient's airway, and a bag is pressed to push air into the **lungs**.
- **Intra-aortic balloon pumps** use a balloon placed in the patient's aorta to help the heart pump. The balloon is on the end of a catheter that is connected to the pump's console, which displays heart rate, pressure, and ECG readings. The patient's ECG is used to time the inflation and deflation of the balloon.

Diagnostic devices most commonly used in the ICU are mobile x-ray units, which can be pushed to the patient's bedside to take x rays using a battery-operated generator that powers an x-ray tube, and point-of-care blood analyzers, which are handheld devices that require a small amount of whole blood and display blood chemistry parameters.

Operation

The ICU is a demanding environment due to the critical condition of patients and the variety of equipment necessary to support and monitor patients. Therefore, when operating ICU equipment, staff should pay attention to the types of devices and the variations between different models of the same type of device, so as not to make an error in operation or adjustment. Although many

KEY TERMS

Apnea—Cessation of breathing.

Arterial line—A catheter inserted into an artery and connected to a physiologic monitoring system to allow direct measurement of oxygen, carbon dioxide, and invasive blood pressure.

Edema—An abnormal accumulation of fluids in intercellular spaces in the body; causes swelling.

Central venous line—A catheter inserted into a vein and connected to a physiologic monitoring system to directly measure venous blood pressure.

Chest tube—A tube inserted into the chest to drain fluid and air from around the lungs.

Endotracheal tube—A tube inserted through the patient's nose or mouth that functions as an airway and is connected to the ventilator.

Gastrointestinal tube—A tube surgically inserted into the stomach for feeding a patient unable to eat by mouth.

Nasogastric tube—A tube inserted through the nose and throat and into the stomach for direct feeding of the patient.

Ventricular fibrillation—An irregular cardiac rhythm characterized by contractions of the ventricular muscle of the heart and signaling impending cardiac arrest; treated by using a defibrillator and medications.

hospitals make an effort to standardize equipment, for example, using the same manufacturer's infusion pumps or patient monitoring systems, older devices and non-standardized equipment may still be used, particularly when the ICU is busy. Clinical staff should be sure to check all devices and settings to ensure patient safety.

ICU patient monitoring systems are equipped with alarms that sound when the patient's vital signs deteriorate, for instance, when breathing stops, blood pressure is too high or too low, or when heart rate is too fast or too slow. Usually, all patient monitors connect to a central nurses' station for easy supervision. ICU staff should be sure that all alarms are functioning properly and that the central station is staffed at all times.

For reusable patient care equipment, clinical staff should be sure to properly disinfect and sterilize devices that contact patients. Disposable items, such as catheters and needles, should be disposed of in an appropriately labeled container.

Maintenance

Since ICU equipment is used continuously on critically ill patients, it is essential that equipment be properly maintained, particularly those devices used for life support and resuscitation. ICU staff should perform daily checks on equipment and inform **biomedical engineering** staff when equipment needs maintenance, repair, or replacement. For mechanically complex devices, service and preventive maintenance contracts are available from the manufacturer or third-party servicing companies.

Health care team roles

ICU equipment is used by an ICU care team, which consists of a critical care attending physician, ICU nurses, respiratory therapists, pharmacists, physical therapists, and nutritionists. Physicians trained in other specialties, such as anesthesiology, cardiology, radiology, surgery, neurology, pediatrics, and orthopedics, may be consulted and called to the ICU to treat patients who require their expertise. Radiologic technologists perform mobile x-ray examinations (bedside radiography). Either nurses or clinical laboratory personnel perform point-of-care blood analysis. ICU equipment is maintained and repaired by the hospital biomedical engineering staff and/or the equipment manufacturer.

Some studies have shown that patients in the ICU following high-risk surgery are at least three times as likely to survive when cared for by "intensivists," physicians trained in critical care medicine.

Training

Manufacturers of more sophisticated ICU equipment, such as ventilators and patient monitoring devices, provide clinical training for all involved staff when the device is purchased. All ICU staff must have undergone specialized training in the care of critically ill patients and must be trained to respond to life-threatening situations, since ICU patients are in critical condition and may experience respiratory or cardiac emergencies.

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American Association of Critical Care Nurses. 101 Columbia, Aliso Viejo, CA 92656. (800) 809-2273.

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National Association of Neonatal Nurses. 4700 West Lake Ave., Glenview, IL 60025-1485. (847) 375-3660.

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Intermittent positive-pressure breathing unit
see **Ventilators**

Internal fetal monitoring see **Electronic fetal monitoring**

Intestinal culture see **Stool culture**

Intestine, large

Definition

The large intestine is located in the abdominal cavity. It is the site of the last phases of digestion and consists of three segments: the cecum, the colon, and the rectum. The colon divides into ascending colon, transverse colon, descending colon, and sigmoid colon. The large intestine is called large because its diameter is considerably greater than the diameter of the **small intestine**.

Description

The large intestine is the terminal part of the **digestive system**. This important system is responsible for the ingestion and digestion of foodstuffs. Along the digestive tract, food is broken down into nutrient molecules small enough to pass into the bloodstream. Nutrient molecules are mostly absorbed in the small intestine, with the remainder being absorbed in the large intestine, which also prepares waste for elimination from the body through the anus.

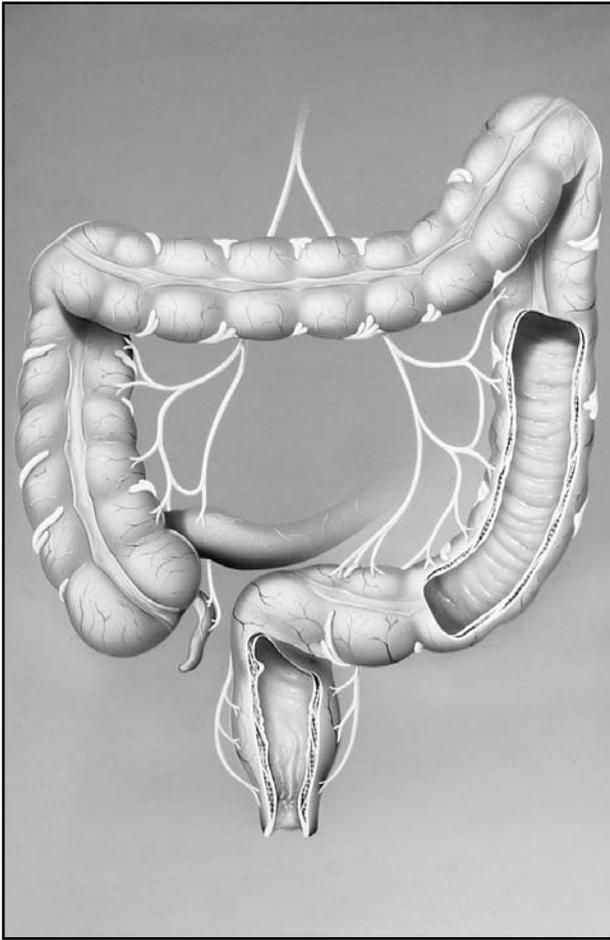
The large intestine is called the ascending colon as it starts from the cecum, which marks the end of the small intestine. The caecum contains the worm-shaped appendix. The ascending colon then passes along the right abdominal wall to the inferior surface of the **liver** and bends sharply at a right angle to the left at a curve called the hepatic flexure. At this point, it crosses the abdominal cavity, passing to the left abdominal wall and is known as the transverse colon. Under the spleen, it bends again at the splenic flexure, and is known as the descending colon, passing along the left abdominal wall to the pelvic region. The colon then forms an S-shaped curve and is called the sigmoid colon. The rectum marks the end of the colon. It is a storage site for solid waste which can then exit the body through an external opening called the anus, controlled by muscles called sphincters.

The large intestine is about 6 ft (1.8 m) long and about 2 in (5 cm) wide in the average, normal adult.

Function

The large intestine has three major functions:

- Recovery of water and essential ions. When the partially digested foodstuffs reach the end of the small intestine (ileum), roughly 80% of their water contents has been absorbed, but considerable water and small ions, such as sodium and chloride, still remain and must be recovered by further absorption. The colon then absorbs most of the remaining water and ions and additionally secretes bicarbonate ions as well as mucus, an important lubricant that protects the intestinal lining.
- Formation and storage of feces. As matter moves through the colon, it is dehydrated, mixed with **bacteria** and mucus, and formed into feces for subsequent storage and elimination. The composition of normal feces is approximately 75% water and 25% solid waste, mostly consisting of bacteria and roughage, that is, undigested protein, fat, fibers, dried digestive juices, and dead cells. Its typical brown color is due to pigments resulting from the bacterial degradation of bilirubin and fecal odor results from gases released by bacteria.



The large intestine consists of four sections: the ascending (left), transverse (top), descending (right), and sigmoid (bottom) colon. (Photograph by John Bavosi. Science Source/Photo Researchers. Reproduced by permission.)

- **Bacterial fermentation.** Fermentation refers to the enzymatic decomposition and utilization of foodstuffs by bacteria. The large intestine has a rich bacterial life that produces a wide variety of enzymes capable of fermenting many of the nutrient molecules that would otherwise not be absorbed. A normal adult harbors some 450 different species of bacteria in the colon and most of these are anaerobes, meaning bacteria that survive only in oxygen-free environments. Bacterial populations in the large intestine digest **carbohydrates, proteins, and lipids** that escape digestion and absorption in the small intestine and they also manufacture **vitamin K** and certain B vitamins.

The movement of bulk matter in the colon is referred to as large intestinal motility and it consists of four different types of muscle-assisted contractions:

- **Segmentation contractions.** These contractions mash and mix the partially digested foodstuff, exposing it to the mucous membrane where nutrient absorption occurs.
- **Peristaltic contractions.** These contractions are wave-like contractions that allow material to advance from the small intestine through the colon.
- **Antiperistaltic contractions.** These contractions occur in a backwards direction toward the ileum, so as to slow down the forward movement of matter through the colon. This provides more residence time for the absorption of nutrients.
- **Giant migrating contractions.** These contractions represent a type of motility only seen in the colon. Giant migrating contractions are a type of very intense and prolonged peristaltic contraction that can strip a large segment of colon free of contents.

Following the ingestion of food, large intestinal motility increases significantly, triggered by the duodenocolic reflex, which is stimulated by the presence of fat in the small intestine. Additionally, giant migrating contractions push feces into the empty rectum. Stretching of the rectum in turn stimulates the defecation reflex. This is a reflex controlled by the pelvic nerves, and it results in relaxation of the ring-like internal anal sphincter, the muscle that constricts or closes the anus. This is followed by voluntary relaxation of the external anal sphincter and defecation.

Role in human health

The importance of the large intestine in human health is mostly derived from its role in removing water from food residues and transporting it into the bloodstream. Along with this water, dissolved **minerals** and ions, notably sodium, potassium, and chlorine, are also transported to the bloodstream. Without these chemicals, the **blood** is chemically unbalanced, a condition that can lead to serious illness and even death.

Common diseases and disorders

- **Appendicitis.** Appendicitis is an inflammation of the appendix. It occurs due to accumulated waste material that cannot move out of the appendix easily because it only has one opening. The symptoms of appendicitis are muscular rigidity, sharp **pain** in the right lower abdomen, and vomiting.
- **Colitis.** Colitis is commonly known as irritable bowel or spastic colon. It refers to the inflammation of the inner lining of the colon. Colitis is related to **stress** and

KEY TERMS

Abdomen—A part of the body that lies between the thorax and the pelvis. It contains a cavity (abdominal cavity) that holds organs such as the pancreas, stomach, intestines, liver, and gallbladder. It is enclosed by the abdominal muscles and the vertebral column (spine).

Abdominal cavity—The hollow part of the body located between the diaphragm, which is the thin muscle below the lungs and heart, and the pelvis, the basin-shaped cavity that contains the reproductive organs, bladder, and rectum. The abdominal cavity contains the abdominal organs.

Anaerobes—Bacteria that live only in environments that are virtually oxygen-free.

Anal sphincter—The ring-like band of muscle that constricts or closes the anus.

Anus—The terminal opening of the digestive tract.

Appendix—A worm-shaped structure projecting from the cecum.

Bilirubin—A waste product from the breakdown of heme, the active group of hemoglobin, the molecule that carries oxygen in the blood. Bilirubin is produced in the liver and excreted in bile.

Cecum—The pouch-like start of the large intestine that links it to the small intestine.

Colon—Part of the large intestine, located in the abdominal cavity. It consists of the ascending colon, the transverse colon, the descending colon, and the sigmoid colon.

Digestion—The conversion of food in the stomach and in the intestines into substances capable of being absorbed by the blood.

Digestive system—Organs and paths responsible for processing food in the body. These are the mouth, the esophagus, the stomach, the liver, the gallbladder, the pancreas, the small intestine, the large intestine, and the rectum.

Feces—Waste product of digestion formed in the large intestine. About 75% of its mass is water, the remainder is protein, fat, undigested roughage, dried digestive juices, dead cells, and bacteria.

Fermentation—Enzymatic breakdown and utilization of foodstuffs by bacteria, as occurs in the large intestine.

Goblet cells—Mucus-secreting cells found scat-

tered among other cells in the epithelium of many organs, especially in the intestinal and respiratory tracts. They are most abundant in the colon.

Hepatic flexure—Sharp right-angle bend of the ascending colon under the liver as it becomes the transverse colon.

Ion—Elements consist of positively charged nuclei surrounded by negatively charged electrons. These charges are balanced and the overall charge of an element is zero. An element becomes an ion, that is a charged species, if it gains or losses electrons. Many small ions are essential for the functioning of the body. The major ones include: the potassium ion (K⁺), the sodium ion (Na⁺), the chlorine ion (Cl), and the HCO₃⁻ ion.

Large intestinal motility—Muscle-assisted contractions occurring in the colon to facilitate movement of intestinal contents. There are four type of motility: segmentation contractions, peristaltic contractions, antiperistaltic contractions and giant migrating contractions.

Large intestine—The terminal part of the digestive system, site of water recycling, nutrient absorption, and waste processing located in the abdominal cavity. It consists of the caecum, the colon, and the rectum.

Mucous membrane—The lubricated lining of several body organs that contains mucus-secreting glands.

Mucus—The slimy secretion of glands found on mucous membranes composed of various proteins, salts, and white blood cells.

Pelvis—The basin-shaped cavity located below the abdomen that contains the reproductive organs, the bladder, and rectum.

Peristalsis—A pattern of wave-like muscle contractions that allows material to advance through the digestive tube.

Peritoneum—The thin membrane that lines the abdominal and pelvic cavities, and covers most abdominal organs.

Rectum—The rectum is a short, muscular tube that forms the lowest portion of the large intestine and connects it to the anus.

KEY TERMS [CONTINUED]

Small intestine—The part of the digestive tract located between the stomach and the large intestine. It consists of the duodenum, the jejunum, and the ileum.

Splenic flexure—Sharp right-angle bend of the transverse colon under the spleen as it becomes the descending colon.

can lead to ulcerative colitis, in which open sores appear in the mucous membrane of the colon.

- **Colorectal cancers.** Colorectal cancers start in the innermost layer of the tissues of the large intestine and can grow through some or all of the layers. They can develop in any of the four sections of the colon or in the rectum.
- **Constipation.** Constipation is caused primarily by insufficient fiber in the diet, lack of **exercise**, or not drinking enough fluids. As a result, fecal matter hardens and large intestinal motility is impaired.
- **Diarrhea.** Diarrhea is a condition characterized by frequent, loose, watery stools that range from yellowish to light brown to green in color. If enough water is lost, **dehydration** occurs.
- **Diverticulosis.** Diverticulosis is characterized by outward ballooning (diverticula) of the large intestine wall caused by chronic constipation.
- **Dysentery.** Dysentery is a general term for various disorders characterized by severe diarrhea, inflamed intestines, and intestinal bleeding. Some forms of dysentery may clear up by themselves, while other forms may continue for years without treatment.
- **Hemorrhoids.** Hemorrhoids are commonly known as piles. They are dilated veins in the anus and rectum.
- **Peritonitis.** Peritonitis refers to inflammation of the peritoneum, the membrane that lines the abdominal and pelvic cavities. It can occur as a result of a ruptured appendix, which empties its contents of fecal matter and waste into the abdominal cavity. This condition is extremely serious.
- **Ptosis of the colon.** Also known as prolapsed colon, this is a common condition that occurs when the colon falls from its normal position to a lower position.

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Monique Laberge, PhD

Intestine, small

Definition

The small intestine is a long coiled tube located in the abdominal cavity. It is the major site of chemical digestion and absorption of nutrients by the body and consists of three sections: the duodenum, the jejunum, and the ileum.

Description

The small intestine is the longest section of the **digestive system**. This important body system digests food by breaking it down into nutrient molecules small enough to pass into the bloodstream. Nutrient molecules are absorbed in the small intestine and sent into the **blood** circulatory system. The digestive system also eliminates solid waste, recycles water, and absorbs **vitamins** from nutrients in the large intestines. Even though some starch breakdown takes place in the mouth and some breakdown of protein is done in the **stomach**, most of the digestion occurs in the duodenum.

The small intestine is a coiled, tube-like organ held in place by two membrane sheets attached to the walls of the abdominal cavity and referred to as the mesentery. Nerves, blood and lymph vessels to and from the small

KEY TERMS

Abdomen—A part of the body that lies between the thorax and the pelvis. It contains a cavity (abdominal cavity) that holds organs such as the pancreas, stomach, intestines, liver, and gallbladder. It is enclosed by the abdominal muscles and the vertebral column (spine).

Abdominal cavity—Hollow part of the body located between the diaphragm, which is the thin muscle below the lungs and heart, and the pelvis, which is the basin-shaped cavity that contains the reproductive organs, the bladder, and the rectum. The abdominal cavity contains the abdominal organs.

Acid—Refers to a compound that is acid or sour. When dissolved in water, acids yield hydrogen ions.

Amino acids—Organic compounds containing mostly the elements carbon, nitrogen, and oxygen that combine to form peptides and proteins.

Base—Refers to a compound that is caustic (soda, lime). Bases dissolve in alcohol and in water, and can combine with fats.

Bile—A greenish yellow fluid produced by the liver and stored in the gallbladder that is secreted in the small intestine to assist in the absorption of fats.

Bile ducts—Passages external to the liver for the transport of bile.

Digestion—The conversion of food in the stomach and in the intestines into substances capable of being absorbed by the blood.

Digestive system—Organs and paths responsible for processing food in the body. These are the mouth, the esophagus, the stomach, the liver, the gallbladder, the pancreas, the small intestine, the colon (large intestine), and the rectum.

Duodenum—The first section of the small intestine, extending from the stomach to the jejunum, the next section of the small intestine.

Epithelial cells—Cells covering the surface of the body and the lining of its cavities. In the small intestine, the epithelial cells cover the villi and contain microvilli.

Epithelium—The covering of the internal and external surfaces of the body and of the lining of blood vessels and small cavities. It consists of cells joined by cementing substances.

Gastric juice—An acidic secretion of the stomach

that breaks down the proteins contained in the ingested food, prior to digestion.

Gland—An organ that produces and releases substances for use in the body, such as fluids or hormones.

Ileum—The last section of the small intestine located between the jejunum and the large intestine.

Jejunum—The section of the small intestine located between the duodenum and the ileum.

Lymph—Colorless liquid that bathes body tissues and circulates in the lymph vessels.

Mesentery—The membrane that connects the jejunum and the ileum to the abdominal cavity walls.

Mucosal folds—Mucosal folds are circular folds found on the inner surface of the small intestine. They increase surface area and help mix the partially broken down foods by acting as baffles.

Mucous membrane—The lubricated lining of several body organs that contains mucus-secreting glands.

Mucus—Slimy secretion of glands found on mucous membranes composed of various proteins, salts, and white blood cells.

Pancreas—The pancreas is a flat, glandular organ lying below the stomach. It secretes the hormones insulin and glucagon that control blood sugar levels and also secretes pancreatic enzymes in the small intestine for the breakdown of fats and proteins.

Peritoneum—Thin membrane that lines the abdominal and pelvic cavities and covers most abdominal organs.

Pylorus—The opening from the stomach into the small intestine.

Small intestine—The part of the digestive tract located between the stomach and the large intestine.

Villi intestinales—Microscopic hair-like structures covered with epithelial cells measuring 1–1.5 mm that line the mucous inner membrane of the small intestine. The epithelial cells of the villi contain microvilli and are responsible for the absorption of nutrients. Being so small and numerous, they effectively increase the absorptive surface area of the small intestine.

intestine lie between the two sheets of the mesentery. In the adult, the small intestine measures on average about 22 ft (6.7 m) with a diameter of 1–2 in (2.5–5 cm). It consists of three segments: the short duodenum, the jejunum, which represents 40% of the small intestine, and the terminal ileum, which accounts for the remaining 60% and which empties into the **large intestine**. The small intestine thus forms a passage going from the pylorus (opening from the stomach) to the large intestine.

The inner mucous membrane of the small intestine is not flat and uniform but folded to such a great extent that its inner lining is referred to as the mucosal folds. The mucosal folds are covered with approximately 20,000 tiny hair-like projections called villi that are lined with epithelial cells studded with microvilli. One villus contains about 500 microvilli and in one square inch of small intestine, there are some ten billion microvilli.

Function

Together, the intestines process 2–3 gal (7.6–11.4 l) of food, liquids, and bodily waste every day. The small intestine is the major site of absorption of almost all nutrients into the blood.

The stomach delivers foodstuffs to the duodenum that it has reduced to a liquid pulp with gastric juices, called the chyme, for further breakdown. The duodenum also receives pancreatic enzymes from the **pancreas** and bile from the **liver** via the pancreatic and common bile ducts. The pancreatic enzymes are required for the chemical breakdown of **fats**, sugars, and **proteins**, and the bile plays an important role in the absorption of fats. To assist the process, the villi sway constantly so as to stir up the chyme for nutrient removal and transport across their membranes into the blood and lymph vessels. The fatty molecules are transferred to the lymph, while sugar (glucose) and amino acids go into the blood and are carried to the liver. The muscles that encircle the small intestine constrict about seven to twelve times a minute to shake, knead, and mix the chyme with its secretions and the gastric juices of the stomach. The small intestine also absorbs enormous quantities of water. Normal water intake for an adult is about 0.5 gal (2 l) of dietary fluid per day. An additional 1.6–1.8 gal (6–7 l) of fluid is delivered to the small intestine by secretions from salivary glands, stomach, pancreas, liver, and its own secretions. Of these 2.1–2.3 gal (8–9 l), the small intestine absorbs 80% on a daily basis.

The absorption of nutrients across the epithelial cell boundary of the small intestine is made possible by maintaining a “sodium electrochemical gradient.” The interior of all cells maintains a low concentration of sodium. The epithelial cells lining the small intestine (enterocytes)

achieve this using a large number of enzymes (Na_+/K_+ ATPases), called sodium pumps. These pumps export sodium ions from the cell in exchange for potassium ions, thus establishing a gradient of both charge and sodium concentration across the cell membrane that facilitates transport. This constant flow of sodium is ultimately responsible for the absorption of water, amino acids, and **carbohydrates** by the small intestine. It is known that each intestinal enterocyte has some 150,000 such sodium pumps, which allow each cell to transport about 5 billion sodium ions out of each cell per minute.

Role in human health

The passage of foodstuffs through the small intestine results in the absorption of most of the water and electrolytes (sodium, chloride, potassium) as well as almost all nutrient molecules, such as glucose, amino acids, and fatty acids. The small intestine not only provides the nutrients required for the functioning of the body, but also plays a critical role in water and acid-base equilibrium. Acid-base equilibrium refers to a condition by which the net rate of acid or base production by the body is balanced by the net rate of acid or base elimination from the body, resulting in stable amounts of hydrogen ions in body fluids.

Common diseases and disorders

The common diseases and disorders of the small intestine include:

- **Adenocarcinoma.** Adenocarcinomas are cancers of the gland cells that line the small intestine. They tend to occur in the duodenum.
- **Adenomas.** Adenomas are non-cancerous gland cell tumors often found in the intestinal villi.
- **Atresia of small intestine.** Atresia of the small intestine is characterized by the absence or closure of parts of the small intestine. Duodenal atresia is diagnosed in 1:5,000 live births and is frequently associated with **Down syndrome**. Jejuno-ileal atresia occurs less frequently (1:1,500 to 1:20,000 live births).
- **Carcinoid tumors.** Carcinoid tumors develop from the neuroendocrine cells that are found in the numerous secretions entering the intestine. About 2,500 carcinoid tumors are diagnosed each year in the United States and they account for about one-third of all tumors that develop in the small intestine and appendix.
- **Crohn’s disease.** Crohn’s disease causes inflammation in the small intestine. It usually occurs in the ileum.
- **Cytomegalovirus (CMV).** CMV is a herpes-type virus that can infect the epithelial cells of the small intestine.

- Duodenal ulcer. Gastric and duodenal ulcers afflict approximately 4 million people in the United States. They are associated with **alcoholism**, chronic lung and kidney disease, and thyroid disorders.
- Dysentery. Dysentery is a general term for various disorders characterized by severe **diarrhea**, inflamed intestines, and intestinal bleeding. Some forms of dysentery may clear up by themselves while other forms may continue for years without treatment.
- Protein-losing enteropathy. Disease of the small intestine characterized by excessive loss of plasma proteins.
- Gastrointestinal stromal tumor (GIST). GIST is most commonly diagnosed in the muscular wall of the jejunum and ileum.
- Gluten sensitive enteropathy. Disease of the small intestine characterized by impaired absorption of nutrients due to loss of villi because of an adverse immune reaction to gluten, a protein found in wheat and other related foods.
- Small intestinal hemorrhages. The major causes of small intestinal hemorrhage are infections, vascular anomalies, and bleeding disorders.
- Small intestinal infarction. Small intestinal infarction is caused by the partial or complete obstruction to blood flow. It usually occurs in people over age 50–55.

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Monique Laberge, PhD

Intracranial ultrasound see **Ultrasonic encephalography**

Intradermal injections

Definition

Intradermal injections are injections given to a patient in which the goal is to empty the contents of the syringe between the layers of the skin.

Purpose

Intradermal injection is often used for conducting skin **allergy tests** and testing for antibody formation.

Precautions

This is a painful procedure and is used only with small amounts of solution. The nurse should ensure that the needle is inserted into the epidermis, not subcutaneously, as absorption would be reduced. It is imperative that the following information is reviewed prior to administration of any medication: the right patient, the right medicine, the right route, the right dose, the right site, and the right time. Because this method of injection is often used in allergy testing, it is important that latex-free syringes are used.

Description

With the intradermal injection, a small thin needle of 25 or 27 gauge and 3/8 to 3/4 inch (1-2 cm) is inserted into the skin parallel with the forearm, with the bevel facing upward. These injections are normally given in the inner palm-side surface of the forearm, with the exception of the human diploid cell rabies vaccine, which is given in the deltoid muscle.

Preparation

After washing his or her hands, the nurse should put on latex-free gloves to complete the procedure. A sterile syringe and a needle should be prepared. If a sterile multiple-dose vial is used, the rubber-capped bottle should be rubbed with an antiseptic swab. The needle is then inserted through the center of the cap, and some air from the syringe inserted to equalize the pressure in the container. Slightly more of the required amount of drug is should then be removed. The syringe should be held vertically at eye level, then the syringe piston should be pushed carefully to the exact measurement line.

If a small individual vial containing the correct amount of drug is used, the outside should be wiped with an antiseptic swab and held in the swab while the top is snapped off. The needle is then inserted into the vial, tak-



Skin must be spread taut for an intradermal injection.
(Delmar Publishers, Inc. Reproduced by permission.)

ing care that the tip of the needle does not scratch against the sides of the vial, thereby becoming blunt.

The **syringe and needle** containing the drug should be placed on a tray with sterile cotton swabs and cleaning disinfectant. If the patient is unfamiliar with the procedure, the nurse should explain what he or she is about to do, and let the patient know that the medication was prescribed by the doctor. As with all drugs prescribed for a patient, the dose on the patient's prescription sheet should be checked prior to administration.

A screen should be drawn around the patient to ensure privacy. The injection site is then rubbed vigorously with a swab, and disinfectant applied to cleanse the area and increase the **blood** supply. With the bevel of the needle facing upwards, the needle is inserted into the skin, parallel with the forearm. The syringe piston should then be pushed in steadily and slowly, releasing the solution into the layers of the skin. This will cause the layers of the skin to rise slightly.

Aftercare

Monitor the patient's reaction and provide reassurance, if required. Dispose of all waste products carefully and place the syringe and needle in a puncture-resistant receptacle.

Complications

If the circulation is depleted, absorption of the drug administered may be slow.

Results

Check for any adverse reactions if the drug is being administered for the first time.

KEY TERMS

Bevel—The flat aperture on one side of a needle at the tip.

Deltoid muscle—A large muscle covering the shoulders.

Sterile—Free from living microorganisms.

Subcutaneous—Beneath the skin.

Health care team roles

As this procedure is often used as a diagnostic tool, the process should be explained fully to the patient.

The health care team should record any side effects or negative reactions to the drug that has been injected; medical staff should be notified.

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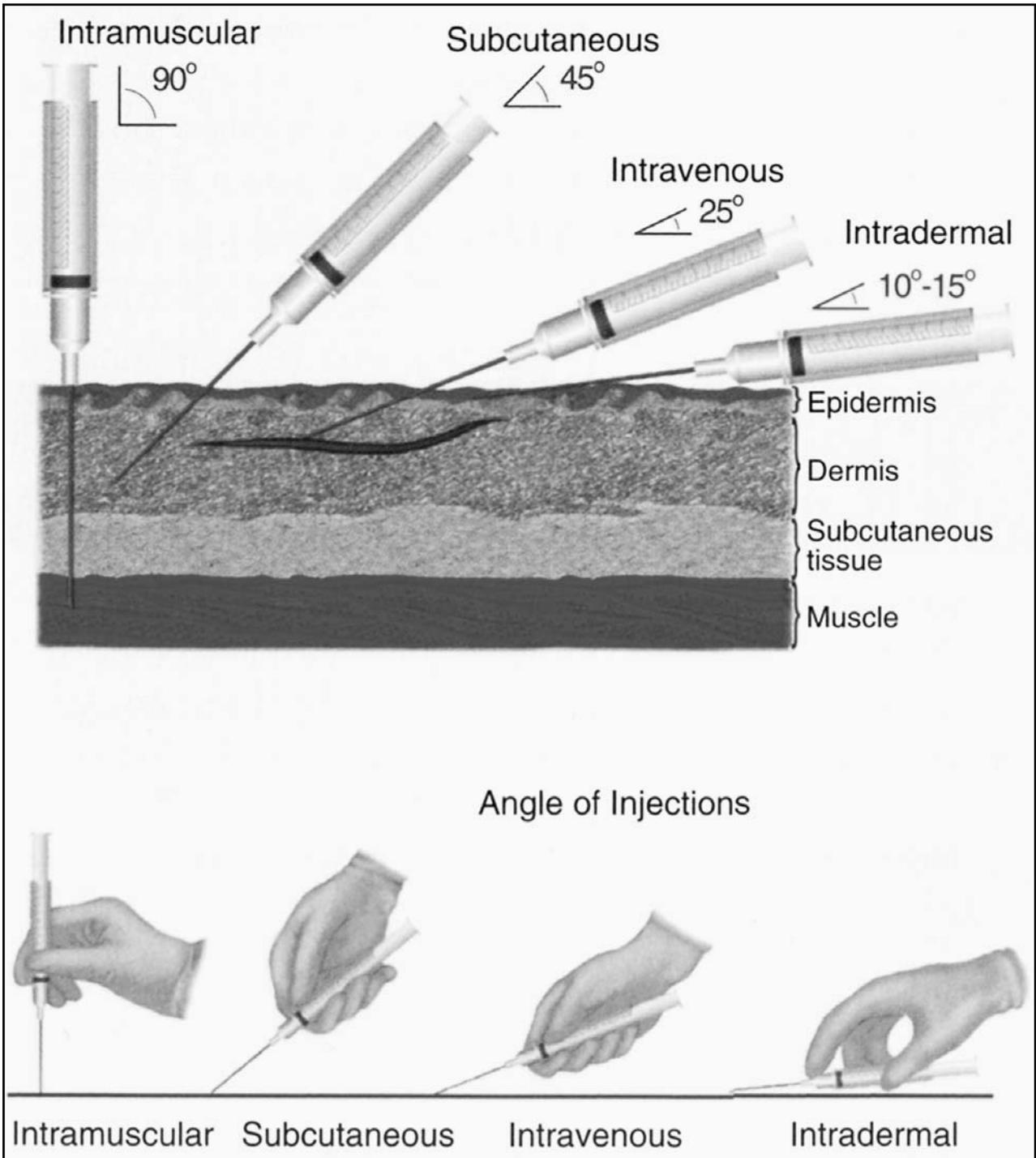
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Margaret A Stockley, R.G.N.

Intramuscular injection

Definition

An intramuscular injection is an injection given directly into the central area of a specific muscle. In this



Angles of insertion for injections. (Delmar Publishers, Inc. Reproduced by permission.)

way, the **blood vessels** supplying that muscle distribute the injected medication via the **cardiovascular system**.

Purpose

Intramuscular injection is used for the delivery of certain drugs not recommended for other routes of

administration, for instance intravenous, oral, or subcutaneous. The intramuscular route offers a faster rate of absorption than the subcutaneous route, and muscle tissue can often hold a larger volume of fluid without discomfort. In contrast, medication injected into muscle tissues is absorbed less rapidly and takes effect more

slowly that medication that is injected intravenously. This is favorable for some medications.

Precautions

Careful consideration in deciding which injectable route is to be used for the prescribed medication is essential. The intramuscular route should not be used in cases where muscle size and condition is not adequate to support sufficient uptake of the drug. Intramuscular injection should be avoided if other routes of administration, especially oral, can be used to provide a comparable level of absorption and effect in any given individual's situation and condition. Intramuscular injections should not be given at a site where there is any indication of **pain**.

Description

Intramuscular (IM) injections are given directly into the central area of selected muscles. There are a number of sites on the human body that are suitable for IM injections; however, there are three sites that are most commonly used in this procedure.

Deltoid muscle

The deltoid muscle located laterally on the upper arm can be used for intramuscular injections. Originating from the Acromion process of the scapula and inserting approximately one-third of the way down the humerus, the deltoid muscle can be used readily for IM injections if there is sufficient muscle mass to justify use of this site. The deltoid's close proximity to the radial nerve and radial artery means that careful consideration and palpation of the muscle is required to find a safe site for penetration of the needle. There are various methods for defining the boundaries of this muscle.

Vastus lateralis muscle

The vastus lateralis muscle forms part of the quadriceps muscle group of the upper leg and can be found on the anteriolateral aspect of the thigh. This muscle is more commonly used as the site for IM injections as it is generally thick and well formed in individuals of all ages and is not located close to any major arteries or nerves. It is also readily accessed. The middle third of the muscle is used to define the injection site. This third can be determined by visually dividing the length of the muscle that originates on the greater trochanter of the femur and inserts on the upper border of the patella and tibial tuberosity through the patella ligament into thirds.

Palpation of the muscle is required to determine if sufficient body and mass is present to undertake the procedure.

Gluteus medius muscle

The gluteus medius muscle, which is also known as the ventrogluteal site, is the third commonly used site for IM injections. The correct area for injection can be determined in the following manner. Place the heel of the hand of the greater trochanter of the femur with fingers pointing towards the patient's head. The left hand is used for the right hip and vice versa. While keeping the palm of the hand over the greater trochanter and placing the index finger on the anterior superior iliac spine, stretch the middle finger dorsally palpating for the iliac crest and then press lightly below this point. The triangle formed by the iliac crest, the third finger and index finger forms the area suitable for intramuscular injection.

Determining which site is most appropriate will depend upon the patient's muscle density at each site, the type and nature of medication you wish to administer, and of course the patient's preferred site for injections.

Preparation

Before **administering medication**, a health care practitioner verify the medication order for accuracy and prepare the medication from the vial or ampule.

- First, ensure you have identified the patient and assist them into a position which is comfortable and practical for access to the injection site you have chosen.
- Locate the correct area for injection using the above guidelines or those taught during medical training. Clean the site with an alcohol swab or other cleansing agent.
- Prepare the syringe by removing the needle cover, inverting the syringe, and expelling any excess air. Approximately 0.1–0.2 ml of air should be left in the syringe so that the air in the top of the syringe chamber, when the **syringe and needle** are pointing down, forces the entire amount of medication to be delivered. This also prevents medication residue from being left in the needle, where it can leak into the subcutaneous and dermal layers when the syringe and needle are removed from the muscle.
- When ready to inject, spread the skin using the fingers of the non-dominant hand. Holding the syringe with the thumb and forefinger of the dominant hand, pierce the skin and enter the muscle. This process should be done quickly with sufficient control so as to lessen the discomfort of the patient. If there is little muscle mass, particularly in infants or the elderly, then you may need

to pinch the muscle to provide more volume of tissue in which to inject.

- Aspirate at the injection site (while syringe and needle are within the muscle) by holding the barrel of the syringe with the non-dominant hand and pulling back on the syringe plunger with the dominant hand. If **blood** appears in the syringe, it is an indication that a blood vessel may have been punctured. The needle and syringe should be immediately withdrawn and a new injection prepared. If no blood is aspirated, continue by slowly injecting the medication at a constant rate until all medication has been delivered.
- Withdraw the needle and syringe quickly to minimize discomfort. The site may be briefly massaged, depending on the medication given. Some medication manufacturers advise against massaging the site after injection, as it reduces the effect and intention of the medication by dispersing it too readily or over too large an area. Manufacturers' recommendations should be checked.
- Discard the used syringe and needle intact as soon as possible in an appropriate disposal receptacle.
- Check the site at least once more a short time after the injection to ensure that no bleeding, swelling or any other signs of reaction to the medication are present. Monitor the patient for other signs of side effects, especially if it is the first time the patient is receiving the medication.
- Document all injections given and any other relevant information.

Aftercare

Monitor for signs of localized redness, swelling, bleeding, or inflammation at injection site. Observe the patient for at least 15 minutes following the injection for signs of reaction to the drug.

Complications

Most complications of intramuscular injections are a result of the drug injected and not the procedure. However, it is possible that localized trauma of the injection site may result as part of the process. Minor discomfort and pain is common for a short period following the injection, but usually resolves within a few hours.

Results

The optimal outcome is a situation in which the medication is safely and effectively delivered to the patient via intramuscular injection without signs of com-



A doctor gives a vaccine by intramuscular injection.
(Custom Medical Stock Photo. Reproduced by permission.)

plications or discomfort. Safety for the health care provider is also paramount.

Health care team roles

The health care provider is obliged to undertake the following when administering an intramuscular injection:

- Inform and educate the patient on the need and effect of the medication being delivered.
- Ensure the correct identification and verification procedures are followed.
- Provide privacy for the patient during the procedure.
- Understand the theory behind selecting appropriate injection sites.
- Demonstrate correct technique when undertaking the procedure.
- Monitor for complications.

- Document all relevant information and ensure safe disposal of equipment.

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Intraoperative care

Definition

The term “intraoperative” refers to the time during surgery. Intraoperative care is patient care during an operation and ancillary to that operation.

Activities such as monitoring the patient’s **vital signs**, **blood** oxygenation levels, fluid therapy, medication transfusion, anesthesia, radiography, and retrieving samples for laboratory tests, are examples of intraoperative care. Intraoperative care is provided by nurses, anesthesiologists, nurse anesthetists, surgical technicians, surgeons, and residents, all working as a team.

Purpose

The purpose of intraoperative care is to maintain patient safety and comfort during surgical procedures. Some of the goals of intraoperative care include maintaining homeostasis during the procedure, maintaining strict sterile techniques to decrease the chance of cross-infection, ensuring that the patient is secure on the operating table, and taking measures to prevent hematomas from safety strips or from positioning.

Precautions

Patients undergoing surgery most often are given some type of anesthesia. The administration of **general anesthesia** has a relaxing effect on the patient’s body, which can suppress cardiovascular function or heighten cardiovascular irritability. It may also result in respiratory depression, loss of consciousness, **paralysis**, and lack of sensation. These effects, some of which are intentional for the period of the surgery, mean the patient is in a very vulnerable position. It is the responsibility of the

health care team in the operating room to maintain the patient’s safety and yet facilitate surgery.

In 1992 the American Association of Nurse Anesthetists (AANA) established guidelines for monitoring patients undergoing general anesthesia. The guidelines call for continuous observation of the patient by the nurse assigned to the patient. Ventilation should be assessed by continuous auscultation of breath sounds, and oxygenation should be monitored by continuous pulse oximetry. Continuous electrocardiograph (ECG) showing the patient’s cardiac function should be in place, and the patient’s **heart** rate and **blood pressure** should be monitored at least every five minutes. A means to monitor the patient’s temperature must be available immediately for use. In case of an emergency backup personnel who are experts in **airway management**, emergency intubation, and advanced cardiac life support (ACLS) must be available. An emergency cart containing the necessary supplies and equipment must be immediately accessible. The ACLS equipment should be checked daily to ensure proper function.

Total analgesia is a goal of general anesthesia in order to facilitate surgery. This means that the patient does not have the normal “pain” sensations that warn of potential injury. The health care team must keep this in mind when they are positioning the patient for a surgical procedure. Although it may be necessary for a patient to be positioned in an unusual way for access to a particular area during surgery, care must be taken to ensure that the patient’s body is in proper alignment and that joints and muscles are not in such an unnatural position that they will be damaged if they remain in that position for a lengthy procedure. Areas of the operating table that come into contact with the patient’s bony prominences must be padded to prevent skin trauma and hematomas.

During a surgical procedure many instruments, drapes, and sponges are used. Also, a multitude of care providers may be working in the operative field performing different tasks. These factors, combined with the complexity and length of some surgical procedures, may provide extensive opportunity for patient trauma from equipment malfunction or the failure of the surgical team to avoid using full weight on the sedated patient. Additionally, it is the responsibility of the nurses working in the operating room to maintain an accurate count of all sponges, instruments, and sharps that may become **foreign bodies** upon incision closure. Nurses who fail to make accurate counts can be held legally liable.

Most surgical procedures are invasive and compromise a patient’s skin integrity. This increases the risk of

infection. To decrease the risk, strict asepsis (sterile technique) must be followed at all times. It is recommended that the ventilation system in an operative area provide a minimum of fifteen exchanges of filtered air per hour. The temperature in the intraoperative area should be maintained at 68–73°F (20–23°C), and the relative humidity should be maintained at 30%–60%. Health care personnel who work in the operating room must not be permitted to work if they have open lesions on the hands or arms, eye infections, **diarrhea**, or respiratory infections. Scrub attire must be worn by all personnel entering the operating room. Fresh scrub attire must be donned daily and, if heavily soiled during one case, should be changed before the next case. Most facilities provide personnel with scrub attire that is professionally laundered. Shoe covers are required and should be changed often. Head and facial hair must be completely contained in a lint-free cap or hood. Properly fitting disposable surgical masks must be worn at all times and discarded immediately after use. Sterile gloves and sterile gowns must be worn by those working in, and in proximity to, the sterile field. Careful skin preparation with appropriate antiseptic solutions is preformed on the patient's arrival to the operating area.

Patients who have a known or suspected allergy to latex should be scheduled for surgery as the first case of the day whenever possible to avoid contact with airborne latex particles (often attached to powder granules from the gloves) that may be in the room from a previous surgery. These patients should also be identified (some facilities use special colored identification bands and colored tapes on the patient's medical record) so that all health care personnel can recognize them. Special care must be taken to limit the uses of equipment containing latex that will contact the patient's skin. This includes anesthesia masks, adhesive tape and dressings, injections drawn from multidose vials with rubber stoppers, adhesive ground plates for electrocautery or diathermy, and pad coverings on the operating table and arm extensions.

Description

Intraoperative care includes the activities performed by the health care team during surgery that ensure the patient's safety and comfort, implement the surgical procedure, monitor and maintain vital functions, and document care given. The intraoperative time period can vary greatly from less than one hour to 12 hours or more, depending on the complexity of the surgery being performed.

Preparation

Prior to surgery the patient or legal guardian must have the surgical procedure explained to them in great detail, including the expected outcomes and all possible complications, in order to give **informed consent**. The explanation should be given to the patient at a time when he or she is relaxed, but when judgment is not clouded by the use of any **pain** medication or anesthesia, which would invalidate the consent. A consent form must be signed by the patient or guardian and witnessed by a staff member as well as the surgeon performing the procedure. It is the duty of the RN admitting the patient to the surgical suite to check the patient's ID band and ensure that all records are intact and accounted for.

After consent is given the patient may be taken to a holding area where a large-bore intravenous catheter is inserted into the patient's arm for use in fluid replacement and to infuse medications during the procedure. The area of the body where the incision will be made is meticulously prepared using drapes, and a skin preparation that is antiseptic and may include the use of alcohol solutions and iodophor. Monitoring devices such as continuous ECG nodes, pulse oximetry probes, and a blood pressure cuff are usually applied prior to skin preparation. Anesthesia, also, is begun before skin prep. Surgery is then ready to begin.

Aftercare

The time after surgery is referred to as the postoperative period and includes the recovery and convalescence phases. The recovery phase is the time immediately after surgery when the effects of anesthesia are wearing off and the patient is waking up. The convalescence phase is spent either in the hospital, in an interim care facility, or at home—depending on the procedure and the preferences of the physician and patient.

Complications

Intraoperative complications are surgery related, anesthesia related, or position related. One complication occurring during the intraoperative period that is not common but can be life threatening is an anaphylactic (allergic) reaction to anesthesia. The intraoperative staff is trained extensively in the treatment of such a reaction, and emergency equipment should always be available in the event it is needed for this purpose. Another anesthesia-related complication is called "awareness under anesthesia." This occurs when the patient receives sufficient muscle relaxant (paralytic agent) to prohibit voluntary motor function but insufficient sedation and analgesia to block pain and the sense of **hearing**. Patients are aware

KEY TERMS

Anaphylactic reaction (anaphylaxis)—A hypersensitive reaction to an antigen resulting in life-threatening, progressive symptoms.

Anesthesia—A classification of medications that are intended to cause the loss of normal sensation.

Aseptic technique—Strict sterile procedures instilled to decrease the risk of contamination of a surgical site or open wound.

ECG—Abbreviation for electrocardiograph. Electro-cardiograph is a tracing of the electrical activity of the heart obtained through electrodes placed on a person's skin in certain areas where electrical activity can be easily be detected.

Hypovolemic shock—A state of shock caused by the sudden loss of large amounts of blood.

Informed consent—Written or oral permission given by a patient or guardian for medical or surgical treatment after a complete explanation is given and any questions the patient has are answered. If consent is given orally, documentation must have two witnesses.

Intraoperative care—Care provided to a patient during surgery that is ancillary to the surgery.

Malignant hyperthermia—A chain reaction triggered in susceptible people by commonly used general anesthetics. Signs include greatly increased body metabolism, muscle rigidity, and eventual hyperthermia which may exceed 110°F (43.3°C). Death may be caused by cardiac arrest, brain damage, internal hemorrhage, or failure of other body systems.

Pulmonary function tests—Tests used to determine ventilation and perfusion capabilities of the lungs.

Pulse oximetry—A method of measuring a patient's blood oxygenation status. A measure of 100% is optimal.

of being “awake” because they hear the sounds and conversation in the room and, in some cases, can feel the pain associated with the skin incision and surgery. However, they cannot respond to these sensations in a way—not even with so small a motion as blinking the eyelid—that will tell someone what they are sensing. This condition creates an exaggerated fear response that can affect hemodynamics and vital signs. Another com-

plicating reaction may be that of malignant hyperthermia. This is a chain reaction triggered in susceptible people by commonly used general anesthetics. Signs include greatly increased body **metabolism**, muscle rigidity, and eventual hyperthermia which may exceed 110°F (43.3°C). Death may be caused by cardiac arrest, **brain** damage, internal hemorrhage, or failure of other body systems.

Complications of surgery include, but are not limited to, hypovolemic **shock** (due to blood loss during surgery), injuries from poor positioning during surgery, infection of the surgical wound, fluid and electrolyte imbalances, aspiration **pneumonia**, blood clots, and paralytic ileus (paralysis of the intestines, causing distention).

Results

The results of a surgical procedure depend greatly on the procedure performed, the skill of the surgeon, the general health of the patient preoperatively, and the ability of the patient's body to recover from the procedure. Some surgeries cure a condition (e.g., an appendectomy for an inflamed appendix). Others are only one step in a long process to cure a disease or repair an injury (e.g., discectomy for a patient suffering from back pain). Still others are performed as palliative measures rather than as a cure. An example of palliative surgery would be the removal of a metastatic abdominal tumor to relieve abdominal pressure. In this example removing the abdominal tumor is not going to cure the **cancer** that exists in other parts of the patient's body; it is simply going to relieve the discomfort caused by the abdominal mass.

Health care team roles

Nurses may fill two different roles in the operating room. The scrub nurse is responsible for providing the surgeon with instruments and supplies and maintaining the sterile field. This role also may be assumed by a scrub or surgical technician. The second role nurses have in the operating room is that of circulating nurse. The circulating nurse is first the patient's advocate, with primary concern and responsibility for the patient's safety and welfare. In addition, the circulating nurse is responsible for anything related to the patient that is not directly contingent to the sterile field. That means all activities necessary to prepare the patient and the operative site for surgery, and assistance required by anesthesia personnel. Of crucial import is that the circulating nurse must be certified to give intravenous medication to the patient in case of an emergency. Finally, nurses must document and process tissue specimens for pathology.

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Intravenous fluid regulation

Definition

Intravenous (IV) fluid regulation refers to the manual or automatic pump control of the rate of flow of IV fluids as they are delivered to a patient through a vein.

Purpose

The purpose of intravenous fluid regulation is to control the amount of fluid that a patient is receiving, usually within a given hour of IV therapy. Without fluid regulation, the IV would run in by gravity at a rapid rate and could cause fluid or drug overload.

Precautions

There are varied types of IV administration sets, and they deliver fluid at different amounts per drop. Nurses should always determine the type of drip chamber that they are using and calculate the IV flow per minute based upon the amount of fluid that the administration set delivers per drop.

There are varied types of IV pumps and IV tubing used to deliver IV fluids. Nurses should be sure to use the correct tubing for the pump selected. The specific directions for the use of each individual pump should be followed.

Description

Manual regulation of IV fluids is performed by adjusting the roller adaptor on the IV tubing until it reaches the appropriate drip rate per minute. To manually regulate the IV rate, the nurse looks at her watch and times the number of drops that fall into the drip chamber over one full minute. If the rate is too slow, the adapter should be rolled to a looser position to speed the dripping of the IV. If the rate is too fast, the roller adapter should be tightened to decrease the dripping of the IV. Nurses should adjust the roller until the IV rate is set at the correct amount of drops per minute to deliver the IV fluids as ordered. The IV rate must be checked every hour or more often according to the policy of the medical setting to be certain that the rate remains accurate.

To regulate the IV fluid to be delivered by an IV pump, the tubing should be threaded into the machine correctly. Nurses should dial in the hourly IV rate (cc to be delivered over an hour) and start the pump following the manufacturers guidelines. IVs must be checked hourly when on a pump to be sure that the rate remains accurate and that the correct amount of fluid is delivered. Most pumps have a reading that shows how much fluid has been delivered over the past hour.

Preparation

The physicians order for IV therapy should be reviewed. An IV therapy order will include the type of IV fluid to be delivered over a specific amount of time. Some physicians will order IV therapy in terms of an hourly rate. (Example: Lactated Ringers IV, run at 125 cc/hour.) More commonly the physician will order IV therapy in terms of eight, 12, or 24 hour time periods. (Example: One liter of D5W IV over the next eight hours.)

If the fluid is ordered by the shift (every eight hours) or for a 24-hour period, the first calculation must be to

KEY TERMS

Diaphoresis—Profuse sweating.

Phlebitis—An inflammation of a vein.

Tachycardia—A condition where the heart rate is faster than normal, usually over 100 beats a minute in an adult.

determine how much fluid is ordered per hour. This can be determined by dividing the total amount of fluid by the total time ordered for delivery. For example, if the doctor ordered 1000 cc to be given over eight hours, divide the 1000 cc by the time (eight hours) to obtain the rate per hour. The hourly rate for the IV would be 125 cc for each hour. Another example would be that the doctor orders 3 liters of IV fluid to be given over 24 hours. Divide 3 liters (3000 cc) by the time (24 hours) to obtain the hourly rate of 125 cc per hour. When using an IV pump, the only calculation needed is the rate per hour because IV pumps when set will deliver an hourly rate of IV fluid automatically. The machine does the calculation and drip control. Nurses should be sure to select the specific tubing that the manufacturer recommends for use with each pump.

When not using an automatic IV pump, an administration set should be selected, and the nurse should look on the packaging for the calibration of the drip rate. Standard IV administration sets have a drip factor of 10, 15, or 20 drops/cc. A microdrip or minidrip administration set has a drip factor of 60 drops/cc and is used primarily for low IV rates, such as those used for pediatric clients. The calibration of the administration set must be known in order to calculate the flow of the IV fluids correctly.

The next step is to convert the drops per hour into drops per minute so that the nurse can literally count the drops delivered each minute to set the IV flow. To calculate the drops per minute, the drip factor of the administration set must be used. The nurse should divide the number of ccs to be delivered per hour by the number of minutes in an hour (60) and multiply by the drip factor of the IV administration set to find the drops per minute. For example, if the patient should receive 125 cc per hour using a set that delivers 10 drops/cc, the nurse would multiply the fraction $125/60$ times 10 to get a drip rate per minute of 20.8 drops/minute. The number should be rounded to 21 drops per minute. Another example would be if the patient should receive 150 cc per hour using a set that delivers 20 drops/cc, the nurse would multiply the fraction $150/60$ times 20 to get a drip rate of 50 drops

per minute. The easiest calculation is using an administration set that delivers 60 drops/cc, because the drops and the minutes cancel each other out. For example, to give 50 cc/hr using a 60 drops/cc administration set, the fraction $50/60$ should be multiplied by 60 to get a drip rate per minute of 50. Once the drip rate per minute is determined, the flow of the IV is ready to be regulated according to the doctor's order.

Aftercare

Regulating IV fluid is an ongoing process from the time that an IV is started until it is completed. Hourly checks of an IV should include assessing the client's response to the IV, the rate of the IV flow, how much fluid has infused, how much fluid remains to be infused, and the condition of the IV insertion site. Adjust the rate if the IV is not flowing at the rate that was ordered. If IV fluid is flowing in slowly, the nurse should check for a kink in the tubing or a positional problem. In addition, the IV could be out of the vein, or a small clot, phlebitis, or **infection** at the site could be slowing the IV down. If an IV is flowing too rapidly, it may be leaking out around the IV insertion site or may run faster when the patient extends the extremity. The whole system, from the insertion site to the IV bag, should be examined. The physician will assess IV fluid needs and reorder IV therapy daily according to client needs.

Complications

Circulatory overload can occur if an IV is not regulated and IV fluids infuse too rapidly for the patient's body to handle. Signs of fluid overload include tachycardia, elevated **blood pressure**, headache, **anxiety**, wheezing or other signs of respiratory distress, diaphoresis, restlessness, distended neck veins, or chest **pain**. If these signs occur, slow the IV rate and contact the physician.

Sluggish IV flow or mechanical failure can also occur, which results in the IV fluid not being delivered as ordered. The sign of sluggish IV flow is an IV rate that is persistently behind in spite of constant regulation. Sluggish IV flow can be caused by kinked tubing; small clots, phlebitis, or infection at the site; infiltration of the IV cannula; or a problem with the needle leaning against the wall of the vessel and cutting off IV flow. If the problem is not positional or equipment related, the IV will need to be restarted in a new vein in order to deliver the IV therapy safely and effectively.

Results

IV fluids when regulated to flow according to the physicians orders have positive therapeutic effects such

as rehydration, restoration of **electrolyte balance**, restoration of **acid-base balance**, replacement of **vitamins, proteins**, and calories, and safe rapid medication administration.

Health care team roles

IV fluid regulation is delegated to registered nurses in most medical settings. Paramedics, LPNs, and IV team technicians who have received special IV training may regulate IV flow rates according to the policies in some medical settings. Patients and their families can be trained to use IV therapy in the home setting. The equipment for home IV therapy, however, will usually include a pump that automatically controls the IV rate. This setting is usually locked so that it cannot be accidentally altered. Patients are taught the signs of complications and learn to trouble-shoot IV alarms. IV nurses visit daily or every few days to change the IV tubing and are on-call to assist the patients and their families 24 hours a day when problems arise.

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Intravenous medication administration

Definition

Intravenous (IV) medication administration refers to the process of giving medication directly into a patient’s

vein. Methods of administering IV medication may include giving the medication by rapid injection (push) into the vein using a syringe, giving the medication intermittently over a specific amount of time using an IV secondary line, or giving the medication continuously mixed in the main IV solution. IV medications are most often given through a peripheral line or saline IV lock, but may also be administered direct IV, through an implanted vascular access port or through a central line.

Purpose

The primary purpose of giving IV medications is to initiate a rapid systemic response to medication. It is one of the fastest ways to deliver medication. The drug is immediately available to the body. It is easier to control the actual amount of drug delivered to the body by using the IV method and it is also easier to maintain drug levels in the **blood** for therapeutic response. The IV route for medication administration may be used if the medication to be delivered would be destroyed by digestive enzymes, is poorly absorbed by the tissue, or is painful or irritating when given by intra-muscular (IM) or subcutaneous (SQ) injection.

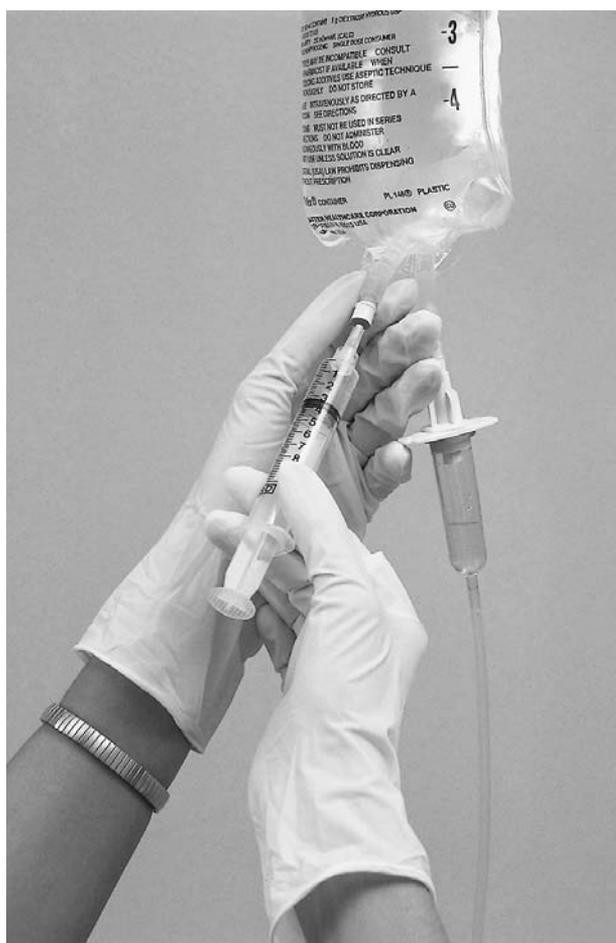
Precautions

Proper IV administration should follow the five “rights” of medication administration to avoid medication errors: be sure it is the right patient, the right drug, the right dose, the right time, and the right route before giving any medication.

The IV line must be intact before any IV medication can be administered. Some IV medications can cause severe tissue damage if injected into the tissue through an infiltrated IV site.

Some IV push medications must be diluted before injection. The health care professional must check the directions for giving the specific drug IV before performing the injection. Administration guidelines for giving IV medications must be followed to avoid serious complications from the drug injection. Most medical settings have an approved IV drug list and instructions for injecting each drug IV. Other resources include the PDR guide, drug administration handbooks, or printed inserts from the pharmaceutical company.

The drug delivery rate is an important factor when administering IV medication. Some IV drugs are meant to be delivered rapidly over several minutes to obtain therapeutic effect. Other drugs are most effective when delivered slowly and intermittently throughout the day. Each drug delivery rate is unique. Administration guide-



Adding medication to an intravenous fluid bag. (Delmar Publishers, Inc. Reproduced by permission.)

lines for giving IV medications must be followed to achieve the therapeutic effect desired.

IV drugs may not be compatible with certain IV fluids or other drugs. Drug incompatibility is a true risk to the patient because it can cause crystallization of the medication that may at the least clog the IV line or at the worst have an embolus effect on the patient. The health care professional must check compatibility warnings that are included in IV drug administration guidelines. The line must be flushed with saline before and after giving medications IV to avoid contact of incompatible solutions or medications.

The effects of medication appear rapidly after an IV injection. The health care professional must know the indications, actions, and adverse effects of the medication that is to be delivered and must observe the patient closely for adverse medication reactions or allergic reactions and be prepared to respond with supportive therapy or drug reversing agents.

Description

IV push medication techniques deliver a bolus (a dose of medication injected all at once intravenously) of medication directly into a vein or access port to produce an immediate peak drug level in the patient's bloodstream. Large quantities of fluid IV push can cause severe complications; follow the recommendations of the drug administration guidelines. To deliver an IV bolus medication, draw the appropriate amount of medication that has been prepared, diluted, and/or reconstituted according to IV drug administration guidelines into a syringe. A bolus injection is most often given through a peripheral IV line, a saline lock, directly into a vein, or through a vascular access port.

When giving an IV bolus medication through a peripheral line with compatible fluid, the health care professional must shut off the IV line using the control clamp. The Y-port closest to the insertion site is cleaned with an alcohol or povidone-iodine pad to prevent bacterial contamination. The health care professional must then connect the medication needle or needle-less system connector to the port. The medication is injected over the period of time ordered, after which the syringe is disconnected and removed. The IV line is reopened using the control clamp and the IV flow is reset to the appropriate setting. If the peripheral line fluid is not compatible with the IV bolus medication, two syringes with 3cc of normal saline are prepared before giving the medication. The line is flushed before and after the IV medication administration with the prepared saline syringes. The Y-port is quite vulnerable to contamination when switching syringes. After the IV line is flushed the second time, the line can be reopened and the IV flow rate reset to the appropriate setting.

A saline (heparin) lock is a peripheral IV device. It is a short IV line that has been locked off to prevent venous fluid from flowing out. It is primarily used to access a vein for intermittent IV drug therapy. A latex cap that can be accessed by a needle or needle-less system connector to deliver drugs or IV fluids intermittently covers the distal tip. When giving an IV bolus medication through a saline lock, prepare two syringes with 3 cc of normal saline as well as the IV bolus medication syringe. (The health care professional should check the medical institution policy because some institutions require the use of heparin to flush IV locks.) The health care professional wipes off the cap of the saline lock with an alcohol or povidone-iodine swab to prevent bacterial contamination. The needle or needle-less system connector is connected to the latex cap of the lock and the patency of the lock is checked by pulling back on the syringe. A flashback of blood into the tubing indicates that the IV

Flow rates for intravenous infusions

Drop factor of tubing (drops/ml)	1000 ml/6 hr (drops/min)	1000 ml/10hr (drops/min)	1000ml/12hr (drops/min)	1000 ml/24hr (drops/min)
10	28	17	14	7
15	42	25	21	10
20	56	34	28	14
60	167	100	84	42

SOURCE: Smith-Temple, J. and J.Y. Johnson. *Nurses' Guide to Clinical Procedures*. 3rd ed. Philadelphia: Lippincott-Raven Pub., 1998.

catheter or needle is in the vein. If no blood appears, a tourniquet is applied above the IV site for about one minute and then the line is aspirated again. Medication should not be given unless the IV is patent (open and unblocked). To continue, the saline is injected into the lock and the insertion site is examined for signs of leaking or puffiness. If the IV lock appears intact, the saline syringe is removed. The medication syringe is connected to the cap using a needle or needle-less connector and the IV push medication is administered over the amount of time that was ordered. The medication syringe is removed and then the second saline syringe is connected to flush the line. Care is taken not to contaminate the cap when switching syringes. Finally the saline syringe is removed and the saline lock apparatus is left well secured to the patient's skin.

In an emergency when a patient has no IV line in and an IV bolus medication needs to be given, the nurse or physician may elect to insert a temporary butterfly IV apparatus connected to a needle. This is not a common situation. In most cases the staff will attempt to insert a regular IV catheter line to enable them to have a stable line for follow-up infusions of medications or fluids. To insert a temporary butterfly IV apparatus, the health care professional washes his/her hands and puts on gloves. A tourniquet is applied and a large vein is selected. The skin over the vein is swabbed with a povidone-iodine swab and the needle is inserted into the skin and then into the vein. When the IV is in place and a blood flashback is visible in the tubing, the tourniquet is removed and the distal end of the line is connected to a syringe of normal saline. The wings of the apparatus are secured with a piece of tape, and the line is aspirated with a syringe to assure proper line placement. If a blood return occurs, the line is slowly injected with 3 cc of normal saline to flush it. The insertion site is checked for puffiness or signs of leakage. Then the saline syringe is removed and rapidly replaced with the medication syringe. The prepared bolus of medication is given over the amount of time ordered. When the medication administration is complete, the syringe is removed and quickly replaced with another 3cc syringe filled with normal saline. The line is flushed

with the saline and the butterfly apparatus is removed from the vein. Pressure is applied to the site using a sterile 2 x 2 gauze pad. This method is not recommended for more than one dose of medication because of the temporary nature of the apparatus. If a patient may require further IV therapy a regular IV catheter should be inserted and connected to an IV line or capped off for use as a saline lock.

IV bolus medication may be given through a vascular access port that has been surgically implanted in the chest. When giving IV medication into an access port follow the procedures for accessing and giving IV medications through the port that are defined by the medical setting. A special needle apparatus is required that will not damage the port or the skin over the port. PICC line and mid-line catheters are not usually used for IV bolus medications because of the length of their tubing. Central lines must be used cautiously when giving IV bolus medication. Since the bolus will be pouring into a large central vein, the effect of the medication will be immediate and can be overwhelming to the patient's body.

IV medication may be given intermittently using a larger amount of fluid to be administered over a longer period of time (such as 50 cc over 20 minutes). Intermittent infusions may be administered through a secondary IV set (piggy back set) using an IV pump or a volume control set using an automatic IV syringe pump. There are many types of tubing and apparatus that can be used to deliver intermittent IV therapy. When administering intermittent IV therapy the instructions as defined on the administration set or in the medical center's IV policies are followed. The basic principles include: ensuring that the IV secondary set (piggy back) is positioned into the correct port on the main IV line and verifying that the pump is set to deliver the IV medication over the correct amount of time that was ordered by the physician. All lines are primed before they are connected to the IV to avoid delivering air through the lines. If the IV medication to be given is not compatible with the IV solution that is hanging, the line is flushed with normal saline before and after running the IV medication. The patient is observed carefully as the medication is delivered for

KEY TERMS

Embolus—An air bubble, blood clot, or foreign matter that lodges in a blood vessel, occluding blood flow.

Necrosis—Tissue destruction or death of tissue cells that is caused by injury, infection, or disease.

Venous thrombosis—A condition in which a vein is clogged off by foreign matter or a blood clot that results in decreased blood flow and oxygen to specific parts of the body.

signs of medication reaction or allergic reaction. When the IV medication has run in, the main IV solution is switched back on and the pump is reset for the maintenance rate as ordered by the physician.

Some IV medications, such as potassium chloride, are mixed into the main IV solution bag and run continuously. These medications are injected into the IV bag by the pharmacy or the nurse prior to hanging the IV solution. They run continuously at the rate of flow ordered by the physician.

Preparation

The patient is placed in a comfortable position, the procedure is explained, and the patient is told the name of the drug to be administered. The patient also should be instructed to alert the health care professional immediately if he/she has unusual feelings or discomfort after medication administration. The patency of the IV line is checked to insure that the line is intact and not leaking. The physician's order is reviewed and the five rights of medication administration are checked. The label on the medication is checked to be sure that it is not outdated. (Outdated medication should not be given.) The IV administration guidelines for the specific drug are reviewed, and the health care professional verifies that the drug is approved for IV administration according to the policies of the medical setting. After washing his/her hands, the health care professional calculates and prepares the drug according to drug administration guidelines. Any necessary equipment is assembled and ready access to emergency response equipment (such as contained in a crash cart) is verified.

The health care professional determines the amount of time over which the drug should be delivered according to the physician's order and/or the IV drug administration guidelines. For IV push medications this is calculated in cc to be delivered per minute. This number is

calculated by dividing the amount to be delivered (in cc) by the time over which the drug should be delivered (in minutes). For example, if the order is to give 10 mg of drug X over 5 minutes, first determine that 10 mg of drug X comes prepared in 6 cc of liquid. Divide 6 cc by 5 minutes to determine that the rate of IV injection should be 1.2 cc per minute. If the drug must be reconstituted, the rate is calculated using the total amount of drug in cc after reconstitution. For example, give 25 mg of drug Y over 5 minutes. Drug Y is a powder that is reconstituted with 5 cc of sterile water. When reconstituted, the medication has a fluid volume of 6 cc. Divide 6 cc by 5 minutes to determine that the drug should be given at 1.2 cc per minute. Intermittent IV drug doses are usually calculated in cc per hour. They are given in larger amounts of fluid that are usually given with an IV pump and most IV pumps are set in cc per hour, not cc per minute. To calculate the cc per hour rate, the cc per minute rate is multiplied by 60. For example, if the order reads give drug Z in 50 cc of normal saline over 20 minutes, calculate the cc to be delivered per minute by dividing 50 cc by 20 minutes and then multiply times 60 minutes. The rate would be 150 cc per hour to deliver the IV medication in 20 minutes.

Aftercare

After an IV medication has been delivered, the patient is observed for adverse or allergic reactions. Used needles are discarded without recapping them in a puncture proof, contaminated needle container. Used IV tubing, bags, gloves, and disposable supplies are discarded in a plastic bag that can be sealed and discarded in the contaminated trash. The health care professional washes his/her hands and documents that the medication that has been given. If reverting to a primary IV line, the health care professional must be sure to reset the IV flow rate to the correct hourly rate that is ordered for the IV fluids.

Complications

Complications of IV medication administration may include:

- infiltration of the IV line when a drug is injected IV bolus
- tissue necrosis when drugs are injected into infiltrated IV sites
- thrombophlebitis of the vein
- injection of air embolism
- serious adverse drug reactions such as hypotension, cardiac arrhythmias, and cardiac arrest
- allergic reaction to the medication

- venous thrombosis
- pain at the IV site

Results

When administered according to the physicians orders, following drug administration guidelines, and using the correct technique and IV apparatus, IV medications can have immediate positive therapeutic effects. The effects of the medication will vary depending upon the type of medication given.

Health care team roles

IV medication administration is delegated to registered nurses in most medical settings. Paramedics, LPNs, and IV team technicians who have received special IV training may give certain medications IV according to the policies of some medical settings. Patients and their families can be trained to use IV therapy pumps that automatically deliver IV medications in the home setting. IV nurses visit the home daily or every few days to change the medication cartridge and check the status of the IV line. The settings for the IV pump delivering IV medications are usually locked so that they cannot be accidentally altered. Patients are taught the signs of complications and learn to trouble-shoot IV alarms. IV nurses remain on-call to assist the patient and the family 24 hours a day when problems arise.

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Intravenous nutrition see **Parenteral nutrition**

Intravenous tubing and dressing change

Definition

Intravenous (IV) infusion is the process whereby fluids, medications, **blood** products, and nutritional substances are administered into a vein by means of an intravascular device. The most commonly used device is the short peripheral venous catheter, which is usually inserted into the veins of the forearm or hand. IV fluids are supplied in plastic bags and delivered via an administration set, i.e., tubing. The fluid to be infused and the flow rate are prescribed by a physician or nurse practitioner.

Purpose

IV infusion is a method of fluid replacement used most often to maintain fluid and **electrolyte balance**, or to correct fluid volume deficits after excessive loss of body fluids, or in patients unable to take sufficient volumes by mouth. Many medications are also given by IV infusion and it is used for prolonged nutritional support of patients with gastrointestinal dysfunction.

Precautions

The insertion of an IV access device creates an open wound and the continued presence of the catheter within the wound keeps it “open,” which provides easy access for opportunistic **bacteria**. These bacteria may be present on a patient’s skin or may come from touch contamination by a practitioner. Technically, the administration of IV solutions takes place within a “closed-system,” but the delivery system usually has a number of connections, which may allow entry of bacteria. Strict adherence to handwashing and **aseptic technique** must always be followed while obtaining venous access and the equipment must be handled carefully to prevent contamination. Before using any materials, the practitioner must ensure that all packaging is intact prior to opening, that expiration dates have not passed, and that there are no visible signs of contamination. The site at which a catheter is placed has been shown to influence the subsequent risk of catheter-related infections; and in adults, hand vein insertions have a lower risk of problems than do upper arm or wrist vein insertions. Similarly, there is a greater risk with insertions in the legs than the arms, but the choice of a site may be limited by patient factors, e.g., preexisting catheters, anatomic deformity, present illness, or trauma. The practitioner must also be aware of any patient **allergies** to latex, iodine, or other substances. For

KEY TERMS

Catheter—A hollow tube that is flexible and used for withdraw or introduce fluids into the body.

Dehydration—A condition that results from a loss of water in the body.

Intravascular—Within a vessel, as a blood vessel.

Semipermeable—Permitting passage of only certain molecules.

Peripheral—That portion of the body that is outside the main region, as arms or legs.

Povidone—A synthetic polymer used as a dispersing and suspending agent as in povidone-iodine, a topical anti-infective agent.

selection of catheters, the Centers for Disease Control (CDC) recommend the use of a Teflon catheter, a polyurethane catheter, or a steel needle. The choice depends on the intended purpose, duration of use, and known complications. Transparent, semipermeable, polyurethane dressings reliably secure the site, permit continuous visual inspection of it, allow patients to bathe or shower without saturating the dressing, and require less frequent changes than standard gauze and tape dressings. Research has shown no clinically important differences between the two with regard to rate of **infection** or occurrence of inflammation.

Description

The initial insertion of a catheter with transparent dressing or sterile gauze should be labeled as to the time and date of insertion in an obvious location near the site (e.g. on dressing or on the bed) and the IV administration set should likewise be labeled as to time and date of hanging. CDC recommendations for care and management of peripheral venous catheter sites, IV administration sets, and dressing changes include the following:

- Hands must be washed before and after palpating, inserting, replacing, or changing dressing.
- The catheter site must be visually inspected and palpated for redness, tenderness, or warmth (phlebitis) daily.
- Sites must be replaced and rotated every 48–72 hours to minimize risk of phlebitis. Catheters inserted under emergency conditions must be replaced with new catheters within 24 hours due to possible break-in aseptic technique. Heparin locks must be replaced within 96 hours. Catheters with signs of phlebitis should be removed immediately or as soon as its use is no longer

clinically indicated. Do not routinely apply topical antimicrobial ointment to site.

- When the catheter is removed or replaced, the site dressing should be replaced. The dressing should also be replaced when it becomes damp, loosened, or soiled. Dressings are changed more frequently for patients that sweat. Avoid touching the site when dressing is replaced.
- The IV tubing, including piggyback tubing and stopcocks, is replaced no more frequently than at 72-hour intervals, unless clinically indicated. Tubing used to infuse blood, blood products, or lipid emulsions is replaced within 24 hours of initiation.
- Injection ports are cleaned with 70% alcohol or povidone-iodine before accessing the system. Heparin locks require a routine flush with normal saline solution, unless they are used to obtain blood specimens, in which case a dilute heparin (10 units/ml) flush solution should be used.

Preparation

- All needed materials must be assembled prior to approaching the patient for catheter insertion or IV tubing and dressing change.
- Hands must be washed before and after the procedure.
- The procedure is explained to the patient and he/she is encouraged to ask questions.
- If the patient's veins are difficult to access, warm soaks can be applied to the area prior to attempted insertion to increase blood flow to that area and facilitate the process.
- Nonlatex or latex gloves are worn for insertion of the catheter and for changing the dressing.
- The site or dressing should be marked with labels carrying the date, time, and initials of the individual performing the procedure.

Aftercare

Follow-up care includes:

- The site is inspected and palpated daily.
- IV fluids and additives are monitored to ensure that they are those ordered by the physician or nurse practitioner.
- The infusion rate is checked to make sure that it is correct as ordered.

Complications

The use of IV devices is frequently complicated by a variety of local or systemic infectious complications to include:

- bloodstream infection
- inflammation and/or infection of the lining of the cavities of the heart
- inflammation of the vein sometimes associated with a clot
- infections in other areas of the body

The risk of complications in IV therapy is actually higher on the second day of therapy and was believed to increase with time, which made routine restarts after three days a common practice. Recent research has shown, however, that a restarted catheter has a significantly higher risk of complication in its first 24 hours than does an initial catheter. Thus, restarting catheters routinely at 72 hours does not reduce the risk of complication in the next 24 hours when compared to simply continuing therapy with the original catheter, provided the site or the original has no signs of inflammation. Once additional studies confirm these data, the recommendations may change.

Results

The results obtained from IV therapy should primarily serve to improve the condition of the patient. A dehydrated patient's fluid volume and electrolyte balance should improve. Any patient ill from an infection should feel improved with IV antibiotic therapy. The purpose of an IV is to alleviate symptoms and assist with enhancing well-being.

Health care team roles

The **registered nurse** is the primary provider of IV catheter insertion, IV fluids, tubing, and dressings. It is the role of this nurse to ensure that the recommended procedures, protocols, and written orders for IV therapy are followed. It is also the duty of the nurse to maintain her skills for IV therapy and keep updated on any changes in recommendations in providing care. Available data suggest that personnel specially trained or designated with the responsibility for insertion and maintenance of IV devices provide a service that reduces the rate of infections and overall costs.

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Intravenous urography

Definition

Intravenous urography is a radiographic study of the **urinary system** using an intravenous contrast agent (dye).

Of the many ways to obtain images of the urinary system, the intravenous injection of a contrast agent has been traditionally considered the best, although other modalities, such as computed tomography (CT) or ultrasound, are better for some disease processes. The **kidneys** excrete the contrast into the urine, which becomes visible when x rayed (radiopaque), creating images of the urinary collection system.

The procedure has several variations and many names, including:

- Intravenous pyelography (IVP).
- Intravenous urography (IVU).
- Pyelography.
- Antegrade pyelography differentiates this procedure from retrograde pyelography, which injects the contrast agent directly into the lower end of the system. The contrast agent flows backward, hence the name "retro-

grade.” Retrograde pyelography is used to better define problems in the lower ureters and is the only way to get x rays if the kidneys are non-functional.

- Nephrotomography, or tomographic slices of the kidneys, is taken by a moving x-ray source emitting x rays onto a film moving in the opposite direction. Images above and below the level of the kidneys are blurred, allowing a more detailed image of the kidneys with no overlying material, such as gas or fecal material.

There are numerous exams available for detecting kidney abnormalities, with varying risks and costs.

- Nuclear renal scans rely on the radiation given off by certain atoms (isotopes), which are injected into the bloodstream. They reach the kidneys, where images are constructed by measuring the radiation emitted. The radiation is no more dangerous than standard x rays. This exam has limited applications, including the evaluation of reflux, chronic obstruction, and renal function. It is also used to evaluate high **blood pressure** that is refractory to treatment, and is commonly used to evaluate the kidney of a renal transplant patient for early rejection where renal artery stenosis is suspected as the cause.
- Ultrasound is a quick, safe, simple, and inexpensive way to obtain views of internal organs. Renal size can be measured as well as the visualization of hydronephrosis, cysts, tumors, and renal calculi. Small stones in the ureters are not as well visualized and the function of the kidneys can not be determined.
- Retrograde pyelography is better able to define problems in the lower part of the ureters, and is the only way to completely opacify the ureters in patients with reduced kidney function. This exam is performed in an operating room by a urologist. A cystoscope is placed into the bladder and a catheter is placed into each ureter to inject the contrast agent. The advantage of this method is that small stones can be removed immediately by the urologist.
- Computed tomography scans (CT or CAT scans) use a fine beam of x rays creating images at precise levels in the body. The information is processed by a computer and imaged onto film with a laser printer. Three-dimensional images can be constructed from this method of imaging. An injection of a contrast agent is necessary to visualize the kidneys in detail. The CT scan is done without IV contrast to look for stones (calculi). In some centers, this modality has replaced IVPs and ultrasound for this application. Special equipment is necessary and the exam can be costly.
- Magnetic resonance imaging (MRI) uses magnetic fields and radio frequency signals instead of ionizing

radiation to create computerized images. This form of energy is entirely safe as long as the patient has no metal in his or her body. It has limited applications and usually is not done for common problems, such as **pain** and hematuria (**blood** in the urine). MRI usually is done if other tests are inconclusive. MRA (magnetic resonance **angiography**) may be done to evaluate the renal arteries, particularly if renal artery stenosis is suspected as a cause of **hypertension** that is refractory to treatment. MRI requires special apparatus and installation and is a very costly exam.

Purpose

An intravenous urogram is ordered to demonstrate the structure and function of the kidneys, ureters, and bladder. Patients complaining of abdominal pain radiating to the back may require this exam to rule out **kidney stones**. Hematuria may also be an indication of kidney stones, **infection**, or tumors. Patients with high blood pressure (hypertension) and recurrent bladder infections may also require an intravenous urogram (but hypertension usually is imaged with MRA or nuclear medicine imagery and this exam is done when renal artery stenosis is the suspected cause of refractory hypertension). Sometimes the exam is ordered to evaluate the function of the kidney in a renal transplant patient. The transplanted kidney is located in the iliac fossa, so special films of the pelvis area are done instead of the normal routine views. The radiographic technologist may also be required to take x rays in the operating room when a retrograde pyelogram is ordered by a urologist during a C and P (**cystoscopy** and pyelography).

Emergency patients with blunt abdominal trauma are usually evaluated with a CT scan or occasionally ultrasound instead of an intravenous urogram.

Precautions

A serious complication of an intravenous urogram is an allergic reaction to the iodine-containing contrast agent. Severe reactions are rare, but can be dramatic and even lethal. For this reason all radiology departments performing this exam are equipped with emergency drugs and oxygen in the x-ray room itself.

Description

The patient will be required to change into a hospital gown and empty his or her bladder. The x-ray technologist will verify that the patient has followed the bowel preparation and complete a detailed questionnaire on the current medical history of the patient. This includes previous contrast reactions, known **allergies**,

risks of **pregnancy**, and current medications. The x-ray technologist will explain the exam in detail to the patient as well as the risks of the contrast material that will be injected intravenously. All departments require that the patient sign a consent form before the examination is started. The x-ray technologist will relay this information to the radiologist who will decide on what type of contrast will be used. Patients who have had an injection with no reaction can be given less expensive iodine-based contrast, whereas patients who take various **heart** medications or those with known allergies or **asthma** will be injected with a more expensive contrast agent (known as non-ionic contrast) that has fewer side effects. Some departments use the non-ionic contrast exclusively.

The patient will be instructed to lie supine (face-up) on the x-ray table and a preliminary KUB will be done. This is an abdominal view of the kidneys, ureter, and bladder used to verify patient preparation, centering, and the radiographic technique needed to demonstrate all the required structures.

Kidney stones may or may not be visualized on the preliminary film. The x-ray technologist prepares the required amount of contrast to be used depending on the weight of the patient (1 ml per pound). This is normally 50–75 cc of contrast for an average-sized patient. The contrast will be injected all at once (bolus injection) or in some cases, through an intravenous drip. Some radiologists prefer to start an intravenous drip with saline as a precautionary measure while others inject with a small butterfly needle. The needle usually remains in place for 10–15 minutes, in case more contrast is needed or in case drugs need to be administered because of an allergic reaction. Most reactions occur immediately but some can take place 10 or 15 minutes after the injection.

The first film is taken immediately after the injection to see a detail of the renal outline (nephrogram). Films are usually taken at five-minute intervals depending on the routine of the radiologist. Compression may be applied to the lower abdomen with a wide band to keep the contrast material in the kidneys longer. This creates a more detailed image of the renal collecting system. When the compression is released after approximately 10 minutes the contrast material drains quickly and a detailed, filled image of the ureters is obtained. Films done in the upright or prone (face-down) position may also be ordered to better visualize the lower ureters. Some departments require routine renal tomographic images to be done as well when the kidneys are well visualized. This allows the kidneys to be seen free of gas or fecal shadows. Sometimes the radiologist requires oblique views of the kidneys or bladder to determine the exact location of calculi (stones). At approximately 20 minutes after the injection a film centered on the bladder may be

required. The x-ray tube is angled slightly caudad (towards the feet) so that there is no superimposition of the pubic area of the pelvis over the bladder. The films are shown to the radiologist and if no further films are necessary the patient will be asked to void (urinate) and a post-void film will be taken. The exam can take from 30 minutes to one hour depending on the number of films required. If the kidney is obstructed, delayed films may be required to complete the exam.

Preparation

In order to obtain the best visualization of the kidneys, ureters, and bladder, the intestines must be free of gas and fecal material. Every radiology department has their own specific requirements. Most include a laxative such as X-Prep or Dulcolax tablets taken around 4 p.m. the day preceding the exam. This is followed with a light fat-free dinner which includes lean meats, noodles, white rice, bread with no butter, and tea or black coffee. Fluids are permitted until midnight, after which no food or liquid is allowed until after the intravenous urogram is completed. Patients who are diabetic are sometimes done early in the morning to avoid any complications. Patients who have had a previous reaction to a contrast material can be given a series of steroids and **antihistamines** the day before the exam as well as the morning of the exam. The patient must consult with their physician before this is administered. In patients with known or suspected renal failure, lab tests, including BUN and creatinine, may be ordered prior to the IVP.

Complications

An allergic reaction to the contrast agent is the primary risk, although kidney damage is also a potential complication. Patients with a possible iodine allergy or a previous reaction to a radiographic contrast agent should inform the x-ray technologist. A detailed history of known allergies, risk of pregnancy, and current medications is required before an intravenous urogram. All radiology departments have consent forms that must be signed by the patient before starting the exam. Emergency equipment and specific drugs such as antihistamines (Benadryl), adrenaline, and atropine are kept in the x-ray room. All radiography technologists must have specific training and education on the various signs and symptoms of an allergic reaction. A mild reaction consists of a skin rash or **hives**, whereas a more serious reaction includes swelling of the larynx, difficulties in breathing, asthmatic attacks, and a severe drop in blood pressure (hypotension).

Since x-rays are involved during this procedure, there is a minimal risk due to radiation. This exam is not

KEY TERMS

Contrast agent—A radiopaque substance used in radiology to permit visualization of body structures.

Intravenous—Into a vein.

done on pregnant women or women who think they may be pregnant.

Results

A normal intravenous urogram indicates no visible abnormality in the structure or function of the urinary system. The radiologist looks for a smooth non-lobulated outline of each kidney, no clubbing or other abnormality of the renal calyces (collecting system), and no abnormal fluid collection in the kidneys that could suggest obstruction. The ureters must contain no filling defects (stones) or deviations due to an adjacent tumor. The bladder must have a smooth outline and empty normally as visualized on the post-void film.

Abnormal results include hydronephrosis (distension of the renal pelvis and calices due to obstruction) as a result of tumors or calculi (stones). Cysts or abscesses may also be present in the urinary system. A delay in renal function can also indicate renal disease. An abnormal amount of urine in the bladder after voiding may indicate prostate or bladder problems.

Intravenous urograms are often done on children to rule out a rapid developing tumor in the kidneys, called a Wilm's tumor. Children are also prone to infections of the bladder and kidneys due to urinary reflux (return back-flow of urine).

Health care team roles

The x-ray technologist must work in conjunction with the doctors and nurses in making sure the patient has not had a previous allergic reaction to a contrast agent. All hospitals have an emergency team ready to react in such a situation, so the technologist must be aware of the procedure to follow when assistance is necessary due to a severe reaction. Details of patient preparation must also be communicated to the hospital wards. In some hospitals the radiologic technologists are trained to give injections, but if this is not the case nurses may be asked to install an intravenous drip before the patient is brought to the radiology department.

Patient education

The x-ray technologist must explain the risks of an allergic reaction to each patient even though severe reactions are extremely rare due to the advances made in the preparation of contrast agents. The x-ray technologist explains to the patient that a warm, flushed feeling or a metallic **taste** in the mouth are normal reactions in some patients. Breathing instructions are also important since the kidneys change position depending on the phase of respiration and to prevent motion artifacts. Sometimes an emergency patient with renal colic (acute abdominal pain) is asked to urinate through a special filter used to trap small stones. All radiographic technologists must be certified and registered with the American Society of Radiologic Technologists or an equivalent organization. Continued education credits are mandatory to remain registered.

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Lorraine K. Ehresman

Iodine see **Antiseptics**

Iodine deficiency see **Mineral deficiency**

Iodine uptake test see **Thyroid radionuclide scan**

Ipecac

Description

There are two categories of ipecac preparations—a syrup used in standard medical practice and a homeopathic remedy. They are given for different purposes. The medicinal effects of ipecac were recognized centuries ago by the Portuguese who settled in South America. They found a plant that can make people vomit and appropriately named it *Caephalis ipecacuanha*, meaning sick-making plant. Nowadays, ipecac is used to treat a variety of conditions. Its most widely accepted use is to induce vomiting in cases of accidental **poisoning**. When ipecac is swallowed, a substance in it called cephaeline irritates the **stomach** and causes vomiting. Syrup of ipecac is now considered the safest drug to treat poison-

ing and is often the most effective. There are different types of ipecac preparations that vary greatly in strength. Syrup of ipecac is best for use at home to treat accidental poisoning. Ipecac fluid extract and ipecac tincture should be avoided as they are much stronger compounds and can be toxic.

Ipecacuanha is a homeopathic remedy made from ipecac by a process of dilution and succussion (shaking). In contrast to syrup of ipecac, it is given to relieve vomiting.

General use

Treatment of poisoning

Standard medical practice uses ipecac to cause vomiting in cases of poisoning in order to remove the toxic substance from the stomach before absorption occurs. It can be used on animals as well as humans. Ipecac is safer and more effective than many other methods for inducing vomiting, such as sticking a finger down a child's throat or using salt water. There are times, however, when ipecac should not be used because it can make certain kinds of poisoning worse. Syrup of ipecac should not be used if the poison is one of the following.

- strychnine
- alkalis (lye)
- strong acids
- kerosene
- fuel oil
- gasoline
- coal oil
- paint thinner
- cleaning fluid

Poisoning is a potentially serious condition. It is best to contact a local poison control center, local hospital emergency room, or the family doctor for instructions before using syrup of ipecac.

Ipecac's reputation for inducing vomiting has encouraged some bulimics to take it on a regular basis in order to purge the contents of the stomach after an eating binge. This misuse of ipecac is extremely dangerous; it can cause **heart** problems, tears in the esophagus or stomach lining, vomiting **blood**, seizures, or even death.

Homeopathy

The homeopathic remedy made from ipecac is called *Ipecacuanha*. Homeopathic preparations are given for a reason completely opposite from that of standard allopathic treatment. In **homeopathy**, ipecac is given to stop



Ipecac plant (*Cephaelis ipecacuanha*). (PlantaPhile Germany. Reproduced by permission.)

vomiting rather than to induce it. According to Hahnemann's law of similars, a substance that would cause vomiting in large doses when given to a healthy person will stimulate a sick person's natural defenses when given in extremely dilute and carefully prepared doses. *Ipecacuanha* is a favorite homeopathic remedy for morning sickness associated with **pregnancy**. It is also given to stop nausea that is not relieved by vomiting; when the vomitus is slimy and white; when there is gagging and heavy salivation; when the tongue is clean despite the patient's feelings of nausea; and when the patient is not thirsty. The nausea may be accompanied by a headache, cough, or heavy menstrual bleeding. The modalities (circumstances) that suggest *Ipecacuanha* as the appropriate homeopathic remedy is that the patient feels worse lying down; in dry weather; in winter; and when exercising or moving about.

A homeopathic practitioner would not necessarily prescribe ipecac for all cases of nausea. *Arsenicum* would be given when the nausea is caused by **food poisoning** and accompanied by strong thirst, *Nux vomica* when the nausea is the result of overindulgence in food or alcohol and accompanied by gas or heartburn. A sick child might be given *Pulsatilla*, particularly if rich foods have been eaten.

On the other hand, a homeopathic practitioner may prescribe ipecac for any of the following conditions that are not related to nausea and vomiting:

- Nosebleeds producing bright red blood.
- Dental bleeding.
- Diarrhea with cramping abdominal **pain**. The stools are green with froth or foam.

KEY TERMS

Bulimia nervosa—An eating disorder characterized by episodic binge eating followed by self-induced vomiting or laxative abuse.

Cephaeline—A chemical compound found in ipecac that irritates the stomach lining and triggers the vomiting reflex.

Fluid extract—A concentrated preparation of a drug.

Law of similars—A principle of homeopathic treatment according to which substances that cause specific symptoms in healthy people are given to sick people with similar symptoms.

Modality—A factor or circumstance that makes a patient's symptoms better or worse. Modalities include such factors as time of day, room temperature, the patient's level of activity, sleep patterns, etc.

Tincture—An alcoholic solution of a chemical or drug.

- Asthma of sudden onset. The patient has to sit up in order to breathe, but cannot bring up any mucus in spite of violent coughing.
- Hoarseness or loss of voice following a cold.
- Physical or mental exhaustion.

Preparations

Syrup of ipecac

Syrup of ipecac is made from the dried roots and rhizomes (underground stems) of *Cephaelis ipecacuanha*. It is available over the counter in 0.5–1 oz bottles. Larger bottles require a doctor's prescription. The dosage for infants under 6 months old should be prescribed by the family doctor or poison control center. For children six months to one year, the usual dose is 5–10 ml or 1–2 tsp. One-half or one full glass (4–8 oz) of water should be taken immediately before or after the dose. The dose may be repeated once after 20–30 minutes if vomiting does not occur. For children one to 12 years of age, the usual dose is 15 ml (1 tbsp) to be taken with one full glass (8 oz) of water. Adults and teenagers should take 15–30 ml of ipecac with at least 1 full glass of water. Syrup of ipecac should not be taken with milk or soda drinks as these foods may prevent it from working properly. If vomiting does not occur within 20–30 minutes after the

first dose, a second dose may be needed. If the second dose fails to induce vomiting, the patient should be taken to a hospital emergency room.

If both activated charcoal and syrup of ipecac are recommended to treat poison, ipecac must be used first. Activated charcoal should not be taken until 30 minutes after taking syrup of ipecac, or until the vomiting caused by ipecac stops.

Homeopathic preparations

Ipecacuanha is available as an over-the-counter remedy in 30x potency. This is a decimal potency, which means that one part of ipecac has been mixed with nine parts of alcohol or water; 30x means that this decimal dilution has been repeated 30 times. The dilute solution of ipecac is then added to sugar tablets so that the remedy can be taken in tablet form.

Precautions

Syrup of ipecac

For inducing vomiting in cases of accidental poisoning, only the syrup form of ipecac should be used. Syrup of ipecac should not be mixed with milk or carbonated drinks as they may prevent vomiting.

Syrup of ipecac should not be used in the following situations (contact poison control center or family doctor for alternative treatments):

- Poisoning caused by strychnine; sustained-release theophylline; such corrosive substances as strong alkalis (lye); strong acids (such as toilet bowl cleaner); and such petroleum products as kerosene, gasoline, coal oil, fuel oil, paint thinner, or cleaning fluids.
- Overdoses of medications given for depression.
- Excessive vomiting.
- A serious heart condition.
- Timing. Do not give ipecac more than 4–6 hours after the poison was ingested.
- Pregnancy.
- Very young children (less than six months old). Infants and very young children may choke on their own vomit or get vomit into their lungs.
- Drowsy or unconscious patients.
- Seizures.

Homeopathic preparations

Ipecacuanha should not be given after *Arsenicum* or *Tabac* because these remedies will counteract it.

Side effects

The following side effects have been associated with the use of syrup of ipecac.

- Loose bowel movements.
- Diarrhea.
- Fast irregular heartbeat.
- Inhaling or choking on vomit.
- Stomach cramps or pains.
- Coughing.
- Weakness.
- Aching.
- Muscle stiffness.
- Severe heart problems often occur in cases of ipecac abuse. Because ipecac stays in the body for a long time, damage to the heart frequently occurs in persons who repeatedly take ipecac to induce vomiting.
- Seizures. These are most likely to occur in patients who accidentally swallow ipecac or in ipecac abusers.
- Death. Deaths have been reported due to ipecac abuse in bulimic persons.

Homeopathic *Ipecacuanha* has been highly diluted and is relatively nontoxic.

Interactions

Ipecac should not be given together with other drugs because it can decrease their effectiveness and increase their toxicity. If both syrup of ipecac and activated charcoal are needed to treat suspected poisons, ipecac should be given first. Activated charcoal should not be given until vomiting induced by ipecac has stopped. Soda pop should also be avoided because it can cause the stomach to swell. The person should lie on the stomach or side in case vomiting occurs.

Homeopathic *Ipecacuanha* is considered complementary to *Arnica* and *Cuprum*. It is counteracted by *Arsenicum* and *Tabac*.

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- American Foundation for Homeopathy. 1508 S. Garfield. Alhambra, CA 91801.
- Homeopathic Educational Services. 2124B Kittredge St. Berkeley, CA 94704. (510) 649-0294.
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Mai Tran

Iron-binding capacity test see **Iron tests**

Iron

Description

Iron is a mineral that the human body uses to produce the red **blood** cells (hemoglobin) that carry oxygen throughout the body. It is also stored in myoglobin, an oxygen-carrying protein in the muscles that fuels cell growth.

General use

Iron is abundant in red meats, vegetables, and other foods, and a well-balanced diet can usually provide an adequate supply of the mineral. But when there is insufficient iron from dietary sources, or as a result of blood loss in the body, the amount of hemoglobin in the bloodstream is reduced and oxygen cannot be efficiently transported to tissues and organs throughout the body. The resulting condition is known as iron-deficiency anemia, and is characterized by fatigue, shortness of breath, pale skin, concentration problems, dizziness, a weakened **immune system**, and energy loss.

Iron-deficiency anemia can be caused by a number of factors, including poor diet, heavy menstrual cycles, **pregnancy**, kidney disease, **burns**, and gastrointestinal disorders. Individuals with iron-deficiency anemia should always undergo a thorough evaluation by a physician to determine the cause.

Children two years old and under also need adequate iron in their diets to promote proper mental and physical development. Children under two who are not breastfeeding should eat iron-fortified formulas and cereals. Women who breastfeed need at least 15 mg of dietary or supplementary iron a day in order to pass along adequate amounts of the mineral to their child in breast milk. Parents should consult a pediatrician or other healthcare

KEY TERMS

Chelation—The use of a medication or herbal substances to inactivate toxic substances in the body. Chelation is used to treat iron overload in some patients.

Decoction—An herbal extract produced by mixing an herb in cold water, bringing the mixture to a boil, and letting it simmer to evaporate the excess water. The decoction is then strained and consumed hot or cold. Decoctions are usually chosen over infusion when the botanical in question is a root or berry.

Ferritin—An iron storage protein found in the blood. High levels of serum ferritin may indicate iron overload.

Hemochromatosis—Also known as iron overload; a genetic condition in which excess iron is stored in the tissues and organs by the body where it can build up to toxic amounts.

Homeopathic remedy—Used to treat illnesses that manifest symptoms similar to those that the remedy itself causes, but administered in extremely diluted doses to prevent any toxic effects.

Infusion—An herbal preparation made by mixing boiling water with an herb, letting the brew steep for 10 minutes, and then straining the herb out of the mixture. Tea is made through infusion.

Thalassemia—A group of several genetic blood diseases characterized by absent or decreased production of normal hemoglobin. Individuals who have thalassemia have to undergo frequent blood transfusions, and are at risk for iron overload.

Tincture—A liquid extract of an herb prepared by steeping the herb in an alcohol and water mixture.

professional for guidance on iron supplementation in children.

It has been theorized that excess stored iron can lead to atherosclerosis and ischemic **heart** disease. Phlebotomy, or blood removal, has been used to reduce stored iron in patients with iron overload with some success. Iron chelation with drugs such as desferrioxamine (Desferal) that help patients excrete excess stores of iron can be helpful in treating iron overload caused by multiple blood transfusions.

Iron levels in the body are measured by both hemoglobin and serum ferritin blood tests.

Normal total hemoglobin levels are:

- neonates: 17-22 g/dl
- one week: 15-20 g/dl
- one month: 11-15 g/dl
- children: 11-13 g/dl
- adult males: 14-18 g/dl (12.4-14.9 g/dl after age 50)
- adult females: 12-16 g/dl (11.7-13.8 g/dl after menopause)

Normal serum ferritin levels are:

- neonates: 25-200 ng/ml
- one month: 200-600 ng/ml
- two to five months: 50-200 ng/ml
- six months to 15 years: 7-140 ng/ml
- adult males: 20-300 ng/ml
- adult females: 20-120 ng/ml

Preparations

Iron can be found in a number of dietary sources, including:

- pumpkin seeds
- dried fruits (apricots)
- lean meats (beef and liver)
- fortified cereals
- turkey (dark meat)
- green vegetables (spinach, kale, and broccoli)
- beans, peas, and lentils
- enriched and whole grain breads
- molasses
- sea vegetables (blue-green algae and kelp)

Eating iron-rich foods in conjunction with foods rich in **vitamin C** (such as citrus fruits) and lactic acid (sauerkraut and yogurt) can increase absorption of dietary iron. Cooking food in cast-iron pots can also add to their iron content.

The recommended dietary allowances (RDA) of iron as outlined by the United States Department of Agriculture (USDA) are as follows:

- children 0–3: 6-10 mg/day
- children 4–10: 10 mg/day
- adolescent and adult males: 10 mg/day
- adolescent and adult females: 10-15 mg/day

- pregnant females: 30 mg/day
- breastfeeding females: 15 mg/day

A number of herbal remedies contain iron, and can be useful as a natural supplement. The juice of the herb stinging nettle (*Urtica dioica*) is rich in both iron and vitamin C (which is thought to promote the absorption of iron). It can be taken daily as a dietary supplement. Dandelion (*Taraxacum officinale*), curled dock (*Rumex crispus*), and parsley (*Petroselinum crispum*) also have high iron content, and can be prepared in tea or syrup form.

In Chinese medicine, dang gui (dong quai), or *Angelica sinensis*, the root of the angelica plant, is said to both stimulate the circulatory system and aid the **digestive system**. It can be administered as a decoction or tincture, and should be taken in conjunction with an iron-rich diet. Other Chinese remedies include foxglove root (*Rehmannia glutinosa*), Korean ginseng (*Panax ginseng*), and astragalus (*Astragalus membranaceus*).

Ferrum phosphoricum (iron phosphate), is used in homeopathic medicine to treat anemia. The remedy is produced by mixing iron sulfate, phosphate, and sodium acetate, which is administered in a highly diluted form to the patient. Other homeopathic remedies for anemia include *Natrum muriaticum*, *Chinchona officinalis*, *Cyclamen europaeum*, *Ferrum metallicum*, and *Manganum aceticum*. As with all homeopathic remedies, the type of remedy prescribed for iron deficiency depends on the individual's overall symptom picture, mood, and temperament. Patients should speak with their homeopathic professional or physician, or healthcare professional before taking any of these remedies.

Iron is also available in a number of over-the-counter supplements (i.e., ferrous fumarate, ferrous sulfate, ferrous gluconate, iron dextran). Both heme iron and non-heme iron supplements are available. Heme iron is more efficiently absorbed by the body, but non-heme iron can also be effective if used in conjunction with vitamin C and other dietary sources of heme iron. Some multivitamins also contain supplementary iron. Ingesting excessive iron can be toxic, and may have long-term negative effects. For this reason, iron supplements should only be taken under the recommendation and supervision of a doctor.

Precautions

Iron deficiency can be a sign of a more serious problem, such as internal bleeding. Anyone suffering from iron-deficiency anemia should always undergo a thorough evaluation by a healthcare professional to determine the cause.

Iron **overdose** in children can be fatal, and is a leading cause of **poisoning** in children. Children should never take supplements intended for adults, and should only receive iron supplementation under the guidance of a physician.

Individuals with chronic or acute health conditions, including kidney **infection**, **alcoholism**, liver disease, rheumatoid arthritis, **asthma**, heart disease, colitis, and **stomach** ulcer should consult a physician before taking herbal or pharmaceutical iron supplements.

If individuals taking homeopathic dilutions of *Ferrum phosphoricum* experience worsening of their symptoms (known as a homeopathic aggravation), they should stop taking the remedy and contact their healthcare professional. A homeopathic aggravation can be an early indication that a remedy is working properly, but it can also be a sign that a different remedy is needed.

Patients diagnosed with hemochromatosis, a genetic condition in which the body absorbs too much iron and stores the excess in organs and tissues, should never take iron supplements.

Side effects

Taking herbal or pharmaceutical iron supplements on an empty stomach may cause nausea. Iron supplementation may cause hard, dark stools, and individuals who take iron frequently experience constipation. Patients who experience dark bowel movements accompanied by stomach pains should check with their doctor, as this can also indicate bleeding in the digestive tract.

Other reported side effects include stomach cramps and chest **pain**. These symptoms should be evaluated by a physician if they occur.

Some iron supplements, particularly those taken in liquid form, may stain the teeth. Taking these through a straw, or with a dropper placed towards the back of the throat, may be helpful in preventing staining. Toothpaste containing baking soda and/or hydrogen peroxide can be useful in removing iron stains from teeth.

Signs of iron overdose include severe vomiting, racing heart, bloody **diarrhea**, stomach cramps, bluish lips and fingernails, pale skin, and weakness. If overdose is suspected, the patient should contact poison control and/or seek emergency medical attention immediately.

Interactions

Iron supplements may react with certain medications, including **antacids**, acetohydroxamic (Lithostat), Dimercaprol, Etidronate, Fluoroquinolones. In addition,

they can decrease the effectiveness of certain tetracyclines (**antibiotics**). Individuals taking these or any other medications should consult their healthcare professional before starting iron supplements.

Certain foods decrease the absorption of iron, including some soy-based foods, foods with large concentrations of **calcium**, and beverages containing **caffeine** and tannin (a substance found in black tea). These should not be taken within two hours of using an iron supplement. Some herbs also contain tannic acid, and should be avoided during treatment with iron supplements. These include allspice (*Pimenta dioica*) and bayberry (*Myrica cerifera*, also called wax myrtle).

Individuals considering treatment with homeopathic remedies should also consult their healthcare professional about possible interactions with certain foods, beverages, prescription medications, aromatic compounds, and other environmental elements—factors known in **homeopathy** as remedy antidotes—that could counteract the efficacy of treatment for iron deficiency.

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Paula Ford-Martin

Iron deficiency anemia

Definition

Anemia can be caused by **iron** deficiency, folate deficiency, **vitamin B₁₂** deficiency, and other causes. Iron deficiency anemia is due to a shortage of iron. It is characterized by the production of red **blood** cells that are smaller than normal (microcytic) and appear pale or light colored (hypochromic) when viewed under a **microscope**. For this reason, the anemia that occurs with iron deficiency is also called hypochromic microcytic anemia.

Description

Iron deficiency anemia is the most common type of anemia throughout the world. In the United States, iron deficiency anemia occurs to a lesser extent than in developing countries because of the higher consumption of red meat and the practice of food fortification (addition of iron to foods by manufacturers). In the United States, iron deficiency anemia is caused by a variety of factors, including excessive losses of iron in menstrual fluids and excessive bleeding into the gastrointestinal tract. In developing countries located in tropical climates, the most common cause of iron deficiency anemia is infestation with hookworm.

Causes and symptoms

Infancy is a period of increased risk for iron deficiency. A human infant is born with a built-in supply of iron, which can be tapped during periods of drinking low-iron milk or formula. Both human milk and cow milk contain rather low levels of iron (0.5-1.0 mg iron/liter). However, about 50% of the iron in human milk is absorbed by an infant, while only 10% of the iron in cow milk is absorbed. During the first six months of life, growth of an infant is made possible by milk in the diet and by the infant's built-in supply. **Premature infants** have a lower supply of iron. For this reason, it is recommended that pre-term infants (beginning at two months of age) be given oral supplements of 7 mg iron/day, in the form of ferrous sulfate. Iron deficiency can develop when infants are fed formulas that are based on cow milk that has not been fortified. For example, unfortified cow milk is given free of charge to mothers in Chile. This practice prevents general malnutrition, but results in the development of mild iron deficiency.

The normal rate of blood loss in the feces is 0.5-1.0 ml per day. About 60% of persons with **cancer** of the colon and rectum experience further blood loss in the range of 10 ml/day, which can lead to iron deficiency anemia. The **fecal occult blood test** is widely used to screen for the presence of cancer of the colon or rectum. In the absence of testing, **colorectal cancer** may be first detected because of the resulting iron deficiency anemia.

Infection with hookworm can also cause iron deficiency anemia. The hookworm is a parasite that thrives in warm climates, including in the southern United States. A hookworm enters the body through the skin, very commonly through bare feet. The hookworm then migrates to the small intestines where it attaches itself to the villi (small, finger-like structures found on the walls of the intestines, which are used for the absorption of nutrients). Hookworms damage the villi, resulting in

blood loss. Further, they produce anticoagulants which promote continued bleeding. Each hookworm can cause the loss of up to 0.25 ml of blood per day.

Bleeding and blood loss through the gastrointestinal tract can also be caused by hemorrhoids, anal fissures, irritable bowel syndrome, aspirin-induced bleeding, blood clotting disorders, and diverticulosis (a condition caused by an abnormal opening from the intestine). Several genetic diseases are characterized by **bleeding disorders**. These include **hemophilia A**, **hemophilia B**, and **von Willebrand's disease**. Of these, only von Willebrand's disease leads to gastrointestinal bleeding.

The symptoms of iron deficiency anemia include weakness and fatigue. These symptoms result from the lack of function of red blood cells, and the reduced ability of red blood cells to carry iron to exercising muscles. Iron deficiency can also affect other tissues, including the tongue and fingernails. Prolonged iron deficiency can result in changes of the tongue, which may become smooth, shiny, and reddened, a condition known as **glossitis**. Fingernails may grow abnormally and acquire a spoon-shaped appearance.

Decreased iron intake is a contributing factor in iron deficiency and the resulting iron deficiency anemia. The iron content of some common foods is:

- whole wheat bread (43 mg/kg)
- spinach (33 mg/kg)
- beef (28 mg/kg)
- raisins (20 mg/kg)
- eggs (20 mg/kg)
- lima beans (15 mg/kg)
- potatoes (14 mg/kg)
- canned tuna (13 mg/kg)
- chicken (11 mg/kg)
- peanut butter (6.0 mg/kg)
- tomatoes (3.0 mg/kg)
- cabbage (1.6 mg/kg)
- apples (1.5 mg/kg)
- corn oil (0.6 mg/kg)

It is readily apparent that apples, tomatoes, and corn oil are relatively low in iron, while whole wheat bread, spinach, and beef are relatively high in iron. The assessment of whether a food is low or high in iron can also be made by comparing the amount of that food eaten per day with the recommended dietary allowance (RDA) for iron. The RDA for iron for an adult male is 10 mg/day, while that for an adult woman is 15 mg/day. The RDA during

pregnancy is 30 mg/day. The RDA for infants of 0-0.5 years of age is 6 mg/day, while that for infants of 0.5-1.0 year of age is 10 mg/day. RDA values are based on the assumption that a person eats a mixture of plant and animal foods.

The above list of iron values alone may be deceptive, because bioavailability varies. Bioavailability means the percent of iron in the food that is absorbed via the gastrointestinal tract to the bloodstream. Non-absorbed iron is lost in the feces. The bioavailability of iron in fruits, vegetables, and grains is very low, but is much higher in meats. The bioavailability of iron in plants ranges from only 1-10%, while that in meat, fish, chicken, and liver is 20-30%. The most readily absorbable source of iron is human milk, which has a 50% bioavailability.

Interactions between various foods also influence the absorption of dietary iron. **Vitamin C**, for example, increases the absorption of dietary iron. Thus, if rice is consumed with a vitamin C-rich food such as orange juice, then the absorption of the rice's iron is enhanced. The increased use of formulas fortified with both iron and vitamin C has led to a marked reduction in anemia in infants and young children in the United States. In contrast, if rice is consumed with tea, certain chemicals (tannins) in the tea reduce the absorption of iron. Another potent inhibitor of iron absorption is phytic acid, a chemical that occurs naturally in legumes, cereals, and nuts.

Diagnosis

Iron deficiency anemia in infants is defined as a hemoglobin level below 109 mg/ml of whole blood, and a **hematocrit** of under 33%. Anemia in adult males is defined as hemoglobin under 130 mg/ml and a hematocrit of under 38%. Anemia in adult females is defined as hemoglobin under 120 mg/ml and a hematocrit of under 32%. Anemia in pregnant women is defined as hemoglobin of under 110 mg/ml and a hematocrit of under 31%.

When an abnormally high presence of blood is found in feces during a fecal occult blood test, a physician needs to examine the gastrointestinal tract to determine the cause or source of bleeding. For this, a sigmoidoscope may be used. This is an instrument that consists of a flexible tube with a light at the end and allows an examiner to directly visualize and examine the interior of the large bowel or colon to a distance of 60 cm from the anus. A **barium enema**, with an x ray, may also be used to detect abnormalities that can cause bleeding.

KEY TERMS

Barium—An element used in liquid suspension with radiography (x rays) due to its high contrast with human tissue.

Diverticulitis—A disease caused by abnormal outpocketings in the walls of the intestines.

Ferrous—A form of iron that has two electrons available for chemical reactions and is readily absorbed by humans; ferrous iron is also referred to as reduced.

Gastroenterology—The study of the structures of the gastrointestinal tract, commonly including the stomach, small intestines and large intestines.

Glossitis—A condition of the tongue in which the tongue becomes red, smooth, and shiny.

Hematocrit—The proportion of whole blood in the body, by volume, that is composed of red blood cells.

Heme—A protein comprising most of the mass of red blood cells that transports oxygen and carbon dioxide.

Hemoglobin—An iron-containing protein within red blood cells. Hemoglobin accounts for about 95% of the protein in the red blood cell.

Hypochromic—Having less than normal color.

Microcytic—Cells that are smaller than normal size.

Occult—Hidden or difficult to observe.

Protoporphyrin IX—A protein. Measuring protoporphyrin IX is useful to assess iron status. Hemoglobin consists of a complex of a protein plus heme. Heme consists of iron plus protoporphyrin IX. Normally during the course of red blood cell formation, protoporphyrin IX acquires iron to generate heme. Protoporphyrin IX builds up to abnormally high levels when iron is deficient.

Recommended Dietary Allowance (RDA)—Quantities of nutrients in the diet that are required to maintain human health. RDAs are established by the Food and Nutrition Board of the National Academy of Sciences and may be revised every few years.

Villi—Small, finger-like structures found on the walls of the intestines that are used for the absorption of nutrients.

If evidence suggests that oral iron supplements are failing in treating anemia, a test for oral iron absorption is indicated. The oral iron absorption test is conducted by ingesting 64 mg iron (325 mg ferrous sulfate) in a single dose. Blood samples are then taken after two hours and four hours. The iron content of the person's serum is then measured. If iron absorption is normal, the concentration of iron should rise by an increment of about 22 micro-moles. Smaller increases in concentration mean that iron absorption is abnormal, and that therapy should involve injections or infusions of iron.

Treatment

Oral iron supplements (pills) may contain various chemical compounds containing iron, often called iron salts. Iron salts include ferrous sulfate, ferrous gluconate, or ferrous fumarate. Injections and infusions of iron can be given using a preparation called iron dextran. In patients with poor gastrointestinal absorption of iron, therapy with injection or infusion is preferable over oral supplements. Treatment of iron deficiency anemia sometimes requires more than therapy with iron. If iron deficiency is due to bleeding from hemorrhoids, surgical correction of the hemorrhoids may be essential to prevent recurrent iron deficiency anemia. If iron deficiency is caused by bleeding due to aspirin treatment, aspirin should be discontinued. If iron deficiency is due to hookworm infestations, therapy for this parasite should be given in conjunction with protection of feet by wearing shoes whenever walking in areas that are potentially infested with hookworms.

Prognosis

The prognosis for treating and curing iron deficiency anemia is excellent. One important issue, however, is failure to take iron supplements. Pregnant women may be advised to take 100-200 mg iron/day, a dose that leads to nausea, **diarrhea**, or abdominal **pain** in 10-20% of women. Such a high dosage is recommended to rapidly cure the anemia during pregnancy. Before conception, problems associated with side effects and nonadherence may be avoided by taking iron doses (100-200 mg) only once a week. This can be continued throughout a woman's fertile period. The problem of adherence is not an issue when infusions are used, although a fraction of persons treated with iron infusions experience flushing, headache, nausea, seizures, or **anaphylaxis**.

A number of studies have shown that iron deficiency anemia in infancy can result in reduced intelligence in early childhood. It is not clear whether iron supplementation given to children with reduced intelligence due to

iron-deficiency anemia in infancy has any influence in allowing a “catch-up” in intellectual development.

Health care team roles

Screening for iron deficiency anemia is commonly conducted by nurses and physicians. However, when professionally-trained personnel are not available, other people may be given specific training to administer the screening test. Laboratory technicians process blood samples collected by screening tests. Physicians and nurses administer iron injections or intravenous infusions. Surgeons or physicians trained in gastroenterology perform gastroscopic examinations. Radiologists interpret the results of x rays taken after infusion of a barium enema.

Prevention

In a healthy population, all mineral deficiencies can be prevented by ingesting inorganic nutrients at levels defined by the RDA. Iron deficiency anemia in infants and young children can be prevented by consuming fortified foods. Cow milk-based infant formulas are generally supplemented with iron (12 mg/L). The iron in liquid formulas is added as ferrous sulfate or ferrous gluconate. Commercial infant cereals are also fortified with iron. In addition, small particles of elemental iron may be added to the cereal. The levels used are about 0.5 gram iron/kg dry cereal, an amount about 10-fold greater than what is naturally present.

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American Society of Hematology, 1900 M Street NW, Suite 200, Washington, D.C. 20036. (202) 776-0544. Fax: (202) 776-0545. <<http://www.hematology.org/>>. ash@hematology.org.

OTHER

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L. Fleming Fallon, Jr., MD, PhD, DrPH

Iron tests

Definition

Iron tests consist of four assays performed on serum or plasma to aid in the diagnosis and treatment of iron deficiency or iron overload. These tests are serum iron, total iron binding capacity (TIBC), serum ferritin, and serum transferrin. Iron is an essential trace element needed for the production of hemoglobin as well as the function of cytochromes (compound molecules that are important in cell respiration) and certain enzymes. Iron in plasma is almost entirely bound to transport **proteins**. The total iron binding capacity (TIBC) is the maximum amount of iron that these proteins can bind. Transferrin, a beta globulin (molecular weight 75,000) is the principal

transport protein for iron in plasma. Therefore, the TIBC is determined mainly by the concentration of serum transferrin. Iron is stored in the epithelial cells of the gastrointestinal tract and in the reticuloendothelial cells of the **liver**, spleen, and bone marrow. Ferritin is the principal form of storage iron. It consists of a protein (apoferritin) and iron in the form of ferric salts.

Purpose

Serum or plasma iron tests are used for the following purposes:

- To help in the differential diagnosis of **anemias**. **Iron deficiency anemia** is the most common form of anemia worldwide and is quite common in the United States—especially in multiparous females, young children, and persons with chronic intestinal bleeding.
- To assess the severity of anemia and monitor the treatment of patients with chronic anemia.
- To diagnose conditions of iron excess, including iron ingestion, thalassemia, hemosiderosis, and hemochromatosis. Hemosiderosis and hemochromatosis are conditions produced by excessive iron stores in the tissues. Hemosiderosis, which results from repeated **blood** transfusions, is not associated with tissue damage. Hemochromatosis, which is a disorder of iron absorption, can cause painful joints, skin bronzing, diabetes, and liver damage if the iron concentration in the body is not lowered. Hemochromatosis is still underdiagnosed because of its long latency period and lack of awareness on the part of medical professionals.

A serum iron test can be used without the others to evaluate cases of iron **poisoning**.

Precautions

Collection of blood samples

Patients should not have their blood tested for iron within four days of a blood transfusion or tests and treatments that use radioactive materials. Recent high **stress** levels or sleep deprivation are additional reasons for postponing iron tests. Clinicians should ask if patients are taking oral contraceptives or multivitamins, since these may alter results.

Blood samples for iron tests should be taken early in the morning because serum iron levels vary during the day, being higher in the morning and lower at night. This precaution is especially important in evaluating the results of iron replacement therapy.

Hemolysis must be avoided during collection of blood samples to prevent interference with test results from iron in the red blood cells.

Interpretation of test results

Some acute and chronic illnesses can increase the release of ferritin from the body stores, resulting in high serum levels. These disorders include infections, late-stage cancers, lymphomas, and severe inflammations. Alcoholics often have high ferritin levels owing to liver inflammation.

Medications and substances that can cause *increased* serum iron levels include chloramphenicol, estrogen preparations, dietary iron supplements, alcoholic beverages, methyldopa, and birth control pills. Medications that can cause *decreased* iron levels include aspirin, cholestyramine, cortisone, methicillin, and testosterone.

Medications and treatments that can cause *increased* ferritin levels include dietary iron supplements, oral contraceptives, theophylline, and x-ray therapy. Decreases in ferritin levels are seen with antithyroid therapy and high doses of ascorbic acid.

Medications that can cause *increased* transferrin levels include cortisone and cortisol. Those that can cause *decreased* transferrin levels include oral contraceptives and carbamazepine.

Description

Iron tests are performed on samples of the patient's blood, withdrawn from a vein into a vacuum tube. The amount of blood taken is between 6 mL and 10 mL (1/3 of a fluid ounce). The procedure, which is called a venipuncture, takes about five minutes.

Iron level test

The iron level test measures the amount of iron in the blood serum that is being carried by a protein (transferrin) in the blood plasma. Serum iron is most often measured by colorimetric analysis. Iron is deconjugated from the transferrin by adding dilute acid or guanidinium. The iron is reduced to Fe^{2+} by ascorbic acid. The reduced iron forms coordinate bonds with the nitrogen groups (a chromophore) forming a colored complex. The most common chromophore is FerroZine which reacts with Fe^{2+} to form a magenta-colored complex that is measured at 570 nm. Thiourea is added to prevent a reaction between FerroZine and **copper**.

Total iron-binding capacity (TIBC) test

The TIBC test measures the amount of iron that the blood would carry if the transferrin were fully saturated. Since transferrin is produced by the liver, the TIBC can be used to monitor liver function and **nutrition**.

Transferrin test

The transferrin test is a direct measurement of transferrin—which is also called siderophilin—levels in the blood. Transferrin is most often measured by rate immunophelometry. Some laboratories prefer this measurement to the TIBC. The saturation level of the transferrin can be calculated by dividing the serum iron level by the TIBC.

Ferritin test

The ferritin test measures the level of a protein in the blood that stores iron for later use by the body. Ferritin is most often measured by double antibody sandwich immunoassay. It is the most sensitive indicator of iron deficiency because a low serum level reflects depleted body stores. The body stores must be fully depleted before the serum iron becomes low or iron deficiency anemia develops. In persons with acute and chronic illness, however, ferritin levels may not reflect the status of the iron stores since more ferritin escapes into the circulation in these conditions.

Preparation

Iron absorption and **metabolism** are influenced by several factors. These should be identified prior to testing via a medical history that includes the following:

- prescription medications and multivitamins that affect iron levels, absorption, or storage
- blood transfusion within the last four days
- recent extreme stress or sleep deprivation
- recent eating habits

Blood collected for iron level or TIBC tests should be collected following a 12-hour fast. Fasting is not required for serum or plasma ferritin.

Aftercare

Aftercare consists of routine care of the area around the venipuncture.

Complications

The primary complication is the possibility of a bruise or swelling in the area of the venipuncture. The patient can apply moist warm compresses if there is any discomfort.

Results

Iron level test

Normal serum iron values are as follows:

- Adult males: 65-175 micrograms/dL.
- Adult females: 50-170 micrograms/dL.
- Children: 50-120 micrograms/dL.
- Infant: 40-100 micrograms/dL.
- Newborns: 100-250 micrograms/dL.

TIBC test

Normal TIBC values are as follows:

- Adult males: 300-400 micrograms/dL.
- Adult females: 300-450 micrograms/dL.

Transferrin test

Normal transferrin values are as follows:

- Adults: 200-400 mg/dL.
- Children: 203-360 mg/dL.
- Newborns: 130-275 mg/dL.

Normal transferrin saturation values are between 30% and 40%.

Ferritin test

Normal ferritin values are as follows:

- Adult males: 20-300 ng/mL.
- Adult females: 20-120 ng/mL.
- Children (one month): 200-600 ng/mL.
- Children (two to five months): 50-200 ng/mL.
- Children (six months to 15 years): 7-140 ng/mL.
- Newborns: 25-200 ng/mL.

Abnormal test results

Serum iron level is *increased* in thalassemia, hemochromatosis, severe hepatitis, liver disease, lead poisoning, acute leukemia, and kidney disease. It is also increased by multiple blood transfusions and intramuscular iron injections.

KEY TERMS

Anemia—A disorder marked by low hemoglobin levels in red blood cells, which leads to a decrease in the oxygen carrying capacity of the blood.

Chromophore—Any chemical group that produces color in a compound.

Cytochrome—A compound molecule consisting of a protein and a porphyrin ring. Cytochromes participate in cell respiration by electron transfer.

Ferritin—A protein found in the liver, spleen, and bone marrow that stores iron. Ferritin consists of a protein called apoferritin and iron in the form of ferric salts.

Hemochromatosis—A disorder of iron absorption characterized by increased iron absorption and excess deposition of iron in the tissues. It can cause painful joints, pancreatic, heart and liver damage if the iron concentration is not lowered.

Hemolysis—The breakdown of red blood cells with liberation of hemoglobin.

Hemosiderosis—An overload of iron in the body resulting from repeated blood transfusions. Hemosiderosis occurs most often in patients with thalassemia.

Iron poisoning—A potentially fatal condition caused by swallowing large amounts of iron dietary supplements. Most cases occur in children who have taken adult-strength iron formulas. The symptoms of iron poisoning include vomiting, bloody diarrhea, convulsions, low blood pressure, and turning blue.

Plasma—The liquid part of blood.

Siderophilin—Another name for transferrin.

Thalassemia—A hereditary form of anemia that occurs most frequently in people of Mediterranean origin.

Transferrin—A protein in the plasma that carries iron derived from food intake to the liver, spleen, and bone marrow.

Iron levels above 350-500 micrograms/dL are considered toxic; levels over 1000 micrograms/dL indicate severe iron poisoning.

Serum iron level is *decreased* in iron deficiency anemia, chronic blood loss, chronic diseases (lupus, rheumatoid arthritis), late **pregnancy**, chronically heavy menstrual periods, and thyroid deficiency.

Abnormal TIBC test

The TIBC is *increased* in iron deficiency anemia, polycythemia vera, pregnancy, blood loss, severe hepatitis, and the use of birth control pills.

The TIBC is *decreased* in malnutrition, severe **burns**, hemochromatosis, anemia caused by infections and chronic diseases, cirrhosis of the liver, and kidney disease.

Abnormal transferrin test

Transferrin is *increased* in iron deficiency anemia, pregnancy, hormone replacement therapy (HRT), and the use of birth control pills.

Transferrin is *decreased* in protein deficiency, liver damage, malnutrition, severe burns, kidney disease, chronic infections, and certain genetic disorders.

Abnormal ferritin test

Ferritin is *increased* in liver disease, iron overload from hemochromatosis, certain types of anemia, acute leukemia, Hodgkin's disease, **breast cancer**, thalassemia, infections, inflammatory diseases, and hemosiderosis. Ferritin levels may be normal or slightly above normal in patients with kidney disease.

Ferritin is *decreased* in chronic iron deficiency and severe protein depletion.

Health care team roles

Iron tests may be ordered by physicians or by nurse practitioners. Blood samples are usually drawn by nurses or phlebotomists. The samples are analyzed in the laboratory by medical laboratory technicians, with the results returned to the physician.

Patient education

Patients should be informed of any abnormal test results. Health care professionals may refer patients with iron deficiency to a dietitian to discuss nutrition therapy. With regard to excessive iron storage, all health care professionals should monitor patients for signs of hemochromatosis, which is easily treated but fatal if untreated.

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Jane E. Phillips

Irregular bite see **Malocclusion**IV fluid regulation see **Intravenous fluid regulation**IV medication administration see **Intravenous medication administration**IV tubing and dressing change see **Intravenous tubing and dressing change**

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Jaundice

Definition

Jaundice is a condition in which the patient has a yellow hue because of high **blood** levels of bilirubin, a breakdown product of hemoglobin that is potentially toxic. The yellow discoloration is most noticeable in the skin, the sclera (whites of the eyes), and the inner surface of the eyelids.

Description

Jaundice is a physical sign or finding, not a disease. Many different diseases or conditions may cause a person's bilirubin level to be elevated. Most important to the understanding of causes of this sign is a good explanation of normal **liver** function with regard to the production and excretion of bile. Bile is a fluid excreted by the liver that aids in digestion and absorption of **fats**.

The liver is a large, solid organ in the right upper quadrant of the abdomen. It is the premier "chemical processing plant" in the body; most incoming and outgoing chemicals pass through it. It is the first stop for all nutrients, toxins, and drugs absorbed by the digestive tract. The liver also collects waste products from the blood for disposal. Many of these outward-bound chemicals (including bilirubin) are excreted into the bile.

Bile is made up of water; chemicals that act as detergents; and substances such as glycogen, bilirubin, cholesterol, and other byproducts of hepatic **metabolism**. It is formed by cellular metabolism and passes into the network of hepatic bile ducts, which join to form the common duct. A branch of this tube carries bile to the **gallbladder**, where it is stored and concentrated. When fats enter the **stomach**, the gallbladder secretes bile into the common bile duct. Before the common bile duct reaches the duodenum, it is joined by another duct from the **pancreas**. The bile and the pancreatic juice are triggered to enter the intestine through a valve called the ampulla of

Vater by the presence of partially digested fats in the duodenum. After entering the intestine, the bile and pancreatic secretions together help to complete the process of digestion.

The liver removes toxins from the bloodstream, including bilirubin. Bilirubin is a potentially toxic waste product from the breakdown of hemoglobin, the oxygen-carrying molecule of red blood cells (RBCs). When bilirubin is first released from old RBCs or other sources, it cannot be dissolved in water. The liver changes it so that it is soluble in water. These two forms are called unconjugated (insoluble) and conjugated (soluble) bilirubin. Because of the type of laboratory test performed on the different forms of this molecule, unconjugated bilirubin is also called indirect bilirubin, and conjugated bilirubin is called direct bilirubin. Bilirubin is a bright yellow pigment and gives bile its characteristic color. If bilirubin cannot be cleared from the body in a timely fashion, it leaks into body tissues and stains them yellow temporarily, resulting in jaundice. The normal level of bilirubin in blood serum is between 0.2 mg/dL and 1.2 mg/dL. When it rises to 3 mg/dL or higher, jaundice becomes evident. "Icteric" is an adjective (based on the Greek word for jaundice) used to describe a jaundiced patient.

Causes and symptoms

There are many different causes of jaundice, but they can be divided into three categories: before, during, or after the liver has performed its task of making bilirubin soluble. These categories can also be called prehepatic, hepatic, and posthepatic causes of jaundice.

Prehepatic causes of jaundice

There are many different prehepatic causes of jaundice. When old RBCs die, hemoglobin is released into the bloodstream. When the rate of formation of new RBCs and the rate of loss of old RBCs are well balanced, the normal liver can keep pace with disposal of used hemoglobin. If the body is having difficulty making

RBCs (due to mineral or vitamin deficiencies), hemoglobin may leak into circulation and overwhelm the liver. Conversely, if RBCs are destroyed rapidly, the liver may also be overwhelmed. Disorders that cause RBCs to disintegrate prematurely are called hemolytic disorders.

One cause of hemolysis (or prematurely destroyed RBCs) to be aware of starts at the neonatal point, in babies born of Rh-negative mothers. Other causes include a long list of drugs, among them rifampin, methyldopa, certain **antibiotics**, quinine, and levodopa. Trauma can also destroy RBCs. Some common causes of trauma include surgery for mechanical **heart** valves, implants, and roughened surfaces of **blood vessels** such as occur in microangiopathic hemolytic anemia. The parasite that causes **malaria** develops inside red blood cells and ruptures the RBCs when it is mature. A number of hereditary defects affect red blood cells, including glucose-6-phosphate dehydrogenase (G6PD) deficiency (in which RBCs disintegrate under certain stresses, particularly when exposed to certain drugs), sickle-cell disease (in which the structure of hemoglobin is abnormal), and spherocytosis (in which a protein in the outer membrane of the RBC causes weakness in the membrane).

An enlarged spleen can also cause hemolysis. The spleen is the reservoir organ, located near the upper end of the stomach, that filters the blood. It is supposed to filter out and destroy only worn-out RBCs. If it becomes enlarged, it filters out normal cells as well. A wide variety of conditions, including many causes of hemolysis listed above, can enlarge the spleen to the point where it removes too many red blood cells. Also, in several types of **cancer** (such as chronic leukemia) and immune-system diseases, antibodies are produced that react with RBCs and destroy them. In addition, if a patient is given an incompatible blood type, it sets off an immune reaction, and hemolysis results.

In all causes of prehepatic jaundice, the predominant bilirubin is insoluble—that is, unconjugated. Hemolysis alone will rarely cause the total bilirubin level to rise above 7 mg/dL.

Hepatic causes of jaundice

Liver diseases of all kinds, whether temporary or life-long, threaten the organ's ability to keep up with bilirubin processing. Some of the more common causes of jaundice include infectious hepatitis (types A, B, C, D, and E, and various other **viruses**), alcoholic hepatitis, and cirrhosis (scarring of the liver, due to various diseases, to the degree that it can no longer function). Starvation, circulating infections, and certain medications (acetaminophen **overdose**, isoniazid, and others) can cause inefficiency in bilirubin disposal. Certain hereditary defects

also affect how the liver processes bilirubin (such as Gilbert's syndrome and Crigler-Najjar syndrome), causing elevated levels of unconjugated bilirubin. Also, there are several inherited conditions in which the liver cannot excrete bilirubin after it is made soluble (such as Dubin-Johnson syndrome and Rotor syndrome), resulting in direct (or conjugated) bilirubin being the predominant form of the molecule. Unlike hemolytic causes of jaundice, which always involve unconjugated bilirubin, the hepatic sources of jaundice often represent mixed results.

Posthepatic causes of jaundice

Posthepatic forms of jaundice include those caused when soluble bilirubin does not reach the intestines after it has left the liver, resulting in elevated direct bilirubin levels. These disorders are called obstructive jaundices. The most common cause of obstructive jaundice is the presence of gallstones in the ducts of the biliary system. Other causes include diseases where the bile ducts have been destroyed, such as the autoimmune disease primary biliary sclerosis, lesions (whether benign or malignant), and trauma. Some drugs (such as anabolic and contraceptive steroids), and occasionally pressures caused by a normal **pregnancy**, cause the bile in the ducts to stop flowing. This process is called cholestasis.

Neonatal jaundice

Several conditions can cause jaundice in a newborn baby. Erythroblastosis fetalis is a disease of newborns marked by the presence of too many immature red blood cells (erythroblasts) in the baby's blood. When a baby and mother have different Rh factors (positive-RH baby and negative-Rh mother), antibodies from the mother may leak into the baby's circulation through the placental exchange and destroy blood cells. This reaction may produce severe hemolysis and jaundice in the newborn. Rh-factor incompatibility is the most common cause. These births are usually induced a week or two early to keep third-trimester hemolysis to a minimum.

Even in the absence of Rh-factor incompatibility, the newborn's bilirubin level may reach threatening levels. Normal newborn jaundice is the result of two conditions occurring at the same time: a prehepatic and a hepatic source of excess bilirubin. During development, the fetal-type hemoglobin is important to extract oxygen from the mother's blood. At birth, the infant extracts oxygen directly from the **lungs** and no longer needs the fetal hemoglobin. So, fetal hemoglobin is removed from the system and replaced with mature hemoglobin. The resulting hemoglobin overload overwhelms the immature system, and bilirubin levels may rise until the third day of

life, and then decline by day five to day 10. During that time, the baby is jaundiced.

These forms of jaundice in the newborn may result in high levels of unconjugated bilirubin. If conjugated bilirubin is found, it is usually due to serious causes, such as obstruction of the biliary system or overwhelming **infection**.

Symptoms

Certain chemicals in bile may cause itching in jaundiced patients. Fatigue is a very common symptom in people with liver disease. In more severe illness, nausea may occur. Poor appetite and weight loss can be a problem for some patients, usually those with acute infection or advanced scarring of the liver (cirrhosis). Depending on the cause of jaundice, patients may or may not have **pain** over the liver (upper right quadrant). Liver pain is common if there are gallstones, and may also occur in acute hepatitis. Patients whose bile does not drain into the **small intestine** adequately will have clay-colored stools. The conjugated form of bilirubin may be excreted by the **kidneys** and result in dark urine. Long-standing jaundice may upset the balance of chemicals in the bile and cause stones to form in the gallbladder or in the ducts.

In newborns, the concern about jaundice is that insoluble or unconjugated bilirubin may get into the **brain** and do permanent damage to the **central nervous system**. This serious condition is called kernicterus. It becomes a concern as bilirubin levels approach 20 mg/dL. Newborns are more likely to have problems with jaundice if they are premature, Asian or Native American, or bruised significantly during the birth process. Jaundice is also more common if a newborn was born after an induced labor, has lost too much weight during the first few days of life, was born at high altitude, or was born to a diabetic mother.

Diagnosis

In most cases, the sign of jaundice is identified based on the appearance of the patient's sclera and complexion. The liver and spleen are palpated to check for enlargement and to evaluate any abdominal pain. The location and severity of abdominal pain and the presence of masses in the abdomen, together with the presence of **fever**, help to distinguish among the causes for jaundice. The differential diagnosis of the cause of jaundice is primarily based on blood-test results.

Laboratory testing reveals the total bilirubin and its components. The capability to evaluate total bilirubin levels and the fractionation into direct (conjugated) and

indirect (unconjugated) components is available in most laboratories. The jaundice may be determined to be of indirect (prehepatic sources, Gilbert's syndrome, or Crigler-Najjar syndrome) or direct (primarily obstructive posthepatic sources, and some hepatic diseases) origin. Liver enzymes, such as aspartate aminotransferase (AST) and alanine aminotransferase (ALT), should be evaluated; elevations would be signs of inflammation or destruction of liver cells. If the AST is at least twice the level of the ALT, this finding strongly supports the suggestion of alcohol abuse as a source of liver disease. If alkaline phosphatase is elevated, this suggests an obstructive (posthepatic) component in the cause of jaundice. Albumin levels and prothrombin times will be abnormal (elevated) if the liver is severely damaged. Microscopic analysis of blood smears for signs of hemolysis is performed.

Liver disease is usually assessed from blood studies and physical-examination findings, but a biopsy may be necessary to clarify less obvious disease. A **liver biopsy** may be performed at the bedside. A thin, cannulated needle is inserted to draw a core of tissue from the liver. The tissue sample is sent for pathologic examination.

Diseases of the biliary system may be identified by imaging techniques, especially with the use of contrast dye. The most common and cost-effective method for beginning to assess the liver and bile ducts is ultrasound. Dilated bile ducts are very suggestive of obstruction, and abnormal amounts of fat or scar tissue may be noticed. Much more detailed information about the structure of the liver and biliary tree is gained with computed tomography (CT) or **magnetic resonance imaging** (MRI). Very detailed investigation of the bile ducts is achieved with endoscopic retrograde cholangiopancreatography (ERCP), for which a fiber-optic scope is put down the gastrointestinal tract via the mouth, all the way to the ampulla of Vater. Dye is injected to map the bile ducts and identify obstruction. A tiny brush-tipped device at the end of the scope light is used to scrape tissue from the duct lining for analysis. Treatment can also be achieved at the same time, as stones can be removed or stents placed to aid in passage of a stone or maintaining bile flow in spite of a tumor.

Treatment

Newborns are the one group of patients in whom the jaundice itself requires attention. Because the insoluble bilirubin can get into the brain, the amount in the blood must not go over certain levels. If there is reason to suspect increased hemolysis in the newborn, the bilirubin level must be measured repeatedly during the first few days of life. If the level of bilirubin shortly after birth

KEY TERMS

Ampulla of Vater—A valve at the distal end of the widened portion of the common bile duct, through which the bile and pancreatic juices enter the duodenum.

Anemia—A condition in which the blood does not contain enough hemoglobin. There are many causes of anemia, including hemolysis, bleeding, and problems producing red blood cells (RBCs).

Biliary system/bile ducts—The gallbladder and the system of tubes that carries bile from the liver into the intestines.

Bilirubin—A breakdown product of hemoglobin that is potentially toxic. The liver collects bilirubin from the bloodstream, alters it, and secretes it into bile.

Hemoglobin—The red pigment in red blood cells that carries oxygen.

Hemolysis—The premature destruction of red blood cells.

Hepatic jaundice—A cause of jaundice; jaundice that occurs while the liver is performing its task of making bilirubin soluble.

Icteric—An adjective, based on the Greek word for jaundice, used to describe a jaundiced patient.

Liver—A large, solid organ in the right upper quadrant of the abdomen that is the body's premier "chemical processing plant" of drugs, nutrients, and toxins.

Neonatal jaundice—Jaundice in a newborn baby, resulting from various conditions.

Pancreas—The organ adjacent to the stomach that produces digestive juices, insulin, and other hormones.

Posthepatic jaundice—A cause of jaundice; jaundice that occurs after the liver has performed its task of making bilirubin soluble.

Prehepatic jaundice—A cause of jaundice; jaundice that occurs before the liver has performed its task of making bilirubin soluble.

Rh incompatibility—When a baby and mother have different Rh factors; a common cause of jaundice in newborns.

Splenectomy—Surgical removal of the spleen, sometimes necessary to control certain types of hemolytic anemia.

threatens to go too high, treatment must begin immediately. Exchanging most of the baby's blood (an exchange transfusion) was the only way to reduce the amount of bilirubin until the late 1960s. Then it was discovered that bright blue light renders the bilirubin harmless. Now jaundiced babies are fitted with eye protection and placed under special lights, wearing only a diaper so that more skin surface can be exposed. The **phototherapy** alters the bilirubin in the blood as it passes through and close to the baby's skin. Under certain conditions, exchange transfusions are still done to rapidly gain control over bilirubin levels.

Most adult patients are treated based on the underlying cause of the jaundice. Surgical removal of the spleen (splenectomy) may arrest hemolytic anemia. Drugs that cause hemolysis or arrest the flow of bile are discontinued or replaced with alternate therapy. The abuse of alcohol or street drugs must stop if the liver is to begin to heal and the jaundice given a chance to subside. Obstructive jaundice frequently requires surgical repair. The gallbladder may need to be removed, or small stones removed from lower in the biliary tract. If there is neoplasm of the liver or biliary tree, partial or total removal is necessary. If the original biliary passageways cannot be restored, new ones are created in surgery.

Prognosis

Prognosis is based on the underlying cause of jaundice. The liver is a very resilient organ, and many patients do well after supportive therapy or surgical intervention for acute causes of jaundice. High bilirubin levels themselves are not dangerous to patients other than neonates, so all symptoms of high bilirubin levels are reversible if the underlying condition is treatable.

Health care team roles

Good supportive care of the jaundiced patient, regardless of the underlying disorder, is important. If alcohol abuse has been an acute or long-standing problem, nursing staff can contribute much in educating the patient about the importance of avoiding alcohol.

Prevention

Many of the numerous causes of jaundice cannot be anticipated or avoided. Alcohol abuse in patients should be identified and support provided to aid in recovery. Erythroblastosis fetalis can be prevented by giving an Rh-negative mother a gamma globulin solution called RhoGAM as a routine part of **prenatal care**. This will decrease the chances her antibody titer will rise against her baby's blood. Liver problems due to medications can

be minimized with appropriate screening blood tests and cessation of the drug if necessary. One cause of liver failure not mentioned previously is anorexia nervosa, in which patients intentionally starve themselves, disabling the body's immune-defense system and overwhelming the liver's ability to detoxify the blood. Patients with this condition need specific psychiatric therapy in addition to adequate nutritional supplementation therapy to prevent liver failure. If it occurs, transplantation may be the only recourse. Malaria may be prevented by taking certain precautions when traveling in tropical or subtropical countries and climates.

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Jejunostomy see **Enterostomy**

Joint aspiration see **Joint fluid analysis**

Joint endoscopy see **Arthroscopy**

related abnormalities, such as occur in the knee or elbow. Synovial or joint fluid is an ultrafiltrate of plasma formed in the synovial membrane of movable joints. The fluid lubricates the bone and cartilage tissues of the joint.

Purpose

The purpose of joint fluid analysis is to diagnose arthritis, an inflammation of the joint, and identify its cause. In addition, removal of the fluid can decrease **pain** in the joint. Diseases which may cause joint swelling include rheumatoid arthritis, systemic lupus erythematosus, **gout**, gonococcal arthritis (caused by the **bacteria** that causes gonorrhea), other types of bacterial arthritis, and viral inflammation of the synovial lining.

Precautions

Universal precautions for the prevention of transmission of bloodborne pathogens should be observed when collecting synovial fluid. Arthrocentesis should not be performed on a patient who is uncooperative, especially if the patient cannot or will not keep the joint immobile throughout the procedure. Sampling of a joint may be contraindicated when there is evidence of **infection** in overlying skin or tissue. The joint space should be accessible. Therefore, a poorly accessible joint space, such as in hip aspiration in an obese patient, should not be subjected to this procedure.

Description

Arthrocentesis

The removal of synovial fluid, arthrocentesis, is also called a joint tap, or closed joint aspiration. The procedure is done by passing a needle into a joint space and aspirating synovial fluid using **aseptic technique**. The joint must be cleaned thoroughly with iodine before inserting the needle to prevent any infection. The size of the needle and volume of fluid withdrawn depends on the size of the joint. The patient is asked to lie on their back and remain relaxed. A local anesthetic, typically a **subcutaneous injection** of lidocaine, xylocaine, or ethyl chloride, is then administered. As the needle enters the joint, a "pop" may be felt or heard; this is normal. Correct placement of the needle in the joint space is normally painless. At this point, the clinician slowly drains some of the fluid into the syringe. The syringe may contain a small amount of sodium heparin. The needle is then withdrawn and an adhesive bandage is placed over the puncture site. The sample is transferred to one or more tubes containing liquid heparin or liquid EDTA anticoagulant.

Joint fluid analysis

Definition

Joint fluid analysis, also called synovial fluid analysis, or arthrocentesis, is a procedure used to assess joint-

The procedure takes about 10 minutes. The physician may need to prioritize the tests that he or she orders since fluid yields from this procedure may be very small. Only a drop of fluid is needed for culture and microscopic examination and these two procedures are given top priority because of their diagnostic importance. Some tests, such as glucose and total hemolytic complement must be evaluated with respect to **blood** levels. Therefore, a blood sample should be collected at the same time.

Causes of arthritis

Arthritis can be classified by cause into five categories. Noninflammatory or **osteoarthritis** is the most common form and results from loss of cartilage covering the bone. Inflammatory arthritis results from damage to the joint caused by immune complexes that deposit in the joint or autoantibodies that attach to and destroy the synovial membrane. The most common cause of inflammatory arthritis is rheumatoid arthritis. Septic arthritis is caused by bacterial infection of the joint. The most commonly implicated organism in sexually active persons is *Neisseria gonorrhoeae*. Gout is joint inflammation caused by deposition of uric acid crystals. When other crystals such as **calcium** pyrophosphate are the cause, the condition is called pseudogout. Hemorrhagic arthritis, bleeding into the joint, is caused by trauma, **hemophilia**, or other bleeding disorder such as thrombocytopenia (low platelet count).

Laboratory tests

Laboratory analysis of joint fluid should include determination of color, transparency, volume, and viscosity; red and white blood cell counts with a differential; examination of wet mounts for synovial crystals; microbiological culture; and tests for glucose, total protein, complement, rheumatoid factor, and mucin clot.

Physical characteristics

Normal joint fluid has a volume between 0.15-3.5 mL. An increased volume is common in all five classes of arthritis. The fluid should be clear and pale yellow. Observation of the color of the supernatant after centrifugation helps to discriminate between a hemorrhagic fluid (bleeding from injury to the joint) and a traumatic tap (puncture of a blood vessel during arthrocentesis). Deep yellow or pink fluid points to a hemorrhagic process whereas a normal color points to a traumatic tap. A clot in the fluid also points to a traumatic tap because large protein molecules such as fibrinogen are not found in the fluid. The specific gravity is normally the same as plasma, but the viscosity is much greater. The viscosity is

measured by inserting a wooden applicator stick into the fluid and removing it. The fluid should form a thread of at least 1.6 in (4 cm) at the end of the applicator stick. Failure to do so indicates a low level of mucoprotein which is most common in inflammatory arthritis.

Microscopic analysis

The white blood cell (WBC) count is performed manually using a hemacytometer. The fluid is diluted in saline rather than a WBC counting fluid because the acetic acid will cause the formation of a mucin plug. The normal WBC count is very low, less than 200 per microliter. High counts are seen in septic arthritis, rheumatoid arthritis, and gout. Persons with osteoarthritis or hemorrhagic arthritis may or may not have a high WBC count. The highest counts with neutrophils predominating are associated with septic arthritis.

The normal differential shows 50-65% monocytes with neutrophils and lymphocytes each accounting for less than 25% of the WBCs. Neutrophils above 80% signal septic arthritis. A higher percentage of lymphocytes favors a diagnosis of rheumatoid arthritis. Neutrophils with dark staining cytoplasmic inclusions (ingested immunoglobulins) point to a diagnosis of rheumatoid arthritis. The red blood cell (RBC) count of synovial fluid is also performed manually. The count is normally less than 2000 per microliter. Higher counts especially in the presence of xanthochromia (abnormal color) indicate a synovial hemorrhage.

Microscopic examination of the fluid for crystals requires a polarizing **microscope** with a red compensating filter. This type of microscope transmits light in a single plane through the specimen. An analyzer filter is placed above the specimen before the ocular is aligned, so that it is out of phase with the polarizing filter. The analyzer filter blocks the light transmitted through the specimen, causing a dark background unless the light is rotated by the object on the slide. Uric acid and calcium pyrophosphate are the two most common crystals seen in joint fluid. They both rotate plane polarized light which causes them to be illuminated by the polarizing microscope. However, they can be differentiated using the red compensating filter. Uric acid crystals are seen as yellow needles when the long axis of the crystal is parallel to the slow vibrating light from the filter. Calcium pyrophosphate crystals are blue when the long axis of the crystal is parallel to the slow vibrating light.

Biochemical and immunological tests

Glucose in synovial fluid is normally within 10 mg/dL of the plasma level. Low glucose is seen in septic and rheumatoid arthritis. Very low levels (less than half

of the plasma level) are seen in rheumatoid arthritis. The total protein of synovial fluid is normally below 2.0 g/dL. Increased total protein is seen in rheumatoid and hemorrhagic arthritis. In rheumatoid arthritis, complement will be low owing to chronic consumption and local immunoglobulin production will cause the ratio of synovial to serum IgG to be greater than 0.5. Rheumatoid factor in joint fluid is positive in about 60% of persons with rheumatoid arthritis and in a lesser number of persons with other autoimmune diseases.

The mucin clot test is used to measure the amount of mucin in the fluid. This substance consists of repeating subunits of hyaluronic acid that will cross link forming a mucin clot when acetic acid is added to the fluid. In infection bacterial hyaluronidase may destroy the mucoprotein causing no clot. In rheumatoid arthritis, damage to the synovial cells results in deficient production of mucoprotein and the mucin clot is either absent or easily broken apart.

Microbiological analysis

All samples of synovial fluid should be cultured and Gram-stained. The **Gram stain** results can be definitive for septic arthritis if neutrophils and bacteria are found, but is not always positive. The fluid should be inoculated on blood agar plates; on chocolate (heated blood) agar plates for gonococcus and *Haemophilus*; and in broth such as thioglycolate for the isolation of anaerobic bacteria. *N. gonorrhoeae* is responsible for about 75% of septic arthritis in young and middle aged adults. *Staphylococcus spp.* account for about 75% of septic arthritis in the elderly. *Staphylococcus*, *Streptococcus*, and *Haemophilus* are the most common genera isolated from children.

Preparation

Prior to the procedure, any risks that are involved should be explained to the patient. The patient will be given a local anesthetic but no pain medications or sedatives are required. If the clinician requests a glucose test, the patient will be asked to fast for six to 12 hours before the procedure. If not, there is no special preparation required for a joint fluid analysis.

Aftercare

Some post-procedural pain may be experienced. For this reason, the patient should arrange to be driven home by someone else. Aftercare of the joints will depend on the results of the analysis.

KEY TERMS

Aspirate—The removal by suction of a fluid from a body cavity using a needle.

Bursae—A closed sac lined with a synovial membrane and filled with fluid, usually found in areas subject to friction, such as where a tendon passes over a bone.

Gout—A painful joint disease characterized by the deposition of uric acid crystals in the joint. These crystals cause swelling and redness.

Hematoma—A localized mass of blood that is confined within an organ or tissue.

Hyaluronic acid—A high molecular weight made of carbohydrate and glucuronic acid that is found in high concentrations in the synovial fluid. This provides thickness to the fluid so it can cushion the joint.

Joint—A moveable portion of bone found between two bones.

Lupus erythematosus—A multisystem disease with an autoimmune etiology. Lupus causes problems with the skin, kidneys, joints and the serosal membranes.

Rheumatoid arthritis—A chronic and progressive inflammation of the joints whose cause is unknown.

Synovial fluid—A transparent lubricating fluid secreted in a sac to protect an area where a tendon passes over a bone.

Complications

While joint fluid analysis is generally a safe procedure, especially when performed on a large, easily accessible joint, such as the knee, some risks are possible. Some of the complications to the procedure, although rare, include infection at the site of the needle stick, an accumulation of blood (hematoma) formation, local pain, injury to cartilage, tendon rupture, and nerve damage.

Results

Normal values typical for synovial fluid are shown below:

- Volume: 0.15-3.5 mL.
- Transparency: clear.
- Color: straw or pale yellow.

- Viscosity: 1.6 in (4 cm) thread or greater.
- Mucin clot: firm.
- Glucose: different from plasma by 10 mg/dL or less.
- Total protein: less than or equal to 2.0 g/dL.
- White blood cell count: less than 200 per microliter.
- Differential: less than 25% granulocytes.
- Crystals: negative.

Health care team roles

The removal of synovial fluid from a joint should be done by a physician. Laboratory tests are performed by clinical laboratory scientists/medical technologists. Physicians interpret the results of laboratory tests.

Resources

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Jane E. Phillips, PhD

Joint integrity and function

Definition

Joints serve as links between structures; in this case, bones in the human body. There are numerous joints in the body that act to stabilize and control bony segments. One example is the knee joint, which joins the femur and tibia. This joint allows the lower leg to swing freely, but also to be stable during the stance phase of gait. Some joints provide the body with stability, while others provide it with mobility. However, most joints provide both stability and mobility.

Description

There are two major types of joints: synarthroses and diarthroses. Synarthroses are joints connected by fibrous tissue. Diarthroses are synovial joints, where two bones

are bound together by a joint capsule, forming a joint cavity. In synovial joints, there is a nourishing lubricating fluid called synovial fluid.

Function

Synarthroses

There are two types of synarthroses: fibrous joints and cartilaginous joints.

FIBROUS JOINTS. In fibrous joints, bones are united by fibrous tissue. There are three types of fibrous joints: gomphosis, suture, and syndesmosis. A gomphosis joint occurs where one bone fits into another bone. The articulating edges are bound together by connective tissue, and the bony surfaces in the articulation are close together. An example of a gomphosis joint is a tooth in the jawbone. An example of a suture is the fibrous joints between the bones of the **skull** of an infant. Before birth fibrous tissue forms soft spots on the skull, called fontanelles. As growth and development occurs the sutures ossify. A syndesmosis joint connects two bones through connective tissue and is found throughout the human body. An example is the tibio-fibular syndesmosis, the connective tissue that binds the distal ends of the fibula and tibia. A syndesmosis allows the fibula and tibia to work in unison as part of the lower leg. The limited motion available at this joint allows the tibia and fibula to move about each other, yet still function as a unit.

CARTILAGINOUS JOINTS. In cartilaginous joints, bones are connected by either fibrocartilage or hyaline cartilage. There are two types of cartilaginous joints: symphyses and synchondroses. A symphysis is a cartilaginous joint where the connecting entity is fibrocartilage. The symphysis is stable but it allows limited motion. An example of a symphysis joint is the attachment of one vertebra to another by an intervertebral disk, a fibrocartilage ring, in the **vertebral column**. In this symphysis joint only minimal motion occurs between vertebrae, thus maintaining stability. The combination of small movements between each successive vertebral attachment is what allows the vertebral column to flex and extend. A synchondrosis is a joint where the articulating surfaces are close together, yet are bound by hyaline cartilage. An example of a synchondrosis is the two distinct portions of long bone separated by a hyaline cartilaginous plate. This typically occurs at the ends of long bones, where a cartilaginous plate separates the diaphysis from the epiphysis. This plate allows the end of bones to grow throughout early human development. As growth and development continues, the hyaline cartilage ossifies and by adulthood the joint is gone. Another example of a synchondrosis in the human body is the articulation

between the first rib and the manubrium, the upper portion of the sternum.

Diarthroses

A diarthroses has a synovial component. The bones are connected to a joint capsule that surrounds the bones and creates a joint cavity. Ligaments also attach bone-to-bone stabilizing the joint and making the diarthrotic joint stable, yet mobile. Again, the knee joint is a good example of a diarthroses; two bones (tibia and femur) that are attached by ligaments called the anterior and posterior cruciate ligaments. An extensive joint capsule also surrounds the knee joint. In synarthroses there are also disks or menisci that aid in maintaining congruency between bones, i.e., the medial and lateral menisci of the knee joint. Making the diarthroses even more unique from the synarthroses is the addition of synovial fluid. The synovial fluid provides lubrication within the joint. In summary, the diarthroses is complex, with ligaments and capsule providing stability, disks or menisci aiding in congruency, and synovial fluid providing lubrication.

Synovial-type joints can be further classified into three categories: uniaxial, biaxial, and triaxial.

UNIAXIAL JOINTS. Uniaxial joints can be further categorized into hinge and pivot joints. Examples of hinge joints are the joints of the fingers, i.e. interphalangeal joints. An example of a pivot-type joint is the articulation between the axis and atlas in the cervical region, allowing true rotation of the head. In a uniaxial joint the motion is in one plane or is said to have one degree of freedom.

BIAXIAL JOINTS. In a biaxial joint, motion occurs in two planes; thus, there are two degrees of freedom. There are two types of biaxial joints: saddle and condyloid. An example of a saddle joint is the carpometocarpal joint of the thumb, where bones fit together like an individual riding a horse while sitting on a saddle. One bone is concave, the other is convex. Examples of condyloid joints are the metacarpophalangeal joints of the fingers.

TRIAXIAL JOINTS. Triaxial joints have three degrees of motion and can move in three planes. There are two types of triaxial joints: ball and socket, and plane joints. An example of a **ball and socket joint** is the hip. The attachment of the carpal bones in the hand are considered plane joints where gliding is permitted between bones.

Role in human health

Synarthrotic joints allow little or no movement. Their main function is to provide stability, and they also join bones to form a larger unit. Diarthrotic joints provide stability and mobility. Joints can be affected by injury,

increased demand, immobilization, or long-term bed rest, and diseases, such as **osteoarthritis**. Injury can occur if a large stress or load is placed on a joint. Constant excessive loading over time can also cause joint structure to break down. Immobilization or long-term bed rest causes muscles around joints to weaken. Furthermore, joints and articular surfaces need some load, such as gravity, to maintain proper integrity. Over time, if load is not present, articular surfaces will weaken and degenerate due to lack of stimulus. Disease processes such as osteoarthritis can also disrupt the integrity of the joint. All of the above problems can affect joint structure and eventually disrupt functions such as walking. Severe joint degradation can lead to disability.

Common diseases and disorders

Increased demand or trauma placed on a joint can cause tearing or even rupture of the ligaments, joint capsule, or hyaline cartilage. Furthermore, immobilization and disease can degrade the joint surfaces. Any one of these complications can disrupt the integrity of the joint. If the integrity of a joint is compromised, there could be decreased motion at the joint and possibly **pain**. Thus, pain and decreased joint mobility can lead to decreased function and eventual disability.

Other pathologies such as osteoarthritis, rheumatoid arthritis, trauma, and **gout** can all negatively affect joint integrity and function. In the acute phases of gout, joint effusion secondary to injury, and rheumatoid arthritis the joint capsule of diarthroidal joints becomes distended due to over production of synovial fluid. Because of this distention, joint receptors are impaired and may provide inaccurate information on position and movement. Furthermore, there is pain associated with these conditions. If treatment is not effective in reducing pain and inflammation, joint integrity and eventual function will be compromised. In situations where injury has occurred to a joint, such as ligament tear or rupture, the joint is unstable. This instability leads to further stresses placed on other structures within the joint. Eventually, if the ligament is not healed or repaired, further damage to the joint will occur because of the increased demand on other structures. An example is tearing of a ligament in the knee or ankle.

Osteoarthritis is a disease process that negatively affects the integrity and function of a joint. In this degenerative disease the articular surfaces of the joint are degrading. As time passes, the degradation of the joint continues. The most common joints affected by osteoarthritis are the knee and the hip. Conservative treatments such as medications and rehabilitation may be used to decrease pain and restore mobility. However,

KEY TERMS

Diathroses—Synovial joints.

Femur—The large upper bone, also known as the thigh bone.

Gait—Refers to walking, i.e. ambulation.

Gomphosis—A joint where a bony structure is implanted deep into another bony structure. An example would be the joint between a tooth and the mandible (jaw bone).

Immobilization—Keeping a joint from moving, i.e. when an individual breaks the lower leg; a cast may be used that covers the knee, thus preventing motion.

Knee joint—A lower limb joint connecting the tibia to the femur. It allows for straightening and bending of the knee.

Stance phase—The point where, when walking, one foot is in contact with the ground.

Suture—A joint where two bony structures are united by dense fibrous tissue. An example is the sutures of the skull.

Symphyses—Joints where bones are connected by a fibrocartilage disk. An example is the symphysis pubis.

Synchondroses—Joints that connect two bony structures by hyaline cartilage. Examples are the ends of long bones, where the bone growth is not yet complete. As the skeleton matures, the hyaline cartilage eventually ossifies.

Syndesmosis—A joint where two bones are joined by a ligament or membrane. An example is the membrane that joins the shaft of the tibia to the shaft of the fibula in the lower leg.

Tibia—The large lower leg bone between the knee and ankle.

there are instances where conservative treatments fail and joint replacement is a viable option, i.e. total knee arthroplasty.

Joint structures need optimum motion and stress to maintain proper function. Moreover, proper cartilage and joint **nutrition** are required for proper joint function. Therefore, it is important to have synovial fluid maintaining nourishment to the joint surfaces and cartilage in an effort to maintain the integrity of the joint. Since joints are not well supplied by **blood** flow it is important that

movement and weight-bearing are encouraged to promote fluid flow between joint surfaces and disks, i.e., menisci.

Resources

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ORGANIZATIONS

American Physical Therapy Association, 1111 North Fairfax St., Alexandria, VA 22314-1488. Phone: (703) 684-APTA or (800) 999-APTA. TDD: (703) 683-6748. Fax: (703) 684-7343. <<http://www.apta.org>>.

OTHER

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Joint mobilization and manipulation

Definition

Joint mobilization is a treatment technique used to manage musculoskeletal dysfunction. Most manipulative and mobilization techniques are performed by physical therapists, and fall under the category of manual therapy.

In most cases, at the end of a long bone there is a joint or articulation. The long bone is attached or joined to another bone by a joint. For example, the femur is attached to the tibia at the knee joint. The knee joint is made up of the surface of the tibia, femur, ligaments, and capsule. Thus, the knee joint is stable and yet mobile. When an individual is sitting in a chair and freely kicks his leg out (knee extension), the tibia moves, while the femur is stationary. However, at the surface of the articulating bones (tibia and femur), there is other movement. This movement is known as slide or glide; some have termed it “joint play.” When an individual kicks his leg out, the lower leg or tibia is not only moving forward, but also gliding across the end of the femur. Mobilization is the treatment technique that involves the clinician applying a force to mimic the gliding that occurs between bones. It is a passive movement, the goal of which is to

produce a slide or glide. Mobilizations are usually completed at slow speed, sometimes with oscillations, and even with a “hold” or stretch. Manipulations are more aggressive, high velocity techniques, or thrusts. They occur very fast, and at the end of available joint play.

Purpose

Mobilizations are used to restore joint play that has been lost due to injury or disease. In order for an individual to kick his leg out, there must be sufficient joint play, or freedom for the tibia to move on the femur. Thus, mobilizations are used when range of motion or mobility is lacking. Furthermore, gentle oscillations within the available joint play range is a technique used to decrease **pain**. Manipulations are quick movements that occur beyond the available joint play range. The purpose of manipulations, or joint thrusts, is to increase the available range if it is not full. Secondly, manipulations are done to break adhesions that disrupt joint movement.

Precautions

Mobilizations and manipulations should not be done in the following circumstances:

- to the spine if there is severe **osteoarthritis** or osteoporosis
- if there is any tumor or malignancy in the area
- to the cervical region if there is dysfunction with the flow of **blood** within the vertebral artery
- if there is bleeding in a joint
- if there is a loose body in the joint
- to total joint replacements
- to joints near a growth plate
- if the joint is degenerative
- until a full diagnosis is reached

Description

Peripheral joint mobilization means mobilizing the joints of the periphery or limbs. There is a grading system for completing mobilizations. The grading system is based on how much joint play is available. Thus, the clinician must know what the total range is by examination through passive movement. Furthermore, there are stretching mobilizations used for **pain management** and stretching. The first common mobilization techniques are sustained joint play movements that have three grades. These mobilizations aid in decreasing pain and increasing mobility.

Grade 1

The clinician applies passive movement in a very small range, approximately 15-25% of the available joint play range.

Grade 2

Bone is passively moved in a moderate range to 50% or half of the available joint play range.

Grade 3

Passive force by the clinician causes one bone to move on the other to the end of the available joint play range.

Within these three grades the stretch or “hold” is approximately five to seven seconds.

The other common mobilization technique is termed oscillatory mobilization. These mobilizations have five grades associated with them. Grades one to two are used to help decrease pain within a joint. Grades three to five are used to increase mobility of joint play. Interestingly, a grade five mobilization is really a manipulation. The following are grades for oscillatory mobilizations:

Grade 1

Slow oscillations within the first 20-25% of the available joint play range.

Grade 2

Slow oscillations within 45-55% of the available joint play range, or from the beginning to the middle of available joint play range.

Grade 3

Slow oscillations from the middle of the available joint play range to the end of available joint play range.

Grade 4

Slow oscillations at the end of the available joint play range.

Grade 5

Bone is passively moved to the end-range, and a fast thrust is performed. This is manipulation.

Preparation

The clinician should be aware of the following prior to performing manipulations:

KEY TERMS

Cryotherapy—Usually an ice or cold treatment after physical therapy treatment.

Femur—The long bone of the thigh which articulates with the hip bone and the tibia.

Knee extension—The act of straightening the knee or kicking the leg out, as in kicking a ball.

Ligaments—Fibrous structures that provide an attachment on bone to bone, and provide stability to joint structures.

Musculoskeletal—Pertains to the muscular and skeletal systems, and the relationship between the two.

Passive movement—Movement that occurs under the power of an outside source such as a clinician. There is no voluntary muscular contraction by the individual who is being passively moved.

Tibia—The larger, longer bone of the lower leg which articulates or joins with the ankle and knee.

- The clinician must use good body mechanics and be comfortable with the patient and the technique.
- The clinician must understand the patient's pain and not proceed if the patient has pain.
- The patient must be comfortable with the clinician, and the procedure must be explained fully to the patient.
- The patient must be relaxed.

Aftercare

Individuals with a chronic joint problem may have Grade 1 and Grade 2 techniques used at the beginning of treatment to decrease pain. Then, after treatment, the patient progresses to more aggressive rehabilitation such as **therapeutic exercise**. At the end of a rehabilitation session, Grades 3 and 4 can be used in conjunction with stretching to increase mobility. In an acute joint pathology, only Grades 1 and 2 should be used. Grades 1 and 2 mobilizations can be used at the beginning of therapy to reduce pain in an effort to increase performance during therapeutic **exercise**. Grades 1 and 2 mobilizations can be used again at the end of the treatment before cryotherapy to help alleviate pain.

Complications

Some complications associated with mobilizations, but more so with manipulations are:

- fracture
- dislocation
- joint capsule tearing
- ligamentous tearing
- muscle or tendon injury
- nerve damage

Results

If done appropriately, mobilizations can help reduce pain and restore joint play, which is critical for normal mobility. Manipulations are beneficial for releasing adhesions and are usually done under anesthesia by a medical physician. Chiropractic manipulations are not discussed here.

Health care team roles

It is important that nurses and other members of the allied health care team be aware of patients who undergo mobilization and monitor pain and any possible inflammation after treatment. Moreover, pain and inflammation may need to be more closely monitored in individuals having manipulation to restore joint mobility. An example of a patient requiring closer monitoring is an individual having manipulation after total knee replacement secondary to increased adhesions and limited range of motion. Today, most manual therapy is done by physical therapists. However, the education for physical therapists to conduct forceful or thrust manipulations continues to grow and is becoming more a part of **physical therapy** education and post education.

Resources

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ORGANIZATIONS

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Joint sprain see **Sprains and strains**

Joint testing see **Joint integrity and function**

Joint x rays see **Arthrography**

Journal therapy

Definition

Journal therapy is the purposeful and intentional use of a written record of one's own thoughts or feelings to further psychological healing and personal growth. It is often used as an adjunct to many **psychotherapy** and recovery programs. Healthcare practitioners maintain that written expression fills a very important role in the therapeutic process by providing a mechanism of emotional expression in circumstances in which interpersonal expression is not possible or viable.

Origins

People have kept journals and diaries to record dreams, memories, and thoughts since ancient times. Emotional expression has also long held a central role in the study and practice of psychology. Throughout history, psychologists have advocated the expression of emotions as essential for good mental and physical health. Since the early 1980s, interest in this topic has resulted in numerous research studies investigating the health benefits of expressive writing.

Benefits

Journal writing produces a number of benefits in healthy people—among other things, it enhances creativity, helps cope with **stress**, and provides a written record of memorable life experiences. Likewise, some researchers have found that journal writing has a number of psychological and physical health benefits for people who are ill.

Aside from a reduction in physical symptoms of disease, the psychological benefits include reconciling emotional conflicts, fostering self-awareness, managing behavior, solving problems, reducing **anxiety**, aiding reality orientation, and increasing self-esteem. Writing therapy has been used as an effective treatment for the developmentally, medically, educationally, socially, or psychologically impaired and is practiced in mental health, rehabilitation, medical, educational, and forensic institutions. Populations of all ages, races, and ethnic backgrounds are served by writing therapy in individual, couple, family, and group therapy formats.

The therapeutic use of expressive writing allows individuals to confront upsetting topics, thus alleviating the constraints or inhibitions associated with not talking about the event. The psychological drain of the inhibition is believed to cause and/or exacerbate stress-related disease processes. Researchers have found that emotional expression facilitates cognitive processing of the traumatic **memory**, which leads to emotional and physiological change. Specifically, written emotional expression promotes integration and understanding of the event while reducing negative emotions associated with it.

Description

Journal writing and other forms of writing therapy are based on the premise that the mind and the body are inseparably joined in the healing process. Although there are many methods of conducting journal writing therapy depending on the therapeutic technique of the psychologist or psychiatrist, the therapist often instructs the participant to write about a distressing or traumatic event or thought in one or more sessions.

Although researchers are uncertain about exactly how writing about traumas produces improvements in psychological well-being, traumatic stress researchers have pointed out that ordinary memories are qualitatively different from traumatic memories. Traumatic memories are more emotional and perceptual in nature. The memory is stored as a sensory perception, obsessional thought, or behavioral reenactment. It is associated with persistent, intrusive, and distressing symptoms, avoidance, and intense anxiety that results in observed psychological and biological dysfunction. Thus, one goal in treating traumatic memories is to find a means of processing them.

A narrative that becomes more focused and coherent over a number of writing sessions is often associated with increased improvement, according to several research studies. The memories become deconditioned and restructured into a personal, integrated narrative. Changes in psychological well-being after writing therapy may result from cognitive shifts about the trauma either during or after the writing process.

Preparations

In a health care setting, the participant often prepares for journal writing by receiving (from the therapist) a set of instructions regarding the length and focus of the writing session or sessions. Other instructions may include writing in a stream-of-consciousness fashion, without censorship or concern about grammar or style.

KEY TERMS

Art therapy—The use of art media to assess and treat an individual's development, abilities, personality, interests, concerns, or conflicts.

Psychodynamic—The scientific study of mental or conditional forces developing especially in early childhood and their effect on behavior and mental states.

Precautions

It is advisable that journal therapy be conducted only by a licensed health professional, such as a certified **art therapy** practitioner or trained psychologist or psychiatrist. While journal writing classes available to the general public may perform a variety of useful functions, these classes are not intended to provide medical therapy. In journal therapy, the participant may, for example, uncover potentially traumatic, repressed, or painful memories. Therefore, a trained health professional may be necessary to supervise the process and treat these symptoms as they arise.

Side effects

There are no known side effects of journal or writing therapy.

Research and general acceptance

Therapeutic writing became an increasingly popular topic in the final decades of the twentieth century, not only among trained health care professionals, but also among self-improvement speakers without medical training. Seminars, workshops, and Internet sites purportedly offering therapy through expressive writing sprang up around the nation and gained popular acceptance. Despite the large body of research indicating that writing confers benefits on healthy people, the topic of writing therapy's effects on diseased individuals has not received a great deal of research attention. Although increasingly used by health care professionals as an adjunct to various therapeutic approaches, the practice has been criticized by some members of the health care community. Some researchers are distrustful of the findings that so much measurable improvement in health status can occur in just a few brief writing sessions.

In the United Kingdom, the focus of journal therapy has been on descriptive accounts and psychodynamic

explanations for subjective improvements in the health status of participants. In the United States, on the other hand, the focus is on formal scientific research aimed at validating the impact of brief, highly standardized writing exercises on physical measures of illness. The research demonstrates that although physical measures of illness may change, the reasons for the change are not always clear.

In the United States, one study on the effects of writing about stressful experiences on symptom reduction in patients with **asthma** or rheumatoid arthritis found that after four months of writing therapy—in conjunction with standard pharmacotherapy—nearly half the patients enrolled in the study experienced clinically relevant improvement. A growing number of studies have documented symptom improvement in patients with psychiatric disorders as well, suggesting that addressing patients' psychological needs produces both psychological and physical health benefits.

Training and certification

Although journal therapy is often provided by certified instructors who receive variable amounts of training in a number of programs around the country, journal therapy is best administered by a licensed psychologist (who may also be an art therapist) or psychiatrist.

Educational, professional, and ethical standards for art therapists who conduct writing therapy are regulated by The American Art Therapy Association, Inc. The American Art Therapy Credentials Board, Inc., an independent organization, grants postgraduate supervised experience. A registered art therapist who successfully completes the written examination administered by the Art Therapy Credentials Board qualifies as Board Certified (ATR-BC), a credential requiring maintenance through continuing education credits.

Resources

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ORGANIZATIONS

The American Art Therapy Association. 1202 Allanson Road. Mundelein, IL 60060-3808. <<http://www.arttherapy.org>>.

The Center for Journal Therapy. 12477 W. Cedar Drive, #102. Lakewood, CO 80228. <<http://www.journaltherapy.com>>.

Genevieve Slomski

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K

Ketone test *see* **Urinalysis**

Kidney dialysis *see* **Dialysis, kidney**

Kidney failure, acute *see* **Acute kidney failure**

Kidney failure, chronic *see* **Chronic kidney failure**

Kidney function tests

Definition

Kidney function tests are a cadre of tests that are used to screen for and manage renal disease. Tests commonly used for this purpose are plasma creatinine, **blood urea nitrogen (BUN)**, electrolytes, and routine **urinalysis**. Additional laboratory tests are performed to evaluate abnormal renal function and help differentiate between causes. The most commonly used follow-up tests are creatinine clearance, plasma and urine osmolality, and urine sodium.

Purpose

Renal function tests are used to screen for renal disease, to differentiate the cause of renal disease, and to determine the extent of renal dysfunction. These tests attempt to define the clinical state of renal dysfunction and not the process of injury. The latter is determined primarily by a combination of clinical data and biopsy to determine the histological pattern of injury.

Precautions

A complete history should be taken prior to kidney function tests to assess the patient's symptoms and food and drug intake. A wide variety of prescription and over-

the-counter medications can affect blood and urine kidney function test results, as can some food and beverages. Renal function tests are performed on both blood and urine. Blood samples are collected by venipuncture from a vein in the crease of the arm. The nurse or phlebotomist performing the procedure should observe **universal precautions** for the prevention of transmission of blood-borne pathogens. The creatinine clearance test requires a timed urine sample. Explicit written instruction must accompany the explanation of how to collect this sample. It is imperative that the patient empty his or her bladder at the start of the test and not include this urine in the collection. It is equally important that all urine produced during the time of the test be saved and refrigerated, and that the bladder be emptied completely and this urine added to the collection at the end of the test.

Description

The **kidneys** are a pair of organs located in the back of the abdominal cavity on either side of the **vertebral column**. Their purpose is to filter the blood and remove wastes and excess water. They also selectively reabsorb compounds that have been filtered, thus conserving essential nutrients, electrolytes, amino acids and other biomolecules. Approximately one-quarter of the cardiac output, 1200 mL of blood per minute are received by the kidneys. Each kidney is made up of functional microscopic units called nephrons. Each nephron contains a capillary tuft, the glomerulus and a tubule. Blood flows into the kidneys, and engorges the capillary tufts. Water and small solutes pass through the vessel walls forming a filtrate of the plasma which enters the underlying space, Bowman's capsule. The walls of the capsule form a tubule that traverses the kidney. Blood leaves the glomerular capillaries through an efferent arteriole which forms a capillary network, the vasa recta, that follows the path of the tubules. The cells of the renal tubule modify the filtrate along its length ultimately forming urine that passes out of the body. The tubule is responsible for two processes, reabsorption and secretion. Reabsorption is

the process of moving solutes from the tubular lumen into the interstitium that bathes the tubules, so that they can be absorbed by the vasa recta. Some substances such as glucose and sodium are one-hundred percent reabsorbed until the plasma level exceeds a certain concentration called the renal threshold. Secretion is the process of transporting solutes from the interstitium into the tubular lumen, so that they can be excreted in the urine. Secretion allows substances such as hydrogen ions to be eliminated at a rate that exceeds glomerular filtration. These processes are controlled by the selective permeability of different segments of the tubule to water, salt and urea, and the response of the distal collecting tubules to hormones such as aldosterone, antidiuretic hormone, and parathyroid hormone.

When kidney function becomes compromised by disease, the processes of glomerular filtration and tubular reabsorption and secretion become affected to different extents. This can result in retention of waste products that are incompletely filtered, loss of essential solutes that are not reabsorbed, and failure of the tubules to respond to hormonal control of electrolyte and water balance. Blood and urine biochemistry tests reflect the extent of this dysfunction and are used to characterize the clinical state of the patient. Fortunately, the kidneys have a large reserve capacity, and a significant amount of damage must be incurred before kidney function tests become significantly abnormal.

There are several renal states that can be categorized by renal function test results, but the two major ones are acute and chronic renal failure. Renal failure is a term used to describe a loss of renal function characterized by uremia, the retention of nitrogenous wastes in the blood. The acute form is rapid in onset and often reversible. It can occur as three different states, termed prerenal, renal (intrarenal), and postrenal failure. Prerenal failure results from decreased blood flow to the kidneys, and its most common cause is congestive **heart failure**. Renal failure results from injury to the glomerulus and the tubules. The most common causes are glomerulonephritis which is mediated by autoantibodies that damage the glomerulus and obstruct the tubules; pyelonephritis which is caused by a bacterial **infection** of the interstitium; and tubular damage caused by drugs, heavy metals, and viral infections. Post renal failure is caused by obstruction below the kidneys. This can result from urinary tract stones, tumors, or anatomic obstruction as in benign prostatic hypertrophy. The chronic form is characterized by slow onset without accompanying symptoms in its early stage. Chronic renal failure often follows episodes of acute renal failure, and it is not reversible. Chronic renal failure is most commonly a sequela to acute glomerulonephritis or pyelonephritis which together account for

more than half the cases. Other causes of chronic renal failure are chronic diseases such as **diabetes mellitus**, renal vascular disease (e.g., atherosclerosis of the renal vessels), **hypertension**, polycystic kidney disease, drug damage, and **kidney stones**. Kidneys from patients with chronic renal failure will appear smaller than average and a biopsy of the kidney will demonstrate scarring of the tubules.

Laboratory tests

Regardless of the cause, most persons with acute renal failure are characterized by three common laboratory findings: reduced creatinine clearance, azotemia (excessive nitrogen compounds in the blood), and hyperkalemia (excessive potassium in the blood). Creatinine is a waste product of muscle **metabolism**. It is produced at a constant rate and filtered freely by the glomeruli without reabsorption. Therefore, creatinine levels in the blood are increased when there is reduced glomerular filtration. Although specific for glomerular disease, plasma creatinine is not a sensitive test, and about 60% of the renal capacity is usually lost before levels become abnormal. A more sensitive indicator of glomerular dysfunction is the creatinine clearance test. This test measures the ratio of urine to plasma creatinine. As plasma levels rise, urine levels fall causing the ratio to decrease before plasma creatinine becomes definitively abnormal.

CREATININE CLEARANCE TEST. The creatinine clearance is defined as the volume of plasma that contains the same amount of creatinine as is excreted in the urine in one minute. Because the tubules do not reabsorb creatinine, all of the creatinine filtered by the glomeruli in a given amount of time is excreted in the urine. This test is an estimate of the glomerular filtration rate. The test is performed by measuring creatinine in a timed urine specimen—a cumulative sample collected over a four, 12, or 24-hour period. Determination of the plasma creatinine is also required to calculate the urine clearance. The clearance formula is $U/P \times V \times 1.73/A$. “U” is the urine creatinine in gm/dL; “P” is the plasma creatinine in mg/dL; and “V” is the volume of urine produced per minute. This is usually calculated by dividing the volume of urine produced per day by 1440 minutes per day. “A” is the person’s body surface area expressed in square meters, and 1.73 is the average body surface area in square meters. During the test, the patient must be well hydrated because under conditions of slow filtrate flow the tubules will secrete some creatinine causing an overestimate of clearance. Creatinine can be measured by a colorimetric method called the Jaffe reaction or by a coupled enzymatic reaction. The Jaffe reaction is performed by mixing a plasma or diluted urine sample with a solution of sodium hydroxide and saturated picric acid. At an

alkaline pH, the creatinine combines with picric acid to form creatinine picrate and the rate of absorbance change is measured over a precisely defined timed interval to eliminate interference from **proteins** and other reducing agents

Azotemia is the accumulation of nitrogenous (azo)waste products in the blood as a consequence of renal failure. The azo compounds routinely measured are creatinine, urea, and uric acid. While an increase of plasma urea or uric acid is not specific for renal disease, both compounds are retained whenever there is a reduction in the glomerular filtration rate. Of the two compounds, urea is the more sensitive, and urea levels can be used with creatinine to help differentiate prerenal and renal failure.

BLOOD UREA NITROGEN (BUN) TEST. Historically, urea concentration has been expressed as the concentration of nitrogen derived from urea, called the BUN. This test is performed by an enzymatic-ultraviolet photometric method using the enzyme urease. The enzyme catalyzes the hydrolysis of urea by water forming ammonia and carbon dioxide. A coupling enzyme, glutamate dehydrogenase, catalyzes the formation of glutamate from alpha-ketoglutarate and ammonia. In this reaction NADPH is converted to NADP⁺ which causes a decrease in the absorbance of 340 nm light. The rate of absorbance decrease is proportional to the urea nitrogen concentration of the sample. Urea is freely filtered by the glomerulus but is reabsorbed by the tubules to a variable extent depending upon the movement of filtrate through the tubule. When filtrate flow is slow, 40% or more of the filtered urea can be reabsorbed. For this reason, BUN levels increase much more than creatinine in prerenal failure. In prerenal failure, the kidney is not damaged, but glomerular filtration is reduced because of insufficient blood flow to the glomeruli. This results in increased retention of all three azo compounds. However, poor renal blood flow is a stimulus for ADH secretion that promotes water and urea reabsorption. Since the tubules are undamaged, they reabsorb a maximal amount of urea. This causes the ratio of plasma BUN to creatinine to increase dramatically. The reabsorption of BUN is impaired in renal failure caused by renal damage because the tubules are impaired. Ratios in prerenal failure are approximately 20:1, twice that seen in renal failure caused by damaged kidneys.

Electrolyte disturbances are common to all forms of renal failure. Potassium is filtered by the glomerulus and partly reabsorbed in the proximal tubule. A significant amount of potassium is secreted by the collecting tubule in response to aldosterone. Therefore, when the kidneys receive insufficient blood flow potassium is incompletely filtered. When the tubules are damaged, potassium lev-

els rise further because the exchange of potassium for sodium is impaired.

Plasma potassium levels must be maintained within a very narrow range to avoid cardiac arrhythmia. Elevated plasma potassium is the single most important (life-threatening) consequence of renal failure. Plasma potassium is the criterion used to determine the need for dialysis and the frequency and duration of treatment. Urine sodium is very useful in helping to differentiate prerenal from renal failure. In prerenal failure, the daily excretion of sodium is lower than normal because the kidneys attempt to reabsorb sodium in order to restore blood flow. However, in renal failure, daily urine sodium loss is increased owing to tubular failure. Urinary sodium is about twofold higher in intrarenal failure than in prerenal failure.

Urinalysis

There are a variety of urine tests that assess kidney function. A simple, inexpensive screening test, routine urinalysis, is often the first test administered when kidney problems are suspected. A first-morning or randomly voided urine sample is examined visually for color and clarity, and a series of up to ten dry reagent strip biochemical tests are performed. Protein, blood, leukocytes, and specific gravity are four tests that are often abnormal in persons with renal failure. Glomerular damage causes albumin and red blood cells to pass through the basement membrane and enter the filtrate in Bowman's space. Leukocytes migrate to the site of injury and enter the filtrate through glomerular lesions and by passing between the tubular cells. Tubular failure disables the concentrating and diluting capacity of the kidneys and the urine produced is consistently of the same specific gravity as the plasma (1.010). Glucose and pH are also useful because a high percentage of diabetics develop renovascular disease, and renal failure results in acidosis (hydrogen ion retention) with concomitant failure to acidify the urine. While these findings can occur in severe lower urinary tract disease, the renal origin of the cells can often be confirmed by microscopic analysis of urinary sediment. In renal injury, stasis, protein, and obstruction of the tubules by cells cause the precipitation of mucoproteins in the tubules. When these are washed out by urine flow, they can be seen using the **microscope**, and are called casts. The finding of cellular casts in the urinary sediment, identifies the kidney as the source of the cells. Experienced technologists can often distinguish glomerular bleeding from bleeding below the kidney because the former causes characteristic abnormalities in red blood cell structure (dysmorphic cells). Furthermore, the presence of cells and casts signifies renal damage and

KEY TERMS

Blood urea nitrogen (BUN)—The nitrogen portion of urea in the bloodstream. Urea is a waste product of protein metabolism in the body.

Creatinine—The metabolized by-product of creatine, an organic compound that assists the body in producing muscle contractions. Creatinine is found in the bloodstream and in muscle tissue. It is removed from the blood by the kidneys and excreted in the urine.

Creatinine clearance rate—The clearance of creatinine from the plasma compared to its appearance in the urine. Since there is no reabsorption of creatinine, this measurement can estimate glomerular filtration rate.

Diuretic—A drug that increases the excretion of salt and water, increasing the output of urine.

Glomerular filtration rate—The rate in milliliters per minute at which plasma is filtered through the glomerular membrane.

Hematuria—The presence of blood in the urine.

Nephrologist—A doctor specializing in kidney disease.

Nephron—The functional unit of the kidney.

Oliguria—The formation of very small amounts of urine.

Osmolality—A measurement of urine concentration that depends on the number of particles dissolved in it. Values are expressed as milliosmols per kilogram (mOsm/kg) of water.

Polyuria—The formation of very large amounts of urine.

Proteinuria—The presence of protein in the urine often caused by damage to the glomerular membrane.

Renal—Pertaining to the kidney

Specific gravity—The ratio of the weight of a body fluid when compared to water.

Urea—A by-product of protein metabolism that is formed in the liver. Because urea contains ammonia, which is toxic to the body, it must be quickly filtered from the blood by the kidneys and excreted in the urine.

Uric acid—A product of purine breakdown that is excreted by the kidney. High levels of uric acid, caused by various diseases, can cause the formation of kidney stones.

Urine—A fluid containing water and dissolved substances excreted by the kidney.

rules out prerenal failure as the cause of abnormal biochemistry results.

Glomerulonephritis is the most common cause of intrarenal failure. Urinary sediment in this condition displays large numbers of both red and white blood cells, and usually a predominance of red blood cell casts. Pyleonephritis, the second most common renal disease is characterized by a predominance of white blood cells and white blood cell casts. **Bacteria** are usually abundant in the sediment signaling the causative infection.

Postrenal failure may also result in abnormal sediment. The presence of large numbers of crystals in association with biochemical evidence of worsening renal function and hematuria may alert the clinician to the presence of a urinary tract stone. The presence of large numbers of abnormal (cancerous) transitional epithelial cells may be shed into the urine by a bladder tumor and seen in the urine microscopic exam. In such cases, an imaging test, the intravenous pyelogram, is often per-

formed in order to identify the size, location, and possible cause of the obstruction.

OSMOLALITY. Urine osmolality is a measure of the number of dissolved particles in urine. It is a more precise measurement than specific gravity for evaluating the ability of the kidneys to concentrate or dilute the urine. Kidneys that are functioning normally will excrete water in relation to the amount consumed. Those with failing kidneys may not be able to concentrate urine. Solutes will equilibrate by passive diffusion in the tubule and the osmolality will be the same as plasma, approximately 290 mOsm/Kg water. The test may be done on a urine sample collected first thing in the morning as water deprivation overnight should concentrate the urine; multiple timed samples, or on a cumulative sample collected over a 24-hour period. In addition, the ratio of urine to plasma osmolality is another useful way to differentiate prerenal and intrarenal failure. In prerenal failure the kidneys attempt to restore blood volume by reabsorbing sodium. This raises the plasma osmolality causing release of

antidiuretic hormone (ADH) from the posterior pituitary. Under the influence of ADH, the tubules reabsorb more water concentrating the urine. As mentioned, the plasma and urine osmolality are the same in intrarenal disease. The urine to plasma osmolality ratio in prerenal failure is usually twofold higher than in renal disease, in which the ratio is one.

The acute and chronic forms of renal failure display some distinguishing characteristics. In chronic renal failure, the tubules become scarred causing water loss. This results in polyuria (increased urine volume) as opposed to oliguria (low urine volume) seen in acute renal failure. Scarring also results in salt wasting causing the serum potassium to be lower than seen in acute renal failure. The urinary sediment shows heavy proteinuria, hematuria (red blood cells) and abundant casts. The casts are usually broad and waxy, which are unique characteristics of end-stage renal failure.

OTHER BLOOD TESTS. Measurement of the blood levels of other analytes regulated or affected in part by the kidneys can be useful in evaluating kidney function and in managing conditions such as osteomalacia and renal acidosis that are secondary to renal disease. These include bicarbonate, **calcium**, magnesium, **phosphorus**, **plasma renin activity**, and parathyroid hormone.

Preparation

Patients will be given specific instructions for collection of urine samples, depending on the test to be performed. During routine urinalysis, the patient will be given a sealed cup to urinate into. Nurses stress that the patient obtain a “clean catch” by initiating urination and placing the sample cup in the urine stream after a few seconds. This prevents the collection of the initial urine which may contain bacteria that are present in the lower urethra or on the skin. Some timed urine tests require an extended collection period of up to 24 hours, during which time the patient collects all urine voided and transfers it to a specimen container. Refrigeration and/or preservatives are typically required to maintain the integrity of such urine specimens. Certain dietary and/or medication restrictions may be imposed for some of the blood and urine tests. The patient may also be instructed to avoid **exercise** for a period of time before a test to prevent changes in creatinine.

Aftercare

If medication was discontinued prior to a kidney function test, it may be resumed once the test is completed.

Complications

Complications for these tests are minimal, but may include slight bleeding from a venipuncture site, hematoma (accumulation of blood under a puncture site), or fainting or feeling light-headed after venipuncture. In addition, suspension of medication or dietary changes imposed in preparation for some blood or urine tests may trigger side-effects in some individuals.

Results

Normal values for many tests are determined by the patient’s age and sex. Reference values can also vary by laboratory, but are generally within the ranges that follow.

Urine tests

- **Creatinine clearance.** For a 24-hour urine collection, normal results are 90-139 mL/min for adult males less than 40 years old, and 80-125 mL/min for adult females less than 40 years old. For people over 40, values decrease by 6.5 mL/min for each decade of life.
- **Urine osmolality.** With restricted fluid intake (concentration testing), osmolality should be greater than 800 mOsm/kg of water. With increased fluid intake (dilution testing), osmolality should be less than 100 mOsm/kg in at least one of the specimens collected. A 24-hour urine osmolality should average 300-900 mOsm/Kg. A random urine osmolality should average 500-800 mOsm/Kg.
- **Urine protein.** A 24-hour urine collection should contain no more than 150 mg of protein.
- **Urine sodium.** A 24-hour urine sodium should be within 75-200 mmol/day.

Blood tests

- **Blood urea nitrogen (BUN)** should average 8-20 mg/dL.
- **Creatinine** should be 0.8-1.2 mg/dL for males, and 0.6-0.9 mg/dL for females.
- **Uric acid levels** for males should be 3.5-7.2 mg/dL and for females 2.6-6.0 mg/dL.

Low clearance values for creatinine indicate diminished ability of the kidneys to filter waste products from the blood and excrete them in the urine. As clearance levels decrease, blood levels of creatinine, urea, and uric acid increase. Since it can be affected by other factors, an elevated BUN, by itself, is suggestive, but not diagnostic, for kidney dysfunction. An abnormally elevated plasma creatinine is a more specific indicator of kidney disease than is BUN.

Inability of the kidneys to concentrate the urine in response to restricted fluid intake, or to dilute the urine in response to increased fluid intake during osmolality testing indicates decreased tubular function. Because the kidneys normally excrete almost no protein in the urine, its persistent presence, in amounts that exceed the normal 24-hour urine value, usually indicates glomerular or tubular injury. These can be distinguished by urine protein electrophoresis. This procedure separates proteins in an electric field based upon their charge. Albuminuria is characteristic of glomerular disease, while urinary excretion of alpha-1 and beta-2 microglobulins is characteristic of tubular damage. Proteinuria of tubular origin is caused by drugs, heavy metals, or viral infection of the kidneys. Urine protein electrophoresis also detects monoclonal immunoglobulin light chains (multiple myeloma and related conditions) and immunoglobulin fragments (systemic autoimmune diseases), which are nonrenal causes of proteinuria.

Health care team roles

Kidney function tests are ordered and interpreted by a physician. Blood samples are collected by a nurse or phlebotomist. Nurses should educate the patient on why the tests are being done and how to collect timed urine samples. In addition, patients with kidney disease may be advised to change their diets. A dietitian may be consulted.

Patient education

Some kidney problems are the result of another disease process such as diabetes or high **blood pressure**. Clinicians should take the time to inform patients about how their disease or its treatment will alter kidney function and the different measures they can take to help prevent these changes.

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ORGANIZATIONS

- National Kidney Foundation (NKF). 30 East 33rd Street, New York, NY 10016. (800)622-9020.
<<http://www.kidney.org>>.

Jane E. Phillips, PhD

Kidney radionuclide scan

Definition

A kidney radionuclide scan, also called a kidney scan or renal scan, is a diagnostic imaging test that involves administering a small amount of radionuclide, also called a radioactive tracer, into the body and then imaging the **kidneys** with a gamma camera. The images obtained can help in the diagnosis and treatment of various kidney diseases and conditions.

Purpose

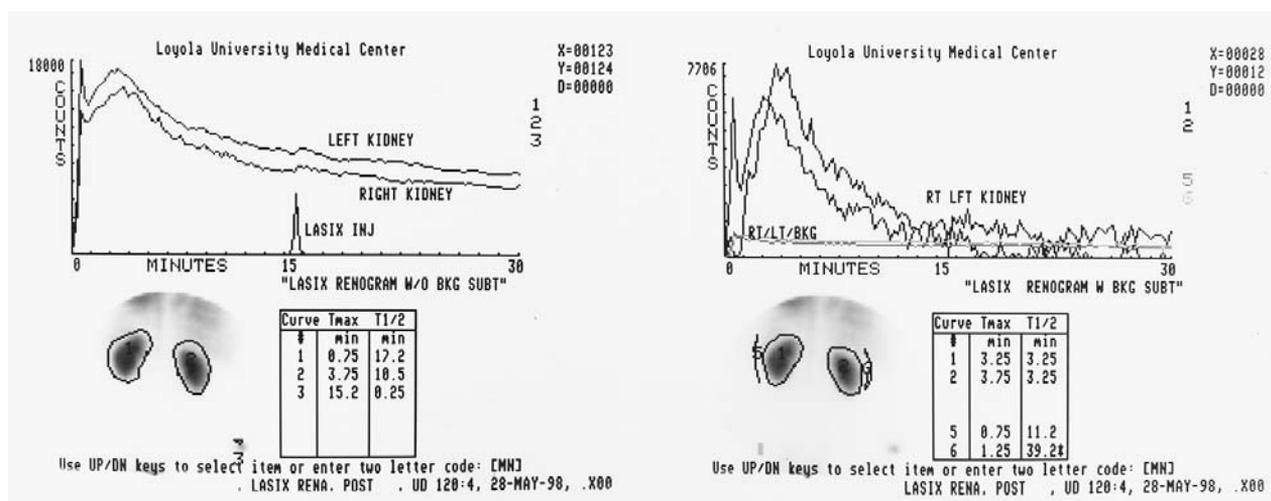
While many tests—such as x rays, ultrasounds, or computed tomography (CT scans)—can reveal the structure of the kidneys, the kidney radionuclide scan is unique in that it also reveals how the kidneys are functioning. Candidates for a kidney scan may include patients who have acute or chronic renal failure, obstruction in their **urinary system**, renal artery stenosis, kidney transplant, trauma to the kidney, reflux nephropathy, renal vascular disorders and/or **hypertension**, or congenital abnormalities.

Precautions

A kidney scan requires the use of a radioactive material; therefore, patients who are pregnant or suspect they may be pregnant are cautioned not to have the test unless the benefits outweigh the risks. Women should inform their doctor if they are breast feeding. The doctor will recommend the woman stop breast feeding for a specified period of time, depending on the particular tracer and dose used.

Description

Kidney scans are performed either in a hospital nuclear medicine department or in an outpatient radiology or nuclear medicine facility. The patient is positioned in front of, or under, a gamma camera—a special piece of equipment that detects the radiation emitted from the body and produces an image. An intravenous injection of the radionuclide is administered. Immediately after the injection imaging begins, and, in most studies, the flow of **blood** to each kidney is evaluated. Serial images of the kidneys are obtained over a specified period of time, depending upon the particular radiopharmaceutical used. Kidney scans may be performed to determine the rate at which the kidneys are filtering a patient's blood. These studies use a radiopharmaceutical called technetium DTPA (Tc99m DTPA). This radiopharmaceutical also can identify obstruction in the renal collecting system. To



A computer-generated time activity curve generated from a renal scan. This time activity curve looks at the radiation count over a period of time. (Photograph by Collette Placek. Reproduced by permission.)

establish the function of the renal tubules, the radiopharmaceutical Technetium DMSA (Tc99m DMSA) is used.

A kidney scan ranges from 45 minutes to three hours in length, depending upon the goals of the test, but the test typically takes about an hour to an hour and a half. It is important to understand that kidney scans can reveal an abnormality, but they do not always identify the specific problem. They are very useful in providing information about how the various parts of the kidneys function, which, in turn, can assist in making a diagnosis.

Typically, posterior images are obtained but images are also obtained at oblique angles. If indicated, the patient may be positioned so that mobility of the kidney is demonstrated by sitting up or lying down for the images. If obstruction or renal function is being evaluated, a diuretic (drug to induce urination), such as Lasix, may be injected. If hypertension or renal artery stenosis is being evaluated, Captopril or Enalapril (ACE inhibitors) may be injected.

Preparation

No special preparation is necessary for a kidney scan. In some instances the patient may be required to drink additional liquids and to empty their bladder before the exam. If another nuclear medicine study was recently performed, the patient may have to wait for a specified period to avoid any interference from residual radioactivity in the body. The patient is instructed to remove metal items from the area to be scanned.

Aftercare

Patients can resume their normal daily activities immediately after the test. Most radioactive tracers are

excreted through the urinary system, so drinking fluids after a kidney scan can help flush the tracer out of the body more quickly.

Complications

Nuclear medicine procedures are very safe. Unlike some of the dyes that may be used in x-ray studies, radioactive tracers rarely cause side effects. There are no long-lasting effects of the tracers themselves, because they have no functional effects on the body's tissues. If pharmaceuticals are injected these can temporarily raise or lower **blood pressure**, or cause one to urinate.

Results

The scan should reveal normal kidney function for the patient's age and medical status, as well as show normal relative position, size, configuration, and location of the kidneys. Initial blood flow images should reflect that blood circulation to both kidneys is equal. Patients whose images suggest a space-occupying lesion or obstruction may require other imaging procedures, such as CT or ultrasound, to provide more information. Also, if the kidneys appear to be abnormal in size, have an unusual contour, or are unusually positioned, other imaging procedures may be required.

Health care team roles

Kidney scans are performed by a nuclear medicine technologist trained in handling radioactive materials, operating the equipment, and processing data obtained during the procedure. The technologist is responsible for explaining the test to the patient, obtaining pertinent

KEY TERMS

Radiopharmaceutical—A radionuclide that is attached to a chemical, or pharmaceutical, agent, i.e., a radioactive drug.

medical history, and administering injecting the radionuclide. All data collected is submitted either to a doctor who is a nuclear medicine specialist or a radiologist for interpretation. Patients obtain the results of the study from their primary care physician or the physician who ordered the study.

Resources

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Kidney stone analysis *see* **Stone analysis**

Kidney stones

Definition

Kidney stones are solid accumulations of material that form in the tubal system of the kidney. Kidney stones cause problems when they block the flow of urine through or out of the kidney. When the stones move along the ureter (the tube that connects the kidney and the urinary bladder), they cause severe **pain**.

Description

Urine is formed by the **kidneys**. **Blood** flows into the kidneys, and specialized tubes (nephrons) within the kidneys allow a certain amount of fluid from the blood, and certain substances dissolved in that fluid, to flow out of the body as urine. However, sometimes tiny crystals may form in the urine, meet, and cling together to create a larger solid mass called a kidney stone. A kidney stone is also called a nephrolith or urolith (nephro refers to the kidney, uro refers to urine, and lith means stone).

Many people do not ever find out that they have stones in their kidneys. These stones are small enough to allow the kidney to continue functioning normally, never causing any pain. These are called silent stones. Kidney stones cause problems when they interfere with the normal flow of urine. They can block (obstruct) the flow down the tube (the ureter) that carries urine from the kidney to the bladder. When pressure in the kidney builds from backed-up urine, the kidney may swell (hydronephrosis). If the kidney is subjected to this pressure for some time, it may cause damage to the delicate kidney structures. When the kidney stone is lodged further down the ureter, the backed-up urine may also cause the ureter to swell (hydroureter). Because the ureters are muscular tubes, the presence of a stone will make these muscular tubes spasm, causing severe pain.

About 10% of all people will have a kidney stone in their lifetime. Kidney stones are most common among:

- Caucasians
- males
- people over the age of 30
- people who previously have had kidney stones
- relatives of persons with kidney stones

Causes and symptoms

Kidney stones can be composed of a variety of substances. The most common types of kidney stones include:

- **Calcium** stones. About 80% of all kidney stones fall into this category. These stones are composed of either calcium and phosphate, or calcium and oxalate. People with calcium stones may have other diseases that cause them to have increased blood levels of calcium. These diseases include primary parathyroidism, sarcoidosis, hyperthyroidism, renal tubular acidosis, multiple myeloma, hyperoxaluria, and some types of **cancer**. A diet heavy in meat, fish, and poultry can cause calcium oxalate stones.

- **Struvite stones.** About 10% of all kidney stones fall into this category. This type of stone is composed of magnesium ammonium phosphate. These stones occur most often when persons have had repeated urinary tract infections with certain types of **bacteria**. These bacteria produce a substance called urease, which increases the pH of urine, making urine more alkaline and less acidic. This chemical environment allows struvite to precipitate in the urine, forming stones.
- **Uric acid stones.** About 5% of all kidney stones fall into this category. Uric acid stones occur when increased amounts of uric acid circulate in the bloodstream. When the uric acid content becomes very high, it can no longer remain dissolved. Molecules of uric acid precipitate out of the urine. A kidney stone is formed when these bits of uric acid begin to cling to each other within the kidney, slowly growing into a solid mass. About half of all persons with this type of stone also have deposits of uric acid elsewhere in their body, commonly in the joint of the big toe. This painful disorder is called **gout**. Other causes of uric acid stones include **chemotherapy** for cancer, certain bone marrow disorders where blood cells are over-produced, and an inherited disorder called Lesch-Nyhan syndrome.
- **Cystine stones.** About 2% of all kidney stones fall into this category. Cystine is a type of amino acid. People with this type of kidney stone have an abnormality in the way their bodies process amino acids in the diet.

People who have kidney stones usually do not have symptoms until the stones pass into the ureter. Prior to this, some individuals may notice blood in their urine. Once the stone is in the ureter, however, most people will experience bouts of very severe pain. The pain is crampy and spasmodic, and is referred to as colic. The pain usually begins in the flank region, the area between the lower ribs and the pelvis. As the stone moves closer to the bladder, a person will often feel the pain radiating along the inner thigh. In women, the pain may be felt in the vulva. In men, the pain may be felt in the testicles. Nausea, vomiting, extremely frequent and painful urination, and obvious blood in the urine are common. **Fever** and chills usually mean that the ureter has become obstructed, allowing bacteria to become trapped in the kidney causing a kidney **infection** (pyelonephritis).

Diagnosis

Diagnosing kidney stones is based on a person's history of the very severe, distinctive pain associated with the stones. Diagnosis includes laboratory examination of a urine sample and an x-ray examination. During the passage of a stone, examination of the urine almost always reveals blood. A number of x-ray tests are used to diag-



X ray of kidney stone. (Custom Medical Stock Photo. Reproduced by permission.)

nose kidney stones. A plain x ray of the kidneys, ureters, and bladder may or may not reveal the stone. A series of x rays taken after injecting iodine dye into a vein is usually a more reliable way of seeing a stone. This procedure is called an intravenous pyelogram (IVP). The dye highlights the **urinary system** as it travels through it. In the case of an obstruction, the dye will be stopped by the stone or will only be able to get past the stone at a slow trickle.

When a person is passing a kidney stone, it is important that all of the urine is strained through a special sieve. This is to ensure that the stone is caught. The stone can then be sent to a special laboratory for analysis so that the chemical composition of the stone can be determined. After the kidney stone has been passed, other tests will be required to understand the underlying condition that may have caused the stone to form. Collecting urine for 24 hours, followed by careful analysis of its chemical makeup, can often determine a number of reasons for stone formation.

Treatment

A person with a kidney stone will say that the most important aspect of treatment is adequate pain relief. Because the pain of passing a kidney stone is so severe, narcotic pain medications such as meperidine or morphine are often required. It is believed that stones may pass more quickly if a person is encouraged to drink large amounts of water (2–3 quarts, or 1.8–2.8 liters, per day). If an individual is vomiting or unable to drink because of the pain, it may be necessary to provide fluids through a vein. If symptoms and urine tests indicate the presence of infection, **antibiotics** will be required.

Although most kidney stones will pass on their own, some will not. Surgical removal of a stone may become necessary when a stone appears too large to pass. Surgery

KEY TERMS

Hydronephrosis—Swelling of a kidney due to elevated pressure from excess fluid accumulation.

Hydroureter—Swelling of a ureter due to elevated pressure from excess fluid accumulation.

Lithotripsy—Technique that uses focused sound waves to pulverize kidney stones, thus avoiding surgery.

Nephron—Tube within the kidney that processes filtrate from the blood, reclaiming some substances and creating urine.

Pyelonephritis—Infection of the kidney.

Ureter—Tube that connects the kidney and urinary bladder, whose function is to transport urine.

may also be required if the stone is causing serious obstructions, pain that cannot be treated, heavy bleeding, or infection. Several alternatives exist for removing stones. One method involves inserting a tube into the bladder and up into the ureter. A tiny basket is then passed through the tube, and an attempt is made to snare the stone and pull it out. Open surgery to remove an obstructing kidney stone was relatively common in the past, but current methods allow the stone to be crushed with shock waves (called **lithotripsy**). These shock waves may be aimed at the stone from outside of the body by passing the necessary equipment through the bladder and into the ureter. The shock waves may be aimed at the stone from inside the body by placing the instrument through a tiny incision located near the stone. The stone fragments may then pass naturally or may be removed through the incision. All of these methods reduce an individual's recovery time considerably when compared to the traditional open operation.

Alternative treatment

Alternative treatments for kidney stones include the use of herbal medicine, **homeopathy**, acupuncture, **acupressure**, hypnosis, or guided imagery to relieve pain. Starfruit (*Averrhoa carambola*) is recommended to increase the amount of urine a person passes and to relieve pain. Dietary changes can be made to reduce the risk of future stone formation and to facilitate the resorption of existing stones. Supplementation with magnesium, a smooth muscle relaxant, can help reduce pain and facilitate stone passing. Homeopathy and herbal medicine, both western and Chinese, recommend a number of remedies that may help prevent kidney stones.

Prognosis

A person's prognosis depends on the underlying disorder causing the development of kidney stones. In most cases, people with uncomplicated calcium stones will recover very well. About 60% of these individuals, however, will have other kidney stones. Struvite stones are particularly dangerous because they may grow extremely large, filling the tubes within the kidney. These are called staghorn stones and will not pass out in the urine. They will require surgical removal. Uric acid stones may also become staghorn stones.

Health care team roles

A physician makes an initial diagnosis of kidney stones. A radiologist confirms the diagnosis. A surgeon is needed to operatively remove a kidney stone. A technician performs a lithotripsy under the supervision of a physician.

Prevention

Prevention of kidney stones depends on the type of stone and the presence of an underlying disease. In almost all cases, increasing fluid intake so that a person consistently drinks several quarts of water a day is an important preventive measure. Persons with calcium stones may benefit from taking a medication called a diuretic, which has the effect of decreasing the amount of calcium passed in the urine. Eating less meat, fish, and chicken may be helpful for individuals with calcium oxalate stones. Other items in the diet that may encourage calcium oxalate stone formation include beer, black pepper, berries, broccoli, chocolate, spinach, and tea. Uric acid stones may require treatment with a medication called allopurinol. Struvite stones will require removal and an affected person should receive an antibiotic. When a disease is identified as the cause of stone formation, treatment specific to that disease may lessen the likelihood of repeated stones.

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- American Association for Clinical Chemistry. 2101 L Street, NW, Suite 202, Washington, DC 20037-1558. (800) 892-1400. (202) 857-0717. Fax: (202) 887-5093. <<http://www.aacc.org>>. info@aacc.org.
- American Foundation for Urologic Disease. 1128 North Charles Street, Baltimore, MD 21201. (800) 242-2383. (410) 468-1800. <<http://www.afud.org>>. admin@afud.org.
- American Urological Association. 1120 North Charles Street, Baltimore, MD 21201. (410) 727-1100. Fax: (410) 223-4370. <http://www.auanet.org/index_hi.cfm>. aua@auanet.org.
- National Kidney Foundation. 30 East 33rd Street, Suite 1100, New York, NY 10016. (800) 622-9010. (212) 889-2210. Fax: (212) 689-9261. <<http://www.kidney.org/>>. info@kidney.org.

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Kidney, ureter, and bladder x-ray study

Definition

A kidney, ureter, and bladder (KUB) x ray is an AP (anteroposterior) abdominal x ray. Despite its name, KUB does not show the ureters and only sometimes shows the **kidneys** and bladder and, even then, with uncertainty.

Purpose

The KUB is used to detect **kidney stones**, **foreign bodies** in children, and to diagnose some gastrointestinal disorders. It is also used as a preliminary film for an intravenous pyelogram and **barium enema**, or as a follow-up x ray after the placement of devices such as ureteral stents and nasogastric or nasointestinal tubes (feeding tubes). It may also be requested in the operating room to detect sponges or clamps before the patient's incision is closed and would be done with the portable x-ray machine.

Precautions

Because of the risks of radiation exposure to the fetus, pregnant women are advised to avoid this x-ray procedure.

A KUB study is a preliminary screening test for kidney stones, and should be followed by a more sophisticated series of diagnostic tests [such as an **abdominal ultrasound**, **intravenous urography**, or computed tomography scan (CT scan)], if kidney stones are suspected.

Description

A KUB is typically a single x-ray procedure. The patient lies supine (face-up) on the x-ray table and may flex the knees if it is more comfortable. The x-ray technologist centers on the iliac crest, making sure the pubic

KEY TERMS

Pubic symphysis—The line of fusion between the pubic bones.

Ureteral stent—A surgical device implanted in patients with damaged ureters that holds the ureter open so that urine can flow freely from the kidneys to the bladder.

symphysis will be visualized. The collimation may be reduced to the ASIS (anterior superior iliac spine) for better detail of the kidney outline, ureter and bladder, especially during an intravenous pyelogram. The radiographic technique of the film should demonstrate peritoneal fat lines, psoas muscles, and both renal (kidney) outlines. The patient is asked to hold his or her breath on expiration. Sometimes a second film is obtained with the patient standing.

Preparation

A KUB study requires no special diet, fluid restrictions, medications, or other preparation. The patient is typically required to wear a hospital gown or similar attire. A lead apron can not be used since it will obstruct necessary structures of the abdomen.

Aftercare

No special aftercare treatment or regimen is required for a KUB study.

Complications

The KUB study is an x-ray procedure, so it does involve minor exposure to radiation.

Results

Normal KUB x-ray films show two kidneys of a similar size and shape, no renal calculi (stones), and a normal bowel gas pattern.

Abnormal KUB films may show calculi (kidney stones). If both kidneys are visible, it may be possible to diagnose renal size discrepancies. The film may also demonstrate an increase in bowel gas, indicating a possible bowel obstruction. In this case an additional film of the abdomen should be done either upright or in a lateral decubitus position. Soft tissue masses may also be visualized on a KUB.

Health care team roles

The x-ray technologist must confirm with the emergency physician that just a KUB is necessary to complete a diagnosis instead of a complete abdominal series. When a KUB is done with the mobile x-ray machine all staff remaining in the room must receive lead shielding. All radiographical technologists must be certified and registered with the A.S.R.T. and continue to upgrade and maintain their certification with ongoing education credits.

Patient education

The x-ray technologist must advise the patient to remain still and follow breathing instructions so that a detailed image of the abdomen may be taken.

Resources

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Kidneys

Definition

The kidneys maintain body fluid volumes and **blood pressure**, filter **blood**, and contribute to waste removal by producing urine.

Description

The kidneys are two bean-shaped organs that sit just below the rib cage on either side of the **spinal cord**. Each is about the size of a bar of soap. At any one time 20–25% of the body's blood flows through them, even though they comprise only 0.5% of the body's total weight. At this rate, the kidneys filter the entire blood supply 60 times per day.

Blood flows into the kidney through the renal artery and exits through the renal vein. Within the kidney are many small capillaries that perfuse it with blood, giving the organ its reddish-brown color.

The gross anatomy of the kidney can be divided into four parts:

- **Capsule:** A thin but tough outer membrane that protects the kidney against **infection** and trauma.
- **Cortex:** The outer layer of the kidney's interior, about 1 cm (0.4 inch) thick.
- **Medulla:** The inner layer of the kidney's interior, which contains triangular structures called renal pyramids. Between pyramids are sections of cortex called renal columns.
- **Renal pelvis:** A large funnel for collecting urine from all parts of the kidney, connected to the bladder by the ureter.

Each cortex and medulla together contain about a million nephrons, microscopic filtering systems that are the basic unit of each kidney. Each nephron has two main components. The first is a vascular system that includes 1) the glomerulus, 2) afferent and efferent arterioles, and 3) peritubular capillaries. The second, tubular component contains five main parts: Bowman's capsule, proximal tubule, loop of Henle, distal tubule, and the collecting duct.

Bowman's capsule forms one end of each nephron. It contains a bundle of tiny capillaries called the glomerulus, which receives its bloodflow from the afferent arteriole. The glomerulus filters **minerals**, nutrients, wastes, and water from the blood that flows through it, and passes them down into the proximal tubule. The glomerulus also returns large plasma **proteins** and red blood cells to the blood supply through the efferent arteriole. The efferent arteriole is connected to a second capillary bed called the peritubular capillaries. These two successive capillary beds create a pressure difference that forces fluid through the nephron.

Once filtrate enters the proximal tubule, specialized cells reabsorb sodium and other ions, water, glucose, and amino acids back into the blood. The fluid then goes into the loop of Henle, which helps concentrate the waste products to be excreted in urine. After the loop of Henle, fluid then flows into the highly coiled distal tubule, where potassium is secreted and more water and sodium are reabsorbed back into the blood. The fluid then flows into the last part of the nephron, the collecting duct, where final adjustments are made to the urine concentration. The collecting ducts respond to the antidiuretic hormone (ADH), which regulates the amount of water reabsorbed by the blood. The urine then flows through the renal pelvis to the ureter, which delivers urine to the bladder for excretion.

Function

By filtering the blood, the kidneys play a very important role in the body. They adjust the water volume,

remove wastes such as urea, ammonia, and drugs, establish **acid-base balance**, determine the composition of blood, help maintain blood pressure, stimulate the production of red blood cells, and determine **calcium** levels.

The maintenance of water volume is a particularly important function. When the body sweats on a hot day or during **exercise**, it needs a way to sense water loss to avoid **dehydration**. Water volume is monitored by specialized osmoreceptors in the hypothalamus that measure sodium concentration in the blood. A high sodium concentration means there is insufficient water; this signals the hypothalamus to increase ADH secretion, which in turn prevents the kidneys from reabsorbing water from the blood in the collecting ducts. If the sodium concentration is low, there is too much water in the blood, so the hypothalamus reduces ADH secretion, which tells the kidneys to increase the water concentration of the urine.

The kidneys are also crucial in removing waste products such as urea, ammonia, and any chemical compounds such as medications from the blood. For this reason patients with damaged kidneys must be monitored closely when they take medications that are excreted in the urine. If the kidneys are not working properly, drug concentrations in the blood could rise to fatal levels.

In addition, the kidneys play a pivotal role in the body's acid-base balance. The blood's pH is maintained by a fixed ratio of hydrogen-to-bicarbonate ions in the blood. If the number of hydrogen ions increase, then the blood becomes acidic, a condition known as acidosis. Likewise, if the number of sodium bicarbonate ions rise, the blood becomes basic, a condition known as alkalosis. The kidneys help sustain this hydrogen-to-bicarbonate ratio by adjusting the amount of bicarbonate in the blood. If the blood is too basic the proximal and distal tubules of the kidney will decrease bicarbonate reabsorption and more bicarbonate will be excreted into the urine. If the blood is acidic, then the proximal tubule will allow reabsorption of bicarbonate back into the blood and excrete more hydrogen into the urine.

Another major task the kidneys perform is to help maintain blood pressure. Kidney cells can recognize when a drop in blood pressure occurs, because when this happens, blood flow to the kidney decreases. This means less sodium is present in the kidney cells, a condition that causes the kidney cells to release an enzyme called renin. Renin converts angiotensin I into angiotensin II, which in turn constricts **blood vessels** and causes sodium retention by the kidneys, thereby raising blood pressure. This is known as the renin-angiotensin system. Angiotensin II also causes the **adrenal glands** to release the hormone aldosterone, which tells the kidneys to allow more sodium and water to be reabsorbed back into the blood. This

KEY TERMS

Adrenal gland—Small gland on top of each kidney that produces and releases several different hormones that are involved in maintaining internal fluid and salt levels and also mediates stress responses.

Angiotensin I—Inactive form of angiotensin that circulates in the blood; it is a precursor of angiotensin II.

Angiotensin II—Active form of angiotensin that constricts blood vessels, thus raising blood pressure.

Capillary—Small blood vessel that is the point of connection for blood and veins and where exchanges occur between the blood and tissue.

Hydronephrosis—Distention of the renal pelvis that occurs when urine is trapped in the kidney and blocked from flowing into the bladder.

Ureter—Carries urine from the kidney to the bladder.

increase in water volume in the blood increases blood pressure. Many medications for high blood pressure act by working on the kidneys to decrease blood volume and therefore blood pressure. These blood pressure medications are collectively known as diuretics.

Role in human health

The kidneys play a crucial role in human health because they perform many vital functions. The kidneys work constantly, simultaneously, and influence each other. Individuals are born with two kidneys but can function with one. However, a person with kidney function at 10–15% of capacity will require dialysis or a kidney transplant to sustain life. Individuals with high blood pressure and diabetes have a significant risk of kidney disease.

Common diseases and disorders

Diabetic nephropathy

Diabetic patients cannot process blood glucose properly, and if their disease is untreated or poorly controlled, it can lead to high blood sugar levels. This can damage the nephrons, leading to diabetic neuropathy. This usually means that soft kidney tissue hardens and thickens, a process called sclerosis; this is especially true for the glomerulus. The American Diabetes Association esti-

mates that 35–45% of type 1 diabetics and 20–30% of type 2 diabetics have damaged kidneys. Because the symptoms of nephropathy may not appear until 80% of kidney function is gone, periodic tests of kidney function and strict compliance with diet and treatment regimens are important for patients with diabetes.

High blood pressure

The kidneys use small blood vessels called capillaries to filter blood and to help create a pressure gradient to move fluid through the nephron. Continuous high blood pressure can damage the fragile walls of these vessels. When this happens, blood may not filter properly, allowing waste products and/or drug levels to build up, sometimes to dangerous or fatal levels.

Kidney stones

Kidney stones occur when crystals form in the lumen of the tubules or in the ureters. The stones are most commonly made of calcium and oxalate or phosphate. The basis of stone formation is not clear but certain foods in certain people can cause them to accrete. **Kidney stones** can be extremely painful, and can also cause hydronephrosis. Patients with kidney stones are encouraged to drink plenty of water in effort to have the stone excreted in the urine. In some cases, kidney stones must be surgically removed.

Polycystic kidney disease

Polycystic kidney disease (PKD) is an inherited disease in which cysts form in the kidney. These fluid-filled cysts can take over a significant amount of space in the kidney, eventually reducing kidney function and causing kidney failure. Most cases of PKD show no symptoms until the patient is well into adulthood. PKD that appears in children is often more virulent, frequently leading to kidney failure and death. **Nutrition** and dietary modification play a major role in controlling the progression of PKD.

Wilms' tumor

Wilms' tumor, or nephroblastoma, is a **cancer** of the kidney that appears during childhood. Both sporadic cases and a few rare inherited cases have been linked to mutations in the Wilm's tumor gene (WT1) on chromosome 11. Many cases of Wilms' tumor are curable if caught early enough.

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ORGANIZATIONS

National Kidney Foundation. 30 East 33rd St. Suite 1100, New York, NY 10016. (800) 622-9010. <<http://www.kidney.org>>.

Polycystic Kidney Disease Foundation. 4901 Main St. Suite 200, Kansas City, MO 64112. (800) PKD-CURE. <<http://www.pkdcure.org>>.

Susan M. Mockus, Ph.D.

Kleihauer-Betke test see **Fetal cell screen**

KOH test

Definition

The KOH (potassium hydroxide) test is the microscopic examination of a skin, nail, or hair sample for the presence of a fungus that infects these structures. The test takes its name from the chemical formula for potassium hydroxide (KOH), the substance used in the test to clear skin cells, protein, and cellular debris, making the **fungi** easier to observe. A sample from the infected area is analyzed under a **microscope** following the addition of a few drops of potassium hydroxide. A stain may be added to make the fungi more easily visible.

Purpose

The KOH test is used for the rapid, differential diagnosis of infections produced by dermatophytes from skin disorders such as eczema and psoriasis which may appear similar. Dermatophytes are a type of fungus that invade the skin, hair, or nails, and produce an **infection** commonly called ringworm (tinea). There are three genera of fungi commonly implicated in human skin, nail, and hair infections. These are *Trichophyton spp.* (found in skin, nail, and hair infections), *Epidermophyton spp.* (skin and nail infections), and *Microsporum spp.* (skin and hair infections). The KOH test may also be used on scrapings from the mouth or vagina for the rapid identification of *Candida spp.*, the cause of yeast infections of the mouth (thrush) and the vagina (vaginitis). If a dermatophyte or yeast infection is found, antibiotic treat-

ment can be started immediately, and further testing is not usually required. The KOH prep cannot identify the specific causative organism. When fungus is found, the specimen can be submitted for **fungal culture** to identify the causative agent(s).

Precautions

There are no specific precautions for patients who require this test. Health care professionals who perform this test should be properly trained in skin scraping, nail, and hair follicle removal procedures, the identification of fungi and yeasts by microscopy, and the safe handling of specimens.

Description

Ringworm of the skin produces red or gray, scaly patches of itchy skin. Hair infection results in brittle hair shafts that fall out easily. Deeper infections may be ulcerative, discolored, and purulent. The health care provider selects an infected area from which to collect the sample. A scalpel or edge of a glass slide is used to gently scrape skin scales from the infected area. For hair samples, a forceps is used to remove hair shafts and follicles from the infected site. If the test is to be performed immediately, the scrapings are placed directly onto a microscope slide and are covered with 10% or 20% potassium hydroxide. If the test will be sent to a laboratory, the scrapings are placed in a sterile covered container for later testing.

After adding KOH, the slide should be allowed to stand for five minutes in order to dissolve skin cells, hair, and debris. If the sample remains unclear after five minutes, it may be left for an additional five to 10 minutes. Dimethyl sulfoxide can be added to the KOH to enhance clearing, and lactophenol cotton blue stain can be added to make the fungi easier to see. The slide may be gently heated to enhance the digestive action of the KOH. If a fluorescent microscope is available, calcofluor white stain may be added to the KOH preparation. This will cause the fungi to become fluorescent, making them easier to identify.

Dermatophytes are easily recognized under the microscope by their long branch-like tubular structures called hyphae. Fungi causing ringworm infections produce septate (segmented) hyphae. Some show the presence of spores formed directly from the hyphae (arthroconidia). Yeast infections of the skin can also be identified by the KOH test. Yeast cells appear round or oval and budding forms may be seen.

Fungal infections of the skin are described by the site of infection. Tinea cruris is a fungal infection occur-

KEY TERMS

Tinea—A superficial infection of the skin, hair, or nails, caused by a fungus and commonly known as ringworm.

ring in the groin or inner thigh, tinea pedis on the feet, tinea capitis on the scalp and hair, and tinea unguium on the nails. Tinea versicolor refers to a fungal infection of the skin caused by *Malassezia furfur*. This organism cannot be cultured, and is recognized by characteristic yellowish skin patches and the microscopic appearance of the organism. The fungus produces curved hyphae and round yeast forms that give it a spaghetti-and-meatball appearance under the microscope.

Preparation

There is no special preparation for the patient prior to sample collection.

Aftercare

The patient will experience slight discomfort from sample collection. The skin site or area exposed when the nail is removed may need to be covered by a gauze bandage.

Complications

There are usually no complications for the patient associated with this test.

Results

A normal, or negative, KOH test shows no fungi (no dermatophytes or yeast). Dermatophytes or yeast seen on a KOH test indicate the patient's symptoms are caused by a fungal infection. Follow-up tests are usually unnecessary.

Health care team roles

Physicians, nurses, or physician assistants usually collect the skin, nail, or hair samples from the patient. The KOH test procedure may be performed by the physician or by a clinical laboratory scientist/medical technologist. If fungal cultures are required, they are performed by a clinical laboratory scientist/medical technologist who specializes in microbiology.

Patient education

The health care professional who collects the sample also explains the testing procedure to the patient, and explains why the test is required. The physician or nurse will also explain the treatment regimen, as well as the importance of adhering to the treatment as required, if a fungal infection is diagnosed.

Resources

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Linda D. Jones, B.A., PBT (ASCP)

KUB see Kidney, ureter, and bladder x-ray study

L

Labor and delivery *see* **Childbirth**

Lacerations *see* **Wounds**

Lactate dehydrogenase isoenzymes test *see*
Liver function tests

Lactation

Definition

Lactation is the medical term used for breastfeeding. It also specifically refers to the synthesis and secretion of milk.

Purpose

Breastfeeding provides a baby with **nutrition** in the form of breast milk. Not only does breast milk contain all the nutrients needed by a rapidly developing newborn, but it also contains antibodies that provide the baby with additional protection from common early childhood diseases.

Precautions

Most common illnesses can not be transmitted via breast milk. However, some **viruses**, including HIV (the virus that causes **AIDS**) can be passed in breast milk; for this reason, women who are HIV-positive should not breastfeed.

Many medications have not been tested in nursing women, so it is not known if these drugs can affect a breast-fed child. A nursing woman should always check with her doctor before taking any medications, including over-the-counter drugs.

These drugs are not safe to take while nursing:

- radioactive drugs for some diagnostic tests

- chemotherapy drugs for **cancer**
- bromocriptine
- ergotamine
- lithium
- methotrexate
- street drugs (including **marijuana**, heroin, amphetamines)
- tobacco

Description

Early in a woman's **pregnancy** her milk-producing glands, called mammary glands, begin to prepare for the baby's arrival and by the sixteenth week of pregnancy the breasts are ready to produce milk. Shortly after the baby is born, the expulsion of the placenta triggers hormone shifts in the woman's body to activate lactation. The levels of the hormones estrogen and progesterone fall abruptly while the level of the hormone prolactin—the main hormone involved in the biosynthesis of milk—increases. The anterior **pituitary gland** secretes prolactin during lactation in very large quantities so that by 36 to 96 hours postpartum the woman's milk volume has dramatically increased. Subsequently, the volume of milk the mother produces levels off and the removal of milk becomes the predominant factor in regulating milk production.

Another hormone called oxytocin controls the release of milk from the breasts. The baby's sucking stimulates nerve endings in the nipple, which signal the mother's pituitary gland to release the oxytocin. This is called the "let-down reflex." While the baby's sucking is the primary stimulus for the reflex, a baby's cry, thoughts of the baby, or the sound of running water also may trigger the response.

Breast milk cannot be duplicated by artificial milk, although both contain protein, fat, and **carbohydrates**. Breast milk changes to meet the specific needs of a baby.



Breastfeeding is healthy for both mother and baby. (Photograph by J.M. Trois. Science Source/Photo Researchers. Reproduced by permission.)

In particular, the mother produces milk called colostrum at the end of pregnancy and in the initial postpartum period. Colostrum is called “first milk” and is thicker than mature milk. It is yellowish in color and is rich in **proteins**, many of which are immunoglobulins that can protect the child against illness and **allergies**. Immunoglobulins are part of the body’s natural defense system against infections and other agents that can cause disease. Breast milk also helps a baby’s own **immune system** mature faster. As a result, breast-fed babies have fewer ear infections, bouts of **diarrhea**, rashes, allergies, and other medical problems than bottle-fed babies do.

There are many other benefits to breast milk. Because it is easily digested, babies do not get constipated. Breast-fed babies have fewer speech impediments due to good cheekbone development and jaw alignment.

Breastfeeding is also good for the mother. It releases hormones that stimulate the uterus to contract, helping the uterus to return to normal size after delivery and reducing the risk of bleeding. The act of producing milk burns calories, which helps the mother to lose excess

weight gained during pregnancy. Breastfeeding also may be related to a lower risk of **breast cancer**, ovarian cancer, and cervical cancer.

Breast milk is free, and saves money by eliminating the need to buy artificial milk (formula), bottles, and nipples. Because breast-fed babies overall have fewer illnesses, their health care costs may be lower.

Breastfeeding should begin as soon as possible after birth and should continue every two to three hours. However, all babies are different; some need to nurse very frequently at first, while others can go much longer between feedings. A baby should be fed at least eight to 12 times in 24 hours. Because breast milk is easily digested, a baby may be hungry again as soon as one and one-half hours after the last meal. Frequent nursing will also help in increasing milk production.

Some babies have no trouble breastfeeding, while others may need some assistance. Once the baby begins to suck, the mother should make sure that most of the areola is in the baby’s mouth. Proper latching-on will help stimulate milk flow and will prevent nipple soreness.

Breastfeeding mothers should offer the baby both breasts at each feeding. Breastfeeding takes about 15-20

minutes on each side. After stopping the feeding on one side, the mother should burp the baby before beginning the feeding on the other breast. The next feeding should begin with the breast that the baby nursed on last.

Mothers can tell if the baby is getting enough milk by checking diapers; a baby who is wetting between four to six disposable diapers (six to eight cloth) and who has three or four bowel movements in 24 hours is getting enough milk.

Preparation

Loose, front-opening clothes and a good nursing bra are recommended. Mothers should find a comfortable chair with lots of pillows, supporting the arm and back, to nurse in. Feet should rest on a low footstool with knees raised slightly. The baby should be level with the breast. The new mother may have to experiment with different ways of holding the baby before finding one that is comfortable for both the mother and baby.

Complications

Breastfeeding problems

New mothers may experience breastfeeding problems, including:

- **Engorged breasts.** Breasts that are too full can prevent the baby from sucking. Expressing milk manually or with a breast pump can help, as can warm showers and compresses.
- **Sore nipples.** In the early weeks nipples may become sore and even cracked. Treatments include changing the position that the baby nurses in, ensuring that the baby has latched on to most of the areola, and using lanolin-based lotion on the nipples. Nipple shields are sometimes effective as a short-term remedy but their use may reduce milk supply, further irritate the breast, and change the baby's sucking pattern.
- **Inverted nipples:** A mother with inverted nipples may still breastfeed in most instances. The baby should be enticed to open the mouth widely before latching on. The mother can use various techniques to evert the nipple such as wearing a breast shell between feedings, rolling the nipple, pulling the nipple out, and applying a breast pump on the breast for a few seconds before starting the breastfeeding session.
- **Infection.** Soreness and inflammation on the breast surface or a **fever** in the mother, may be an indication of a breast infection called **mastitis**. **Antibiotics** and

Suggestions for breastfeeding women who work outside the home

Stay at home as long as possible, and work part-time, if possible.
 Try taking a few hours away from the baby to anticipate problems.
 Have an extra set of towels, an extra bra, and a change of clothes at the work site.
 Take a quart of liquid to work and remember to drink it frequently.
 When choosing a pump, consider portability as well as cost and comfort.
 Practice with a pump ahead of time to get used to it and so that the milk will let-down quickly.
 If working full-time and manual expression or a manual pump is objectionable or does not work well, rent a dual hook-up electric pump to keep at work.
 Find a place at work to feel comfortable and have some privacy while pumping, and have a backup place in mind as well.
 If the baby will be in day care, be certain the day care provider is supportive of breastfeeding.
 Arrange to nurse the baby during the day if possible.
 Arrive early at the day care provider's site to nurse the baby right before going to work to help the baby settle down and allow time for talking with the provider.

SOURCE: Wheeler, L. *Nurse-Midwifery Handbook: A Practical Guide to Prenatal and Postpartum Care*. Philadelphia: Lippincott-Raven Pub., 1997.

continued nursing on the affected side may solve the problem.

Results

There are no rules about when to stop breastfeeding. A baby needs breast milk or artificial milk for at least the first year of life. As long as a baby eats age-appropriate solid food, the mother may nurse for several years.

Health care team roles

Several members of the health care team, including obstetricians, nurses, midwives, and lactation consultants, are equipped to provide guidance and support to mothers who wish to breastfeed their babies. By meeting specific eligibility requirements and passing an independent examination, lactation consultants may be certified by the International Board of Lactation Consultants. Such certification demonstrates that these consultants possess the necessary skills, knowledge, and attitudes to provide quality breastfeeding assistance. It is important for new mothers to understand that breastfeeding is something that mothers and babies must learn to do together. The development of a satisfying breastfeeding relationship requires patience on the mother's part and the mother may benefit from the support and guidance of a lactation consultant or other qualified member of her health care team.

KEY TERMS

Areola—The pigmented, circular area surrounding the nipple of each breast.

Bromocriptine—A drug used to treat Parkinson's disease that can decrease a woman's milk supply.

Ergotamine—A drug used to prevent or treat migraine headaches. This can cause vomiting, diarrhea, and convulsions in infants.

Immunoglobulin—A protein produced by plasma cells; a component of the immune system. Transferred in utero and through breast milk providing passive immunity to the baby.

Lactation—Secretion of milk from the breasts; the act of breastfeeding.

Latch-on—The process whereby the baby opens the mouth widely and first exerts negative pressure on the mother's nipple and then positive pressure. Good latch-on will result in adequate transfer of milk into the baby's mouth and prevent sore nipples from occurring.

Lithium—A drug used to treat manic depression (bipolar disorder) that can be transmitted in breast milk.

Methotrexate—An anticancer drug also used to treat arthritis that can suppress an infant's immune system when taken by a nursing mother.

Postpartum—Refers to the six-week period after childbirth.

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- The International Lactation Consultant Association (ILCA). 1500 Sunday Dr., Suite 102, Raleigh, NC 27607. (919) 787-4916. <<http://users.erols.com/ilca/index.html>>.

Nadine M. Jacobson

Lactation consulting

Definition

Lactation consultants assist lactating mothers in self-care and management techniques related to breastfeeding.

Description

Lactation consulting has emerged as a new field over the past twenty years. Because scientific inquiry has consistently shown breastfeeding to be the recommended source of **nutrition** for infants through the first year of life, more mothers are opting to nurse their infants. Lactation consultants try to meet the educational needs of these mothers and sometimes of other health care providers who have an interest in their patients' breastfeeding needs.

Lactation consulting is the only specialty within health care that places the advocacy of the woman who wishes to breastfeed her baby as its primary responsibility. The mother and her baby are described as a nursing couple or a nursing dyad—two separate people forming one unit. If other members of the health care team choose a plan of care that could be detrimental to the nursing dyad relationship, then the lactation consultant may need to suggest an alternate course if one is available.

Caring for the mother and baby

The primary function of the lactation consultant is to gently guide the mother's breastfeeding in a manner that involves the least intrusion and generates a minimal amount of complications. The consultant's skills are based on scientific information and familiarity with breastfeeding.

A useful approach for the consultant is to make suggestions to the mother while explaining the rationale behind these recommendations. The mother can then determine how to adapt these recommendations to best promote her needs and the needs of her baby. Potential problems that a lactation consultant would assist a client with are nipple soreness, breast engorgement, and milk production. A lactation consultant should be knowledgeable in the various components of science of lactation: milk production, normal breastfeeding behaviors, and factors that may impact the breastfeeding relationship.

Work settings

Lactation consulting can occur in a variety of settings—within the hospital, in the home, in a clinic or

physician's office, in prenatal classes, as part of routine **postpartum care**, by operating a telephone help line, or through referrals to peer support groups. The location of practice is frequently determined by what other credentials the individual had prior to becoming a lactation consultant. In the hospital setting, the lactation consultant often is a **registered nurse** on the maternity unit. In a clinic such as the Special Supplemental Food Program for Women, Infants and Children (WIC), the consultant may be a registered dietician.

Hospital setting

Every postpartum mother who is breastfeeding should ideally be observed feeding her newborn at least one time prior to being discharged home. In the hospital setting, the role of the lactation consultant is to observe every mother breastfeeding and to ensure that maternity staff receive training in basic breastfeeding management and common problems and are capable of making such observations. The maternity staff can then refer complicated problems to the lactation consultant.

Lactation consultants in the hospital setting also act as an advisor in the development of breastfeeding policies and procedures for the facility. The consultant may compile handouts and other reading resource materials for breastfeeding mothers, as well as design forms for documentation of breastfeeding activities. If the nursing mother needs to use a breast pump or other breastfeeding device, the consultant may be the one responsible for assisting the mother in obtaining the equipment and training the client in its use.

Outpatient settings

There are several outpatient facilities that the lactation consultant might practice in. Some of these are **public health** clinics, health care provider offices, home health care, or as a consultant in private practice.

PUBLIC HEALTH CLINIC. Working in a public health clinic, such as Women, Infants, and Children (WIC), the lactation consultant will be an active advocate for breastfeeding because WIC, through the U.S. Department of Agriculture (USDA) has undertaken a breastfeeding promotion program. WIC participants represent a significant proportion of the low income and at-risk population of women and infants. The WIC program is having an impact on meeting the Healthy People 2010 breastfeeding goals for the United States. Women who are breastfeeding in the WIC program receive priority treatment and additional services. The breastfeeding mother will receive an enhanced food package including additional fruit juice, dairy products, legumes, carrots, and canned tuna fish.

In the WIC program, the lactation consultant may be responsible for the training of peer counselors. Peer counselors are individuals of a similar background as other WIC clients who have breastfed or are breastfeeding a child and have an interest in supporting other mothers to do the same. WIC clients come from ethnically diverse backgrounds, and peer counselors are particularly useful in expressing sensitivity to the different cultures, socioeconomic backgrounds, and value systems. WIC uses peer counselors to promote breastfeeding and lactation consultants to manage breastfeeding problems.

HEALTH CARE PROVIDER OFFICES. In the clinic/office setting the consultant will conduct prenatal education in breastfeeding, will make rounds in the hospital on patients who have delivered and will provide follow-up after discharge through home visits and a telephone help line sometimes referred to as a "warm line." The lactation consultant in a health care provider's office will serve as a resource person for doctors and nurses by providing updates on breastfeeding research and information on medications that are contraindicated for the mother to take while breastfeeding.

HOME HEALTH CARE. If a mother is discharged prior to 48 hours after delivery, the home health visit is particularly important for assessing proper initiation of breastfeeding. The lactation consultant making such a visit may also be a registered nurse and will be checking the mother and baby for recovery and transition, in addition to breastfeeding. As part of such an assessment conducted by a registered nurse, certain phenomena should be observed. The infant should be having at least six wet diapers and four stools a day after the milk is "in." The mother's bleeding should be decreasing, she should not have a temperature—be afebrile—and any incisional discomfort should be under control with proper medications. The home assessment may involve taking **vital signs** on the mother and the infant.

Relatives and siblings may make for a hectic environment as compared with another setting, but the home environment allows for a more realistic environment in which to observe breastfeeding, and the consultant also gets a view of the client's support system. Involving family members in breastfeeding education will help relatives to understand the benefit of breastfeeding and may prompt a more supportive environment for the mother. The lactation consultant may wish to encourage the mother to make use of a telephone help line if she has any problems and concerns that were not addressed during the home visit.

PRIVATE PRACTICE. A private practice affords the lactation consultant the greatest flexibility but simultaneously constrains the consultant with more administrative

KEY TERMS

Consulting—Providing advice or an opinion.

Lactation—Secretion of milk from the breasts; the act of breastfeeding.

responsibilities. The independent lactation consultant may operate out of a home office or maintain a regular office, possibly sharing it with other consultants or health care providers. The source of referrals for the independent lactation consultant is from clients themselves, from other lactation consultants, from other health care providers, and from hospitals.

Education and training

The field of lactation consulting attracts people from a varied background. Some hold advanced degrees in medicine, nursing and nutrition and have been working in maternal child health. Others are lay counselors who obtained the necessary education to become lactation consultants after having had a positive breastfeeding experience of their own.

Professional education for lactation consultants was first offered in the early 1980s. The International Board of Lactation Consultant Examiners (IBLCE) started to offer a certification exam for lactation consulting in 1985. Shortly thereafter, the International Lactation Consultant Association (ILCA) became the professional association for lactation consultants.

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Language acquisition

Definition

Language acquisition is defined as a natural progression or development in the use of language, typified by infants and young children learning to talk. It is an unconscious process that occurs when language is used in ordinary conversation. Language acquisition is distinguished from intentional study of a language by its informality.

Description

Theories of language acquisition

Developmental psychologists are not agreed as to how humans acquire the ability to speak their first language. It was only in the 1950s that the availability of portable tape recorders made it possible for researchers to record children's speech patterns for later analysis in the laboratory. One early theory of language acquisition was based on imitation, which is the notion that children learn to speak by imitating adults and older children. The difficulty with the imitation theory is that it fails to account for the ability of even small children to form new sentences from words they know. A second theory, associated with the behavioral school of psychology, maintains that language acquisition is explained by reinforcement. Children learn to speak because their parents give them positive reinforcement when they speak correctly and negative reinforcement (correction or criticism) when they speak ungrammatically. This theory does not hold up under the findings of recent research that parents reinforce the *meaning* of what children say rather than its grammatical correctness. In addition, children often chatter to themselves or to no one in particular for the sheer pleasure of talking. This activity is hard to explain in terms of the reinforcement theory.

A third theory of language acquisition is called nativism. This theory holds that humans are neurologically "programmed" from birth with the capacity to acquire language as soon as their nervous system reaches a certain point of maturation. Noam Chomsky maintained that the human **brain** has a built-in language acquisition device, or LAD, that analyzes the parts of speech in the language that a child hears. The phases of language acquisition and the age at which children begin to acquire language are similar enough across different cultures and different languages to give some support to the nativist view.

Biological and neuroanatomical features of language acquisition

EVOLUTION AND DEVELOPMENT OF THE HUMAN VOCAL TRACT AND NERVOUS SYSTEM. Language is, as far as we know, unique to humans. Chimpanzees are able to learn a rudimentary sign language, but they cannot combine vocalized sounds into meaningful structured combinations as humans do. The human mouth and throat appear to have been modified over the course of evolutionary history for speech. The human larynx is situated low in the throat, and the sharp right-angle bend at the back of the mouth divides the human vocal tract into two resonant cavities (the mouth and the throat) that allow for the production of a large range of vowel sounds.

The maturation of certain neural circuits in a child's brain may explain why language development proceeds most rapidly in young children after the first year of life. Although babies are born with most of their nerve cells already formed, their head size, brain weight, and junctions between nerve cells (synapses) continue to increase in the first year after birth. The long-distance connections in the child's nervous system are not complete until nine months of age, and the rate of **metabolism** in the child's brain reaches adult levels by ten months. There appears to be a neurologically determined critical period for language acquisition. Children acquire language easily until age four, or six at the latest. After **puberty**, it is rare for humans to learn to speak if they have not done so earlier.

AREAS OF THE BRAIN ASSOCIATED WITH LANGUAGE. The areas of the brain that govern the interpretation and production of language were discovered in the nineteenth century by physicians studying patients with **speech disorders**. In 1861, Pierre Paul Broca, a French physician, was able to demonstrate from post-mortems of patients who had lost the ability to speak, that the loss of this ability is associated with damage to an area of the brain toward the front of the left hemisphere. In 1876, a German physician named Karl Wernicke found that damage to an area in the posterior part of the left temporal lobe of the brain is also associated with **language disorders**. This area, now called Wernicke's area, is connected to Broca's area by a group of nerve fibers called the arcuate fasciculus.

When a person reads aloud, information from the eyes travels along the optic nerve to the primary visual cortex of the brain. From the primary visual cortex, the information is transmitted to Wernicke's area, where it is interpreted. From Wernicke's area, it is carried by the arcuate fasciculus to Broca's area, then to the primary motor cortex. When a person repeats a word that is spoken, the information is carried from the nerves in the ear

to the primary auditory cortex in the brain. It is then transmitted from the primary auditory cortex to Wernicke's area, then to Broca's area via the arcuate fasciculus, then to the primary motor cortex.

Stages of language acquisition

A young human's acquisition of language takes place in a series of six stages:

- Prelinguistic stage (birth to six months): The baby cries, coos, laughs, and makes other sounds.
- Babbling (six to 12 months): The baby makes nonspecific sounds from all human languages.
- One-word (holophrastic) stage (1–2 years): The child speaks single words in isolation, in his or her first language.
- Two-word stage (24–30 months): The child forms two-word phrases or strings that reflect the language being acquired. The vocabulary increases; the child begins to learn words at the rate of one word every two waking hours.
- Telegraphic speech (30–36 months): Children begin to utter short phrases like telegraph messages, without formal grammatical structure.
- Fluent speech (three years +): The child learns grammar and syntax (patterns of sentence formation) with surprising rapidity and accuracy; sentences increase in length and complexity.

Function

Human language functions as a means of interpersonal communication, to convey thoughts, feelings, and many other forms of information. It is necessary to human social life as well as to intellectual development. Language also stimulates the expression of human creativity: poetry, drama, novels, short stories, vocal music, and similar forms of art are based on language.

Role in human health

The fact that language is unique to humans implies that language acquisition is necessary to full psychosocial as well as intellectual development. People who lose the ability to speak normally in later life because of a stroke or a condition known as primary progressive **aphasia** often become depressed because they feel cut off from others. Children and adolescents with dyslexia (a learning disability that affects reading and is sometimes related to problems understanding spoken language) often have additional difficulties learning to inter-

KEY TERMS

Aphasia—The loss of previously held ability to speak or to understand written or spoken language, caused by disease or injury to the brain.

Arcuate fasciculus—A group of nerve fibers in the brain that connects Wernicke’s area with Broca’s area.

Broca’s area—An area in the left hemisphere of the brain associated with the motor impulses necessary for speech. It is named for Pierre Paul Broca (1824-1880), a French physician.

Dyslexia—A reading disorder associated with impairment of the ability to integrate auditory and visual information, or to process sounds accurately.

Holophrastic—An early stage in language acquisition in which a single word serves the function of a phrase or sentence.

Nativism—The theory that humans have neural circuits that are genetically programmed to acquire language.

Specific language impairment (SLI)—A developmental disorder of childhood characterized by significant delays in language development in the absence of deafness, autism, mental retardation, or similar handicaps.

Wernicke’s area—An area in the left hemisphere of the brain that is important in the reception and interpretation of speech. Wernicke’s area is connected to Broca’s area by the arcuate fasciculus.

Williams syndrome—A rare congenital disorder caused by a deletion of the elastin gene on chromosome 7. Children with Williams syndrome have normal language skills even though they are usually mildly retarded.

act with others and feeling comfortable in social situations.

Studies of “wild” children and children reared by emotionally disturbed parents who did not talk to them indicate that children who do not learn to speak by age eight never achieve normal fluency. This feature of language acquisition implies that language is an important component of the social dimension of human nature. Humans who have never acquired the ability to communicate with others cannot be completely socialized.

Common diseases and disorders

Aphasia

Aphasia refers to the loss of a previously held ability to speak or to understand written or spoken language. Aphasia is most often the result of a stroke or head trauma, but it can occur in relation to other neurological disorders. Primary progressive aphasia is a disorder of the nervous system in which the person’s ability to speak gradually deteriorates. In Broca’s aphasia, caused by damage to Broca’s area, the person can understand what words mean, but has trouble with speech output. Broca’s aphasia is sometimes called motor or expressive aphasia. In Wernicke’s aphasia, caused by damage to Wernicke’s area, the person cannot understand spoken language. They can speak, but their speech is ungrammatical and incoherent. Wernicke’s aphasia is sometimes called fluent or receptive aphasia.

Dyslexia

Dyslexia is a disorder that affects the ability to read. Its symptoms may include problems with spelling, difficulty recognizing the sounds in words, problems processing visual information, and difficulty saying words quickly when asked to do so. Present dyslexia research is focused on studying the parts of the brain that process speech sounds and relate them to **vision** and other language areas in the brain.

Williams syndrome

Williams syndrome is a rare congenital disorder that occurs once in every 20,000 births. It results from a deletion of the genetic material on human chromosome 7 that makes a protein called elastin. Although children with Williams are usually mildly retarded, they often have normal language abilities. The dissociation of language acquisition from general intelligence in Williams syndrome suggests that human speech is not simply a byproduct of intelligence as such.

Specific language impairment (SLI)

Specific language impairment, or SLI, refers to a group of inherited syndromes in which children with normal intelligence and **hearing** are slow to acquire and use language. SLI is thought to affect 5–7% of children starting school. A cross-cultural study done in 1999 suggests that SLI may differ from other language disorders in that the number and specific types of problems the children had were related to their specific first language. The study showed that children learning Italian or Hebrew had fewer difficulties with verbs, for example, than children learning English.

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10801 Rockville Pike, Rockville, MD 20852-3279.
(301) 897-5700 or (800) 638-8255. Fax: (301) 571-0457.
<<http://www.asha.org>>.
- International Dyslexia Association. 8600 LaSalle Road,
Chester Building, Suite 382, Baltimore, MD 21286-2044.
(410) 296-0232. Fax: (410) 321-5069.
<<http://www.interdys.org>>.
- National Aphasia Foundation. 156 Fifth Avenue, Suite 707,
New York, NY 10010. (800) 922-4622.
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- National Institute of Child Health and Human Development
(NICHD). National Institutes of Health, Bldg. 31, Room
2A32, Bethesda, MD 20892-2425. (301) 496-5133 or
(800) 370-2943. <<http://www.nichd.nih.gov>>.
- National Institute on Deafness and Other Communication
Disorders (NIDCD). National Institutes of Health, Bldg.
31, Room 3C35, Bethesda, MD 20892-2320.
(301) 496-7243. <<http://www.nidcd.nih.gov>>.
- National Institute of Neurological Disorders and Stroke
(NINDS). Building 31, Room 8A06, 9000 Rockville
Pike, Bethesda, MD 20892. (301) 496-5751.
<<http://www.ninds.nih.gov>>.
- National Organization for Rare Disorders, Inc. (NORD) P. O.
Box 8923, New Fairfield, CT 06812-8923.
(203) 746-6518 or (800) 999-NORD. Fax:
(203) 746-648. <<http://www.rarediseases.org>>.
- Williams Syndrome Association. P.O. Box 297, Clawson, MI
48017-0297. (248) 541-3630. Fax: (248) 541-3631.
<<http://www.williams-syndrome.org>>.

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Language development see **Language acquisition**

Language disorders

Definition

A language disorder is a communication disorder characterized by an impaired ability to understand and/or use words in their proper context, whether verbal or nonverbal.

Description

Language disorders belong to a broad category of disorders called *communication disorders* that also include speech and **hearing** disorders. As of 1998, communication disorders were affecting one person out of every 10 in the United States. Language disorders are characterized by one or more of the following features: sound substitutions in words, difficulty in processing sounds into syllables and words, improper use of words, confusion about their meaning, difficulty in expressing ideas and thoughts, inappropriate use of grammatical forms, limited vocabulary development and inability to follow directions, remember questions or numbers and letters in sequence. Language disorders can be classified as either developmental or acquired.

Developmental language disorders

Developmental language disorders occur in children who do not develop functional language skills. Clinically, they are diagnosed as language-delayed or language-disordered. Language-delayed children can have receptive language impairments, expressive language impairments or both.

Receptive language impairments refer to a difficulty understanding language at the level of meaning. The vocabulary range is usually very limited. The purpose of simple grammatical constructions is also not properly understood. For example, that adding an “-s” to a noun makes it plural, or that “’s” is a possessive form, or that a verb with an “-ed” ending means that the action occurred in the past. There is also difficulty in understanding nonverbal signals, such as body language, or difficulty understanding sarcasm and irony, or indirect requests and sentences.

Expressive language impairments refer to the use of defective language patterns, for example using too few words in sentences. Or the sentences may be truncated, or contain words that lack proper endings, or miss the verbs “is” and “are.” Limited or ambiguous vocabulary is also a feature. Affected individuals have difficulty using language properly, and as a result, they often seem rude or

blunt. There is also a distinct pattern of changing topics very abruptly.

Acquired language disorders

Acquired language disorders, also called *aphasias*, are language impairments caused by damage to the areas of the **brain** responsible for language function. Various aspects of language may be affected depending on the location and extent of the brain damage. Language function is believed to be associated with the left hemisphere of the brain and some aphasias are accordingly classified with respect to the affected brain area:

- **Broca's aphasia.** This type of aphasia is an expressive aphasia and it is associated with damage to Broca's area, a region located in the frontal lobe of the left hemisphere of the brain. It is characterized by an impaired ability to produce language.
- **Wernicke's aphasia.** This type of aphasia is a receptive aphasia and it is associated with damage to Wernicke's area, a region located in the left temporal lobe of the brain. It is characterized by an impaired ability to understand language.
- **Dyslexia.** Dyslexia is a neurological learning difficulty that also affects the learning of language skills. It is characterized by an impaired ability to manage verbal codes in **memory** and difficulties with writing, spelling, and reading. Other symbolic functions, such as mathematics and musical notation, can also be affected.

Causes and symptoms

Developmental language disorders have been associated with a wide variety of causes, such as hearing impairment, cognitive impairment, autism, or a physical handicap that prevents the child from interacting normally with his environment, such as mental retardation, or a cleft lip or palate. Emotional/psychological problems may also be a cause, and lack of intellectual stimulation as well. Often, there is no identifiable cause for a developmental language disorder.

Acquired language disorders or aphasias resulting from brain damage can be caused by **cerebral palsy**, stroke, tumor or **head injury** affecting the left hemisphere of the brain. It should be noted that individual differences do exist in brain function and when coupled with differences in the extent of the brain damage, the degree of impairment caused by aphasia is then unique to the affected individual.

Although the symptoms of language disorders vary from one individual to the next, and also depend on whether they are developmental or acquired, they do

present a range of characteristic symptoms. Generally speaking, in the case of developmental disorders, a child's language skills are considered delayed when the child is noticeably behind his or her peers in the acquisition of basic language skills. Sometimes a child will have a greater receptive (understanding) impairment than an expressive (speaking) impairment, but the overall result is the same as both functions are required for the full development of language skills.

Some general symptoms are typical of an aphasic language disorder. Most affected individuals experience *anomia*, or difficulty finding words and some aphasic people try to cope with this difficulty by providing descriptions or definitions for the missing words. This is called circumlocution. Another symptom is paraphasia, meaning the use of an incorrect or unrecognizable word in place of the desired word. There are three types of paraphasias. Phonemic or literal paraphasias are faulty words that sound very close to the intended word (for example, using "bait" instead of "bake"). Verbal or semantic paraphasias are faulty words that are close in meaning to the target word (for example, using "apple" instead of "orange"). The third type of paraphasias are neologisms, or invented words that do not exist in the speaker's language. Another symptom is perseveration, meaning the repetition of a word or sentence when it is not required. The aphasic person gets stuck in a pattern of repetitive sentences without being able to break out of it.

Diagnosis

The early diagnosis of language disorders is important because they are first and foremost a communication disorder that always leads to social and educational isolation. Evaluation procedures, usually performed by a speech-language pathologist, are used to diagnose the disorders and any child whose language is not similar to that of other children of the same age should be evaluated. While faulty language patterns are considered normal "baby talk" during early childhood, they become indicative of a language disorder if they are not outgrown as expected. Because of brain development patterns, it is easier to learn language and communication skills before the age of five, thus the importance of timely diagnosis. One or a combination of typical features usually occur in a child affected by a language disorder or developmental language delay. The child may hear or see a word but be incapable of understanding its meaning. He may have trouble getting others to understand what he wants to communicate or display a high level of inattention or lack of organizational skills. These are all pointers that are used to establish diagnosis.

Treatment

The treatment of language disorders belongs to speech pathology, the specialty concerned with disorders of speech and language. Language therapy with preschoolers is centered on working with parents and other family members to create an optimal environment for learning language. For example, when speaking with a child who has aphasia, it helps to minimize distractions, and to speak slowly and clearly. If the child has difficulty understanding, the use of short and simple sentences is beneficial. Pairing gestures with speech to help comprehension also helps. So does allowing the child ample time to respond and the formulation of questions that can be answered easily with a yes or no or other single word. Speech pathologists can recommend strategies to help families of children with language disorders. School-age children with developmental language disorders can benefit from special education programs, usually monitored by a speech pathologist.

Prognosis

Prognosis is dependent on the cause of the language disorder. If the cause is brain damage, the acquired disorder usually remains. In the case of developmental language disorders, many affected children are able to catch up with their peers, but many also continue to have difficulty with the gap between their skill level and that of their peers, which may increase over time. Since many factors influence outcome, it is not possible to predict which individuals are most likely to recover or how significant the progress will be. Developmental language disorders also have different stages that follow the overall development of children. At different ages, different demands are made on the language system. For example, language-disordered children in the preschool years may appear to catch up to peers by age five or six years, but in later years, as language demands evolve, (e.g., the stage of learning how to read), new impairments usually become apparent.

Health care team roles

Language disorders are usually treated by a speech pathologist working with a collaborative team consisting of the family, physicians, educational professionals as well as special educators. The team usually includes:

- Speech-language pathologists. These specialists have several responsibilities, including: providing individual therapy to the language-impaired; informing teachers and health care professionals on how to identify children who are at risk; performing the evaluation of spoken and written language skills; interviewing family

members and teachers; observing the child in the classroom setting so as to evaluate language skills; assessing reading, spelling and writing levels for older children and adolescents.

- Audiologists. Audiologists are specialists of hearing disorders and their expertise may be required in cases where the language disorder is associated with a hearing deficiency.
- Reading specialists. These specialists are special educators who design remedial reading and language skill acquisition therapies.
- Teachers of the language handicapped. These specialized teachers are trained to teach language-delayed children.

Prevention

There are no specific preventive measures for language disorders, but their early detection will often improve the chances of a successful special education therapy. Thus, identifying children that are at risk of developing a language disorder is important. The following conditions are considered to represent high-risk factors and children exposed to them should be tested early and regularly:

- diagnosed medical conditions, such as chronic ear infections
- biological factors, such as fetal alcohol syndrome
- genetic defects, such as Down syndrome
- neurological defects, such as cerebral palsy
- family history, such as family incidence of literacy difficulties

Resources

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KEY TERMS

Anomia—Difficulty finding words.

Aphasia—Acquired language disorder caused by damage to the areas of the brain responsible for language function.

Broca's aphasia—Language disorder associated with damage to Broca's area, a region in the frontal lobe of the left hemisphere of the brain. It is characterized by an impaired ability to produce language.

Communication disorder—Disorder characterized by an impaired ability to communicate. Communication disorders include language, speech and hearing disorders. They are associated with a wide variety of physical and psychological causes.

Dyslexia—Dyslexia is a specific learning difficulty that hinders the learning of literacy skills. This problem with managing verbal codes in memory is neurological and tends to run in families. Other symbolic systems, such as mathematics and musical notation, can also be affected.

Language disorder—Communication disorder characterized by an impaired ability to understand and/or use words in their proper context, whether verbal or nonverbal. The disorder can be either developmental or acquired.

Paraphasia—Use of an incorrect or unrecognizable word.

Speech disorder—Communication disorder characterized by an impaired ability to produce speech sounds or by problems with voice quality.

Speech pathology—The field of speech pathology, formerly known as speech therapy, is concerned with disorders of speech and language. A speech pathologist is a professional trained to diagnose and treat language and speech disorders.

Wernicke's aphasia—Language disorder associated with damage to Wernicke's area, a region in the left temporal lobe of the brain. It is characterized by an impaired ability to understand language.

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Martins I. P., "Childhood aphasias." *Clinical Neuroscience* 4 (1997): 73-77.

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ORGANIZATIONS

American Speech-Language-Hearing Association (ASHA)
10801 Rockville Pike, Rockville, MD 20852.
(800)638-8255. <<http://www.asha.org/>>.

The International Dyslexia Association 8600 LaSalle Road,
Chester Building, Suite 382, Baltimore, MD 21286-2044.
(410) 296-0232. <<http://www.interdys.org/>>.

It Takes Two To Talk—The Hanen Program for Parents of
Children with Language Delays. The Hanen Center, Suite
403 - 1075 Bay Street, Toronto ON M5S 2B1, Canada.
(416) 921-1073. <<http://www.hanen.org/>>.

National Institute on Deafness and Other Communication
Disorders (NIDCD), National Institutes of Health, 31
Center Drive, MSC 2320, Bethesda, MD 20892-2320.
<<http://www.nidcd.nih.gov/>>.

OTHER

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welcome.html](http://www.mankato.msus.edu/dept/comdis/kuster2/welcome.html)>.

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Speech Language Pathology."
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Monique Laberge, PhD

Laparoscope

Definition

A laparoscope is a telescope-like **endoscope** used to view the abdominal cavity for diagnosis and treatment during a minimally invasive surgical procedure called **laparoscopy**.

Purpose

A laparoscope is used to directly examine the abdominal and pelvic organs to diagnose certain conditions and—depending upon the condition—to perform therapeutic surgery. Laparoscopes are commonly used in gynecologic laparoscopy to examine the outside of the uterus, the Fallopian tubes, and the ovaries—particularly in pelvic **pain** cases where the underlying cause of pain could not be determined using diagnostic imaging (e.g., ultrasound; computed tomography). Gynecologic conditions diagnosed using laparoscopy include endometriosis, ectopic **pregnancy**, ovarian cysts or tumors, pelvic inflammatory disease, pelvic **abscess**, **infertility**, uterine fibroids, and **cancer**. Laparoscopes are used in general surgery to examine abdominal organs such as the **gallbladder**, bile ducts, **liver**, appendix, and intestines (external surface). Laparoscopy can identify **appendicitis**, cholecystitis, cirrhosis, hernias, ascites, and abdominal cancers.

During the laparoscopic procedure, certain conditions can be treated surgically using special laparoscopic instruments and devices designed to be used with laparoscopes. For example, appendectomy, cholecystectomy, biopsy of the ovary or liver, hernia repair, and removal of endometriotic tissue or cysts, can all be performed laparoscopically. Medical devices that can be used in conjunction with laparoscopy include surgical lasers and electro-surgical units. Other procedures that can be performed laparoscopically include hysterectomy, oophorectomy, tubal ligation, and lymphadenectomy. Laparoscopic surgery is now preferred over open surgery for several types of procedures due to its minimally invasive nature and associated lower complication rate.

A relatively new type of laparoscope is the microlaparoscope—a smaller laparoscope used to perform microlaparoscopy in the physician's office. Common clinical applications of microlaparoscopy in gynecology include pain mapping (e.g., endometriosis), and sterilization and fertility procedures. Common applications in general surgery include evaluation of chronic and acute abdominal pain (e.g., appendix), basic trauma evaluation, biopsies, and evaluation of abdominal masses.

Laparoscopes are most commonly used by gynecologists, urologists, and general surgeons for abdominal and pelvic applications. In addition to expanding applications in these areas, orthopedic surgeons are now using laparoscopes for spinal applications, and cardiac surgeons for minimally invasive **heart** surgery.

Description

Laparoscopes are rigid, telescope-like endoscopes used during laparoscopic procedures for either viewing or operating. Viewing laparoscopes typically range from 5 to 10 mm in diameter, and operating laparoscopes usually range from 8 to 12 mm in diameter. Operating laparoscopes have a separate instrument channel in their shaft where laparoscopic **surgical instruments** can be inserted to perform therapeutic procedures. Viewing laparoscopes do not have an instrument channel and are used primarily for diagnosis. Microlaparoscopes of approximately 2 mm in diameter are available for diagnostic procedures performed in the physician's office. Although most laparoscopes are rigid, some manufacturers supply semi-flexible or flexible laparoscopes to increase the viewing range. The size and type of laparoscope chosen depends upon the type of procedure being performed, the patient's size and age, and the patient's medical condition.

Laparoscopes have an optical system of lenses, prisms, and mirrors to provide magnification of tissue and organs, a wide field of view, and high image resolution. A bundle of illuminating fibers are located in the laparoscope's shaft surrounding the lenses and are connected to a separate fiber-optic light source that provides light during the procedure. Most laparoscopes have integral cameras or allow connection of a camera for transmitting images during the procedure. The images from the laparoscope are transmitted to one or more viewing monitors, which the surgeon uses to visualize the internal anatomy and guide any surgical procedures. Video and photographic equipment are used to document the procedure.

Operation

Laparoscopy is typically performed in the hospital under **general anesthesia**, although some laparoscopic procedures can be performed using **local anesthesia** and conscious sedation. Once the patient is under anesthesia, a urinary catheter is inserted to collect urine during the procedure. As the procedure begins, a small incision is made just below the navel and a cannula or trocar is inserted into the incision to accommodate the insertion of the laparoscope. Other incisions (one or two) may be made in other areas of the abdomen to allow for insertion of other laparoscopic instrumentation. A laparoscopic insufflation device is used to inflate the abdomen with carbon dioxide gas to create a space in which the laparoscopic surgeon can maneuver the instruments.

Once the laparoscope is inserted, the surgeon manipulates it to view the anatomical areas of interest. Depending on the surgeon's preference and the type of



A laparoscope can be used for internal examination and minor surgery through only a small incision. (Photograph by John Watney. Science Source/Photo Researchers. Reproduced by permission.)

procedure, an eyepiece can be attached to the scope for direct viewing, or television/video cameras can be attached for viewing on a monitor. Instruments such as forceps, graspers, and manipulators can be used in conjunction with operating laparoscopes. For example, a uterine manipulator would be used in gynecologic procedures involving the uterus (e.g., hysterectomy).

After laparoscopic diagnosis and treatment are completed, the laparoscope, cannula, and other instrumentation are removed, and the incision is sutured and bandaged.

Complications related to the use of a laparoscope can occur during laparoscopy. The most serious complication is laceration of a major abdominal **blood** vessel resulting from improper positioning, inadequate insufflation (inflation) of the abdomen, abnormal pelvic anatomy, or too much force during scope insertion. Thin patients with well-developed abdominal muscles are at higher risk, since the aorta may only be an inch (2-3 cm) or so below

the skin. Obese patients are also at higher risk because more forceful and deeper needle and scope penetration is required. There is also a risk of bleeding from vessels, and adhesions that may require repair by open surgery if bleeding cannot be stopped using laparoscopic instrumentation. In laparoscopic procedures that use electro-surgical devices, **burns** to the incision site are possible due to conduction of electrical current through the laparoscope due to a fault or malfunction in the equipment.

Any abdominal surgery, including laparoscopy, carries the risk of unintentional organ injury (punctures and perforations). For example, the bowel, bladder, ureters, or fallopian tubes may be injured during the procedure by the laparoscope itself. These injuries are often unavoidable due to the patient's anatomy or medical condition. Patients at higher risk for bowel injury include those with chronic bowel disease, pelvic inflammatory disease, a history of previous abdominal surgery, or severe endometriosis. Some types of laparoscopic procedures have a higher risk of organ injury. For instance, during laparoscopic removal of endometriosis adhesions or ovaries, the ureters may be injured due to its proximity to each other.

Several clinical studies have shown that the complication rate during laparoscopy is associated with surgeon experience. Surgeons experienced in laparoscopic procedures have fewer complications than surgeons performing their first 100 cases.

Maintenance

The success of the laparoscopic procedure is highly dependent upon the condition of the laparoscope and its associated accessories. Improper disinfection, sterilization, and handling of laparoscopic equipment can result in equipment damage, unnecessary wear, and ultimately surgical errors. All clinical staff using laparoscopes and related equipment should be well-trained and familiar with disassembling and assembling scopes and accessory parts (e.g., couplers; adapters; instrumentation) so that defects in equipment can be recognized before a complication occurs or equipment malfunctions. Manufacturers of laparoscopic equipment usually provide maintenance guidelines, including cleaning techniques, for their scopes and accessories. The hospital **biomedical engineering** department and/or the scope manufacturer will implement actual repairs to equipment. The introduction of disposable accessories (e.g., trocars; couplers) has simplified preparation for procedures and minimized maintenance needs.

Health care team roles

Laparoscopy may be performed by a gynecologist, general surgeon, gastroenterologist, or other physician,

depending upon the patient's condition. An anesthesiologist is required during the procedure to administer general and/or local anesthesia and to perform patient monitoring. Nurses and surgical technicians/assistants aid with scope positioning, video system adjustments and image recording, and laparoscopic instrumentation. Clinical staff trained in the daily maintenance, disinfection, and sterilization of laparoscopes are required to sterilize equipment between procedures and make sure all scopes are in working order.

Training

Physicians and surgeons using laparoscopes should be well-trained in laparoscopic techniques. A surgeon skilled and experienced in open surgical techniques cannot necessarily transfer those skills to laparoscopic techniques because a different skill set is involved in minimally invasive surgery. Organizations focused on laparoscopy, and laparoscope manufacturers, offer clinical training in laparoscopic surgery.

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ORGANIZATIONS

- American College of Obstetricians and Gynecologists. 409 12th Street SW, P.O. Box 96920, Washington, DC 20090-6920. <<http://www.acog.org>>.
- Society of American Gastrointestinal Endoscopic Surgeons (SAGES). 2716 Ocean Park Boulevard, Suite 3000, Santa Monica, CA 90405. (310) 314-2404. <<http://www.endoscopy-sages.com>>.
- Society of Laparoendoscopic Surgeons. 7330 SW 62nd Place, Suite 410, Miami, FL 33143-4825. (305) 665-9959. <<http://www.sls.org>>.

KEY TERMS

Ascites—Accumulation of fluid in the abdominal cavity; Laparoscopy may be used to determine its cause.

Cannula—A small tube inserted into the incision site through which laparoscopes and instruments are inserted; used in conjunction with a trocar.

Cholecystitis—Inflammation of the gallbladder; often diagnosed using laparoscopy.

Electrosurgical device—A medical device that uses electrical current to cauterize or coagulate tissue during surgical procedures; often used in conjunction with laparoscopy.

Endometriosis—A disease involving occurrence of endometrial tissue (lining of the uterus) outside the uterus in the abdominal cavity; often diagnosed and treated using laparoscopy.

Hysterectomy—Surgical removal of the uterus; often performed laparoscopically.

Insufflation—Inflation of the abdominal cavity using carbon dioxide; performed prior to laparoscopy to give the surgeon space to maneuver surgical equipment.

Oophorectomy—Surgical removal of the ovaries; often performed laparoscopically.

Trocar—A small sharp instrument used to puncture the abdomen at the beginning of the laparoscopic procedure.

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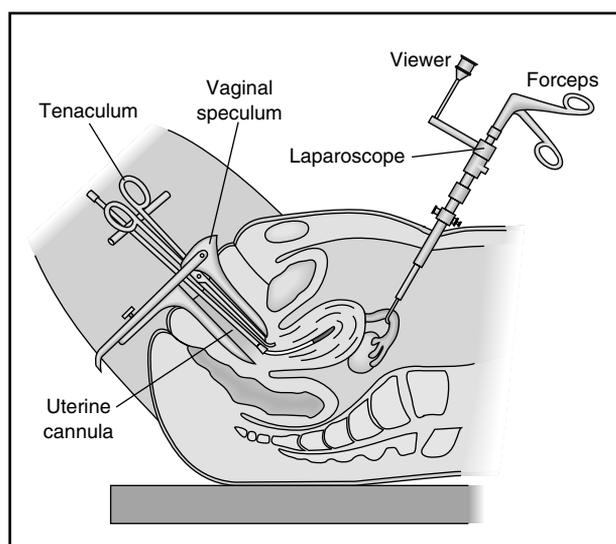
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Jennifer E. Sisk, M.A.

Laparoscopy

Definition

Laparoscopy is a minimally invasive surgical procedure performed to examine the abdominal and pelvic organs.



A laparoscopy procedure. (Delmar Publishers, Inc. Reproduced by permission.)

Purpose

Laparoscopy is performed to directly examine the abdominal and pelvic organs to diagnose certain conditions and—depending upon the condition—to perform surgery. Laparoscopy is commonly used in gynecology to examine the outside of the uterus, the Fallopian tubes, and the ovaries—particularly in pelvic **pain** cases where the underlying cause of pain cannot be determined using diagnostic imaging (e.g., ultrasound; computed tomography). Gynecologic conditions diagnosed using laparoscopy include endometriosis, ectopic **pregnancy**, ovarian cysts or tumors, pelvic inflammatory disease, pelvic **abscess**, **infertility**, uterine fibroids, and **cancer**. Laparoscopy is used in general surgery to examine abdominal organs such as the **gallbladder**, bile ducts, **liver**, appendix, and intestines (external surface). Laparoscopy can identify **appendicitis**, cholecystitis, cirrhosis, hernias, ascites, and abdominal cancers.

During the laparoscopic procedure, certain conditions can be treated surgically using special laparoscopic instruments and devices designed to be used with laparoscopes. For example, appendectomy, cholecystectomy, biopsy of the ovary or liver, hernia repair, and removal of endometriotic tissue or cysts can all be performed laparoscopically. Medical devices that can be used in conjunction with laparoscopy include surgical lasers and electro-surgical units. Other procedures that can be performed laparoscopically include hysterectomy, oophorectomy, tubal ligation, and lymphadenectomy. Laparoscopic surgery is now preferred over open surgery for several types of procedures due to its minimally invasive nature and associated lower complication rate.

A relatively new development is microlaparoscopy performed in the physician's office using smaller laparoscopes. Common clinical applications in gynecology include pain mapping (e.g., endometriosis), and sterilization and fertility procedures. Common applications in general surgery include evaluation of chronic and acute abdominal pain (e.g., appendix), basic trauma evaluation, biopsies, and evaluation of abdominal masses.

Laparoscopy has been most commonly used by gynecologists, urologists, and general surgeons for abdominal and pelvic applications. In addition to expanding applications in these areas, laparoscopy is now being used by orthopedic surgeons for spinal applications and by cardiac surgeons for minimally invasive **heart** surgery.

Precautions

Patients should be carefully screened for **allergies** to anesthetic agents used for laparoscopy. Obese patients, very thin patients, and patients with abnormal anatomy have a higher risk of complications, and laparoscopy should be performed with caution in these patients. Preoperative imaging examinations may be helpful to visualize any anatomical abnormalities. Some daily medications, such as **blood** thinners or arthritis medications, may need to be stopped for a certain time period prior to the procedure. Any medications taken on a regular basis, including over-the-counter medicines, should be discussed with the physician and anesthesiologist. Patients who have had prior abdominal surgical procedures may have resulting scar tissue that would interfere with laparoscopy; thus, these patients are usually not considered good candidates for laparoscopic procedures.

Description

Laparoscopy is typically performed in the hospital under **general anesthesia**, although some laparoscopic procedures can be performed using **local anesthesia**. Once the patient is under anesthesia, a urinary catheter is inserted to collect urine during the procedure. To begin the procedure, a small incision is made just below the navel and a cannula or trocar is inserted into the incision to accommodate the insertion of the **laparoscope**. Other incisions (one or two) may be made in other areas of the abdomen to allow for insertion of other laparoscopic instrumentation. A laparoscopic insufflation device is used to inflate the abdomen with carbon dioxide gas to create a space in which the laparoscopic surgeon can maneuver the instruments.

Laparoscopes, which have integral cameras for transmitting images during the procedure, are available in various sizes depending upon the type of procedure

being performed. The images from the laparoscope are transmitted to a viewing monitor, which the surgeon uses to visualize the internal anatomy and guide any surgical procedure. Video and photographic equipment are used to document the procedure.

After laparoscopic diagnosis and treatment are completed, the laparoscope, cannula, and other instrumentation are removed, and the incision is sutured and bandaged.

Robotic systems are available to assist with laparoscopy. A robotic arm attached to the operating table may be used to hold and position the laparoscope in order to reduce unintentional camera movement that is common when a surgical assistant holds the laparoscope. The surgeon controls the robotic arm movement by foot pedal, voice-activated command, or handheld control panel.

Microlaparoscopy has become more common over the past few years. This procedure involves the use of smaller laparoscopes (e.g., 2 mm compared to 5 to 10 mm for hospital laparoscopy) with the patient undergoing local anesthesia with conscious sedation in a physician's office. Video and photographic equipment used are similar to that used for general laparoscopy.

Preparation

Because laparoscopy requires general anesthesia in most cases, the patient is required to fast for several hours before the procedure. Sometimes bowel cleansing is also required. The patient is screened by anesthesiology staff regarding allergies to medication and previous experiences (e.g., allergic reaction) with anesthesia.

Aftercare

Following laparoscopy, patients are required to remain in a recovery area until the immediate effects of anesthesia wear off and until normal voiding is accomplished after urinary catheter removal. **Vital signs** are monitored to ensure that no reactions to anesthesia have occurred and no internal injuries are present. For healthy patients undergoing elective procedures such as tubal ligation, diagnostic laparoscopy, or hernia repair, laparoscopy is usually an outpatient procedure and patients are discharged from the recovery area within a few hours after the laparoscopy. Due to the aftereffects of anesthesia, patients should not drive themselves home. Patients with more serious medical conditions, or patients undergoing emergency laparoscopy, may be kept in the hospital overnight or for a few days.

Discharged patients receive instructions regarding activity level, medications, and side effects of the proce-



This surgeon is performing a laparoscopic procedure on a patient. (Photo Researchers, Inc. Reproduced by permission.)

cedure. Depending upon the nature of the laparoscopic procedure and the patient's medical condition, daily activity may be restricted for a few days and strenuous activity restricted for several days to weeks. Pain-relieving medications are usually prescribed for several days following the procedure. In addition, **antibiotics** to prevent **infection** may also be prescribed. Patients are instructed to watch for signs of a urinary tract infection or unusual pain, which may indicate organ injury.

Complications

The most serious complication that can occur during laparoscopy is laceration of a major abdominal blood vessel resulting from improper positioning, inadequate insufflation (inflation) of the abdomen, abnormal pelvic anatomy, and too much force exerted during scope insertion. Thin patients with well-developed abdominal muscles are at higher risk, since the aorta may only be an inch or so below the skin. Obese patients are also at higher risk because more forceful and deeper needle and scope penetration is required. During laparoscopy, there is also a risk of bleeding from vessels, and adhesions that may require repair by open surgery if bleeding cannot be stopped using laparoscopic instrumentation. In laparoscopic procedures that use electrosurgical devices, **burns** to the incision site are possible due to conduction of electrical current through the laparoscope caused by a fault or malfunction in the equipment.

KEY TERMS

Ascites—Accumulation of fluid in the abdominal cavity; Laparoscopy may be used to determine its cause.

Cholecystitis—Inflammation of the gallbladder, often diagnosed using laparoscopy.

Electrosurgical device—A medical device that uses electrical current to cauterize or coagulate tissue during surgical procedures; often used in conjunction with laparoscopy.

Embolism—Blockage of an artery by a clot, air or gas, or foreign material. Gas embolism may occur as a result of insufflation of the abdominal cavity during laparoscopy.

Endometriosis—A disease involving occurrence of endometrial tissue (lining of the uterus) outside the uterus in the abdominal cavity; often diagnosed and treated using laparoscopy.

Hysterectomy—Surgical removal of the uterus; often performed laparoscopically.

Insufflation—Inflation of the abdominal cavity using carbon dioxide; performed prior to laparoscopy to give the surgeon space to maneuver surgical equipment.

Oophorectomy—Surgical removal of the ovaries; often performed laparoscopically.

Pneumothorax—Air or gas in the pleural space (lung area) that may occur as a complication of laparoscopy and insufflation.

Subcutaneous emphysema—A pathologic accumulation of air underneath the skin resulting from improper insufflation technique.

Trocar—A small sharp instrument used to puncture the abdomen at the beginning of the laparoscopic procedure.

Complications related to insufflation of the abdominal cavity include gas inadvertently entering a blood vessel and causing an embolism, pneumothorax, and subcutaneous **emphysema**. One common, but not serious, side effect of insufflation is pain in the shoulder and upper chest area for a day or two following the procedure.

Any abdominal surgery, including laparoscopy, carries the risk of unintentional organ injury (punctures and perforations). For example, the bowel, bladder, ureters, or fallopian tubes may be injured during the laparoscop-

ic procedure. Many times these injuries are unavoidable due to the patient's anatomy or medical condition. Patients at higher risk for bowel injury include those with chronic bowel disease, pelvic inflammatory disease, a history of previous abdominal surgery, or severe endometriosis. Some types of laparoscopic procedures have a higher risk of organ injury. For instance, during laparoscopic removal of endometriosis adhesions or ovaries, the ureters may be injured due to their proximity to each other.

During the recovery period following laparoscopy, complications may also occur. An organ injury may be overlooked, so patients should be monitored for any unusual pain, particularly in association with the bowel, as bowel injuries may not be apparent during the procedure. Other complications include urinary tract infection (resulting from catheterization) and minor infection of the incision site.

Several clinical studies have shown that the complication rate during laparoscopy is associated with surgeon experience. Surgeons experienced in laparoscopic procedures have fewer complications than surgeons performing their first 100 cases.

Results

In diagnostic laparoscopy, the surgeon will be able to see signs of a disease or condition (e.g., endometriosis adhesions; ovarian cysts; diseased gallbladder) immediately, and can either treat the condition surgically or proceed with appropriate medical management. In diagnostic laparoscopy, biopsies may be taken of questionable areas, and laboratory results will govern medical treatment. In therapeutic laparoscopy, the surgeon performs a procedure that rectifies a known medical problem, such as hernia repair or appendix removal. Because laparoscopy is minimally invasive in comparison to open surgery, patients experience less trauma and postoperative discomfort, have fewer procedural complications, can return to daily activities sooner, and have a shorter hospital stay.

Health care team roles

Laparoscopy may be performed by a gynecologist, general surgeon, gastroenterologist, or other physician—depending upon the patient's condition. An anesthesiologist is required during the procedure to administer general and/or local anesthesia and to perform patient monitoring. Nurses and surgical technicians/assistants are needed during the procedure to assist with scope positioning, video system adjustments and image recording, and laparoscopic instrumentation.

Resources

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- Society of American Gastrointestinal Endoscopic Surgeons(SAGES). 2716 Ocean Park Boulevard, Suite 3000, Santa Monica, CA 90405. (310) 314-2404. <<http://www.endoscopy-sages.com>>.
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Jennifer E. Sisk, M.A.

Large intestine see **Intestine, large**

Laryngeal cancer see **Head and neck cancer**

Laryngitis see **Sore throat**

Laryngoscopy

Definition

Laryngoscopy is a procedure used to view the inside of the larynx (the voice box).

Purpose

The purpose of seeing inside the larynx is to assess the vocal cords and to detect tumors, **foreign bodies**, nerve or structural injury, or other abnormalities.

Precautions

A patient undergoing a laryngoscopy should be assessed for **allergies** to local anesthetics or other pharmacologic agents in order to prevent possible allergic reactions.

Patients may have fears concerning this procedure. Prior to laryngoscopy, the physician should explain the procedure in detail and assure the patient that he or she will be closely monitored for respiratory or other problems.

Description

Two methods of laryngoscopy allow the examiner to view the structures of the larynx and the surrounding areas. A light and lens affixed to a surgical viewing instrument called an **endoscope** are used in both methods.

Indirect laryngoscopy

Indirect laryngoscopy, the simplest form of laryngeal examination, involves the placement of a small, angled mirror at the back of the throat, allowing the examiner to reflect light onto the larynx and view its major structures. However, since the mirror must remain in the back of the throat, examination of the larynx during normal speech is hindered. Also, a strong gag reflex in some patients may limit the usefulness of this procedure.

A rigid endoscope may also be used to perform an indirect laryngoscopy. An examination using a rigid scope involves placement of the tip of the instrument through the mouth and into the back of the throat. A prism at the tip allows the examiner to view the larynx. This type of exam provides clear and highly magnified images of the vocal cords and allows better examination of the larynx during phonation (the production of vocal sounds). Another advantage to these instruments is that photographic or video recordings can be made through the endoscope for future review, also allowing more than one person to observe the laryngeal area.

Direct laryngoscopy

In direct laryngoscopy, a flexible, fiber-optic endoscope is threaded through the nasal passage and down into the throat. This procedure is used to detect or remove

KEY TERMS

Aspirate—To draw by suction.

Biopsy—The removal of a sample of tissue for study under the microscope.

Endoscope—An instrument used for visualizing the interior of a hollow organ such as the larynx.

Epiglottis—The lid-like appendage that covers the glottis during swallowing.

False cords—The protective valves of the larynx that prevent food from entering the trachea.

Laryngectomy—The surgical removal of the larynx.

Larynx—The organ of sound production, sometimes called the voice box. The larynx is made of cartilage and muscle.

Phonation—The production of vocal sounds. Examination of the larynx may be facilitated by asking the patient to produce a high-pitched “e-e-e” sound, since this lifts the epiglottis.

True cords—Also called vocal cords, these are two small shelves of muscular tissue within the larynx. They supplement the protective valves of the larynx that prevent food from entering the trachea. Their main function is to vibrate against each other and generate a sound tone.

lesions or foreign bodies in the larynx, or to diagnose **cancer** by removing tissue for biopsy or samples for culture. Once the instrument is inserted, flexible glass fibers illuminate the laryngeal area and transmit the image to the external part of the scope. From this position, an image of the larynx and vocal folds (including their movement and position during respiration and speech) can be clearly obtained.

Bronchoscopy is a similar, but more extensive procedure in which the tube is continued through the larynx and down into the trachea and bronchi.

Preparation

Patients should not eat for several hours before the examination.

Patients undergoing indirect laryngoscopy should sit in an upright position and breathe normally. The patient should be leaning slightly forward, with the head lifted. This facilitates the passage of the laryngeal mirror into the mouth and facilitates the procedure.

Topical anesthetics, such as lidocaine or dyclonine, may be used during laryngoscopy to suppress the gag reflex. The patient should be warned that the agent may **taste** bad and that the effects may be unpleasant. Anesthetized patients may feel as if their swallowing mechanism is impaired, and many experience an ill-defined sense of insecurity. Patients who are receiving anesthesia should be warned about these side effects and reassured throughout the procedure.

The gag reflex can also be reduced in the adult by the intravenous injection of diazepam (Valium). The typical dose is 10 mg. Diazepam may be used as an alternative for patients who are allergic to local anesthetics or who require both agents to allow adequate examination. Diazepam should be injected slowly into a large vein, and is only appropriate for healthy adults.

Complications

This procedure carries no serious risks, although the patient may experience soreness of the throat or cough up small amounts of **blood** until the irritation subsides. After the procedure, the patient should ingest nothing by mouth until the gag reflex returns. Once the reflex returns, fluid intake should be encouraged because it promotes the expectoration of secretions, and lozenges or gargles may be used to relieve a **sore throat**.

Vital signs should be assessed frequently for 24 hours to detect bleeding or complications such as difficult or labored respiration (dyspnea).

Results

A normal result would be the absence of signs of disease or damage.

An abnormal finding, such as a tumor or an object lodged in the tissue, would either be removed or examined for further medical attention.

Health care team roles

A nurse plays an important role in explaining the procedure to the patient, preparing the patient for the procedure, and assisting the physician in conducting the procedure. A nurse also assists patient recovery after the procedure, administering fluids and lozenges once the gag reflex returns, and monitoring vital signs.

Resources

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- National Institute on Deafness and Other Communication Disorders, 31 Center Dr., MSC 2320, Bethesda, MD 20892-2320. <<http://www.nidcd.nih.gov>>.

Jennifer F. Wilson

Laser-assisted in-situ keratomileusis see Refractive eye surgeries

Laser surgery

Definition

Laser is an acronym that stands for Light Amplification by Stimulated Emission of Radiation. Laser surgery uses an intensely hot, precisely focused beam of light to remove or vaporize tissue and control bleeding in a wide variety of noninvasive and minimally invasive procedures.

Purpose

Laser surgery may be used to:

- cut or destroy tissue that is abnormal or diseased without harming healthy, normal tissue
- shrink or destroy tumors and lesions
- cauterize (seal) **blood vessels** to prevent excessive bleeding

Precautions

Although many laser surgeries can be performed in the physician's office rather than in a hospital, practitioners must be at least as thoroughly trained and highly skilled their counterparts in a hospital setting. The American Society for Laser Medicine and Surgery, Inc. recommends that:

- All operative areas be equipped with oxygen and other drugs and equipment required for **cardiopulmonary resuscitation** (CPR).
- Nonphysicians performing laser procedures be properly trained, licensed, and insured.
- A qualified and experienced supervising physician be able to respond to and manage unanticipated events or other emergencies within five minutes of the time they occur.
- Emergency transportation to a hospital or other acute-care facility be available whenever laser surgery is performed in a nonhospital setting.

All patients who are considering laser surgery should be fully informed about the procedure's relative risks and benefits, as well as any alternatives that may exist. Some types of laser surgery, for example, should not be performed on pregnant women or on patients with severe cardiopulmonary disease or other serious health problems. The patient should understand why laser surgery a better choice than traditional surgery (in this instance), and how much experience the physician has in performing the laser procedure the patient is considering. Generally, surgical nurses will inform patients about the planned procedure and, if hospital policy permits nurses to do so, obtain their **informed consent** to proceed; some hospitals require doctors to do this.

Description

The first working lasers were introduced in 1960. They were initially used to treat diseases and disorders of the eye, where transparent tissues gave ophthalmic surgeons a clear view of how the narrow, concentrated beam was being directed. Dermatologic surgeons helped further pioneer laser surgery, developing and improving many early techniques and refining surgical procedures.

Lasers are medically useful because they can be directed with pinpoint accuracy to cut, vaporize, or weld tissue while cauterizing **blood** vessels and nerves to reduce or eliminate surgical bleeding and postoperative **pain**. This reduces postoperative swelling and scarring as well as the length of the recovery period. A laser's heat often destroys **bacteria** and **viruses** in the surgical field, creating a more sterile environment that is less prone to

infection. Because a smaller incision is required, laser procedures often take less time than traditional surgery. Lasers can also be tailored to particular applications.

All lasers operate on the principle of selective photothermolysis, meaning that the laser's wavelength, energy density, power, and exposure time determine what types of tissue will be affected and the effects that will be produced. Lasers can be further adapted to different medical procedures with special delivery (such as fiberoptic cables) that help apply the laser beam.

Laser applications

Sometimes described as “scalpels of light,” lasers are used alone or with conventional **surgical instruments** and can be tailored with seemingly infinite precision for a vast number of surgical procedures. For these reasons laser surgery is often standard operating procedure for specialists in cardiology, dentistry, dermatology, gastroenterology, gynecology, neurosurgery, oncology, ophthalmology, orthopedics, otolaryngology, pulmonology, and urology.

Lasers are used to erase birthmarks, skin discolorations, and skin changes due to aging; to remove benign, precancerous, or cancerous tissues or tumors; to stop snoring; remove tonsils; remove or transplant hair; and relieve pain and restore function in patients too weak to undergo more invasive surgery. Lasers are also used to treat angina; cancerous or noncancerous tumors that cannot be removed or destroyed; cold and canker sores, gum disease and tooth sensitivity or decay; ectopic **pregnancy**, endometriosis, and fibroid tumors; gallstones; **glaucoma**, mild-to-moderate nearsightedness, **astigmatism**, and other conditions that impair **vision**; migraine headaches; noncancerous enlargement of the prostate gland; nosebleeds; ovarian cysts; ulcers; **varicose veins**; warts; and numerous other conditions, diseases, and disorders.

Types of lasers

CARBON DIOXIDE LASER. Carbon dioxide (CO₂) lasers were the first to find surgical applications, and they remain the most used of all **medical lasers**. CO₂ laser light is absorbed readily by water in the cells, allowing tissue to be cut precisely with minimal bleeding. The laser beams can be concentrated into a fine beam that slices like a scalpel, or diffused to shave or vaporize tissue. This versatility makes them valuable in many types of procedures from wart removal to **brain** surgery.

NEODYMIUM:YTRIUM-ALUMINUM-GARNET LASER. Neodymium:yttrium-aluminum-garnet laser (Nd:YAG) lasers can penetrate tissue more deeply than other lasers, allowing surgeons to operate on parts of the body that

could previously be reached only through invasive surgery. Nd:YAG lasers are the most frequently used laser in dental procedures, and are also well suited for respiratory surgery because they cauterize and seal the tiny vessels of the lung. They are also used to excise tumors with minimal damage to healthy tissue, and may even eliminate micrometastases before they can spread to another region.

Other types of YAG lasers are:

- The KTP laser, produced when Nd:YAG laser light is passed through a potassium-titanyl-phosphate (KTP) crystal. This green laser is used frequently for vascular lesions (such as leg veins) and to remove certain tattoo colors.
- The erbium (Er:YAG) laser, which penetrates less deeply into tissue; it is used in dental and hair removal procedures.
- The holmium (Ho:YAG) laser, used in orthopedic surgery to eliminate extraneous bone and cartilage, to destroy **kidney stones**, in endoscopic sinus procedures, and for prostate removal.

ARGON LASER. Another laser to find early medical application, the argon laser produces a blue-green light that is selectively absorbed by hemoglobin and melanin. This means that argon laser light is drawn to areas that are heavily pigmented or rich in blood vessels. Argon lasers are most often used for ophthalmic surgery and surface skin blemishes (birthmarks, enlarged blood vessels) because they vaporize and seal blood vessels on contact. In a special procedure known as photodynamic therapy (PDT), this laser is also used in conjunction with light-sensitive dyes to shrink or dissolve tumors.

Preparation

Because laser surgery is used to treat such a wide variety of conditions, patients should be given specific, detailed instructions about how to prepare for their procedure. Diet, activities, and medications may or may not have to be limited prior to surgery, so it's important that nurses offer written and/or verbal preoperative **patient education** and instructions. Many procedures require a preoperative **physical examination** to determine the patient's general health and current medical status, especially if **general anesthesia** will be used. Patients should also be given a realistic expectation of the procedure's outcome and the duration of recovery.

Aftercare

Many laser surgeries are performed on an outpatient basis, and patients are usually permitted to leave the



Cosmetic laser surgery in progress. The wavelengths of the laser's light can be matched to a specific target, enabling the physician to destroy the capillaries near the skin's surface without damaging the surrounding tissue. (Photograph by Will & Deni McIntyre, Photo Researchers, Inc. Reproduced by permission.)

hospital, medical office, or surgical center once their **vital signs** have stabilized. Patients who have been sedated should not be discharged until they have completely recovered from the anesthesia and they are oriented and alert. Most practitioners require discharged patients to be accompanied by a responsible adult. Patients should not drive themselves to or from the facility.

The physician may prescribe analgesic medication for postoperative pain, and should provide easy-to-understand written instructions that describe how the patient's recovery should progress, the actions to take in the event of complications, and how to recognize complications requiring emergency medical treatment.

Complications

The risks and complications associated with laser surgery are comparable to those for other surgical procedures. Treated areas can become infected following laser surgery; this should be suspected if burning, crusting of the skin, itching, pain, scarring, severe redness, and swelling appear at the treatment site. Other risks are associated with anesthesia and complications such as hemor-

rhage, perforation, or infection. Fortunately, errors of this sort tend to occur when a physician is poorly supervised while learning a new skill. Serious complications are rare with experienced doctors.

Some complications may be cosmetic: lighter or darker skin may appear when a laser is used to remove sun damage or age spots from an olive- or dark-skinned individual. This abnormal pigmentation may or may not disappear in time. Black, Asian, Hispanic, or dark-skinned patients should make sure that their surgeon has performed laser procedures successfully on people of color.

Laser surgery also involves unique risks: Imprecisely aimed lasers can burn or destroy healthy tissue, cause injuries that are painful and sometimes permanent, and even compound the problems they are supposed to solve. Errors or inaccuracies in laser eye surgery can damage or worsen a patient's vision, for example. Scarring or rupturing of the cornea is uncommon, but laser surgery on one or both eyes can increase sensitivity to light or glare, reduce night vision, permanently cloud vision, or cause sharpness of vision to decline throughout

KEY TERMS

Argon—A colorless, odorless gas, which, when used in a laser, emits a blue-green beam.

Astigmatism—A condition in which one or both eyes cannot filter light properly because the corneal surface is irregular. This results in blurred, indistinct images unless corrected by glasses, contact lenses, or laser surgery.

Carbon dioxide—A heavy, colorless gas that dissolves in water.

Cauterize—The use of heat or chemicals to stop bleeding, prevent the spread of infection, or destroy tissue.

Cornea—The outer, transparent lens that covers the pupil of the eye and admits light.

Endometriosis—An often painful gynecologic condition in which endometrial tissue migrates from the inside of the uterus to other organs inside and beyond the abdominal cavity.

Glaucoma—A disease of the eye in which increased pressure within the eyeball can cause gradual loss of vision. Iridectomy is the laser surgical procedure that helps relieve the pressure.

Invasive surgery—Surgery that involves making an incision in the patient's body and inserting instruments or other medical devices into it.

Nearsightedness—A condition in which one or both eyes cannot focus normally, causing objects at a distance to appear blurred and indistinct. Also called myopia.

Ovarian cyst—A benign or malignant growth on an ovary. An ovarian cyst can disappear without treatment or become extremely painful and have to be surgically removed.

Papillomavirus—A group of viruses that cause several types of warts, some of which can cause cancer.

Vaporize—To dissolve solid material or convert it into smoke or gas with a laser.

Varicose veins—Peripheral veins, usually in the legs, that have valvular insufficiency. This allows blood to pool in the vessels of the lower extremities, permanently dilating the veins.

surgery on any part of the face near the eyes or eyelids, and a United States Food and Drug Administration (FDA) mandate requires both health care personnel and patients to use special protective eyewear whenever a CO₂ laser is used.

An unexpected risk associated with laser surgery is the “plume” or smoke that is emitted when lasers vaporize tissue. Studies have shown that although the particles in the smoke are very small (0.5–5.0µm), they are small enough to pass through a surgical mask. This is a concern for both patient and health care personnel because viral DNA has been shown to survive in the smoke produced when warts are removed by a laser, and some forms of papillomavirus are infectious. To guard against any possible contagion, a vacuum system with a multistage filter is recommended to suction the smoke produced during laser procedures; it must be held very close (about 1 cm) from the target to be effective.

Results

The nature and severity of the problem addressed by the laser procedure, the skill of the surgeon performing the procedure, as well as the patient's general health and realistic expectations about the result of the procedure are among the factors that influence the outcome of laser surgery.

Patients considering any type of laser surgery should be fully apprised of the risks, benefits and potential complications of the procedure as well as any alternative treatment that might be feasible in place of laser surgery. It is especially important for patients undergoing cosmetic procedures to have realistic expectations about the outcomes of these procedures.

Health care team roles

Laser surgery may be performed by a general surgeon, cardiologist, dentist, oral surgeon, dermatologist, gynecologist, ophthalmologist, otolaryngologist, plastic surgeon, urologist or other physician specialist, assisted by specially trained surgical nurses. Preoperative blood work is performed by laboratory technologists, and when necessary, imaging studies may be performed by radiologic technicians.

Patient education

Nurses have a vital role in delivering pre- and post-operative patient education. There is considerable evidence that well-informed patients achieve better clinical outcomes and experience higher levels of satisfaction with treatment. Patients considering laser surgery should

the day. To guard against some of these risks, patients must wear protective eye shields while undergoing laser

be provided with detailed information about the anticipated outcomes of the surgery and the duration of recovery process.

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- American Society for Dermatologic Surgery. 930 North Meacham Road, Schaumburg, IL 60173-6016. (847) 330-9830. <<http://www.asds-net.org>>.
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Barbara Wexler

Lasers in medicine see **Medical lasers**

LASIK see **Refractive eye surgeries**

Laughing gas see **Nitrous oxide**

Laxatives

Definition

Laxatives are products that promote bowel movements.

Purpose

Laxatives are used to treat constipation—the passage of small amounts of hard, dry stools, usually fewer than three times a week. Before recommending use of laxatives, differential diagnosis should be performed. Prolonged constipation may be evidence of a significant problem, such as localized peritonitis or diverticulitis. Complaints of constipation may be associated with obsessive-compulsive disorder. Use of laxatives should be avoided in these cases. Patients should be aware that patterns of defecation are highly variable, and may vary from two to three times daily to two to three times weekly.

Laxatives may also be used prophylactically for patients, such as those recovering from a **myocardial infarction** or those who have had recent surgery, who should not strain during defecation.

Description

Laxatives may be grouped by mechanism of action.

Saline cathartics include dibasic sodium phosphate (Phospo-Soda), magnesium citrate, magnesium hydroxide (milk of magnesia), magnesium sulfate (Epsom salts), sodium biphosphate, and others. They act by attracting and holding water in the intestinal lumen, and may produce a watery stool. Magnesium sulfate is the most potent of the laxatives in this group.

Stimulant and irritant laxatives increase the peristaltic movement of the intestine. Examples include cascara and bisacodyl (Dulcolax). Castor oil works in a similar fashion.

Bulk producing laxatives increase the volume of the stool, and will both soften the stool and stimulate intestinal motility. Psyllium (Metamucil, Konsil) and methylcellulose (Citrucel) are examples of this type. The overall effect is similar to that of eating high-fiber foods, and this class of laxative is most suitable for regular use.

Docusate (Colace) is the only representative example of the stool softener class. It holds water within the fecal mass, providing a larger, softer stool. Docusate has no effect on acute constipation, since it must be present before the fecal mass forms to have any effect, but may be useful for prevention of constipation in patients with

KEY TERMS

Carbohydrates—Compounds, such as cellulose, sugar, and starch, that contain only carbon, hydrogen, and oxygen, and are a major part of the diets of people and other animals.

Cathartic colon—A poorly functioning colon, resulting from the chronic abuse of stimulant cathartics.

Colon—The large intestine.

Diverticulitis—Inflammation of the part of the intestine known as the diverticulum.

Fiber—Carbohydrate material in food that cannot be digested.

Hyperosmotic—Hypertonic, containing a higher concentration of salts or other dissolved materials than normal tissues.

Osteomalacia—A disease of adults, characterized by softening of the bone. Similar to Rickets which is seen in children.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies, or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies, or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

Steatorrhea—An excess of fat in the stool.

Stool—The solid waste that is left after food is digested. Stool forms in the intestines and passes out of the body through the anus.

recurrent problems, or those who are about to take a constipating drug, such as narcotic **analgesics**.

Mineral oil is an emollient laxative. It acts by retarding intestinal absorption of fecal water, thereby softening the stool.

The hyperosmotic laxatives are glycerin and lactulose (Chronulac, Duphalac), both of which act by holding water within the intestine. Lactulose may also increase peristaltic action of the intestine.

Precautions

Short term use of laxatives is generally safe except in **appendicitis**, fecal impaction, or intestinal obstruction. Lactulose is composed of two sugar molecules; galactose and fructose, and should not be administered to patients who require a low galactose diet.

Chronic use of laxatives may result in fluid and electrolyte imbalances, steatorrhea, osteomalacia, **diarrhea**, cathartic colon, and **liver** disease. Excessive intake of mineral oil may cause impaired absorption of oil soluble **vitamins**, particularly A and D. Excessive use of magnesium salts may cause hypermagnesemia.

Lactulose and magnesium sulfate are **pregnancy** category B. Casanthranol, cascara sagrada, danthron, docusate sodium, docusate **calcium**, docusate potassium, mineral oil and senna are category C. Casanthranol, cascara sagrada and danthron are excreted in breast milk, resulting in a potential increased incidence of diarrhea in the nursing infant.

Interactions

Mineral oil and docusate should not be used in combination. Docusate is an emulsifying agent which will increase the absorption of mineral oil.

Bisacodyl tablets are enteric coated, and so should not be used in combination with **antacids**. The antacids will cause premature rupture of the enteric coating.

Recommended dosage

See specific resources.

Resources

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National Digestive Diseases Information Clearinghouse. 2 Information Way, Bethesda, MD 20892-3570.
niddic@erie.com.
<<http://www.niddk.nih.gov/Brochures/NDDIC.htm>>.

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Lead poisoning see **Trace metal tests**

Learning theory

Definition

Learning is defined as a relatively permanent change in behavior as a result of experience. This definition excludes changes that might occur solely as a result of maturation, injury, or disease. To learn is to adapt. A child might stick his or her finger in a light socket, but not more than once. Sea lions in an aquarium will learn to bark and slap the water if these behaviors prompt people to toss them food. Changes that occur as a result of learning are not always positive. We may acquire bad (maladaptive) habits, as well as good ones. Three basic kinds of learning have been studied extensively by psychologists. These are: classical conditioning, operant conditioning, and observational learning.

Description

Classical conditioning

The pioneer of the study of classical conditioning was Ivan Pavlov. While studying salivation in dogs as part of his research on digestion, Pavlov discovered an interesting phenomenon. Dogs that had been repeatedly given meat in order to induce salivation began to salivate before the presentation of the meat. The sight of the pan containing the meat, or the sound of the experimenter's footsteps coming toward the laboratory was enough to initiate salivation. This was curious. Dogs do not normally salivate to the sound of footsteps, thus they must have acquired this response as a result of experience. In other words, learning had taken place.

Pavlov recognized the potential importance of the dogs' behavior, and subsequently turned his attention to the study of what we now know as conditioned **reflexes**. By carefully scrutinizing the dogs' behaviors under controlled laboratory conditions, Pavlov discovered and described the principles of classical conditioning. In order to understand its operation, there are a few key terms that need to be explained. An unconditional stimulus refers to a thing or event that triggers a response (change) reflexively or automatically. This response is referred to as an unconditional response. It is automatically produced; no learning is needed for it to occur. A neutral stimulus is a stimulus that elicits no response (or at least not the response being studied). When a neutral stimulus is repeatedly paired with an unconditional stimulus it will produce an effect similar to that of the unconditional stimulus. This mutated neutral stimulus, if you will, is referred to as a conditioned stimulus and the response it produces is called a conditioned response. The conditioned response, unlike the unconditioned

response, is learned. Each pairing of an unconditional stimulus with a conditional stimulus is referred to as reinforcement. The pairing strengthens or reinforces the conditioned response. In classical conditioning it is important to remember that the initial stimulus and its response (i.e., the unconditioned stimulus and response) occur naturally; they are instinctual, so to speak.

HOW CLASSICAL CONDITIONING WORKS. In the first stage, the unconditioned (natural) response to an unconditioned stimulus occurs automatically. It is a natural, reflexive reaction. For example, eating meat will make a dog salivate to aid in digestion. In the second stage, a neutral stimulus is paired with the natural or unconditioned stimulus. Using our example of the dog and meat, suppose we ring a bell just before the meat is given to the dog. If we do this repeatedly the bell alone will cause the dog to salivate and this represents the third stage of classical conditioning. In other words the conditioned stimulus now produces a conditioned response. This response was not present before the conditioning process (or learning) took place. Conditioning occurs most quickly and effectively when the conditioned stimulus immediately precedes the unconditioned stimulus.

Because of classical conditioning, certain events can produce unwanted distress for reasons that are largely unrelated to the event itself. Young children, for example, often become fearful during their first visit to a barber. Barbers often wear white smocks, similar to those worn by doctors. There are also numerous metallic instruments (scissors, razors) in plain sight in the barbershop. Unpleasant experiences at the doctor's office (e.g., an injection) could become associated with accompanying stimuli (the doctor's white coat, silver instruments) in such a way that similar stimuli (in other settings) could trigger an **anxiety** response. Some children's barbers make a point of wearing colored (as opposed to white) jackets, and take pains to reduce any similarities between their work areas and doctors' examining rooms.

Viewpoints

On the basis of his research, Pavlov assumed that the basic associations established through classical conditioning were universal. In other words, he believed that all animals would show conditioning, and that any natural response could be conditioned to any and all neutral stimuli. More recent research has shown that there are restrictions on the kinds of associations that are amenable to conditioning. For example when tastes, sounds, and visual stimuli were used as conditioned stimuli prior to being given a nausea-inducing drink, rats very quickly learned to associate **taste** with illness, and forever after avoided similar tasting food. This happened even if the

nausea occurred several hours after the ingestion. Moreover, neither the visual nor the auditory stimuli created aversion responses. Apparently all animals, including humans, are biologically prepared to learn some associations rather than others. It is as if nature prepares each species to learn what is best suited to its survival.

Operant conditioning

If the sole mechanism of learning were classical conditioning only a very limited number of responses could be learned. A dog may learn to salivate at the sound of a bell but how are new, voluntary responses learned? How does the animal learn to operate on its environment?

Operant conditioning provides some insight. In classical conditioning the animal is relatively passive. In operant conditioning the animal is an active part of its environment. It operates on the environment. Two pioneers of this approach are Edward L. Thorndike (1874-1949) and B. F. Skinner (1904-1990). At about the same time that Pavlov was performing his experiments with dogs, Thorndike began experimenting with cats. He devised a box from which a cat could escape only if it performed a particular action. For example, the cat would have to press a lever, which would, in turn, cause a rope to pull a bolt from the door and thus allow it to escape. Through trial-and-error the cat would eventually escape from the box. Thorndike noticed that over successive trials, it took progressively less and less time for the cat to solve its problem. Thorndike reasoned that the gratifying experience of being released from the box caused the correct response (pressing the lever) to occur more rapidly on the subsequent trials.

Skinner's research extended and elaborated this simple fact of life: behavior that is rewarded is more likely to recur.

Much of Skinner's research utilized laboratory rats and pigeons. He designed the now famous Skinner Box—a soundproof chamber with a bar or key, which, if pressed or pecked, would dispense a reward of food or water. Once the rat was placed into the box, the experimenter had total control over its environment. The equipment could be programmed to deliver positive or negative reinforcement. For example, the box could be rigged with a lever that, when pressed, turned off a mild electric shock (negative reinforcement). A negative reinforcer is one that strengthens a response by removing an aversive or unpleasant stimulus.

Before a response can be reinforced, it must first occur. Suppose you wanted to teach a dog to climb a ladder. Because this action has no probability of occurring spontaneously, you would wait forever for it to occur so that it could be reinforced. What to do? The solution is to

use a procedure known as shaping. When we shape a behavior, we define some ultimate target behavior and then reinforce all actions that are even remotely related to the target behavior. Thus the dog might receive a reward for placing a paw on the bottom rung of the ladder. The trainer then requires responses that are more and more similar to the final, desired response. These responses that are rewarded on the way to the final target behavior are called successive approximations. With shaping (and patience) various animals can be taught to produce extraordinary sequences of behaviors. There are bears in the Russian circus that drive motorcycles. Seeing eye dogs act as the “eyes” for the blind, and can also be taught to assist people with **spinal cord** injuries by turning on light switches or opening doors. The basic principles of operant conditioning have important practical implications. These principles are at the **heart** of behavior modification therapy—a treatment approach that has demonstrated some impressive successes in schools, prisons, mental hospitals, and rehabilitation wards.

Observational learning

While classical conditioning and reinforcement principles are powerful and ubiquitous determinants of behavior, they do not tell the whole story, especially when it comes to human learning. We do not always learn through direct experience. Indeed, we wouldn't survive for very long if we could not learn from watching others. Observational learning plays a role in almost every aspect of our activities, from learning how to hold a fork, drive a car, smoke a cigarette, or have sex. Observational learning occurs in fish, birds, and mammals too. For example, if given a choice, rats will prefer to eat food that they have seen other rats choose. Research has demonstrated that children imitate their parents' food aversions. After the first few months of *The Simpsons* television show, many young girls across the country began expressing an interest in playing the baritone saxophone—Lisa Simpson's instrument of choice.

The observational learning perspective emphasizes that what is learned is ‘knowledge’ about behavior, in addition to the behavior itself. Role models can be quite influential. If you want to encourage a child to read, read to them, surround him or her with books and with people who read them. Not surprisingly, modeling effects cut both ways. Antisocial role models can cultivate negative patterns of behavior in the observer. Children who grow up in households where wife abuse is common are “learning” that physical assaults and intimidation are effective ways of controlling others. Models are most likely to be imitated when they have status, when their actions are rewarded, when the modeled behaviors are in the observer's repertoire, and when the observer is moti-

vated to emulate the model. While it is disheartening to realize how easily antisocial behaviors can be acquired, the overall legacy from learning theories is one of hope. What is learnable is also (potentially) teachable. This fact inspires parents, teachers and therapists. And what is learned can also be unlearned. No matter how distressed we may feel, we are not stuck forever with our current state. Humans are remarkably capable of change through learning.

Resources

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Timothy E. Moore

Leg veins x ray see **Phlebography**

Leukemias, acute

Definition

Acute leukemia is a type of **cancer** in which excessive quantities of abnormal white **blood** cells are produced.

Description

Medical science further classifies acute leukemia by the type of white blood cell that undergoes mutation. The most common of these are:

- Acute lymphoblastic leukemia (ALL), in which excessive quantities of lymphoblasts, or immature lymphocyte white blood cells, are produced.
- Acute myeloblastic leukemia (AML), also known as acute nonlymphocytic leukemia (ANLL), in which excessive quantities of other types of immature white blood cells are produced.

Acute leukemias progress rapidly, while the **chronic leukemias** progress more slowly. The vast majority of the childhood leukemias are of the acute form.

The cells that make up blood are produced in the bone marrow and the **lymphatic system**. Bone marrow is the spongy tissue found in the large bones of the body. The lymphatic system includes the spleen (an organ in the upper abdomen), the thymus (a small gland beneath the breastbone), and the tonsils (a mass of lymphatic tissue located in the throat). In addition, the lymphatic vessels (tiny tubes that branch like **blood vessels** into all parts of the body) and lymph nodes (pea-shaped organs that are found along the network of lymphatic vessels) are also part of the lymphatic system. Lymph is a milky fluid that contains cells. Clusters of lymph nodes are found in the neck, underarm, pelvis, abdomen, and chest.

The cells found in the blood include red blood cells (RBCs) that carry oxygen and other materials to all tissues of the body; white blood cells (WBCs) that fight **infection**; and platelets, which play an important role in the clotting of the blood. White blood cells can be further subdivided into three main types: granulocytes, monocytes, and lymphocytes.

The granulocytes, as their name suggests, have particles (granules) inside them. These granules contain special **proteins** (enzymes) and several other substances that can break down chemicals and destroy microorganisms, such as **bacteria**. Monocytes are the second type of white blood cell. They are also important in defending the body against pathogens.

Lymphocytes are the third type of white blood cell. There are two primary types of lymphocytes—T lymphocytes and B lymphocytes—with different functions in the **immune system**. B cells protect the body by making antibodies. Antibodies are proteins that can attach to the surfaces of bacteria and **viruses**. This "attachment" sends signals to many other cell types to come and destroy the antibody-coated organism. T cells protect the body against viruses. When a virus enters a cell, it produces certain proteins that are projected onto the surface of the infected cell. T cells recognize these proteins and make certain chemicals that are capable of destroying the virus-infected cells. In addition, T cells can destroy some types of cancer cells.

Bone marrow makes stem cells, which are the precursors of the different blood cells. These stem cells mature through stages into either RBCs, WBCs, or platelets. In acute leukemias, the maturation process of the white blood cells is interrupted. The immature cells (or "blasts") proliferate rapidly and begin to accumulate in various organs and tissues, thereby affecting their normal function. This uncontrolled proliferation of the

immature cells in the bone marrow affects the production of the normal red blood cells and platelets as well.

As noted, there are two types of acute leukemias—acute lymphocytic leukemia and acute myelogenous leukemia. Different types of white blood cells are involved in the two leukemias. In acute lymphocytic leukemia (ALL), it is the T or the B lymphocytes that are involved. The B cell leukemias are more common than T cell leukemias. Acute myelogenous leukemia, also known as acute nonlymphocytic leukemia (ANLL), is a cancer of the monocytes and/or granulocytes.

Leukemias account for 2% of all cancers. Because leukemia is the most common form of childhood cancer, it is often regarded as a disease of childhood. However, leukemias affect far more adults than children. Half of the cases occur in people who are 60 years of age or older. The incidence of acute and chronic leukemias is about the same. According to the estimates of the American Cancer Society (ACS), approximately 29,000 new cases of leukemia are diagnosed each year in the United States. Of these, 27,000 will be diagnosed in adults, 2,000 in children.

Causes and symptoms

Leukemia strikes both sexes and all ages. The human T-cell leukemia virus (HTLV-I), a virus with similarities to the human **immunodeficiency** virus (HIV), is believed to be the causative agent for some kinds of leukemias, but this has not yet been proven, and the cause of most leukemias is not known. Acute lymphoid leukemia (ALL) is more common among Caucasians than among African-Americans, while acute myeloid leukemia (AML) affects both races equally. The incidence of acute leukemia is slightly higher among men than women. People with Jewish ancestry have a higher likelihood of getting leukemia. A higher incidence of leukemia has also been observed among persons with **Down syndrome** and some other genetic abnormalities.

Reports in *Science News* cited studies that found a gene that regulates folic acid **metabolism** in the body to be more prevalent in acute lymphocytic leukemia (ALL) patients. **Folic acid** is known to be involved in the process of DNA maintenance and repair, and this gene diverts folic acid from this function. It is therefore hypothesized that this gene plays a role in the development of ALL, and that folic acid supplementation could lower the risk for developing ALL. This gene has not been found to play a part in other leukemias, such as AML.

Exposure to ionizing radiation, such as occurred in Japan after the atomic bomb explosions, has been shown

to increase the risk of getting leukemia. Electromagnetic fields are suspected of being a possible cause, as are certain organic chemicals, such as benzene. Having a history of diseases that damage the bone marrow, such as aplastic anemia, or a history of cancers of the lymphatic system puts people at a high risk for developing acute leukemias. Similarly, the use of anticancer medications, immunosuppressants, and the antibiotic chloramphenicol are also considered risk factors for developing acute leukemias.

The symptoms of leukemia are generally vague and non-specific. A patient may experience all or some of the following symptoms:

- weakness or chronic fatigue
- fever of unknown origin, chills and flu-like symptoms
- weight loss that is not due to dieting or **exercise**
- frequent bacterial or viral infections
- headaches
- skin rash
- non-specific bone **pain**
- easy bruising
- bleeding from gums or nose
- blood in urine or stools
- swollen and tender lymph nodes and/or spleen
- abdominal fullness
- night sweats
- petechiae, or tiny red spots under the skin
- more rarely, sores in the eyes or on the skin

Diagnosis

For a successful outcome, treatment for acute leukemia must begin as soon as possible, but there are no screening tests available. If the doctor has reason to suspect leukemia, he or she will conduct a very thorough **physical examination** to look for enlarged lymph nodes in the neck, underarm, and pelvic region. Swollen gums, enlarged **liver** or spleen, bruises, or pinpoint red rashes all over the body are some of the signs of leukemia. Urine and blood tests may be ordered to check for microscopic amounts of blood in the urine and to obtain a complete differential blood count. This count will give the numbers and percentages of the different cells found in the blood. An abnormal blood test might suggest leukemia; however, the diagnosis must be confirmed by more specific tests.

The doctor may perform a bone marrow biopsy to confirm the diagnosis of leukemia. During the biopsy, a

cylindrical piece of bone and marrow is removed. The tissue is generally taken out of the hipbone. These samples are sent to the laboratory where they are examined under a **microscope** by a hematologist, oncologist, or pathologist. In addition to the diagnostic biopsy, another biopsy will also be performed during the treatment phase of the disease to see if the leukemia is responding to therapy.

A spinal tap (lumbar puncture) is another procedure that the doctor may order to diagnose leukemia. In this procedure, a small needle is inserted into the spinal cavity in the lower back to withdraw some cerebrospinal fluid and to look for leukemic cells.

Standard imaging tests, such as x rays, computed tomography scans (**CT scans**), and **magnetic resonance imaging** (MRI) may be used to check whether the leukemic cells have invaded other areas of the body, such as the bones, chest, **kidneys**, abdomen, or **brain**. A gallium scan or bone scan is a test in which a radioactive chemical is injected into the body. This chemical accumulates in the areas of cancer or infection, allowing them to be viewed with a special camera.

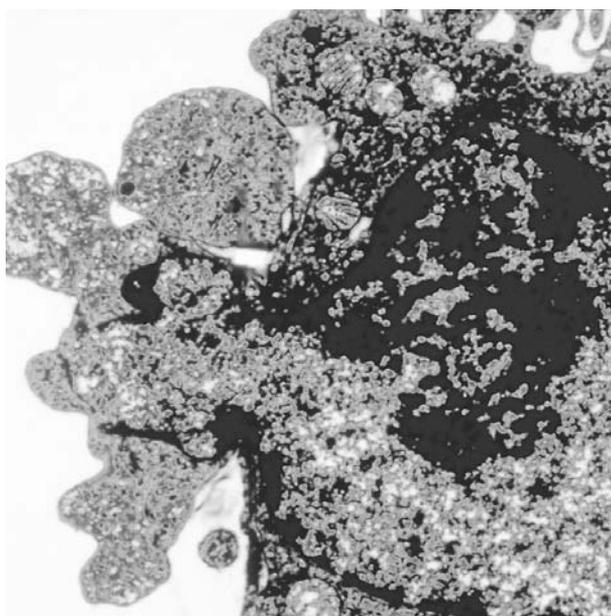
Treatment

As noted, treatment must be begun as soon as possible. The goal of treatment is remission, or an arresting of the disease process of the leukemia. There are two phases of treatment for leukemia. The first phase is called induction therapy. As the name suggests, during this phase, the primary aim of the treatment is to reduce the number of leukemic cells as much as possible and induce a remission in the patient. Once the patient shows no obvious signs of leukemia (no leukemic cells are detected in blood tests and bone marrow biopsies), the patient is said to be in remission.

The second phase of treatment is then initiated. This is called continuation or maintenance therapy, and the goal is to kill any remaining cancer cells and to maintain the remission for as long as possible.

Chemotherapy

Chemotherapy is the use of drugs to kill cancer cells. It is usually the treatment of choice in leukemia, and is used to relieve symptoms and achieve long-term remission of the disease. Generally, combination chemotherapy, in which multiple drugs are used, is more efficient than using a single drug for the treatment. Some drugs may be administered intravenously through a vein in the arm; others may be given by mouth in the form of pills. If the cancer cells have invaded the brain, then chemotherapeutic drugs may be put into the fluid that surrounds the brain through a needle in the brain or back.



An enhanced transmission electron microscopy (TEM) of acute myelogenous leukemia cells. (Photograph by Robert Becker, Ph.D., Custom Medical Stock Photo. Reproduced by permission.)

This is known as intrathecal chemotherapy. Because leukemia cells can spread to all the organs via the blood stream and the lymphatic vessels, surgery is not considered an option for treating leukemias.

Radiation

Radiation therapy, which involves the use of x rays or other high-energy rays to kill cancer cells and shrink tumors, may be used in some cases. For acute leukemias, the source of radiation is usually outside the body (external radiation therapy). If the leukemic cells have spread to the brain, radiation therapy can be given to the brain.

Bone marrow transplantation

Bone marrow transplantation is a process in which the patient's diseased bone marrow is replaced with healthy marrow. There are two ways of doing a bone marrow transplant. In an *allogeneic* bone marrow transplant, healthy marrow is taken from a donor whose tissue is either the same as or very closely resembles the patient's tissues. The donor may be a twin, a brother or sister (sibling), or a person who is not related at all. First, the patient's bone marrow is destroyed with very high doses of chemotherapy and radiation therapy. Healthy marrow from the donor is then given to the patient through a needle in a vein to replace the destroyed marrow.

KEY TERMS

Antibodies—Proteins made by the B lymphocytes in response to the presence in the body of infectious agents, such as bacteria or viruses.

Biopsy—The surgical removal and microscopic examination of living tissue for diagnostic purposes.

Chemotherapy—Treatment with drugs that act against cancer.

Computerized tomography (CT) scan—A series of x rays put together by a computer in order to form detailed pictures of areas inside the body.

Cytokines—Chemicals made by the cells that act on other cells to stimulate or inhibit their function. Cytokines that stimulate growth are called growth factors.

Immunotherapy—Treatment of cancer by stimulating the body's immune defense system.

Lumbar puncture—A procedure in which the doctor inserts a small needle into the spinal cavity in the lower back to withdraw some spinal fluid for testing. Also known as a spinal tap.

Magnetic resonance imaging (MRI)—A medical procedure using a magnet linked to a computer to picture areas inside the body.

Maturation—The process by which stem cells transform from immature cells without a specific function into a particular type of blood cell with defined functions.

Radiation therapy—Treatment using high-energy radiation from x-ray machines, cobalt, radium, or other sources.

Remission—A disappearance of a disease as a result of treatment. Complete remission means that all disease is gone. Partial remission means that the disease is significantly improved by treatment, but residual traces of the disease are still present.

In the second type of bone marrow transplant, called an autologous bone marrow transplant, some of the patient's own marrow is taken out and treated with a combination of **anticancer drugs** to kill all the abnormal cells. This marrow is then frozen to preserve it. The marrow remaining in the patient's body is destroyed with high-dose chemotherapy and radiation therapy. The marrow that was frozen is then thawed and given back to the patient through a needle in a vein. This type of bone mar-

row transplant is currently being investigated in clinical trials.

Biological therapy or immunotherapy is a mode of treatment in which the body's own immune system is harnessed to fight the cancer. Interferon is a biological therapy that is increasingly being used. Substances that are routinely made by the immune system (such as growth factors, hormones, and disease-fighting proteins) are either synthetically made in a laboratory or their effectiveness is boosted and they are then put back into the patient's body. This treatment mode is also being investigated in clinical trials all over the country at major cancer centers.

Prognosis

Like all cancers, the prognosis for leukemia depends on the patient's age and general health. According to statistics, more than 60% of the patients with leukemia survive for at least a year after diagnosis. Acute myelocytic leukemia (AML) has a poorer prognosis rate than acute lymphocytic leukemias (ALL) and the chronic leukemias. In the last 15 to 20 years, the five-year survival rate for patients with ALL has increased from 38% to 57%.

Interestingly enough, since most childhood leukemias are of the ALL type, chemotherapy has been highly successful in their treatment. This is because chemotherapeutic drugs are most effective against actively growing cells. Due to the new combinations of anticancer drugs being used, the survival rates among children with ALL have improved dramatically. Ninety-five percent of all childhood ALL patients will enter remission, and 60–75% will remain in remission after five years, depending upon the type. T-cell ALL is considered curable in half of all cases, while B-cell ALL is rarely, if ever curable. The worst prognosis is for non-tytable ALL, whose victims are usually below one year of age.

Health care team roles

In most cases, a diagnosis of leukemia is made in a physician's office, a general medical clinic, or emergency room by a primary care practitioner. Children and adolescents with leukemia are likely to be diagnosed by their primary care physician, or pediatrician. However, oncologists, or physicians that specialize in the diagnosis and treatment of cancer are also often involved. Hematologists, physicians that specialize in the diagnosis and treatment of disorders of the blood and the organs that produce blood cells, may become involved through consultation. A pathologist, or physician who specializes in studying tissue and cell samples, often to assist other

physicians in reaching the correct diagnosis, also may be consulted.

Both registered nurses and licensed practical nurses provide direct care to leukemia patients in general hospitals, homes, or other healthcare facilities. Good supportive nursing care and observation are necessary to:

- Prevent or monitor for the infections to which leukemia patients are so susceptible.
- Monitor for anemia and bleeding.
- Assist in treatments such as chemotherapy, radiation, bone-marrow transplantation, or in giving blood transfusions.
- Monitor vital signs.
- Provide teaching regarding the prevention of infection, the normal course of leukemia, including the fatigue so many patients feel, the signs and symptoms of anemia, and good dental care (both leukemia and chemotherapy are apt to cause sensitivity in the mouth, vulnerability to infection and bleeding).

Clinical laboratory scientists draw blood samples that are ordered by the physician to monitor the leukemia from the outset, during treatment, and also during remission. Radiologic technologists take x rays to visualize and monitor parts of the body that may be affected by the leukemia.

Prevention

Most cancers can be prevented by changes in lifestyle or diet, which will reduce the risk factors. However, in leukemias, there are no such known risk factors. Therefore, at the present time, no way is known to prevent leukemias from developing. People who are at an increased risk for developing leukemia because of proven exposure to ionizing radiation or exposure to the toxic liquid benzene, and people with Down syndrome, should undergo periodic medical checkups.

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ORGANIZATIONS

- American Cancer Society. 1599 Clifton Road, N.E., Atlanta, Georgia 30329. (800) 227-2345.
<<http://www.cancer.org>>.
- Cancer Research Institute. 681 Fifth Avenue, New York, N.Y. 10022. (800) 992-2623.
<<http://www.cancerresearch.org>>.
- National Cancer Institute. 9000 Rockville Pike, Building 31, Room 10A16, Bethesda, Maryland, 20892.
(800) 422-6237. <<http://wwwic.nci.nih.gov>>.
- Leukemia Society of America, Inc. 600 Third Avenue, New York, NY 10016. (800) 955-4572.
<<http://www.leukemia.org>>.

OTHER

- University of Pennsylvania Cancer Center. Oncolink.
<<http://cancer.med.upenn.edu>>.

Joan M. Schonbeck

Leukemias, chronic

Definition

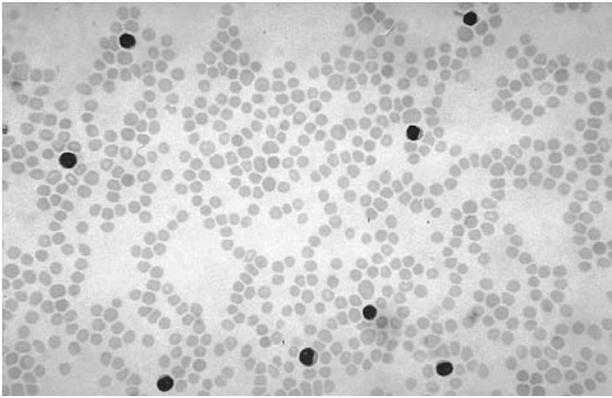
Chronic leukemia is a type of **cancer** in which excessive quantities of abnormal white **blood** cells are produced, usually slowly, often over a period of years.

Description

Medical science further classifies chronic leukemia by the type of white blood cell that undergoes mutation. The most common of these are:

- Chronic lymphocytic leukemia (CLL), in which mature-appearing white blood cells called lymphocytes are produced.
- Chronic myeloid (or myelogenous) leukemia (CML), also known as chronic granulocytic leukemia (CGL), is the result of uncontrolled proliferation of white blood cells called granulocytes.

Chronic leukemias are much less rapid-growing than acute leukemia, and affect adults far more often than children. In fact, nearly all the people who develop CLL are over 50 years of age. CML is also a disease primarily of middle-aged to elderly people, but 3% of all childhood leukemias are classified as CML, and the average age for developing CML is between ages 10 and 12.



A magnified stain of chronic lymphocytic leukemia cells.
(Custom Medical Stock Photo. Reproduced by permission.)

The cells that make up blood are produced in the bone marrow and the lymph system. The bone marrow is the spongy tissue found in the large bones of the body. The lymph system includes the spleen (an organ in the upper abdomen), the thymus (a small organ beneath the breastbone), and the tonsils (an organ in the throat). The lymph vessels (tiny tubes that branch like **blood vessels** into all parts of the body) and lymph nodes (small pea-shaped organs that are found along the network of lymph vessels) are also part of the lymph system. The lymph itself is a milky fluid that contains cells. Clusters of lymph nodes are found in the neck, underarm, pelvis, abdomen, and chest.

The cells found in the blood are the red blood cells (RBCs), which carry oxygen and other materials to all tissues of the body; white blood cells (WBCs), which fight **infection**; and the platelets, which play an important role in the clotting of the blood. The white blood cells can be further subdivided into three main types: granulocytes, monocytes, and lymphocytes.

The granulocytes have particles (granules) inside them that contain special **proteins** (enzymes) and several other substances that can break down chemicals and destroy microorganisms such as **bacteria**. Monocytes are the second type of white blood cell. They are also important in defending the body against pathogens.

The lymphocytes form the third type of white blood cell. The two primary types of lymphocytes, T lymphocytes and B lymphocytes, have different functions within the **immune system**. The B cells protect the body by making antibodies, which are proteins that can attach to the surfaces of bacteria and **viruses**. This attachment sends signals to many other cell types to destroy the antibody-coated organism. The T cells protect the body against viruses. When a virus enters a cell, it produces certain proteins that are projected onto the surface of the

infected cell. The T cells recognize these proteins and make certain chemicals that are capable of destroying the virus-infected cells. In addition, the T cells can destroy some types of cancer cells.

The bone marrow makes stem cells, which are the precursors of the different blood cells. Stem cells mature into RBCs, WBCs, or platelets. In chronic leukemias, blood cells suddenly begin to proliferate rapidly and begin to accumulate in various organs and tissues, thereby affecting their normal function. This uncontrolled proliferation of the immature cells in the bone marrow affects the production of the normal red blood cells and platelets as well.

Different types of white blood cells are involved in chronic lymphocytic leukemia and chronic myeloid leukemia. Although some blasts, or immature cells (the hallmark of acute leukemia), are also present in chronic leukemia, it is the T or B lymphocytes that gradually mutate and become cancerous. The scenario is similar for chronic myelogenous leukemia, also known as chronic granulocytic leukemia (CGL), which occurs when unusually large numbers of granulocytes begin to appear in the bloodstream.

Leukemias account for 2% of all cancers. According to the estimates of the American Cancer Society (ACS), approximately 29,000 new cases of leukemia are diagnosed each year in the United States. Of these, 27,000 will be diagnosed in adults, 2000 in children. Leukemia is the most common form of childhood cancer, and it is often regarded as a disease of childhood. However, leukemias, especially chronic leukemia, affect far more adults than children. Half of all leukemia cases occur in people who are 60 years of age or older, and the overwhelming majority of chronic leukemias occur in adults. The incidence of both acute and chronic leukemias is about the same.

Causes and symptoms

Leukemia strikes both sexes and all ages. The human T-cell leukemia virus (HTLV-I), a virus with similarities to the human immunovirus (HIV), is believed to be the causative agent for some kinds of leukemias, but this has not yet been proven. To date, the cause of most leukemias is not known. Lymphoid leukemias are more common among Caucasians than among African-Americans, while myeloid leukemias affects both races equally. The incidence of leukemia is slightly higher among men than women. People with Jewish ancestry have a higher likelihood of getting leukemia. A higher incidence of leukemia has also been observed among persons with **Down syndrome** and some other genetic abnormalities. Patients with chronic myeloid leukemia often show a

chromosome abnormality called the Philadelphia chromosome, that occurs when one chromosome attaches to another.

Exposure to ionizing radiation, such as occurred in Japan after the atomic bomb explosions, has been shown to increase the risk of getting leukemia. Electromagnetic fields are suspected of being a possible cause, as are certain organic chemicals such as benzene. Having a history of diseases that damage the bone marrow, such as aplastic anemia, or a history of cancers of the **lymphatic system** puts people at a high risk for developing leukemias. Similarly, the use of anticancer medications, immunosuppressants, and the antibiotic chloramphenicol are also considered risk factors for developing leukemias.

The symptoms of chronic leukemia are generally vague and non-specific, and are frequently overlooked until they are noticed on routine **physical examination**, especially when a routine blood test such as a **complete blood count** (CBC) is performed. A CBC may show unusually large numbers of a certain type of lymphocyte in the blood. Chronic leukemias may go for years without manifesting any symptoms at all, but also can develop symptoms similar to **acute leukemias**. Chronic myeloid leukemia, in particular, has two phases, a chronic one that can last for several years, and a malignant phase in which immature granulocytes are suddenly generated in huge numbers, producing similar symptoms to acute leukemia. In such cases, a patient may experience all or some of the following symptoms:

- weakness or chronic fatigue
- fever of unknown origin, chills, and flu-like symptoms
- unexplained weight loss
- frequent bacterial or viral infections
- viscous (sticky) blood (which slows down the supply to various organs)
- headache
- non-specific bone pain
- easy bruising
- bleeding from gums or nose
- blood in urine or stools
- swollen and tender lymph nodes and/or spleen
- abdominal fullness
- night sweats
- petechiae, or tiny red spots under the skin
- priapism, or persistent, painful erection of the penis
- rarely, sores in the eyes or on the skin

Diagnosis

As noted, there are often no symptoms present for chronic leukemia, and there are no screening tests available. If the physician has reason to suspect leukemia, a very thorough physical examination will be conducted to look for enlarged lymph nodes in the neck, underarm, and pelvic region. Swollen gums, enlarged **liver** or spleen, bruises, or pinpoint red rashes all over the body are some of the signs of leukemia. Urine and blood tests may be ordered to check for microscopic amounts of blood in the urine and to obtain a complete differential blood count, which gives the numbers and percentages of the different cells found in the blood. An abnormal blood test might suggest leukemia. However, the diagnosis has to be confirmed by more specific tests.

The physician may perform a bone marrow biopsy, during which a cylindrical piece of bone and marrow is removed, generally taken from hipbone. A spinal tap (lumbar puncture) is another procedure that may be ordered. In this procedure, a small needle is inserted into the spinal cavity in the lower back to withdraw some cerebrospinal fluid and to look for leukemic cells.

Standard imaging tests such as x rays, computed tomography (CT) scans, and **magnetic resonance imaging** (MRI) may be used to check whether the leukemic cells have invaded other areas of the body, such as the bones, chest, **kidneys**, abdomen, or **brain**. A gallium scan, or bone scan, is a test in which a radioactive chemical is injected into the body. The chemical accumulates in the areas of cancer or infection, allowing them to be viewed with a special camera.

Treatment

The need for treatment is assessed according to the degree of enlargement of the liver and spleen, a serious decline in the number of platelets in the blood, and whether or not anemia is present, and if present, how severe. Once begun, the goal of treatment is the same as for acute leukemia: remission, or an arresting of the disease process. There are two phases of treatment for leukemia. The first phase is called induction therapy, in which the main aim is to reduce the number of leukemic cells as much as possible and induce a remission in the patient. Once no leukemic cells are detected in blood tests and bone marrow biopsies, the patient is said to be in remission.

The second phase of treatment is then initiated. This is called continuation, or maintenance therapy, and the aim in this case is to kill any remaining cells and to maintain the remission for as long as possible.

KEY TERMS

Antibodies—Proteins made by the B lymphocytes in response to the presence of infectious agents in the body, such as bacteria or viruses.

Biopsy—The surgical removal and microscopic examination of living tissue for diagnostic purposes.

Chemotherapy—Treatment with anticancer drugs.

Computerized tomography (CT) scan—A series of x rays put together by a computer in order to form detailed pictures of areas inside the body.

Immunotherapy—Treatment of cancer by stimulating the body's immune defense system.

Lumbar puncture—A procedure in which the doctor inserts a small needle into the spinal cavity in the lower back to withdraw some spinal fluid for testing; also known as a spinal tap.

Magnetic resonance imaging (MRI)—A medical procedure using a magnet linked to a computer to picture areas inside the body.

Maturation—The process by which stem cells transform from immature cells without a specific function into a particular type of blood cell with defined functions.

Radiation therapy—Treatment using high-energy radiation from x-ray machines, cobalt, radium, or other sources.

Remission—A disappearance of a disease as a result of treatment. Complete remission means that all disease is gone; partial remission means that the disease is significantly improved by treatment, but residual traces are still present.

Chemotherapy

Chemotherapy is usually the treatment of choice in leukemia, and is used to relieve symptoms and achieve long-term remission of the disease. Generally, combination chemotherapy, in which multiple drugs are used, is more efficient than using a single drug for the treatment. Some drugs may be administered intravenously (through a vein), while others may be given by mouth in the form of pills. If the cancer cells have invaded the brain, then chemotherapeutic drugs may be put into the fluid that surrounds the brain through a needle in the brain or back. This is known as intrathecal chemotherapy.

Radiation

Radiation therapy, which involves the use of x rays or other high-energy rays to kill cancer cells and shrink tumors, may be used in some cases. For leukemias, the source of radiation is usually outside the body (external radiation therapy). If the leukemic cells have spread to the brain, radiation therapy can be given to the brain.

Bone marrow transplantation

Bone marrow transplantation is a process in which the patient's diseased bone marrow is replaced with healthy marrow. There are two ways of doing a bone marrow transplant. In an allogeneic bone marrow transplant, healthy marrow is taken from a donor whose tissue is either the same as or very closely resembles the patient's tissues. The donor may be a twin, a sibling, or a person who is not related at all. First, the patient's bone marrow is destroyed with very high doses of chemotherapy and radiation therapy. Healthy marrow from the donor is then administered to the patient through a needle in a vein to replace the destroyed marrow.

In the second type of bone marrow transplant, called an autologous bone marrow transplant, some of the patient's own marrow is taken out and treated with a combination of **anticancer drugs** to kill all the abnormal cells. This marrow is then frozen to save it. The marrow remaining in the patient's body is destroyed with high-dose chemotherapy and radiation therapy. The thawed marrow is returned to the patient intravenously. This mode of bone marrow transplant is currently being investigated in clinical trials.

Biological therapy, or immunotherapy, is a mode of treatment in which the body's own immune system is harnessed to fight the cancer. Interferon is a biological therapy that is increasingly being used. Substances that are routinely made by the immune system, such as growth factors, hormones, and disease-fighting proteins, are either synthetically made in a laboratory or their effectiveness is boosted, and they are then put back into the patient's body. This treatment mode is also being investigated in clinical trials all over the country at major cancer centers.

Because leukemia cells can spread to all the organs via the bloodstream and the lymph vessels, surgery is not considered an option for treating leukemias.

Prognosis

Like all cancers, the prognosis for leukemia depends on the patient's age and general health. According to statistics, more than 60% of the patients with leukemia survive for at least a year after diagnosis. More than half the

patients diagnosed with chronic lymphocytic leukemia survive for at least five years due to the slowness of the disease process. Eventual death for CLL patients usually is the result of repeated and overwhelming infections. The outlook for chronic myeloid leukemia is generally less optimistic. Overall, average survival time for CML patients from the time of diagnosis is three years. However, 20% of all CML patients survive for at least 10 years, and bone marrow transplantation is improving the outcome.

Health care team roles

In most cases, a diagnosis of leukemia is made in a physician's office, a general medical clinic, or an emergency room by a primary care practitioner. Children and adolescents with leukemia are likely to be diagnosed by their primary care physician, pediatrician, or pediatric nurse practitioner. Oncologists, specialists in the diagnosis and treatment of cancer, are also often involved.

Hematologists, specialists in the diagnosis and treatment of disorders of the blood and the organs that produce blood cells, may be consulted. A pathologist, a specialist in studying tissue and cell samples, may also assist in diagnosis.

Both registered Nurses (RNs) and licensed practical nurses (LPNs) are often the people who deal the most with leukemia patients both in general hospitals, homes, or other health care facilities. Good supportive nursing care and observation are necessary to:

- Prevent or monitor for infections.
- Monitor for anemia and bleeding.
- Assist in treatments such as chemotherapy, radiation, bone-marrow transplantation, or blood transfusions.
- Monitor vital signs.
- Provide teaching regarding the prevention of infection, the normal course of leukemia, including fatigue, the signs and symptoms of anemia, and good dental care (both leukemia and chemotherapy can cause sensitivity in the mouth, and vulnerability to infection and bleeding).

Clinical laboratory scientists draw blood samples to monitor the leukemia from the outset, during treatment, and also during remission. Radiologic technologists chest x rays to visualize and monitor parts of the body that may be affected.

Prevention

There is no known way to prevent leukemias. People who are at an increased risk for developing leukemia because of proven exposure to ionizing radiation or

exposure to the toxic liquid benzene, and people with Down syndrome, should undergo periodic medical checkups.

Resources

BOOKS

- Behrman, Richard E. *Nelson Textbook of Pediatrics*. Philadelphia: W. B. Saunders, 1995.
- Berkow, Robert, and Mark H. Beers, eds. *Merck Manual of Diagnosis and Therapy, 17th ed.* Whitehouse Station, NJ: Merck Research Laboratories, 1999.
- Murphy, Gerald P. *Informed Decisions: The Complete Book of Cancer Diagnosis, Treatment and Recovery*. Atlanta, GA: American Cancer Society, 1997.

ORGANIZATIONS

- American Cancer Society. 1599 Clifton Road, N.E., Atlanta, Georgia 30329. (800) 227-2345.
<<http://www.cancer.org>>.
- Cancer Research Institute. 681 Fifth Avenue, New York, N.Y. 10022. (800) 992-2623.
<<http://www.cancerresearch.org>>.
- Leukemia Society of America, Inc. 600 Third Avenue, New York, NY 10016. (800) 955 4572.
<<http://www.leukemia.org>>.
- National Cancer Institute. 9000 Rockville Pike, Building 31, Room 10A16, Bethesda, Maryland, 20892. (800) 422-6237. <<http://wwwicic.nci.nih.gov>>.
- Oncolink. University of Pennsylvania Cancer Center.
<<http://cancer.med.upenn.edu>>.

Joan M. Schonbeck

Levodopa see **Antiparkinson drugs**

LGI see **Barium enema**

Licensed practical nurse

Definition

Licensed practical nurses (L.P.N.s) work under the direction of physicians and registered nurses to provide wellness, preventive, and other health care services to people of all walks of life, including those who are sick, injured, convalescent, and disabled.

Description

L.P.N.s, or licensed vocational nurses (L.V.N.s), as they are called in Texas and California, provide basic bedside care. They work under the supervision of an **registered nurse**, physician, or other health care provider.

L.P.N.s work as part of the health care team taking **vital signs**, including temperature, pulse, **blood pressure**, and respiration. They record patients' progress, including patients' food and beverage intake and output. L.P.N.s help hospitalized, bedridden, and other patients with personal hygiene, assisting with bathing and dressing, as well as caring for patients' comfort and emotional well-being.

L.P.N.s can be scrub nurses. Scrub nurses directly assist surgeons in the operating room. They are responsible for setting up sterile instruments and supplies and handing them to the operating surgeon or surgical assistant during the procedure. L.P.N.s prepare and give injections and **enemas**. They treat bedsores, apply dressings, give alcohol rubs and massages, care for tracheostomies, apply ice packs and hot water bottles, and insert catheters. Often, L.P.N.s observe patients so that the nurses can report adverse reactions to treatments or medications. They help to prepare patients for testing by feeding them or giving them necessary liquids. L.P.N.s also collect patient samples for testing and perform some routine laboratory tests. In some states, L.P.N.s are allowed to administer prescribed medications or start intravenous fluids. L.P.N.s also help deliver babies, and care for and feed infants.

In some cases, experienced L.P.N.s supervise other health care professionals, including nursing assistants and aides. In addition to clinical tasks, L.P.N.s provide a variety of clerical or administrative services. Especially when they work in doctors' offices and clinics, L.P.N.s often assist the administrative staff by making appointments, keeping records and answering phones. As other types of nurses, L.P.N.s take part in educating patients about health care, preventive health maintenance, and at-home treatment. They help to promote preventive measures in community health and act to safeguard health and life. L.P.N.s who work in private homes, caring for people who are unable to care for themselves full-time, often help with daily tasks, such as cooking and running errands.

L.P.N.s often assume broad responsibilities when working in **nursing homes**. In addition to providing general bedside services, L.P.N.s employed in nursing homes might assist the health care team, which general includes registered nurses and physicians, with evaluating residents' needs, initiating care plans and overseeing the activities of nurse aides.

In 1998, L.P.N.s held about 692,000 jobs. It is important that anyone considering a career as a L.P.N. is caring and sympathetic in nature. The job can be emotionally stressful because these nurses often work with the critically or chronically ill. It requires that the nurse

exhibit emotional stability and be able to take direction from other types of nurses, doctors and other supervisory staff.

L.P.N.s enjoy flexible work schedules, especially in the hospital setting, where they can work nights and weekends. Most who work full time work a 40-hour week. One in four L.P.N.s worked part time in 1998. Some of the drawbacks of the job are the **stress** levels, which can be exacerbated by heavy workloads and patients who are confused or irrational due to their illnesses. Most L.P.N.s spend much of their working hours on their feet, and the job can often require heavy lifting. At times, because of the nature of their work, L.P.N.s can be at risk for exposure to caustic chemicals, radiation and infectious diseases, including hepatitis. It is important that L.P.N.s always observe health guidelines.

L.P.N.s earned median annual earnings of \$26,940 in 1998. The highest area of reported median annual earnings was in personnel supply services, which was at \$30,200 a year. The lowest annual earnings were reported by L.P.N.s working in doctors' offices and clinics, which was \$24,500. L.P.N.s who work hourly are reported to make from \$12 to \$18 an hour.

Work settings

L.P.N.s work in all types of health care settings, including hospitals, clinics, **public health** environments, home health care agencies, assisted living facilities, rehabilitation facilities and nursing homes. Thirty-two percent of L.P.N.s worked in acute care hospitals in 1998, while 28% worked in nursing homes and 14% worked in doctors' offices and health care clinics. Many others work for temporary help agencies, residential care facilities, schools and government agencies.

Education and training

L.P.N.s must pass a licensing examination once they complete a state-approved practical nursing program. While most state-approved programs require a high school diploma, some do not and will allow someone with a high school diploma or specific GED score to participate in the program. Many programs require that potential students pass an entrance exam and interview with the program's director.

About 1,100 state-approved programs provided practical nursing training in 1998. Nearly six in every 10 of these students went to technical or vocational schools. Three in 10 of these students attended programs in community and junior colleges; while the remaining students graduated from programs in high schools, hospitals, colleges, and universities.

Practical nursing programs prepare students to qualify and pass the National Council Licensure Examination. After their scholastic training, L.P.N.s should be able to utilize the nursing process to care for patients. They learn to teach patients about health maintenance and prevention of disease. Essentially, L.P.N.s learn to function as generalists in practical nursing in a variety of health care settings. Practical nursing programs usually require that students go through about a year of learning in the classroom and supervised clinical practice. In the classroom, these nurses discover basic nursing concepts and patient care. These nurses take classes in such subjects as: anatomy, physiology, medical-surgical nursing, **medical terminology**, pediatrics, **pharmacology**, obstetrics, psychiatric nursing, advanced nursing procedures, geriatrics, administration of drugs, **nutrition**, health and wellness, and **first aid**. Clinical practice might be in the hospitals in addition to other health care settings, including community health care clinics, schools, nursing homes and rehabilitation settings.

Advanced education and training

L.P.N.s can continue their educations to become registered nurses, or RNs. RNs have expanded roles, working collaboratively with physicians and other health care providers. They often oversee the work of L.P.N.s. RNs must graduate from a nursing program and pass a national licensing examination to become licensed. They must periodically renew their licenses and, depending on which state they work, must also take continued education courses for license renewal. There were more than 2,200 entry-level RN programs in the United States in 1998. RNs can pursue one of three educational options. They can achieve an associate degree in nursing, which is usually offered at community and junior colleges and is about two years long; a bachelor of science degree in nursing, taken at colleges and universities and usually taking from four to five years; or a diploma program, which is given in hospitals and lasts about two to three years. Licensed graduates of any of these levels usually qualify to start work at the staff nurse level. Most RNs graduate with either an associate's or bachelor's degree. There has been talk of the requirement for an RN changing to a bachelor's degree or higher; however, this would not affect current associate degree RNs and would probably take place on a state-by-state basis. Most agree that there are more opportunities for advancement for RNs with bachelor's degrees in nursing. A bachelor's often is necessary for administrative positions and is required for admission to graduate nursing programs of all types, including research, consulting, teaching and clinical specialization. Today an increasing number of nurse executives are saying that they want a majority of their hospi-

KEY TERMS

Registered nurse—A nurse who has graduated from a nursing program, including an associate degree, bachelor of science degree or diploma program, and passed a national licensing examination.

Scrub nurse—Scrub nurses directly assist surgeons in the operating room. They are responsible for setting up sterile instruments and supplies and handing them to the operating surgeon or surgical assistant during the procedure.

tal staff nurses to have bachelor's degrees because of the more complex demands of patient care. In 1996, 27 percent of RNs reported having a diploma, 31% had a bachelor's degree and 32% held an associate's degree.

Students in R.N. programs take courses in anatomy, physiology, microbiology, nutrition, psychology, chemistry, nursing, and other behavioral sciences. In addition to classroom instruction, nursing students receive supervised clinical experience in hospitals and other health care facilities. Nursing students received a variety of clinical experience in settings such as hospital maternity, psychiatric, pediatric, and surgical wards. They also gain experience in public health departments, home health agencies and ambulatory clinics.

Once they become RNs, nurses can go on to become **advanced practice nurses**, which include nurse practitioners, clinical nurse specialists, certified registered nurse anesthetists and certified nurse-midwives. Advanced practice nurses generally have master's degrees or certificates. Nurse practitioners deliver front-line primary and acute care. They can prescribe medications and diagnose and treat common acute illnesses and injuries. Nurse practitioners provide immunizations, conduct physical exams and provide care to manage chronic diseases, such as diabetes. Certified nurse-midwives are trained to provide prenatal and gynecological care to healthy women. They also deliver babies in all types of settings, including at the patient's home, and provide **postpartum care**. Clinical nurse specialists specialize in areas such as cardiology, oncology and pediatrics. Certified registered nurse anesthetists administer anesthetics to patients in in-patient, outpatient and in-office settings. They are often the sole providers of anesthesia.

RNs can also go on to careers in teaching, research or administration. These areas require master's in nursing degrees or Ph.D. or other doctorate level degrees.

Doctorally-prepared RNs tend to go into education or research.

Future outlook

The future looks good for L.P.N.s. Job growth in this area of nursing is expected to grow as fast as the average for all occupations through 2008. The job growth can be attributed to a rapidly aging population, which will require long-term care. The area that appears to be not as promising for L.P.N.s is in the acute care hospital setting, where the number of openings for L.P.N.s is expected to decline. This is due to an expected decrease in the number of admitted patients. Nursing home employment for L.P.N.s is expected to grow; in fact, geriatric care is where L.P.N.s will find the most opportunity. The growth in nursing home employment of L.P.N.s is not only attributed to the growth in the aging population but also to an expected increase in the number of patients who are released early from hospitals but cannot yet take care of themselves at home.

Home health care looks promising for L.P.N.s. Many of the aged and ill will prefer to stay at home rather than be admitted to a nursing home. Technological advances will make it possible for more people to live out much of their remaining years at home.

Employment also is expected to grow much faster than average in settings that will benefit from advances in health care technology, including outpatient surgery centers, emergency medical centers and some physicians' offices and clinics. Here, too, L.P.N.s will find more opportunity in the future.

Resources

ORGANIZATIONS

Central School of Practicing Nursing, 4600 Carnegie Avenue, Cleveland, OH 44103. <www.cspnohio.org>.

OTHER

Occupational Outlook Handbook, U.S. Department of Labor, Bureau of Labor Statistics, Division of Information Services, 2 Massachusetts Ave. NE, Room 2860, Washington, DC 20212. (202) 691-5200. <<http://stats.bls.gov>>.

Lisette Hilton

Ligament sprain see **Sprains and strains**

Ligament tests see **Orthopedic tests**

Light therapy see **Phototherapy**

Lipase tests see **Amylase and lipase tests**

Lipid tests

Definition

Lipid tests routinely performed on plasma include measurement of total cholesterol, triglycerides, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein (LDL) cholesterol. Lipid tests may also be performed on amniotic fluid and include tests for lecithin and other pulmonary surfactants.

Purpose

The purpose of **blood** lipid testing is to determine whether abnormally high or low concentrations of a specific lipid are present. Low levels of cholesterol are associated with **liver** failure and inherited disorders of cholesterol production. Cholesterol is a primary component of the plaques that form in atherosclerosis and is therefore the major risk factor for the rapid progression of **coronary artery disease**. High blood cholesterol may be inherited, or result from other conditions such as biliary obstruction, **diabetes mellitus**, hypothyroidism, and nephrotic syndrome. In addition, cholesterol may be increased in persons who have a diet rich in saturated **fats** and cholesterol and who lead a sedentary lifestyle. Low levels of triglyceride are seen in persons who have malnutrition or malabsorption. Increased levels are associated with diabetes mellitus, hypothyroidism, **pancreatitis**, glycogen storage diseases, and estrogens. Diets rich in either **carbohydrates** or fats may cause elevated triglycerides in some persons. Although not a component of the atherosclerotic plaque, triglycerides increase blood viscosity and promote **obesity** that can contribute to coronary disease. The majority of cholesterol and triglyceride testing is performed to screen persons for increased risk of coronary artery disease.

Lipid tests are performed on amniotic fluid to determine the maturity of the fetal **lungs**. Tests are performed prior to delivery to ensure that there is sufficient pulmonary surfactant to prevent collapse of the lungs during exhalation.

Description

Cholesterol screening can be performed with or without fasting and should include total and HDL cholesterol tests. The frequency of cholesterol testing depends on the patient's risk for CAD. Adults over 20 with total cholesterol levels below 200 mg/dL need to be tested once every five years. People with higher levels should be tested for LDL cholesterol and tested at least once per year thereafter, if the LDL cholesterol is 130

mg/dL or higher. The National Cholesterol Education Program (NCEP) suggests further evaluation when the patient has any of the symptoms of CAD or if she or he has two or more of the following risk factors for CAD:

- high **blood pressure**
- cigarette smoking
- diabetes
- low HDL levels
- family history of CAD
- age, men over 45 years and women over 55 years

Measurements of cholesterol and triglycerides are routinely performed using enzymatic methods. For cholesterol, the cholesterol oxidase method is used. Plasma or serum is mixed with a reagent containing cholesterol ester hydrolyase, cholesterol oxidase, peroxidase, and a chromogen. The cholesterol ester hydrolyase converts cholesterol esters (cholesterol coupled to a fatty acid) to free cholesterol. This reacts with cholesterol oxidase forming an oxidation product and hydrogen peroxide. The peroxidase enzyme catalyzes the oxidation of the chromogen by the hydrogen peroxide. This forms a red colored product that can be measured with a spectrophotometer. The amount of light absorbed at 500 nm is directly proportional to cholesterol concentration. HDL cholesterol is usually measured by the same reaction except that the enzymes are coupled to polyethylene glycol (PEG). In the presence of sulfated cyclodextrin, these enzymes will not react with the cholesterol in LDL, VLDL, or chylomicrons. LDL cholesterol is measured by first precipitating the other lipoproteins using a mixture of antibodies to apolipoprotein C and apolipoprotein E. The LDL cholesterol can be separated by centrifugation and then measured using the cholesterol oxidase reaction. Alternatively, LDL cholesterol can be calculated using the Friedewald formula. LDL cholesterol = total cholesterol minus (HDL cholesterol + triglyceride/5). This formula will underestimate LDL cholesterol when triglycerides are above 400 mg/dL.

Triglycerides are routinely measured using the glycerol kinase reaction. The reagent contains the enzymes lipase, glycerol kinase, glycerol phosphate oxidase, and peroxidase. It also contains adenosine triphosphate (ATP) and a chromogen. Triglycerides are composed of glycerol that is bound (esterified) to three long chain fatty acids. The lipase sequentially splits the fatty acids from the molecule forming glycerol and free fatty acids. The glycerol kinase catalyzes the transfer of **phosphorus** from ATP to the glycerol forming glycerol-phosphate. The glycerol phosphate oxidase is used to oxidize this to dihydroxyacetone phosphate. This reaction generates hydrogen peroxide. In the final step, the peroxidase

enzyme catalyzes the oxidation of the chromogen by the hydrogen peroxide. This forms a red-colored product that can be measured with a spectrophotometer. The amount of light absorbed at 500 nm is directly proportional to triglyceride concentration. An important potential interfering substance in this reaction is glycerol, which is a common additive to many medications. If the Friedewald formula is used to calculate LDL cholesterol, the triglyceride measurement must be corrected by subtracting the plasma glycerol concentration from the triglyceride result.

Measurement of pulmonary surfactants

During the first half of gestation, lecithin and sphingomyelin levels in amniotic fluid are approximately equal. During the second half of **pregnancy**, lecithin production increases, but the sphingomyelin remains constant. Lecithin is the principal pulmonary surfactant secreted by the alveolar cells (type II granular pneumocytes) of the lung. Lecithin and the other surfactants prevent collapse of the air sacs during expiration. Infants born prematurely may suffer from **respiratory distress syndrome** (RDS) because levels of pulmonary surfactant are insufficient to prevent collapse of the air sacs. Tests for RDS are called fetal lung maturity (FLM) tests. The reference method for determining fetal lung maturity is the amniotic fluid L/S ratio. This is measured by thin layer chromatography in which lecithin and sphingomyelin in the amniotic fluid are separated and stained to determine their relative concentrations. An L/S ratio of 2:1 or higher is consistent with fetal lung maturity. Amniotic fluid levels of other surfactants such as phosphatidyl glycerol (PG), phosphatidyl glycerol, phosphatidyl inositol, and phosphatidyl ethanolamine may be measured by high performance liquid chromatography (HPLC). PG in amniotic fluid can be detected by a latex-coated antibody (latex agglutination) test. PG is an important marker for fetal lung maturity because a falsely positive test for lecithin may occur when the fluid is contaminated with blood or meconium. Since PG is not present in blood or meconium, and is only present when lecithin is adequate, a positive test is conclusive evidence of lung maturity. Measurement of lecithin which comprises about three quarters of the total surfactant composition at birth is most often measured by fluorescence polarization. This assay has replaced the L/S ratio as the FLM test in most labs. Most of the pulmonary surfactants are present in the form of lamellar bodies. These can be counted in the amniotic fluid using an electronic cell counter at the platelet threshold. The number of lamellar bodies is proportional to the quantity of surfactant.

KEY TERMS

Amniocentesis—A procedure to remove amniotic fluid from the womb using a fine needle.

Atherosclerosis—A disease of the coronary arteries in which cholesterol is deposited in plaques on the arterial walls. The plaque narrows or blocks blood flow to the heart. Atherosclerosis is sometimes called coronary artery disease, or CAD.

High-density lipoprotein (HDL)—A type of lipoprotein that protects against CAD by removing cholesterol deposits from arteries or preventing their formation.

Hypercholesterolemia—The presence of excessively high levels of cholesterol in the blood.

Hypertriglyceridemia—The presence of excessively high levels of TAG in the blood.

Lecithin—A phospholipid found in high concentrations in surfactant.

Lipid—Any organic compound that is greasy, insoluble in water, but soluble in alcohol. Fats, waxes, and oils are examples of lipids.

Lipoprotein—A complex molecule that consists of a protein membrane surrounding a core of lipids. Lipoproteins carry cholesterol and other lipids from the digestive tract to the liver and other body tissues. There are five major types of lipoproteins.

Low-density lipoprotein (LDL)—A type of lipoprotein that consists of about 50% cholesterol and is associated with an increased risk of CAD.

Plaque—An abnormal deposit of cholesterol, TAG, dead cells, lipoproteins and calcium on the wall of an artery.

Surfactant—A compound made of fats and proteins that is found in a thin film along the walls of the air sacs of the lungs. Surfactant keeps the surface pressure low so that the sacs can inflate easily and not collapse.

Tocolytic drug—A compound given to women to stop the progression of labor.

Triacylglyceride—A chemical compound that forms about 95% of the fats and oils stored in animal and vegetable cells. TAG levels are sometimes measured as well as cholesterol when a patient is screened for heart disease.

Precautions

Tests for triglycerides and LDL cholesterol must be performed following a 12-hour fast. The nurse or phlebotomist collecting the blood sample should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. Acute illness, high **fever**, starvation, or recent surgery lowers blood cholesterol and triglyceride levels. If possible, patients should also stop taking any medications that may affect the accuracy of the test.

Amniotic fluid is collected by a process called **amniocentesis**. This procedure is usually performed between the after the 33rd week of gestation to evaluate lung maturity. Spontaneous abortion can occur as a consequence of this procedure. Its overall incidence following amniocentesis is approximately 1%. Complications include premature labor and placental bleeding. The fluid may be contaminated with blood or meconium (intestinal contents of the fetus), which can interfere with some fetal lung maturity tests.

Preparation

Patients who are scheduled for a lipid profile test should fast (except for water) for 12-14 hours before the blood sample is drawn. If the patient's LDL cholesterol is to be measured, he or she should also avoid alcohol for 24 hours before the test. When possible, patients should also stop taking any medications that may affect the accuracy of the test results. These include **corticosteroids**, estrogen or androgens, oral contraceptives, some diuretics, haloperidol, some **antibiotics**, and **niacin**. Antilipemics are drugs that lower the concentration of fatty substances in the blood. When these are taken by the patient, blood testing may be done frequently to evaluate liver function as well as lipid levels.

Aftercare

Aftercare with the blood lipid tests includes routine care of the skin around the needle puncture. Most patients have no aftereffects, but some may have a small bruise or swelling. A washcloth soaked in warm water usually relieves any discomfort. In addition, the patient should resume taking any prescription medications that were discontinued before the test.

Care after amniocentesis requires that the clinician watch the patient for any signs of **infection** or possible injury to the fetus. Some things to look for are fever, vaginal bleeding, or vaginal discharge. The patient may feel sick and there may be some cramping. She should be advised to rest and to avoid strenuous activity. If labor is impending, supportive care should be provided to the

patient and tocolytic agents may be necessary to prevent the premature birth of the baby.

Complications

The primary risk to the patient with the lipid blood tests is a mild stinging or burning sensation during the venipuncture, with minor swelling or bruising afterward.

Amniocentesis, while much safer in the third trimester, and much safer now that it is done with the guidance of ultrasound technology does present a risk of **miscarriage** and fetal injury. The patient should be watched for any signs of bleeding, infection, or impending labor.

Results

The normal values for serum **lipids** depend on the patient's age, sex, and race. Normal values for people in Western countries are usually given as 140-220 mg/dL for total cholesterol in adults, although as many as 5% of the population have a total cholesterol higher than 300 mg/dL. Among Asians, the figures are about 20% lower. As a rule, both total and LDL cholesterol levels rise as people get older. Normal values for HDL cholesterol are also age and sex dependent. The range for males between 20-29 years is approximately 30-63 mg/dL and for females of the same age group it is 33-83 mg/dL. Normal values for fasting triglycerides are also age and sex dependent. The reference range for adult males 20-29 years is 45-200 mg/dL and for females of the same age group it is 37-144 mg/dL. As with cholesterol, the normal range increases with age.

Since diet and lifestyle affect normal values, which are determined by the interval between the 5th and 95th percentile of the group, it is more helpful to evaluate cholesterol and triglycerides from the perspective of desirable plasma levels. Desirable values defined by the Nation Cholesterol Education Program (NCEP) in 2001 are as follows:

- Total cholesterol: Less than 200 mg/dL; 200-239 mg/dL is borderline high and greater than 240 mg/dL is high.
- HDL cholesterol: Less than 40mg/dL is low.
- LDL cholesterol: Less than 100 mg/dL is optimal; near optimal is 100-129 mg/dL; borderline high is 130-159 mg/dL; high is 160-189 mg/dL; and very high is anything over 190 mg/dL.
- Total cholesterol: HDL ratio: Under 4.0 in males; 3.8 in females.

FLM tests

Low levels of surfactant in amniotic fluid are denoted by an L/S ratio less than 2.0 or a lecithin level less than or equal to 0.10 mg/dL. Lung development can be delayed in premature births and in babies whose mothers have diabetes.

Health care team roles

Physicians will order the blood lipid tests on patients who have risk factors for **heart** disease or who have not been tested within the past five years. A dietician may be consulted if test results are abnormal. FLM tests are ordered by a physician, usually an obstetrician. Lipid tests are performed by clinical laboratory scientists/medical technologists or clinical laboratory technicians/medical laboratory technicians.

Patient education

Nurses should explain the results of abnormal blood lipid tests to patients and advise them on lifestyle changes. **Patient education** is important in fetal lung maturity testing. The situation faced by the expectant parents may be very critical, and the more information they can be given, the better choices they can make.

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Jane E. Phillips

Lipids

Definition

Lipids are a wide-ranging group of organic compounds found in all living organisms, including humans,

KEY TERMS

Hypercholesterolemia—An excess of cholesterol in the blood.

Hyperlipidemia—A group of disorders characterized by an excess of fatty substances, such as cholesterol, triglycerides, and lipoproteins, in the blood.

Protoplasmic—Relating to protoplasm, a colorless jellylike substance that is the main constituent of all human cells and tissue.

plants, and animals. Lipids are the body's reserve supply of energy. Unlike other organic compounds, lipids are soluble in alcohol, ether, and other organic substances but not in water.

Description

Lipid comes from the Greek word *lipos*, meaning fat. Cells make lipids in the human body and, along with **carbohydrates** and **proteins**, are components of all life. Among the major classes of lipids in humans are acids, glycerol-derived lipids (including **fats** and oils), and steroids. The two major lipids found in the **blood** are cholesterol and triglycerides.

Cholesterol

Cholesterol is a lipid that is essential for repairing **cell membranes**, manufacturing **vitamin D** on the skin's surface, and creating hormones, especially testosterone and estrogen. To circulate in the bloodstream, cholesterol must attach to proteins. The combination of cholesterol and protein is called lipoprotein.

The two major lipoprotein groups are high-density lipoprotein (HDL), commonly referred to as "good" cholesterol, and low-density lipoprotein (LDL), also known as "bad" cholesterol. HDL helps prevent fat buildup throughout the body by carrying cholesterol from the arteries to the **liver**, where it is disposed of. LDL carries most of the cholesterol in the body, so an excess of LDL can clog the arteries with cholesterol buildup.

High levels of LDL are 100 milligrams or more per deciliter (mg/dL) of blood for people with **heart** or vascular disease or diabetes, 160 mg/dL for people with two risk factors, and 190 mg/dL or more for people with no risk factors. A high LDL level is a primary cause of coronary heart disease (CHD) and stroke. This is because when LDL accumulates in the body, it forms a plaque

that sticks to the walls of arteries, slowing or restricting blood flow and oxygen delivery to the heart and other vital organs. This causes atherosclerosis, commonly referred to as hardening of the arteries. The buildup of plaque usually occurs over a few years and without cholesterol tests the patient may not know about the problem until angina (chest pains) or an acute **myocardial infarction** (heart attack) occurs.

Among the key risk factors for high LDL are age, gender, smoking, diabetes, and a family history of the disorder. About 25% of people with high LDL can control the disorder with a diet low in saturated fats and cholesterol, weight control, and regular **exercise**. About 75% of people with high LDL require lipid-lowering medications in addition to the weight, diet, and exercise guidelines. First-line drugs recommended by the National Cholesterol Education Program to treat high LDL are bile acid sequestrants such as cholestyramine (Questran) and colestipol (Colestid), **niacin** (either over-the-counter or time-released prescription drugs such as Niaspan, Slo-Niacin, and Nicobid), and HMG-CoA reductase inhibitors, including fluvastatin (Lescol), pravastatin (Pravachol), cervistatin (Baycol), lovastatin (Mevacor), simvastatin (Zocor), and atorvastatin (Lipitor). The second-line drug choice are fibric acid derivatives such as gemfibrozil, clofibrate, and fenofibrate (Tricor.) Estrogen replacement therapy should also be considered as complementary therapy in postmenopausal women.

Levels of HDL between 30 and 75 mg/dL are associated with decreased risk of CHD and stroke. But HDL levels under 30 mg/dL are associated with a greater risk for CHD and stroke.

Triglycerides

Triglycerides are another form of fat that comes from foods and is carried through the bloodstream to the tissues. High levels of triglycerides in the blood can mean that there is too much fat in the diet. Hypertriglyceridemia (high levels of triglycerides) is associated with coronary heart disease, especially since elevated triglycerides levels are usually associated with unhealthy low levels of HDL, which is necessary for good health.

High triglyceride levels (more than 150 mg/dL) can be caused by excessive intake of alcohol or high-calorie foods. Other risk factors include a family history of high triglycerides, **obesity**, **hypertension** (high **blood pressure**), and diabetes. Treatment generally includes controlling other disorders such as diabetes and high blood pressure, proper diet and regular exercise, and fibric acid derivatives such as gemfibrozil, clofibrate, or fenofibrate.

Other lipids

Lipoprotein(a) is a cholesterol-carrying molecule similar in structure to LDL and is believed to carry a protein that interferes with the body's ability to dissolve blood clots. Elevated levels may contribute to heart attacks. Apolipoprotein A-1 is a molecule associated with healthy hearts and may lower the risk of heart disease due to high HDL. Apolipoprotein B is associated with high LDL and may be more effective in predicting heart disease in women. Remnant lipoproteins are byproducts of chylomicrons, lipid particles common in the blood during fat digestion and assimilation, and/or very low density lipoproteins. Initial research suggest they may be a risk factor for CHD.

Function

Lipids manufactured by cells in the body form part of the protoplasmic structure of cells. Lipids act as a reserve source of energy. When broken down to be used as energy, lipids are converted to an energy-rich compound called adenosine triphosphate by a process known as fatty acid oxidation or beta oxidation.

Role in human health

Lipids are important to the human body since they helps produce hormones, and builds cell membranes and other needed tissue. Lipids, both lipoproteins and triglycerides, are made and stored in the body and are used as energy sources. Lipids also play a major role in cardiovascular health.

Common diseases and disorders

The two primary conditions associated with lipids are hyperlipidemia and hypercholesterolemia. These conditions have no overt symptoms but can lead to several serious disorders, primarily:

- Angina, which is chest **pain** that occurs when the heart does not get enough oxygen. When angina is not caused by **stress** or physical exertion and becomes frequent and more severe, it is called unstable angina, and may indicate an impending heart attack.
- Atherosclerosis, also called hardening of the arteries, a condition in which fatty deposits called plaque build up inside the arteries, restricting blood flow.
- Coronary heart disease, in which the arteries narrow, restricting the flow of blood and oxygen to the heart. Lack of sufficient oxygen to the heart can lead to angina or a heart attack. Most cases of CHD are due to atherosclerosis.

- Stroke, a group of **brain** disorders involving loss of brain functions that occur when the blood supply to any part of the brain is interrupted. Strokes are most commonly caused by atherosclerosis.

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Ken R. Wells

Lipoproteins test

Definition

Lipids are water insoluble molecules and must be transported in the plasma as macromolecular complexes containing protein called lipoproteins. The lipoproteins are large aggregates (micelles) composed of cholesterol, triglycerides, phospholipids, **proteins**, and small amounts of **carbohydrates**. Generally, the core of the lipoprotein contains hydrophobic lipids surrounded by a sheath of protein and lipids arranged with the hydrophilic ends directed outward. Carbohydrates and enzymes are present in the outer sheath. The proteins that become part of the lipoprotein are called apoproteins. Lipoproteins are grouped into four main classes depending upon their density. In order from least to greatest density these are: chylomicrons, very low density lipoprotein (VLDL), low density lipoprotein (LDL), and high density lipoprotein (HDL).

Purpose

Lipoproteins are measured to classify persons with severe hyperlipoproteinemia or hypolipoproteinemia. The hyperlipoproteinemias result from increased production or decreased clearance of lipoproteins from the **blood** and may be inherited or secondary to other diseases or conditions. Some common causes of secondary hyperlipoproteinemia include **diabetes mellitus**, hypothyroidism, biliary cirrhosis, estrogens and **pancreatitis**. The cholesterol content of the LDL (LDL cholesterol) and HDL (HDL cholesterol) are measured, along with total cholesterol and triglycerides, to evaluate the patient's risk for coronary **heart** disease. In addition, a subclass of LDL called lipoprotein(a) or Lp(a) may be measured in persons who have a family history of **coronary artery disease** (CAD) or predisposing risk factors for CAD.

Description

Measurement

Measurement of lipoproteins may be performed by ultracentrifugation of the plasma. When plasma is subjected to very high centrifugal force, the lipoproteins can be separated in a gradient salt solution on the basis of their density. Since the density is directly related to protein content, the lipoproteins can also be separated by electrophoresis.

Electrophoresis is the separation of charged particles in an electrical field and is dependent on the amount and nature of the apoproteins within the lipoprotein. The

electrophoretic positions of the lipoproteins are often used to describe them. Thus, HDL is also called alpha-1 lipoprotein, VLDL is called prebeta lipoprotein, and LDL is called beta lipoprotein. Chylomicrons do not migrate and are not given any designation. When one or more plasma lipid levels are extremely elevated or reduced, either of these methods may be used to determine which lipoproteins are abnormal. On the basis of these findings, abnormal lipoproteins are classified into patterns. Since severe disorders of lipoprotein **metabolism** are often inherited, the abnormal patterns are called phenotypes. There are five abnormal lipoprotein phenotypes (Type I through Type V), each characterized by the presence of an extremely high quantity of one or two lipoproteins. Persons with severe hyperlipoproteinemia often have skin and tissue infiltration of fat deposits, and persons with Type II and Type III are predisposed to premature atherosclerosis owing to high levels of plasma cholesterol. Lipoprotein phenotyping is not performed as a screening test to evaluate risk of coronary artery disease.

Immunological methods are used to measure the quantity of specific apoproteins present in the plasma. Testing for apoA-I and apoB-100 the principal apoproteins of HDL and LDL, respectively is often performed in persons with elevated lipids who have risk factors associated with coronary artery disease. Measurement of a form of LDL, called Lp(a) is performed on these persons as well as on those who have normal lipid levels, but a family history of CAD.

HDL cholesterol is routinely measured along with total cholesterol and triglycerides as a screening test for coronary artery disease. If the total cholesterol is 200 mg/dL or higher the LDL cholesterol is measured. The measurement of HDL cholesterol is based upon the measurement of cholesterol (see entry on **lipid tests**) under conditions that inhibit the reaction with all lipoproteins except HDL. The measurement of LDL cholesterol involves precipitating the HDL, VLDL, and chylomicrons using antibodies to apoproteins A, and E, followed by measurement of the LDL cholesterol in the supernatant. When the triglyceride concentration is below 400 mg/dL, the LDL cholesterol is often estimated using the Friedewald formula [LDL cholesterol = total cholesterol minus (HDL cholesterol + triglyceride/5)]. It should be noted that this formula will underestimate LDL cholesterol when triglycerides are above 400 mg/dL.

Chylomicrons

Chylomicrons are made in the intestines mainly from dietary triglycerides. They are approximately 95% triglyceride and only 2% protein by weight. The major apoproteins of chylomicrons are apoC, B, and A.

Chylomicrons are degraded in the plasma by the enzyme lipoprotein lipase, which splits the triglycerides into glycerides, and fatty acids, which are mainly absorbed by cells. Smaller chylomicron remnants are returned to the **liver**, where they are degraded by hepatic lipase. In the blood, some of the apoprotein A and C from chylomicrons are transferred to HDL. The chylomicrons are lighter than water and will float to the top of the plasma when it is stored overnight in the refrigerator. Since plasma from a fasting specimen should not contain chylomicrons, the observation of this floating layer is significant and indicates a deficiency of peripheral lipase activity. Chylomicrons are found in the fasting plasma of persons with Type I and Type V hyperlipoproteinemia.

Very low-density lipoproteins (VLDL)

VLDL are formed in the liver using apoproteins partly recycled from chylomicron remnants. VLDLs are about 10% protein and 60-70% triglycerides by weight; consequently they account for only 10-15% of the plasma cholesterol. The triglycerides carried by the VLDL are derived from carbohydrate metabolism. VLDL is released into the circulation, where it is partly degraded. Excessively elevated VLDL is responsible for Type IV hyperlipoproteinemia and is most often caused by hyperinsulinemia, which promotes triglyceride production. When both chylomicrons and VLDL are greatly increased, the abnormality is defined as Type V hyperlipoproteinemia.

Some free cholesterol, triglycerides, and apoproteins from VLDL are transferred to HDL in the circulation. This forms a lipoprotein of greater density and roughly equal cholesterol and triglyceride content called intermediate density lipoprotein (IDL). The IDL is converted to LDL by enzymatic removal of triglycerides and apoC. IDL is not found in significant amounts in the circulation unless there is a defect in conversion of VLDL to LDL. Such cases are caused by a deficiency of apo E-III or apo C-III activated lipase. This results in the accumulation of IDL in the plasma. This is responsible for Type III hyperlipoproteinemia.

Low-density lipoprotein (LDL)

The LDL is composed of about 25% protein and 45-55% cholesterol by weight. LDL carries cholesterol to the cells and is then degraded by lysosomal hydrolysis. Since LDL contains the majority of the plasma cholesterol and is responsible for cholesterol transport to cells, it is positively correlated with the risk of coronary artery disease. LDL accumulates in the plasma when there is a deficiency of the apoB-100 receptor on cells. This is responsible for the Type II hyperlipoproteinemia. Low

levels of LDL occur in two inherited conditions. Abetalipoproteinemia results from a complete deficiency of apoB. This is an autosomal recessive condition associated with severe metabolic problems including intestinal malabsorption, motor nerve dysfunction, fat soluble vitamin deficiency and anemia. Hypobetalipoproteinemia is an autosomal dominant condition in which LDL levels are about 10% of normal. This condition may be associated with fat soluble vitamin deficiency that is treated by vitamin supplementation and with a very low risk for coronary artery disease.

High-density lipoproteins (HDL)

HDL is approximately 50% protein by weight. Phospholipids account for 25-30% of its mass and cholesterol for 15-20%. HDL is made in the liver partly from VLDL and chylomicrons. It binds to and esterifies cellular cholesterol and transports it to the liver, where it is used to make bile salts and acids. HDL provides the main route for cellular cholesterol clearance and its level is inversely related to coronary artery disease. Absent or nearly absent HDL occurs in an autosomal recessive hypolipoproteinemia called Tangier disease. This is caused by a deficiency of both apoA-I and apoA-II, the principal lipoproteins of HDL. Persons with this disease develop premature CAD.

Lipoprotein a or Lp(a)

Lp(a) contains apoB bound to another apoprotein that is designated apo(a). Like LDL it is about 27% protein and 65% lipid by weight and has prebata mobility on electrophoresis. The amount of Lp(a) in plasma is normally below 150 mg/dL. Elevated levels are considered to be an independent risk factor for developing coronary artery disease. High levels are inherited as an autosomal dominant trait and are not influenced by diet or **exercise**. It is speculated that the link between Lp(a) and atherosclerosis is related to the similarity between apo(a) and plasminogen. Plasminogen is the precursor of plasmin which initiates the lysis of blood clots.

Measurement guidelines

The Expert Panel of the National Cholesterol Education Program (NCEP) sponsored by the National Institutes of Health has published guidelines for the detection of high cholesterol in adults which are listed below. The NCEP panel recommends that adults over the age of 20 be tested for cholesterol and HDL every five years. If the cholesterol is high, the HDL is low (below 40 mg/dl), or other risk factors are present, a complete lipoprotein profile that includes total cholesterol, triglyc-

KEY TERMS

Atherosclerosis—Disease of blood vessels caused by deposits of cholesterol, fats, lipoproteins, cells and calcium on the inside walls of the vessels.

Cardiovascular disease—Disease that affects the heart and blood vessels.

Cholesterol—A fat-like substance called a lipid. It is used to build cell membranes, hormones and bile acids. The body makes cholesterol and gets it from food.

Lipoproteins—The packages in which cholesterol and TAGs travel throughout the body.

erides, HDL cholesterol, and LDL cholesterol should be performed.

Preparation

Initial screening for total cholesterol and HDL cholesterol may be performed on nonfasting persons. The tests require a blood specimen usually collected by venipuncture or fingerstick. The nurse or phlebotomist performing the test should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. If results require follow-up testing, the patient must fast for 12 hours before the test, eating nothing and drinking only water. The person should not have alcohol for 24 hours before the test. There should be a stable diet and no illnesses occurring in the preceding two weeks. A test for lipoprotein electrophoresis requires a 12-hour fast and a blood sample collected in EDTA.

Complications

Discomfort or bruising may occur at the puncture site or the person may feel dizzy or faint. Pressure to the puncture site until the bleeding stops reduces bruising. Warm packs to the puncture site relieve discomfort.

Results

In April 2001, the NIH released new NCEP guidelines to assist doctors and nurses in identifying who is at risk for CAD.

Total cholesterol guidelines are:

- desirable: < 200 mg/dL
- borderline high: 200-239 mg/dL
- high: > 240 mg/dL

High density lipoprotein guidelines reflect the fact that this lipoprotein is inversely related to risk for CAD.

LDL cholesterol guidelines are:

- low: < 40 mg/dL
- desirable: < 130 mg/dL (deciliter)
- optimal: < 100 mg/dL
- near optimal: 100-129 mg/dL
- borderline high: 130-159 mg/dL
- high: 160-189 mg/dL
- very high: > 190 mg/dL

The NCEP also identified factors that patients may have that make the risk of heart disease higher. Health care professionals are advised to help the patient lower their cholesterol as much as possible, if they have two or more of these risk factors:

- Cigarette smoking.
- High **blood pressure**, with a measurement of > 140/90 mm Hg (millimeters of mercury). In addition, it is considered a risk factor if the patient is on blood pressure lowering medications, even if they have achieved a normal blood pressure.
- Age, over 45 years in men and over 55 years in women. Estrogen, a sex hormone in women protects against heart disease. The levels of estrogen are lower after a woman goes through **menopause**, roughly after the age of 55.
- Low HDL cholesterol (less than 35 mg/dL). Note that HDL > 60 mg/dL is a negative risk factor for CAD.
- Family history of premature heart disease. Premature heart disease is defined as heart disease seen before age 55 in a male relative or before age 65 in a female relative.
- Diabetes mellitus.

Some people have normal variations in their lipoprotein and total cholesterol levels. Repeat testing may be necessary, especially if a value is at a borderline risk category point.

Health care team roles

Lipoprotein testing is ordered by a physician. A nurse or phlebotomist usually collects the blood sample for the tests. Testing is most often performed by clinical laboratory scientists/medical technologists or clinical laboratory technicians/medical laboratory technicians. All clinicians should be well versed in the NCEP guidelines and treatment recommendations including both dietary and drug interventions. Patient's with high cho-

lesterol levels may be requested to consult a dietician in order to evaluate their meal plans, and learn how to follow the Step 1 or 2 diets that may be needed to lower the LDL cholesterol.

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Jane E. Phillips

Liquid diets see **Fad diets**

Lithotripsy

Definition

Lithotripsy is a therapeutic medical procedure used to disintegrate stones (calculi) in the urinary tract and **kidneys**. Extracorporeal shock wave lithotripsy (ESWL) uses shock waves generated outside the body and is non-invasive. Intracorporeal shock wave lithotripsy (ISWL) delivers shock waves through a specially designed scope used for the urinary tract (ureteroscopy) and kidneys (nephroscopy) and is a minimally invasive procedure. Ultrasound lithotripsy also uses a scope to deliver ultrasonic waves (mechanical vibrations) and is minimally invasive.

Purpose

Lithotripsy is used when a kidney stone is too large to pass on its own, or when a stone becomes stuck in a ureter (a tube which carries urine from the kidney to the bladder) and will not pass. **Kidney stones** are extremely painful and can cause serious medical complications,

such as kidney damage, if not removed. Usually, stones smaller than 5 mm in diameter can pass without intervention, while stones larger than 7 mm in diameter require lithotripsy or the placement of a urethral or ureteral stent to help them pass. Stones larger than 10 mm require lithotripsy or surgery.

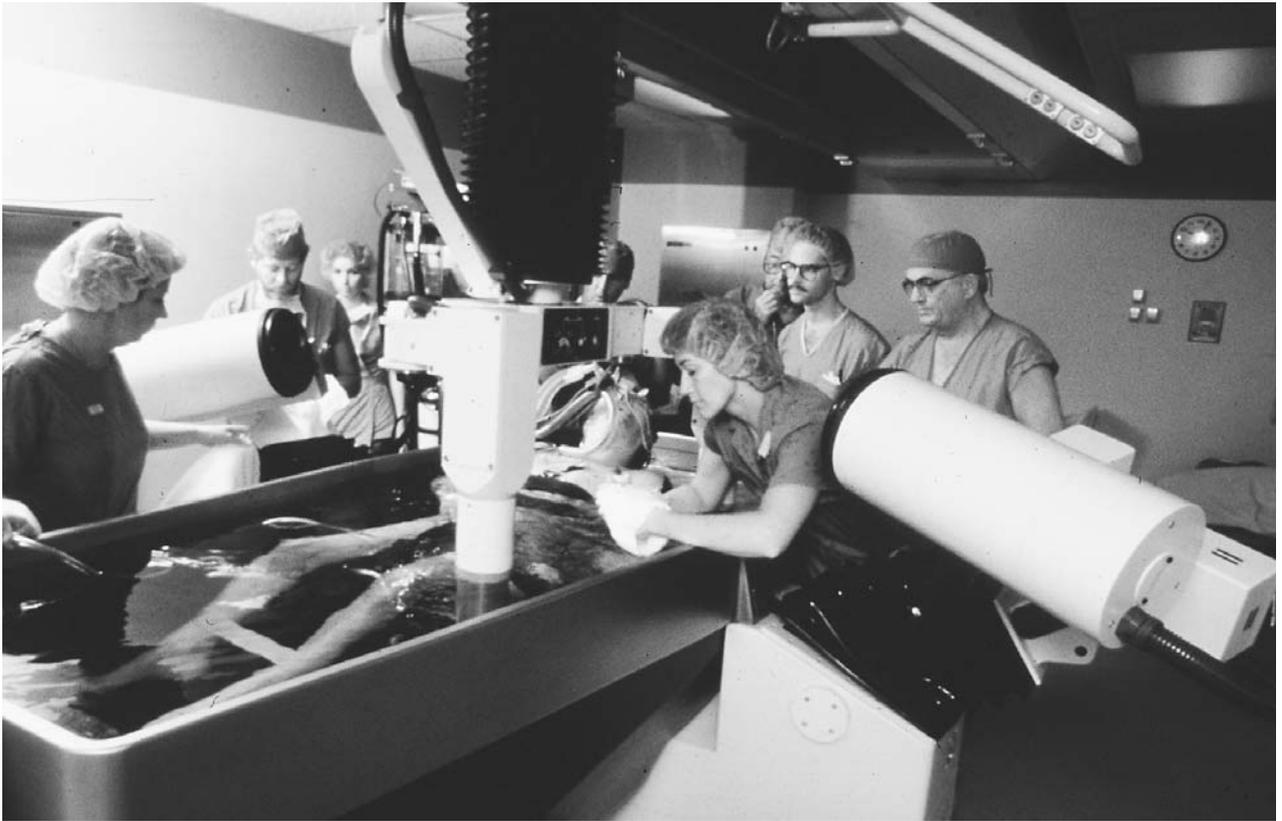
ESWL is a noninvasive alternative to open surgery (which is only very rarely performed for stones now) or percutaneous nephrolithotomy. ESWL is used in patients with stones less than or equal to 1 cm located in the kidneys or ureters. ISWL is a minimally invasive endoscopic technique that is used in patients with stones over 1 cm, with stones in the lower urinary tract, with impacted stones, and when ESWL is unsuccessful. Both ESWL and ISWL can also be used to fragment **gallbladder** and bile duct stones.

Precautions

ESWL should not be considered for patients with severe skeletal deformities, patients weighing over 300 lbs (136 kg), patients with abdominal aortic aneurysms, or patients with uncontrollable **bleeding disorders**. Patients who are pregnant should not be treated with ESWL. Patients with cardiac **pacemakers** should be evaluated by a cardiologist familiar with lithotripsy. Lithotripsy may temporarily inhibit the pacemaker or cause circuit damage leading to erratic functioning or cessation of the pacemaker. The cardiologist should be present during the lithotripsy procedure in the event there are problems with the pacemaker.

Description

Lithotripsy uses focused shock waves to fragment a stone in the kidney or the ureter. In ESWL, the patient is placed on a table in contact with a water-filled cushion; and a shock wave is generated, travels through the water, and shatters and fragments the stone. Older ESWL systems involved immersing the patient in a tub of water; but this space-consuming, awkward method has been replaced by water-filled cushions. Once the stone is fragmented, the resulting gravel is left to pass on its own; the patient may have been stented prior to the procedure to widen the urethra and or ureters to allow the fragments to pass easily and with less **pain**. In ISWL, a ureteroscopy is inserted through the urethra and bladder and into the ureters, or a nephroscope is inserted, usually through an incision in the patient's back. Once the stone is located using the **endoscope**, an electrohydraulic, laser, or ultrasound lithotripter can be used to fragment the stone. In ISWL using an electrohydraulic lithotripter, a probe is inserted through the endoscope and against the stone, and shock waves are delivered by a generator. In laser ISWL,



A lithotripter in use by patient in tub. This noninvasive method crushes kidney stones through shock waves. (Photo Researchers, Inc. Reproduced by permission.)

a pulsed-dye laser is used to deliver laser energy through a fiber inserted through the endoscope and into the stone. Ultrasound ISWL uses a generator to produce mechanical vibrations delivered to the stone via a probe tip inserted through the generator. In ISWL, after the stone is fragmented, the pieces can be removed using a grasper or basket or left to pass on their own if they are small enough.

Preparation

Prior to the lithotripsy procedure, a complete **physical examination** is done, including a urine analysis, followed by imaging tests to determine the number, location, and size of the stone or stones. A test called an intravenous pyelogram, or IVP, is often used to locate the stones and determine the degree of obstruction (blockage). An IVP involves injecting a dye (contrast medium) into a vein in the arm. This dye, which shows up on x ray, travels through the bloodstream and is excreted by the kidneys. The dye then flows down the ureters and into the bladder. The dye surrounds the stones, and x rays are then used to evaluate the stones and the anatomy of the **urinary system**. For those patients who are allergic to the dye, ultrasound, which uses focused sound waves, or

computed tomography without contrast dye is performed. **Blood** tests are done to determine if any potential bleeding problems exist. For women of childbearing age, a **pregnancy test** is done to make sure the patient isn't pregnant; and elderly patients have an electrocardiogram (ECG) done to make sure no potential **heart** problems exist. Some patients may have a stent placed prior to the lithotripsy procedure. A stent is a plastic tube placed in the ureter which allows the passage of gravel and urine after the procedure is completed.

Aftercare

Most patients have a lot of blood in their urine after the lithotripsy procedure. This is normal and should clear after several days to a week or so. Lots of fluids should be taken to encourage the flushing of any gravel remaining in the urinary system. The patient may be asked to urinate through a strainer and collect any stone fragments that pass for examination by the physician. Patients with stents may experience some discomfort during urination or during certain movements; this is normal. The patient should follow up with the urologist in about two weeks to make sure that everything is going as planned. If a stent

KEY TERMS

Aneurysm—A dilation of the wall of an artery which causes a weak area prone to rupturing.

Bladder—Organ in which urine is stored prior to urination.

Bleeding disorder—Problems with the clotting mechanism of the blood.

Cardiologist—A physician who specializes in problems with the heart and its vessels.

Computed tomography—An imaging examination that uses x-rays to produce a cross-sectional image of the anatomical area of interest; used to image the urinary tract and kidneys to detect kidney stones.

ECG—Electrocardiogram; a tracing of the electrical activity of the heart.

Gravel—The debris which is formed from a fragmented kidney stone.

IVP (Intravenous pyelogram)—The use of a dye, injected into the veins, used to locate kidney stones. Also used to determine the anatomy of the urinary system.

Kidney stones—Also called calculi; hard masses that form in the urinary tract and which can cause pain, bleeding, obstruction, or infection. Stones are primarily made up of calcium and can vary in size from a few millimeters to over a centimeter and more in diameter.

Nephroscope—An endoscope, a thin flexible tube with optics, used to examine the kidneys and through which intracorporeal lithotripsy can be performed.

Percutaneous nephrolithotomy—A minimally invasive endoscopic procedure involving a small incision in the back through which a nephroscope is inserted to remove stones from the kidney; used in conjunction with ISWL and after unsuccessful ESWL.

Stent—A small, short plastic tubular device placed in the urethra or ureters to widen them in order for stones and stone fragments to pass easily.

Ultrasound—Sound waves used to determine the internal structures of the body.

Ureter—A tube which carries urine from the kidney to the bladder.

Ureteroscope—An endoscope, a thin flexible tube with optics, used to examine the ureters and through which intracorporeal lithotripsy can be performed.

Urethra—A tube through which urine passes during urination.

Urologist—A physician who specializes in problems of the urinary system.

has been inserted, it is normally removed at this time. Patients may return to work whenever they feel able.

Occasionally, the ESWL procedure does not break stones into pieces small enough to pass. In these cases, an endoscope may be used to remove the pieces after the ESWL procedure.

Complications

Abdominal pain is not uncommon after lithotripsy, but it is usually not cause to worry. However, persistent or severe abdominal pain may imply unexpected internal injury. Colicky renal pain is very common as gravel is still passing. Other problems may include perirenal hematomas (blood clots around the kidneys); hemorrhage; **pancreatitis** (inflammation of the **pancreas**); damage to nearby organs and tissues (during ISWL); and obstruction by stone fragments. The most common complication is urinary tract **infection**, sometimes present

prior to the procedure due to obstruction by stones. Prophylactic **antibiotics** are administered to treat infection. Other postprocedural complications sometimes associated with the administration of anesthetics include nausea, vomiting, and allergic reaction.

Health care team roles

Lithotripsy is performed by a urologist or urologic surgeon, sometimes in conjunction with a radiologist, and with assistance from nursing staff for patient monitoring and medication administration during the procedure. The procedure may also be performed by a uro-radiologist. If ISWL requires **general anesthesia** or conscious sedation, an anesthesiologist and/or **nurse anesthetist** may need to be present for the procedure. Because ESWL uses x rays to locate the stones, a radiologic technologist may be required to assist with operating the x-ray equipment.

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ORGANIZATIONS

American Urological Association. 1120 North Charles Street, Baltimore, MD 21201. 410-727-1100. <<http://www.auanet.org>>.

National Kidney Foundation. 30 East 33rd Street, Suite 1100, New York, NY 10016. (800) 622-9010. <<http://www.kidney.org>>.

Society of Urologic Nurses and Associates. East Holly Avenue, Box 56, Pitman, NJ 08071-0056. 609-256-2335. <<http://suna.inurse.com/>>.

Jennifer E. Sisk, M.A.

Liver-spleen scan see **Liver radionuclide scan**

Liver

Definition

The liver is the largest gland and largest internal organ in the human body (the skin is the largest organ overall).

Description

Weighing 3-3.5 lbs (1.4-1.6 kg), the liver is a dark red, wedge-shaped gland approximately eight and a half inches long (roughly the size of a football). It is located in the right side of the abdominal area just below the diaphragm and above the **stomach**.

Approximately 1.5 qts (1.5 L) of **blood** flow through the liver each minute. The liver holds about 13% of the body's blood supply. It is furnished with blood from two large vessels, the portal vein and the hepatic artery (hepatic means liver). Blood that has circulated through the stomach, spleen, and intestine enters the liver through the portal vein as part of the portal circulation system.

The liver extracts nutrients and toxins from this blood, which is then returned through the hepatic vein to the right side of the **heart**. The hepatic artery supplies oxygenated blood directly from the heart to the liver.

Function

Some of the liver's many important functions include:

- Production of bile which is stored in the gall bladder and used to digest **fats**. If the excretion of bile is blocked, the stools become pale and retain fat. As a result, fat-soluble **vitamins** (vitamins A,D, E, and K) are not properly absorbed and levels of bilirubin, the main component of bile, rises in the blood. Once bilirubin levels reach a certain level, **jaundice** or yellowing of the skin and eyes occurs.
- Synthesis of **proteins**, including albumin. Albumin is the predominant protein in blood plasma and helps to retain fluid within the **blood vessels**. The loss of albumin results in fluid shifting from blood vessels to the surrounding tissue. The result is swelling of tissue, a condition called edema.
- Production of blood-clotting factors that control bleeding. Loss of clotting factors leads to increased chance of hemorrhage.
- **Metabolism** of hormones and medications, such as estrogen and acetaminophen (Tylenol). When the liver is damaged, its ability to metabolize hormones decreases. This can result in changes to estrogen and testosterone levels in the body. Symptoms of these changes include loss of pubic hair and the development of spider angiomas, small clusters of red blood vessels on the skin of the upper body, in both males and females. Men sometimes experience a decrease of testicular size and development of breast tissue (a condition called *gynecomastia*). A decline in the body's ability to metabolize medications means that normal doses can turn into toxic levels. Therefore, doses of medicines are often reduced for people who have liver disease.
- Regulation of glucose levels. Loss of liver cells leads to poorly controlled glucose levels. Glucose levels may soar after eating (hyperglycemia) or fall dangerously low between meals (hypoglycemia). This poor regulation of blood sugar is due to a different mechanism than the mechanisms that lead to diabetes types I and II.
- Conversion of ammonia, a by-product of metabolism, into a less toxic form called urea. Inability to convert ammonia to urea results in elevated ammonia levels in the blood. This can result in a condition called hepatic encephalopathy, which is a neurological syndrome characterized by alterations in mental status and behavior.

ior. Although acute episodes can be reversible, severe cases of hepatic encephalopathy can lead to **coma** and death.

Role in human health

A healthy liver enables the human body to:

- produce energy when needed
- manufacture new proteins
- store certain vitamins, **minerals**, and sugars
- regulate transport of fat stores
- regulate blood clotting
- facilitate the digestive process by producing bile
- control the production and excretion of cholesterol
- neutralize and destroy toxic substances
- metabolize alcohol
- monitor proper chemical and drug blood levels
- cleanse the blood and discharging waste products into the bile
- maintain hormone balance
- serve as the main fetal blood forming organ
- resist infection
- regenerate its damaged tissue
- store **iron**

Common diseases and disorders

Symptoms and signs of liver disease:

- jaundice, or abnormal yellowing of the skin and eyes (often the first, and may be the only, sign of liver disease)
- dark urine
- gray, yellow, or light colored stools
- nausea, vomiting, and/or loss of appetite
- intestinal bleeding due to liver diseases obstructing blood flow. (Bleeding may result in vomiting of blood, and bloody or black stools.)
- abdominal swelling (Liver disease may cause ascites, an accumulation of fluid in the abdominal cavity.)
- prolonged generalized itching
- an increase or decrease of more than 5% body weight in two months
- abdominal **pain**

- sleep disturbances, mental confusion, and coma that may result from an accumulation of toxic substances that impair **brain** function
- fatigue or loss of stamina
- loss of sexual drive or diminished performance

The most common liver diseases are as follows:

Viral hepatitis

- Hepatitis A spreads through contaminated water and food.
- Hepatitis B may be transmitted through transfusions, cuts, kissing, tooth brushing, ear piercing, tattooing, dental work, or during sexual contact.
- Hepatitis C primarily spreads through infected blood.

The liver often becomes tender and enlarged, and the patient usually experiences **fever**, weakness, nausea, vomiting, jaundice, and aversion to food. The virus may be present in the bloodstream, intestines, feces, saliva, and other body secretions. Hepatitis is common in the United States and some forms of it can be extremely infectious. Most people recover from viral forms of the disease without treatment, but some die and others may develop a chronic, disabling illness. In the United States there are more than four million hepatitis carriers.

Alcohol-related liver disorders

Liver disorders related to alcohol include fatty liver, alcoholic hepatitis, and alcoholic cirrhosis.

Fatty liver, the most common alcohol-related liver disorder, causes liver enlargement and abdominal discomfort. Swollen livers are often tender or painful, and may cause jaundice and liver function abnormalities.

Alcoholic hepatitis often results in nausea, vomiting, abdominal pain, fever, jaundice, liver enlargement and tenderness, and white blood cell count elevation. At times alcoholic hepatitis may be asymptomatic.

Cirrhosis

Over 25,000 Americans die from cirrhosis each year. It is the seventh leading cause of death. Among those 25-44, it is the fourth disease-related cause of death. Cirrhosis of the liver occurs when damaged liver cells are replaced by scar tissue causing diminished blood flow, which causes additional liver cell death. Loss of liver function results in gastrointestinal disturbances, emaciation, liver and spleen enlargement, jaundice, fluid accumulation in the abdomen and other tissues. Obstructed circulation often causes massive vomiting of blood.

KEY TERMS

Ascites—Accumulation of fluid in the abdominal cavity.

Bile—Yellowish substance released by the liver into the intestines to digest fats.

Any severe liver injury may cause cirrhosis. Over half of the deaths from cirrhosis result from alcohol abuse, hepatitis, and other **viruses**. Toxins, chemicals, excessive iron or **copper**, severe drug reactions, and bile duct obstruction may also cause cirrhosis.

Gallstones

Gallstones form when cholesterol and/or pigment in bile crystallize into gall stones. Gall stones vary in size from small pebbles to golf balls. Occasionally gallstones become lodged in the bile ducts leading from the **gallbladder** to the duodenum (first part of the **small intestine**). This may cause extreme abdominal pain. When gall stones block bile ducts, bile cannot flow into the intestines, and backs up into the bloodstream causing jaundice.

Gallstones are more common in people over 40, especially among women and the obese. Each year in the United States, 400-500,000 gallbladders are surgically removed.

Children's liver disorders

Tens of thousands of American children contract liver diseases causing hundreds of deaths each year. The most common of these diseases are:

Biliary atresia is caused by the lack, or inadequate size, of bile ducts connecting the liver to the intestine. Unable to excrete bile, death results from cirrhosis and bleeding by two years of age.

Chronic active hepatitis destroys liver cells replacing them with scar tissue. It is caused by an unknown process that resembles an allergy to the child's own liver tissue.

Galactosemia, an inherited disease, is caused by the lack of an enzyme needed to digest milk sugar. As a result, milk sugar accumulates in the liver and other organs, leading to cirrhosis of the liver, **cataracts**, and brain damage.

Wilson's disease occurs when copper accumulates in the liver due to an inherited abnormality, causing cirrhosis and brain damage.

Reyes syndrome is a fatal disorder in which fat accumulates in the liver.

Cirrhosis may result from extensive liver injury.

Liver cancer

Most **liver cancer** results from the spread of **cancer** from other organs to the liver (metastasis).

Resources

BOOKS

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ORGANIZATIONS

American Liver Foundation. 75 Maiden Lane, Suite 603, New York, NY 10038. 1-800-GOLIVER (1-800) 465-4837 <<http://www.liverfoundation.org/>>.

Bill Asenjo, MS, CRC

Liver biopsy

Definition

A **liver biopsy** is a medical procedure performed to obtain a small piece of liver tissue for diagnostic testing. The sample is examined under a **microscope** by a doctor who specializes in the effects of disease on body tissues (a pathologist) to detect abnormalities of the liver. Liver biopsies are sometimes called percutaneous liver biopsies, because the tissue sample is obtained by going through the patient's skin. This is a useful diagnostic procedure with very low risk and little discomfort to the patient.

Purpose

A liver biopsy is usually done to evaluate the extent of damage that has occurred to the liver because of chronic and acute disease processes or toxic injury. Biopsies are often performed to identify abnormalities in liver tissues after imaging studies and radiopharmaceutical scans have failed to yield clear results.

A liver biopsy may be ordered to diagnose or stage any of the following conditions or disorders:

- jaundice
- cirrhosis
- repeated abnormal results from liver function tests
- alcoholic liver disease
- unexplained swelling or enlargement of the liver (hepatomegaly)
- suspected drug-related liver damage such as acetaminophen poisoning
- hemochromatosis, a condition of excess **iron** in the liver
- intrahepatic cholestasis, the build up of bile in the liver
- hepatitis
- primary cancers of the liver, such as hepatomas, cholangiocarcinomas, and angiosarcomas
- metastatic cancers of the liver (These are over 20 times as common in the United States as primary cancers.)
- post liver transplant to measure graft rejection
- fever of unknown origin
- suspected **tuberculosis**, sarcoidosis, or amyloidosis

Precautions

When performing the liver biopsy and **blood** collection that precedes it, the physician and other health care providers should follow **universal precautions** for the prevention of transmission of bloodborne pathogens. Some patients should not have percutaneous liver biopsies. They include those with any of the following conditions:

- a platelet count below 100,000
- a prothrombin test time greater than three seconds over the reference interval
- a liver tumor with a large number of veins
- a large amount of abdominal fluid (ascites)
- **infection** anywhere in the **lungs**, the lining of the chest or abdominal wall, the biliary tract, or the liver
- benign tumors (angiomas) of the liver (These tumors consist mostly of enlarged or newly formed **blood vessels** and may bleed heavily.)
- biliary obstruction

Description

Percutaneous liver biopsy is sometimes called aspiration biopsy or fine needle aspiration (FNA) because it is done with a hollow needle attached to a suction syringe. The special needles that are used to perform a

liver biopsy are called Menghini or Jamshedi needles. The amount of specimen collected should be about 1-2 cc. In many cases the biopsy is done by a doctor who specializes in x rays and imaging studies (a radiologist). The radiologist will use computed tomography scan (CT scan) or ultrasound to guide the needle to the target site for the biopsy. Some ultrasound guided biopsies are performed using a biopsy gun which has a spring mechanism which contains a cutting sheath. This type of procedure gives a greater yield of tissue.

An hour or so before the biopsy, the patient will be given a sedative to aid in **relaxation**. The patient is then asked to lie on the back with the right elbow to the side and the right hand under the head. The patient is instructed to lie as still as possible during the procedure. He or she is warned to expect a sensation resembling a punch in the right shoulder when the needle passes a certain nerve (the phrenic nerve) but to hold still in spite of the momentary feeling.

Following these instructions to the patient, the doctor marks a spot on the skin where the needle will be inserted. The right side of the upper abdomen is thoroughly cleansed with an antiseptic solution, generally iodine. The patient is then given a local anesthetic at the biopsy site.

The doctor prepares the needle by drawing sterile saline solution into a syringe. The syringe is then attached to the biopsy needle, which is inserted into the patient's chest wall. The doctor then draws the plunger of the syringe back to create a vacuum. At this point the patient is asked to take a deep breath and hold it. The needle is inserted into the liver and withdrawn quickly, usually within two seconds or less. The negative pressure in the syringe draws or pulls a sample of liver tissue into the biopsy needle. As soon as the needle is withdrawn, the patient can breathe normally. This step takes only a few seconds. Pressure is applied at the biopsy site to stop any bleeding and a bandage is placed over it. The liver tissue sample is placed in a cup with a 10% formalin solution and sent to the laboratory immediately. The entire procedure takes 10 to 15 minutes. Test results are usually available within a day.

Most patients experience minor discomfort during the procedure, but not severe **pain**. Mild medications of a non-aspirin type can be given after the biopsy if the pain lasts for several hours.

Preparation

Liver biopsies require some preparation of the patient. Since aspirin and ibuprofen (Advil, Motrin) are known to inhibit platelets and lessen clotting function, it is best to avoid these medications for at least a week

KEY TERMS

Aspiration—The technique of removing a tissue sample for biopsy through a hollow needle attached to a suction syringe.

Bile—Liquid produced by the liver that is excreted into the intestine to aid in the digestion of fats.

Biliary—Relating to bile.

Biopsy—The surgical removal and microscopic examination of living tissue for diagnostic purposes.

Cholestasis—A blockage in the flow of bile.

Cirrhosis—A progressive disease of the liver characterized by the death of liver cells and their replacement with fibrous tissue.

Formalin—A clear solution of diluted formaldehyde that is used to preserve liver biopsy specimens until they can be examined in the laboratory.

Gross inspection—A visual examination of the tissue with the unaided eye performed by a pathologist.

Hepatitis—Inflammation of the liver, caused by infection or toxic injury.

Jaundice—Also termed icterus. An increase in blood bile pigments that are deposited in the skin, eyes, deeper tissue and excretions. The skin and whites of the eye will appear yellow.

Menghini needle/Jamshedi needle—Special needles used to obtain a sample of liver tissue by aspiration.

Percutaneous biopsy—A biopsy in which the needle is inserted and the sample removed through the skin.

Prothrombin test—A common test to measure the amount of time it takes for a patient's blood to clot. Units are in seconds.

Vital signs—A person's essential body functions, usually defined as the pulse, body temperature, and breathing rate. Vital signs are checked periodically during procedures like liver biopsies to make sure that the patient is not having physical problems as a result of the procedure.

before the biopsy. The doctor should check the patient's records to see whether he or she is taking any other medications that may affect blood clotting. A platelet count

(or **complete blood count**) and prothrombin time are performed prior to the biopsy. These tests determine whether there is an abnormally high risk of uncontrolled bleeding from the biopsy site which may contraindicate the procedure. The patient should limit food or drink for a period of four to eight hours before the biopsy.

Before the procedure, the patient or family member should sign a consent form. The patient will be questioned for any history of allergy to the local anesthetic and asked to empty the bladder so that he or she will be more comfortable during the procedure. His or her pulse rate, temperature, and breathing rate (**vital signs**) will be noted so that the doctor can tell during the procedure if he or she is having any physical problems.

Aftercare

Liver biopsies are now considered outpatient procedures in most hospitals. Patients are asked to lie on their right sides for one hour and then to rest quietly for three more. At regular intervals, a nurse checks the patient's vital signs. If there are no complications, the patient is sent home but is asked to stay within an hour from the hospital since delayed bleeding may occur.

Patients should arrange to have a friend or relative take them home after discharge. Bed rest for a day is recommended, followed by a week of avoiding heavy work or strenuous **exercise**. The patient can resume eating a normal diet.

Some mild soreness in the area of the biopsy is normal after the anesthetic wears off. Irritation of the muscle that lies over the liver can also cause mild discomfort in the shoulder for some patients. Acetaminophen can be taken for minor soreness, but aspirin and ibuprofen products are best avoided. The patient should, however, call the doctor if there is severe pain in the abdomen, chest, or shoulder; difficulty breathing; or persistent bleeding. These signs may indicate that there has been leakage of bile into the abdominal cavity, or that air has been introduced into the cavity around the lungs.

Complications

The complications associated with a liver biopsy are usually very small. The most significant risk is prolonged internal bleeding. In about 0.4% of cases, a patient with **liver cancer** will develop a fatal hemorrhage from a percutaneous biopsy. These fatalities result because some liver tumors are supplied with a large number of blood vessels and bleed very easily. Other complications from percutaneous liver biopsies include the leakage of bile or the introduction of air into the chest cavity (pneumothorax). There is also a small chance that an infection may

occur, or an internal organ such as the lung, gall bladder, or kidney could be punctured. This risk is decreased when using the ultrasound or CT guided procedure.

Results

After the biopsy, the liver sample is sent to the pathology laboratory and examined. A normal (negative) result would find no evidence of pathology in the tissue sample. It should be noted that many diseases of the liver are focal and not diffuse; an abnormality may not be detected, if the sample was taken from an unaffected site. If symptoms persist, the patient may need to undergo a repeat biopsy.

The pathologist will perform a gross inspection of the sample to note any changes in appearance. In cirrhosis, the sample will be fragmented and hard. Fatty liver, seen in heavy drinkers, will float in the formalin solution and will be yellow. Carcinomas are white. The pathologist will also look for deposition of bile pigments (green) indicating cholestasis (obstruction of bile flow). In preparation for microscopic examination, the tissue will be frozen and cut into thin sections. These will be mounted on glass slides and stained with various dyes to aid in identifying microscopic structures. Using the microscope, the pathologist will examine the tissue samples, and identify abnormal cells or microarchitecture and any deposited substances such as iron or **copper**. In liver **cancer**, small dark malignant cells will be visible within the liver tissue. An infiltration of white blood cells may signal infection. The pathologist also checks for the number of bile ducts and whether they are dilated. He or she also looks at the health of the small arteries and portal veins. Fibrosis will appear as scar tissue and fatty changes are diagnosed by the presence of lipid droplets. Many different findings may be noted and a differential diagnosis (one out of many possibilities) can often be made. In difficult cases, other laboratory tests such as liver function enzymes, will aid the clinician in determining the final diagnosis.

Health care team roles

The liver biopsy requires the skill of many clinicians including the radiologist, hepatologist and pathologist in order to make the diagnosis. Nurses will assist the physician during the biopsy procedure and in caring for the patient after the procedure. Tissues are prepared for microscopic evaluation by a histologic technician.

Patient education

Patients should be told what to expect in the way of discomfort pre- and post-procedure. In addition, they

should be advised about what medications they should not take before or after the biopsy. It is important for the clinician to reassure the patient concerning the safety of the procedure.

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ORGANIZATIONS

- American Liver Foundation. 1425 Pompton Avenue, Cedar Grove, NJ 07009. (800) 465-4837. <<http://www.liver-foundation.org>>.

Jane E. Phillips, PhD

Liver cancer

Definition

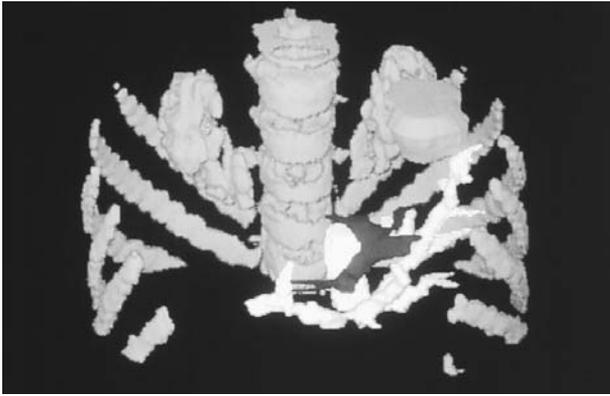
Liver cancer is a form of cancer with a high mortality rate. Liver cancers are classified into two types. They are either primary, when the cancer starts in the liver itself; or metastatic, when the cancer has metastasized (spread) to the liver from some other part of the body.

Description

Primary liver cancer

Primary liver cancer is a relatively rare disease in the United States, representing about 2% of all malignancies. It is much more common in other parts of the world, representing from 10-50% of malignancies in Africa and parts of Asia. According to the American Cancer Society, in the United States during 1998, more than 14,000 new cases of primary liver cancer were diagnosed, and approximately 13,000 deaths were attributable to it.

TYPES OF PRIMARY LIVER CANCER. In adults, most primary liver cancers belong to one of two types: hepatomas, also known as hepatocellular carcinomas, which start in the liver tissue itself; and cholangiocarcinomas, which are cancers that develop in the bile ducts



A three-dimensional computed tomography (CAT) scan of a patient's abdomen showing a malignant tumor (upper right) in the liver. (Photo Researchers, Inc. Reproduced by permission.)

inside the liver. About 90% of primary liver cancers are hepatomas. In the United States, about one person in every 40,000 will develop a hepatoma; in Africa and Asia, over 8 persons in 40,000 will develop this form of cancer. Two rare types of primary liver cancer are mixed-cell tumors and Kupffer cell **sarcomas**.

There is one type of primary liver cancer that usually occurs in children younger than four years of age and between the ages of 12-15. This type of childhood liver cancer is called a hepatoblastoma. Unlike liver cancers in adults, hepatoblastomas have a good chance of being treated successfully. Approximately 70% of children with hepatoblastomas experience complete cures. When the tumor is detected early, the survival rate is over 90%.

Metastatic liver cancer

The second major category of liver cancer, metastatic liver cancer, is about 20 times as common in the United States as primary liver cancer. Because **blood** from all parts of the body must pass through the liver for filtration, cancer cells from other organs and tissues easily reach the liver, where they can lodge and grow into secondary tumors. Primary cancers in the colon, **stomach**, **pancreas**, rectum, esophagus, breast, lung, or skin are the most likely to metastasize to the liver. It is not unusual for the metastatic cancer in the liver to be the first noticeable sign of a cancer that started in another organ. Second only to cirrhosis, metastatic liver cancer is the most common cause of fatal liver disease.

Causes and symptoms

Risk factors for primary liver cancer

The exact cause of primary liver cancer is still unknown. In adults, however, certain factors are known

to place some individuals at higher risk of developing liver cancer. These factors include:

- Gender. The male/female ratio for hepatoma is 4:1.
- Age over 60 years.
- Environmental exposure to carcinogens (cancer causing substances). Examples of environmental carcinogens are aflatoxin, substance produced by a mold that grows on rice and peanuts; thorium dioxide, used at one time as a contrast dye for x rays of the liver; and vinyl chloride, used in manufacturing plastics.
- Use of oral estrogens for **contraception** (birth control).
- Hereditary hemochromatosis. Hemochromatosis is a disorder characterized by abnormally high levels of **iron** storage in the body. It often progresses to cirrhosis.
- Cirrhosis. Hepatomas appear to be a frequent complication of cirrhosis of the liver. Between 30-70% of hepatoma patients also have cirrhosis. It is estimated that a patient with cirrhosis has 40 times the chance of developing a hepatoma than a person with a healthy liver. Cirrhosis usually results from alcohol abuse or chronic viral hepatitis.
- Exposure to hepatitis B (HBV) or hepatitis C (HBC) **viruses**. In Africa and most of Asia, exposure to hepatitis B is an important factor; in Japan and some Western countries, exposure to hepatitis C is associated with a higher risk of developing liver cancer. In the United States, nearly 25% of patients with liver cancer have evidence of HBV **infection**. Hepatitis B and C are commonly found among intravenous drug abusers.

Symptoms of liver cancer

The early symptoms of primary, as well as metastatic, liver cancer are often vague and not specific to liver disorders. The long delay between the beginning of the tumor's growth and signs of illness is the major reason the disease has such a high mortality rate. At the time of diagnosis, patients are often tired, with **fever**, abdominal **pain**, and loss of appetite. They may look emaciated and generally ill. As the tumor grows bigger, it stretches the membrane surrounding the liver (the capsule), causing pain in the upper abdomen on the right side. The pain may extend into the back and shoulder. Some patients develop ascites (a collection of fluid) in the abdominal cavity. Others may have gastrointestinal bleeding. In addition, the tumor may block the ducts of the liver or the gall bladder, leading to **jaundice**. In patients with jaundice, the whites of the eyes and the skin may turn yellow, and the urine becomes dark-colored.

Diagnosis

Physical examination

When a diagnosis of primary liver cancer is suspected, the physician will scrutinize the patient's history for risk factors and pay close attention to the condition of the abdomen during the **physical examination**. Masses or lumps in the liver and ascites can often be felt while the patient is lying flat on the examination table. The liver is usually swollen and hard in patients with liver cancer; it may be sore when the physician presses on it. In some cases, the patient's spleen is also enlarged. The physician may be able to hear a bruit (an abnormal sound) or friction rub when a **stethoscope** is used to listen to the **blood vessels** that lie near the liver. These abnormal sounds are caused by the pressure of the tumor on the blood vessels.

Laboratory tests

Blood tests, performed by a laboratory technologist or technician, may be used to evaluate liver function or to confirm risk factors, such as hepatitis B or C infection. About 75% of patients with liver cancer show evidence of hepatitis infection. Between 50-75% of primary liver cancer patients have abnormally high blood serum levels of alpha-fetoprotein (AFP). The AFP test, however, cannot be used by itself to confirm a diagnosis of liver cancer, because cirrhosis or chronic hepatitis can also produce high alpha-fetoprotein levels. Tests for alkaline phosphatase, bilirubin, lactic dehydrogenase, and other chemicals indicate that the liver is not functioning normally. Though useful, abnormal liver function test results can not alone establish the diagnosis of liver cancer.

Imaging studies

Imaging studies are used to locate specific areas of abnormal tissue in the liver. Liver tumors as small as an inch across can be detected by ultrasound or computed tomography scan (CT scan). Imaging studies, however, cannot tell the difference between a hepatoma and other abnormal masses or nodules in the liver. A sample of liver tissue for biopsy is needed to make the definitive diagnosis of a primary liver cancer. CT or ultrasound may be used to guide the physician in selecting the best location for obtaining the biopsy sample.

Chest x rays may be used to see whether the liver tumor is primary or has metastasized from a primary tumor in the **lungs**. Imaging studies, including chest x rays, are usually performed by a radiology technician.

Liver biopsy

Liver biopsy provides the definite diagnosis of liver cancer. A sample of the liver or tissue fluid is removed with a fine needle and is examined by a pathologist, under a **microscope**, for the presence of cancer cells. In about 70% of cases, the biopsy is positive for cancer. In most cases, there is little risk to the patient from the biopsy procedure. In about 0.4% of cases, however, the patient develops a fatal hemorrhage from the biopsy because some tumors are supplied with a large number of blood vessels and bleed very easily.

Laparoscopy

The physician also may perform a **laparoscopy** to assist in the diagnosis of liver cancer. A **laparoscope** is a small tube-shaped instrument with a light at one end that is inserted into the patient's abdomen. A small piece of liver tissue is removed and sent for biopsy (microscopic examination for the presence of cancer cells).

Treatment

Treatment of liver cancer is based on several factors, including the type of cancer (primary or metastatic); stage (early or advanced); the location of other primary cancers or metastases; the patient's age; and other coexisting diseases, including cirrhosis. For many patients, treatment of liver cancer is primarily intended to relieve the pain caused by the cancer; it aims to relieve symptoms but not to cure the disease.

Surgery

Few liver cancers in adults can be cured surgically because they are usually too advanced by the time they are discovered. If the cancer is contained within one lobe of the liver, and if the patient does not have cirrhosis, jaundice, or ascites, then surgery is the best treatment option. Patients who can have their entire tumors removed have the best chances for survival. Unfortunately, only about 5% of patients with metastatic cancer (from primary tumors in the colon or rectum) fall into this group. If the entire visible tumor can be removed, about 25% of patients will be cured. The surgical procedure that is performed is called a partial hepatectomy, or partial removal of the liver. The surgeon will remove either an entire lobe of the liver (a lobectomy) or cut out the area around the tumor (a wedge resection).

Chemotherapy

Some patients with metastatic cancer of the liver may have their lives prolonged for a few months by **chemotherapy**, although cure is not possible. If the

KEY TERMS

Aflatoxin—A substance produced by molds that grow on rice and peanuts. Exposure to aflatoxin is thought to explain the high rates of primary liver cancer in Africa and parts of Asia.

Alpha-fetoprotein—A protein in blood serum that is found in abnormally high concentrations in most patients with primary liver cancer.

Cirrhosis—A chronic degenerative disease of the liver, in which normal cells are replaced by fibrous tissue. Cirrhosis is a major risk factor for the later development of liver cancer.

Hepatitis—A viral disease characterized by inflammation of the liver cells (hepatocytes). People infected with hepatitis B or hepatitis C virus are at an increased risk for developing liver cancer.

tumor cannot be removed by surgery, then a catheter may be placed in the main artery (hepatic artery) of the liver and an implantable infusion pump can be installed. The pump allows much higher concentrations of the anti-cancer drug to be carried to the tumor than is possible with chemotherapy carried through the bloodstream. The drug used for infusion pump therapy is usually floxuridine (FUDR), given for 14-day periods alternating with 14-day rests.

Systemic chemotherapy, given through a peripheral vein, can also be used to treat liver cancer. The drugs usually used are 5-fluorouracil (Aflurcil, Efudex) or methotrexate (MTX, Mexate). Systemic chemotherapy does not, however, significantly increase survival time.

Radiation therapy

Radiation therapy may be used to relieve some symptoms of the disease. In general, radiation therapy will not prolong survival. Radioimmunotherapy is an experimental form of radiation therapy used to treat some types of liver cancer. A radioactive isotope is given intravenously and concentrates in the liver, where it radiates the tumor internally.

Liver transplantation

Since 1998, removal of the entire liver (total hepatectomy) and liver transplantation have very rarely been used to treat liver cancer. This is because very few patients are eligible for this procedure, either because the cancer has spread beyond the liver or because there are

no suitable donors. Further research in the field of transplant immunology may make liver transplantation a viable treatment modality.

Prognosis

Liver cancer has a very poor prognosis because it is often not diagnosed until it has metastasized. Fewer than 10% of patients survive three years after the initial diagnosis; the overall five-year survival rate for patients with hepatomas is around 4%. Most patients with primary liver cancer die within several months of diagnosis. Patients with liver cancers that metastasized from cancers in the colon live slightly longer than those whose cancers spread from cancers in the stomach or pancreas.

Health care team roles

Like other cancer patients, patients with liver cancer are usually cared for by a multidisciplinary team of health professionals. The patient's family physician or primary care physician collaborates with other physician specialists, such as surgeons and oncologists. Radiologic technicians perform x ray, CT and MRI scans and nurses and laboratory technicians may obtain samples of blood, urine and other laboratory tests. Nurses also perform patient and family education.

Before and after any surgical procedures, including biopsies, nurses explain the procedures and help to prepare patients and families. Patients may also benefit from counseling from social workers, other mental health professionals or pastoral counselors.

Prevention

Presently, there are no useful strategies for preventing metastatic cancers of the liver. Primary liver cancers, however, are 75-80% preventable. Current strategies focus on widespread **vaccination** for hepatitis B; early treatment of hereditary hemochromatosis; and screening of high-risk patients with alpha-fetoprotein testing and ultrasound examinations.

Lifestyle factors that may be modified in order to prevent liver cancer include avoidance of exposure to environmental carcinogens, toxic chemicals, and foods harboring molds that produce aflatoxin. Most important, however, is avoidance of alcohol and drug abuse. Alcohol abuse is responsible for 60-75% of cases of cirrhosis, which is a major risk factor for eventual development of primary liver cancer. Hepatitis is a widespread disease among persons who abuse intravenous drugs.

Resources

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ORGANIZATIONS

- American Cancer Society. 1599 Clifton Road, N.E., Atlanta, GA 30329. (800)227-2345.
- American Liver Foundation. 1425 Pompton Avenue, Cedar Grove, NJ 07009. (800)465-4837.
- Cancer Research Institute. 681 Fifth Avenue, New York, NY 10022. (800)992-2623.
- National Cancer Institute (National Institutes of Health). 9000 Rockville Pike, Bethesda, MD 20892. (800)422-6237.

Barbara Wexler

Liver function tests

Definition

Liver function tests, or LFTs, include tests that are routinely measured in all clinical laboratories. LFTs include bilirubin, a compound formed by the catabolism of hemoglobin; ammonia, a product of protein catabolism that is normally converted into urea by the liver before being excreted by the **kidneys**; **proteins** that are made by the liver including total protein, albumin, prothrombin, and fibrinogen; cholesterol and triglycerides, which are made and excreted via the liver; and the enzymes alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), and lactate dehydrogenase (LDH). Other liver function tests include serological (tests to demonstrate antibodies) and DNA tests for hepatitis and other **viruses**, tests for antimitochondrial and smooth muscle antibodies, transthyretin (prealbumin), protein electrophoresis, bile acids, alpha-fetoprotein, and a constellation of other enzymes that help differentiate necrotic versus obstructive liver disease.

Purpose

Liver function tests done individually do not give the physician very much information, but used in combination along with a careful history, **physical examination**, and imaging studies they contribute to making an accurate diagnosis of the specific liver disorder. Different tests will show abnormalities in response to liver inflammation, liver injury due to drugs, alcohol, toxins or viruses, liver malfunction due to blockage of the flow of bile, and liver cancers.

Precautions

Blood for LFTs is collected by venipuncture. The nurse or phlebotomist performing the procedure must be careful to observe **universal precautions** for the prevention of transmission of bloodborne pathogens. Blood for ammonia testing should be iced immediately after collection, stored anaerobically until measured, and assayed within 30 minutes to prevent an increase in ammonia caused by deamination of amino acids in the blood. Hemolysis will falsely increase tests for LD, AST, and ALT.

Bilirubin: Drugs that may cause increased blood levels of total bilirubin include anabolic steroids, **antibiotics**, antimalarials, ascorbic acid, Diabinese, codeine, diuretics, epinephrine, oral contraceptives, and **vitamin A**.

Ammonia: Muscular exertion can increase ammonia levels, while cigarette smoking produces significant increases within one hour of inhalation. Drugs that may cause increased levels include alcohol, barbiturates, narcotics, and diuretics. Drugs that may decrease levels include broad-spectrum antibiotics, levodopa, lactobacillus, and potassium salts.

ALT: Drugs that may increase ALT levels include acetaminophen, ampicillin, codeine, dicumarol, indomethacin, methotrexate, oral contraceptives, tetracyclines, and verapamil. Previous intramuscular injections may cause elevated levels.

GGT: Drugs that may cause increased GGT levels include alcohol, phenytoin, and phenobarbital. Drugs that may cause decreased levels include oral contraceptives.

LD: Strenuous activity may raise levels of LDH. Alcohol, anesthetics, aspirin, narcotics, procainamide, and fluoride may also raise levels. Ascorbic acid (**vitamin C**) can lower levels of LDH.

Description

The liver is the largest and one of the most important organs in the body. As the body's "chemical factory," it regulates the levels of most of the biomolecules found in

the blood, and acts with the kidneys to clear the blood of drugs and toxic substances. The liver metabolizes these products, alters their chemical structure, makes them water soluble, and excretes them in bile. Laboratory tests for total protein, albumin, ammonia, transthyretin, and cholesterol are markers for the synthetic function of the liver. Tests for cholesterol, bilirubin, ALP, and bile salts are measures of the secretory (excretory) function of the liver. The enzymes ALT, AST, GGT, LD, and tests for viruses are markers for liver injury.

Some liver function tests are used to determine if the liver has been damaged or its function impaired. Elevations of these markers for liver injury or disease tell the physician that something is wrong with the liver. ALT and bilirubin are the two primary tests used largely used for this purpose. Bilirubin is measured by two tests, called total and direct bilirubin. The total bilirubin measures both conjugated and unconjugated bilirubin while direct bilirubin measures only the conjugated bilirubin fraction in the blood. Unconjugated bilirubin is formed from heme in the reticuloendothelial cells in the spleen that remove old red blood cells from the circulation. The RE cells release the bilirubin into the blood where it is bound by albumin and transported to the liver. The bilirubin is taken up by liver cells and conjugated to glucuronic acid, which makes the bilirubin water soluble. This form will react directly with a Ehrlich's diazo reagent, hence the name direct bilirubin. While total bilirubin is elevated in various liver diseases, it is also increased in certain (hemolytic) **anemias** caused by increased red blood cell turnover. Neonatal hyperbilirubinemia is a condition caused by an immature liver than cannot conjugate the bilirubin. The level of total bilirubin in the blood becomes elevated, and must be monitored closely in order to prevent damage to the **brain** caused by unconjugated bilirubin, which has a high affinity for brain tissue. Bilirubin levels can be decreased by exposing the baby to UV light. Direct bilirubin is formed only by the liver, and therefore, it is specific for hepatic or biliary disease. Its concentration in the blood is very low (0-0.2 mg/dL) and therefore, even slight increases are significant. Highest levels of direct bilirubin are seen in obstructive liver diseases. However, direct bilirubin is not sensitive to all forms of liver disease (e.g., focal intrahepatic obstruction) and is not always elevated in the earliest stages of disease, and therefore, ALT is needed to exclude a diagnosis.

ALT is an enzyme that transfers an amino group from the amino acid alanine to a ketoacid acceptor (oxaloacetate). The enzyme was formerly called serum glutamic pyruvic transaminase (SGPT) after the products formed by this reaction. Although ALT is present in other tissues besides liver, its concentration in liver is far

greater than any other tissue, and blood levels in nonhepatic conditions rarely produce levels of a magnitude seen in liver disease. The enzyme is very sensitive to necrotic or inflammatory liver injury. Consequently, if ALT or direct bilirubin are increased, then some form of liver disease is likely. If both are normal, then liver disease is unlikely.

These two tests along with others are used to help determine what is wrong. The most useful tests for this purpose are the liver function enzymes and the ratio of direct to total bilirubin. These tests are used to differentiate diseases characterized primarily by hepatocellular damage (necrosis) from those characterized by obstructive damage (cholestasis or blockage of bile flow). In hepatocellular damage, the transaminases, ALT and AST, are increased to a greater extent than alkaline phosphatase. This includes viral hepatitis, which gives the greatest increase in transaminases (10-50 fold normal), hepatitis induced by drugs or poisons (toxic hepatitis), alcoholic hepatitis, hypoxic necrosis (a consequence of congestive **heart failure**), chronic hepatitis, and cirrhosis of the liver. In obstructive liver diseases, the alkaline phosphatase is increased to a greater extent than the transaminases (ALP>ALT). This includes diffuse intrahepatic obstructive disease which may be caused by some drugs or biliary cirrhosis, focal obstruction that may be caused by malignancy, granuloma, or stones in the intrahepatic bile ducts, or extrahepatic obstruction such as gall bladder or common bile duct stones, or pancreatic or bile duct **cancer**. In both diffuse intrahepatic obstruction and extrahepatic obstruction, the direct bilirubin is often greatly elevated because the liver can conjugate the bilirubin, but this direct bilirubin cannot be excreted via the bile. In such cases the ratio of direct to total bilirubin is greater than 0.4.

Aspartate aminotransferase, formerly called serum glutamic oxaloacetic transaminase (SGOT), is not as specific for liver disease as is ALT, which is increased in **myocardial infarction, pancreatitis**, muscle wasting diseases, and many other conditions. However, differentiation of acute and chronic forms of hepatocellular injury are aided by examining the ratio of ALT to AST, called the DeRitis ratio. In acute hepatitis, Reye's syndrome, and infectious mononucleosis the ALT predominates. However, in alcoholic liver disease, chronic hepatitis, and cirrhosis the AST predominates.

Alkaline phosphatase is increased in obstructive liver diseases, but it is not specific for the liver. Increases of a similar magnitude (three- to five-fold normal) are commonly seen in bone diseases, late **pregnancy**, leukemia, and some other malignancies. The enzyme gamma-glutamyl transferase (GGT) is used to help differentiate the source of an elevated ALP. GGT is greatly increased in

obstructive **jaundice**, alcoholic liver disease, and hepatic cancer. When the increase in GGT is two or more times greater than the increase in ALP, the source of the ALP is considered to be from the liver. When the increase in GGT is five or more times the increase in ALP, this points to a diagnosis of alcoholic hepatitis. GGT, but not AST and ALT, is elevated in the first stages of liver inflammation due to alcohol consumption, and GGT is useful as a marker for excessive drinking. GGT has been shown to rise after acute persistent alcohol ingestion and then fall when alcohol is avoided.

Lactate dehydrogenase (LD) is found in almost all cells in the body. Different forms of the enzyme (isoenzymes) exist in different tissues, especially in **heart**, liver, red blood cells, brain, kidney and muscles. LD is increased in megaloblastic and hemolytic anemias, leukemias and lymphomas, myocardial infarction, infectious mononucleosis, muscle wasting diseases, and both necrotic and obstructive jaundice. While LD is not specific for any one disorder, the enzyme is elevated (two- to five-fold normal) along with liver function enzymes in both necrotic and obstructive liver diseases. LD is markedly increased in most cases of **liver cancer**. An enzyme pattern showing a marked increase in LD and to a lesser degree ALP with only slightly increased transaminases (AST and ALT) is seen in cancer of the liver (space occupying disease). Such findings should be followed-up with imaging studies and measurement of alpha-fetoprotein and carcinoembryonic antigen, two tumor markers prevalent in hepatic cancers.

Some liver function tests are not sensitive enough to be used for diagnostic purposes, but are elevated in severe or chronic liver diseases. These tests are used primarily to indicate the extent of damage to the liver. Tests falling into this category are ammonia, total protein, albumin, cholesterol, transthyretin, fibrinogen, and the prothrombin time.

Analysis of blood ammonia aids in the diagnosis of severe liver diseases and helps to monitor the course of these diseases. Together with the AST and the ALT, ammonia levels are used to confirm a diagnosis of Reye's syndrome, a rare disorder usually seen in children and associated with **infection** and aspirin intake. Reye's syndrome is characterized by brain and liver damage following an upper respiratory tract infection, chickenpox, or **influenza**. Ammonia levels are also helpful in the diagnosis and treatment of hepatic encephalopathy, a serious brain condition caused by the accumulated toxins that result from liver disease and liver failure. Ammonia levels in the blood are normally very low. Ammonia produced by the breakdown of amino acids is converted by the liver to urea. When liver disease becomes severe, failure of the urea cycle results in elevated blood ammonia

and decreased urea (or blood urea nitrogen, BUN). Increasing ammonia signals end-stage liver disease and a high risk of hepatic **coma**.

Albumin is the protein found in the highest concentration in blood, making up over half of the protein mass. Albumin has a half-life in blood of about three weeks and decreased levels are not seen in the early stages of liver disease. A persistently low albumin in liver disease signals reduced synthetic capacity of the liver and is a sign of progressive liver failure. In the acute stages of liver disease, proteins such as transthyretin (prealbumin) with a shorter half-life may be measured to give an indication of the severity of the disease.

Cholesterol is synthesized by the liver and cholesterol balance is maintained by the liver's ability to remove cholesterol from lipoproteins, and use it to produce bile acids and salts that it excretes into the bile ducts. In obstructive jaundice caused by stones, biliary tract scarring, or cancer, the bile cannot be eliminated and cholesterol and triglycerides may accumulate in the blood as low-density lipoprotein cholesterol. In acute necrotic liver diseases triglycerides may be elevated due to hepatic lipase deficiency. In liver failure caused by necrosis, the liver's ability to synthesize cholesterol is reduced and blood levels may be low.

The liver is responsible for production of the **vitamin K** clotting factors. In obstructive liver diseases a deficiency of vitamin K-derived clotting factors results from failure to absorb vitamin K. In obstructive jaundice, **intramuscular injection** of vitamin K will correct the prolonged prothrombin time. In severe necrotic disease, the liver cannot synthesize factors I (fibrinogen) or factors II, VII, IX, and X from vitamin K. When attributable to hepatic necrosis, an increase in the prothrombin time by more than two seconds indicates severe liver disease.

Serum protein electrophoresis patterns will be abnormal in both necrotic and obstructive liver diseases. In the acute stages of hepatitis, the albumin will be low and the gamma globulin fraction will be elevated owing to a large increase in the production of antibodies. The alpha-1 globulin and alpha-2 globulin fractions will be elevated owing to production of acute phase proteins. In biliary cirrhosis the beta globulin may be elevated owing to an increase in beta lipoprotein. In hepatic cirrhosis the albumin will be greatly decreased, and the pattern will show bridging between the beta and gamma globulins owing to production of IgA. The albumin to globulin ratio (A/G) ratio will fall below one.

The most prevalent liver disease is viral hepatitis. Tests for this condition include a variety of antigen and antibody markers and nucleic acid tests that are discussed in detail elsewhere (see entry on hepatitis tests). Acute

KEY TERMS

Bile acid—A detergent that is made in the liver and excreted into the intestine to aid in the absorption of fats.

Biliary—Relating to bile.

Cirrhosis—A liver disease where there is a loss of normal liver tissues, replaced by scar tissue. This is usually caused by chronic alcohol abuse but can be caused by blockage of the bile ducts.

Detoxification—A process of altering the chemical structure of a compound to make it less toxic.

Hepatitis—Inflammation of the liver.

Hepatocyte—Liver cell.

Isoenzyme—One of a group of enzymes that brings about the same reactions on the same chemicals, but are different in their physical properties.

Jaundice—Hyperbilirubinemia or too much bilirubin in the blood. Bilirubin will be deposited in the skin and the mucosal membranes. The whites of the eyes and the skin appear yellow.

Neonatal jaundice—A disorder in newborns where the liver is too premature to conjugate bilirubin which builds up in the blood.

viral hepatitis is associated initially with 20 to 100 fold increases in transaminases and is followed shortly afterward by jaundice. Such patients should be tested for hepatitis B surface antigen (HbsAg) and IgM antibodies to hepatitis B core antigen (anti-HBc IgM), and anti-hepatitis C virus (anti-HVC) to identify these causes. In addition to hepatitis A-G, viral hepatitis may be caused by Epstein-Barr virus (EBV) and cytomegalovirus (CMV) infections of the liver. Tests for these viruses such as the infectious mononucleosis antibody test, anti-viral capsid antigen test (anti-VCA), and anti-CMV test are useful in diagnosing these infections.

Liver disease may be caused by autoimmune mechanisms in which autoantibodies destroy liver cells. Autoimmune necrosis is associated with systemic lupus erythematosus and chronic viral hepatitis usually caused by hepatitis B and hepatitis C virus infections. These conditions give rise to anti-smooth muscle antibodies and anti-nuclear antibodies, and tests for these are useful markers for chronic hepatitis. Antibodies to mitochondrial antigens (antimitochondrial antibodies) are found in the blood of more than 90% of persons with primary bil-

iary cirrhosis, and those with M2 specificity are considered specific for this disease.

Preparation

Patients are asked to fast and to inform clinicians of all drugs, even over the counter drugs, that they are taking. Many times liver function tests are done on an emergency basis and fasting and obtaining a medical history are not possible.

Aftercare

Patients will have blood drawn into a vacuum tube and may experience some **pain** and burning at the site of injection. A gauze bandage may be placed over the site to prevent further bleeding. If the person is suffering from severe liver disease, they may lack clotting factors. The nurse should be careful to monitor bleeding in these patients after obtaining blood.

Results

Reference ranges vary from laboratory to laboratory and also depend upon the method used. However, normal values are generally framed by the ranges shown below. Values for enzymes are based upon measurement at 37°C.

- ALT: 5-35 IU/L (values for the elderly may be slightly higher, and values also may be higher in men and in African-Americans).
- AST: 0-35 IU/L.
- ALP: 30-120 IU/LALP is higher in children, older adults and pregnant females.
- GGT: males 2-30 U/L; females 1-24 U/L.
- LD: 0-4 days old: 290-775 U/L; 4-10 days: 545-2000 U/L; 10 days-24 months:180-430 U/L; 24 months-12 years:110-295 U/L; 12-60 years:100-190 U/L; 60 years: >110-210 U/L.
- Bilirubin: (Adult, elderly, and child) Total bilirubin: 0.1-1.0 mg/dL; indirect bilirubin: 0.2-0.8 mg/dL; direct bilirubin: 0.0-0.3 mg/dL. (Newborn) Total bilirubin: 1-12 mg/dL. Note: critical values for adult: greater than 1.2 mg/dL. Critical values for newborn (requiring immediate treatment): greater than 15 mg/dL.
- Ammonia: 10-70 micrograms per dL (heparinized plasma). Normal values for this test vary widely, depending upon the age of the patient and the type of specimen.
- Albumin: 3.2-5.4 g/L.

Abnormal results

ALT: Values are significantly increased in cases of hepatitis, and moderately increased in cirrhosis, liver tumor, obstructive jaundice, and severe **burns**. Values are mildly increased in pancreatitis, heart attack, infectious mononucleosis, and **shock**. Most useful when compared with ALP levels.

AST: High levels may indicate liver cell damage, hepatitis, heart attack, heart failure, or gall stones.

ALP: Elevated levels occur in diseases that impair bile formation (cholestasis). ALP may also be elevated in many other liver disorders, as well as some lung cancers (bronchogenic carcinoma) and Hodgkin's lymphoma. However, elevated ALP levels may also occur in otherwise healthy people, especially among older people.

GGT: Increased levels are diagnostic of hepatitis, cirrhosis, liver tumor or metastasis, as well as injury from drugs toxic to the liver. GGT levels may increase with alcohol ingestion, heart attack, pancreatitis, infectious mononucleosis, and Reye's syndrome.

LD: Elevated LD is seen with heart attack, kidney disease, hemolysis, viral hepatitis, infectious mononucleosis, Hodgkin's disease, abdominal and lung cancers, germ cell tumors, progressive **muscular dystrophy** and pulmonary embolism. LD is not normally elevated in cirrhosis.

Bilirubin: Increased indirect or total bilirubin levels can indicate various serious anemias, including hemolytic disease of the newborn and transfusion reaction. Increased direct bilirubin levels can be diagnostic of bile duct obstruction, gallstones, cirrhosis, or hepatitis. It is important to note that if total bilirubin levels in the newborn reach or exceed critical levels, exchange transfusion is necessary to avoid kernicterus, a condition that causes brain damage.

Ammonia: Increased levels are seen in primary liver cell disease, Reye's syndrome, severe heart failure, hemolytic disease of the newborn, and hepatic encephalopathy.

Albumin: Albumin levels are increased due to **dehydration**. They are decreased due to a decrease in synthesis of the protein which is seen in severe liver failure and in conditions such as burns or renal disease that cause loss of albumin from the blood.

Health care team roles

A physician will order the liver function tests that he or she feels are necessary, and the nurse or phlebotomist will draw the blood. Patients will probably be referred to an internist or hepatologist if results are abnormal. LFTs

are performed by clinical laboratory scientists/medical technologists or clinical laboratory technicians/medical laboratory technicians.

Patient education

Health care providers should inform the patient of any abnormal results and explain how these values reflect the status of their liver disease. It is important to guide the patient in ways to stop behaviors such as taking drugs or drinking alcohol, if these are the causes of the illness.

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Jane E. Phillips, PhD

Liver radionuclide scan

Definition

A **liver** scan, also known as a liver-spleen scan, is a diagnostic imaging procedure to evaluate the liver and spleen for suspected disease.

Purpose

A liver scan is performed to determine the size, configuration, relative function of the liver and spleen, and to detect space occupying lesions such as, cysts, an **abscess**, and tumors. Liver scans are indicated if a patient has abdominal **pain**, if a patient's liver enzymes (determined by **blood** tests) are abnormal, if the patient is jaundiced, and to detect and monitor metastatic disease. A liver scan may also be helpful in diagnosing specific disorders, by detecting features which are characteristic of a disorder, such as cirrhosis of the liver. This study may also be part of the battery of tests used to evaluate potential candidates for liver transplant.

Precautions

Women who are pregnant are cautioned against having this test unless the benefit of having the test out-

KEY TERMS

Radionuclide—A substance which emits radiation that can be detected by a scanner as the substance disintegrates.

weighs the risks. If a woman is breast feeding, she will be required to stop for a specified period of time, depending on the dose given.

Description

This test is performed in an out-patient facility or a hospital x-ray or nuclear medicine department. The patient is injected intravenously with a radioactive tracer, or radionuclide, that accumulates in certain cells of the liver, spleen, and bone marrow. Approximately 15 minutes after the injection, the patient is asked to lie down on a bed. A gamma camera or scintillation camera is positioned above the upper abdomen and may lightly touch the patient. It is important for the patient to lie quietly. Position changes and brief periods of breath holding may be required. The test usually takes approximately 30 minutes. Occasionally, a SPECT (Single Photon Emission Computed Tomography) study is indicated to further pinpoint an area of abnormality. The SPECT procedure is the same, but the camera will circle around the patient, in order to provide a cross sectional image of the liver.

Preparation

No physical preparation is required. The patient will be asked to remove metal objects from the area to be imaged. If the patient has had other recent nuclear scans, a waiting period may be necessary so that any residual radiation in the body will not interfere. The patients should understand that there is no danger of significant radioactive exposure to themselves or others. Only small amounts of radionuclide are used. The total amount of radiation absorbed is often less than the dose received from ordinary x rays.

Aftercare

No special aftercare is necessary.

Results

A normal scan will show a liver of normal size, shape, and position. It is expected that the liver will accumulate the radioactive tracer in a uniform fashion. Areas that appear absent may represent a cyst, abscess, or a

tumor and therefore other imaging tests such as ultrasound or CT may be required to assess the nature of the abnormality. Too much radioisotope in the spleen and bones compared to the liver, known as “colloid shift,” can indicate portal **hypertension** or cirrhosis. Liver diseases such as hepatitis may also cause an abnormal scan, but is rarely diagnosed from the information revealed by this study alone. Again, other diagnostic tests are performed along with a liver scan to evaluate specific abnormalities and to arrive at a diagnosis.

Health care team roles

The injection and scan are performed by a nuclear medicine technologist, who will also obtain pertinent medical history from the patient and explain the test. The technologist is trained to handle radioactive materials, operate the scanner, and to process the data. The images are interpreted by a medical doctor who is a radiologist or nuclear medicine specialist. The patient received the results of the scan from their personal physician or doctor who ordered the test.

Resources

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Local anesthetic see **Anesthesia, local**

Long-term insurance

Definition

Long-term insurance provides for a person’s care in cases of chronic illness or disability. Policies are available with a wide range of coverage options.

Long-term insurance refers to coverage of health services, which may include community health care, nursing **home care**, and home support. Long-term health

insurance is normally for the elderly, but is sometimes also applicable to younger individuals with disabilities.

Description

A major health care challenge looms over America as the population ages and people live longer. The country lacks a comprehensive health system that serves the needs of millions of older persons and individuals with long-term disabilities.

Long-term care options are often fragmented, uncoordinated, and costly for patients, their families and, in some instances, public coffers. Millions of Americans, according to the American Association of Retired Persons (AARP), are denied access to long-term care services because they cannot pay for services, do not qualify for public funding or cannot access the types of services that they need and can afford.

People of all ages usually prefer to receive long-term care in their own homes, or in home-like assisted-living facilities. More than three-quarters of older Americans in need of long-term care live in the community, with most receiving no paid services. The majority of long-term care is provided by unpaid, informal caregivers, such as family and friends. In 1996, more than 22 million households in the United States included a caregiver who was age 50 or older. About 73% of unpaid caregivers were women, nearly one-third of whom were over age 65. Many caregivers, especially women, balance multiple caregiving roles by providing for both their parents and their children.

Medicare does not cover most long-term care services. In 1997, 68% of nursing home residents were dependent on **Medicaid** to finance at least some of their care. For many, long-term insurance is unaffordable, and many cannot qualify because of pre-existing conditions.

Long-term insurance policies are often complex. People who purchase them may not read the fine print, then are forced to cancel the policy later because it does not fit their needs. Increasing rates factored into some long-term policies, known as “climbing premiums,” may also become prohibitively expensive.

Long-term care insurance can benefit the consumer, provided that such items as affordability, coverage gaps, and timing of purchase are carefully considered. It may be advisable to check the financial stability and the claims ratio of the insurance company. Long-term insurance is a serious financial investment and should be considered a part of estate planning. A qualified, independent professional should be consulted to review the policy before purchase. The state health insurance assistance program (SHIP) is also available to answer questions.

The type of care that a client seeks is another important consideration before purchasing a policy. There is as yet no universal standard for defining long-term care facilities. A placement that is covered under one company's policy may not be covered under another's. Physicians can also play a part in denial of a placement by stating that the facility of choice is either not adequate or too advanced for the patient's needs.

When to buy a policy is another important consideration. Individuals with a pre-existing diagnosis for a debilitating condition or illness may not be eligible for coverage. This clause is common in most insurance policies of any type. But purchasing a policy too far in advance of an anticipated need can work against a buyer. The health care industry is currently in a state of flux, and technological advances are rapid. The benefits provided in a policy that is purchased at one point in time may not match the care available in the distant future, giving the company reason to deny benefits.

Generally, long-term insurance operates as an indemnity program for potential nursing home and/or home health-care costs. Additionally, many policies provide coverage for adult daycare, for care delivered in an assisted-living facility, and for hospice care. Rarely are all costs covered.

Some long-term care policies are pure indemnity programs which pay the insured a daily benefit contracted for by the insured. The pure indemnity program pays the full daily benefit regardless of the amount of care that the insured receives per diem.

Other long-term care policies pay for covered losses, or the cost of care actually received each day, up to the selected daily benefit level. This type of policy is also referred to as a “pool-of-money” contract.

Long-term insurance is available either as part of a group or individual coverage, although most are currently purchased by individuals. Most policies cover skilled, custodial and intermediate long-term care services. A purchaser is wise not to consider a contract that does not cover each level of long-term care services.

A recent change in the U.S. federal tax law allows for a portion of a long-term insurance premium to be tax-deductible. This deduction increases with the insured's age.

Benefits under a long-term care contract are triggered in a tax-qualified policy when the insured becomes unable to perform a number of activities associated with normal daily living or suffers from a cognitive impairment that requires supervision.

Non tax-qualified policies usually offer more liberal eligibility criteria, which includes long-term benefits because of a medical necessity.

KEY TERMS

Indemnity—Protection, as by insurance, against damage or loss.

Long-term insurance can help pay for needed services, as well as protect against the risk of significant financial loss. It may also provide choices about services and where they are received. Normally, neither employer health insurance nor Medicare pays for significant long-term care expenses, although Medicare does pay for short-term skilled care. Medicaid, the federal/state health insurance for those with limited assets and income, does pay for long-term care, but patients must use most of their savings or assets before these benefits can be realized.

Viewpoints

Long-term insurance policies can be expensive and may be restrictive in what they provide. Before purchasing a policy, individuals should make certain that it is within their means and will meet their anticipated needs. Some policies allow policy holders to tap into survivor death benefits to use for health care needs. Several different policies should be compared in detail. Recommendations from elderly advocate organizations can be helpful. Young people with disabilities have fewer options for long-term insurance because many policies exempt individuals with a pre-existing condition.

Professional implications

Health care professionals should be aware of the pros and cons of long-term insurance and be able to answer patients' questions. Long-term insurance may involve special billing procedures.

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American Association for Retired Persons (AARP) 601 E St., NW, Washington DC 20049. (800) 424-3410.
<<http://www.aarp.org>>.

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Low-cholesterol diet see **Diet therapy**

Low-fat diet see **Diet therapy**

Low-phenylalanine diet see **Diet therapy**

Low-purine diet see **Diet therapy**

Low-salt diet see **Diet therapy**

Low back pain, physical therapy for see **Back and neck pain, physical therapy for**

Lower gastrointestinal exam see **Barium enema**

Lower limb orthoses

Definition

A lower limb orthosis is an external force system used to compensate or control for decreased or abnormal forces in the hip, knee, ankle, or foot.

Purpose

Orthoses may be used for any of the following reasons: to lend stability to a weak joint, correct or maintain alignment, control motion in the presence of abnormal tone, immobilize a body part, protect an inflamed joint, or provide proprioceptive feedback. Individuals who have upper or lower motor neuron dysfunction, inflammatory joint diseases, **sports injuries**, or skeletal deformities may use orthoses.

Description

Foot orthoses

Foot orthoses are fabricated for individuals who have abnormal joint alignment in the foot, causing inappropriate motion during stance and gait. Abnormal mechanics may lead to **pain** and increased stress in the joints of the foot, leg and even back. Custom foot orthoses are made based upon a cast of the individual's foot, following a thorough biomechanical assessment of stance and gait. Based on the findings, rigid, semi-rigid, or soft inserts are fabricated to fit into the client's shoe to provide support where needed, for example, under the arch, the metatarsals, and/or the heel. The University of California Biomechanics Laboratory (UCBL) orthosis is a specific custom-molded orthosis that snugly holds the heel and midfoot in optimal alignment with regards to mediolateral stability.

Ankle-foot orthoses (AFOs)

In adults and children with neuromotor dysfunction, AFOs can be used to maintain appropriate alignment, provide mediolateral stability, and help with toe clearance or heel rise during the gait cycle. The supramalleolar orthosis (SMO) evolved from the UCBL orthosis to address not only mediolateral stability, but also anterior-posterior issues, including foot clearance. It extends to the area above the malleoli, and may be solid or include a mechanical ankle joint.

Ankle-foot orthoses that extend to the area just below the knee provide more stability than the SMO, and may be either static or dynamic. Static AFOs prohibit ankle motion; the most common is the solid AFO. The solid AFO prevents foot drop during gait and also can help to control knee extension or hyperextension, depending on how the ankle is set. Dynamic AFOs may allow for plantarflexion and/or dorsiflexion of the ankle through the use of either a mechanical joint or the location of trimlines. Various methods, such as pin stops and check straps, can be used to limit the amount of plantarflexion or dorsiflexion allowed as well. These options provide versatility in setting the range of ankle motion for individuals who have some control and/or expected return of function.

A variety of ankle supports are also available for individuals with musculoskeletal function. Air casts provide stability to those rehabilitating from ankle sprains, while Achilles straps may be used for tendonitis. Night splints and arch straps may help with positioning in those with plantar fasciitis.

Knee-ankle-foot-orthoses (KAFOs)

A KAFO is used when the knee needs to be stabilized and an AFO is insufficient. For example, KAFOs may be used in patients who have had a stroke, **spinal cord injury** or traumatic injury to the limbs. A conventional KAFO consists of double metal uprights connected to the shoe via a stirrup. A thermoplastic KAFO is custom-formed for total contact to the patient's thigh and calf. A variety of knee joints are available to allow for or restrict flexion and extension movement.

Knee orthoses

There are three categories of orthoses that address musculoskeletal impairments at the knee joint. Athletes use prophylactic orthoses in hopes of preventing knee injury. Rehabilitative orthoses are used post-operatively to allow protected motion to occur at the knee joint.



A girl with rheumatoid arthritis walks with the aid of braces. (Photograph by John Moss. Photo Researchers, Inc. Reproduced by permission.)

Functional orthoses are designed to provide stability and proprioceptive input to a patient returning to daily activities. Research is inconclusive on the effectiveness of prophylactic orthoses; however, studies do indicate that functional orthoses may be helpful in preventing further injuries in individuals who have already sustained an injury.

Hip-knee-ankle-foot orthoses (HKAFOs)

The hip guidance orthosis (HGO) and the reciprocating guidance orthosis (RGO) are two types of lumbosacral HKAFOs that can be used by adults or children to produce a reciprocal gait pattern. In both types, the user is braced from mid-trunk to the feet. These orthoses are most commonly used in children with myelomeningocele, but are also used by patients with traumatic **spinal cord injury**, **muscular dystrophy**, **cerebral palsy**, and **multiple sclerosis**.

KEY TERMS

Donning and doffing—Putting on and taking off an orthosis or prosthesis.

Legg-Calve-Perthes disease—Flattening of the femoral head in children, related to avascular necrosis.

Myelomeningocele—A neural tube defect causing herniation of the spinal cord, its meninges and cerebrospinal fluid, often leading to paraplegia.

Plantar fasciitis—Inflammation of the layer of fascia surrounding the muscles of the soles of the feet.

Proprioceptive input—Sensations of body movement and position without the use of visual cues.

Thermoplastic—A material used in orthosis fabrication that is formable when heated and rigid when cooled.

Trimline—The border of the orthosis, the location of which is a factor in determining the level of support or flexibility available.

Hip orthoses

Postoperative total hip orthoses sometimes are used after a total hip replacement in order to prevent the motions of hip flexion, adduction and internal rotation that can cause dislocation. In infants with developmental dysplasia of the hip, which causes hip instability, a Pavlik harness or hip abduction orthosis is used to position the hips in flexion and abduction to encourage desired bone development and prevent dislocation. Hip abduction orthoses are also used to treat children with Legg-Calve-Perthes disease.

Operation

Donning and doffing an orthosis can be a challenge at first, especially for children or for individuals with upper extremity impairments. The orthotist provides specific instructions for donning and doffing with the least difficulty. In addition, he or she provides instructions regarding the need to monitor skin for possible breakdown.

Maintenance

Orthotic maintenance may include resetting joint angles, which is usually done by an orthotist or a physical therapist under the direction of an orthotist. Screws in joint mechanisms also may loosen occasionally, and tightening can usually be done by the patient or caregiver

at home with directions from the orthotist. As with operation, maintenance may vary depending on the type of orthosis, and users should follow the instructions of their orthotists.

Health care team roles

The patient, family, physician, orthotist and physical therapist all play important roles in orthotic intervention. The patient and family provide information about their lifestyles, home environment, and support network that allow for a realistic assessment of the ability to don, doff, care for and use an orthosis. The physician often plays an important role in identifying the need for an orthosis and preliminarily educating the patient about goals of orthotic intervention. The physical therapist and orthotist often cooperate in performing the preorthotic assessment. The physical therapist usually has important information regarding the patient's impairments and functional abilities, and may have an idea about what type of orthosis may be appropriate. The orthotist assesses limb function, takes necessary measurements for fabrication, and has extensive, up-to-date knowledge about what types of orthoses and components may best fit the patient's needs.

Training

The orthotist educates the patient about donning, doffing, caring for and using the orthosis. A wearing schedule is often provided for the patient to gradually grow accustomed to the orthosis. Because the physical therapist usually sees the patient regularly, he or she monitors the patient's progress with all aspects of orthotic intervention.

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ORGANIZATIONS

American Academy of Orthotists and Prosthetists. 526 King Street, Suite 201, Alexandria, VA 22314. (703) 836-0788. <<http://www.oandp.org>>.

Peggy Campbell Torpey, MPT

Lower limb prostheses

Definition

A lower limb prosthesis is an artificial replacement for any or all parts of the lower extremity (leg).

Purpose

A prosthesis is used to provide an individual who has an amputated limb with the opportunity to perform functional tasks, particularly ambulation (walking), which may not be possible without the limb. In 2000, there were more than 1.5 million people in the United States with amputations. Amputation surgery most often is performed due to complications of peripheral vascular disease or neuropathy; trauma is the second leading cause of amputation. Amputations performed because of tumor or congenital limb deficiency are less common.

Description

There are several levels of lower limb amputation, including partial foot, ankle disarticulation, transtibial (below the knee), knee disarticulation, transfemoral (above the knee), and hip disarticulation. The most common are transtibial (mid-calf) and transfemoral (mid-thigh). The basic components of these lower limb prostheses are the foot-ankle assembly, shank, socket, and suspension system.

Foot-ankle assembly

The foot-ankle assembly is designed to provide a base of support during standing and walking, in addition to providing shock absorption and push-off during walking on even and uneven terrain. Four general categories of foot-ankle assemblies are non-articulated, articulated, elastic keel, and dynamic-response. One of the most widely prescribed foot is the solid-ankle-cushion-heel (SACH) foot, due to its simplicity, low cost, and durability. It may be inappropriate, however, for active community ambulators and sports participants. Articulated assemblies allow motion at the level of the human ankle; this motion may occur in one or more planes, depending on whether it is a single-axis or multi-axis foot. These assemblies offer more mobility at the cost of less stability and increased weight. The elastic keel foot is designed to mimic the human foot without the use of mechanical joints; the dynamic-response foot is designed to meet the demands of running and jumping in athletic users.

Shank

The shank corresponds to the anatomical lower leg, and is used to connect the socket to the ankle-foot assembly. In an endoskeletal shank, a central pylon, which is a narrow vertical support, rests inside a foam cosmetic cover. Endoskeletal systems allow for adjustment and realignment of prosthetic components. In an exoskeletal shank, the strength of the shank is provided by a hard outer shell that is either hollow or filled with lightweight material. Exoskeletal systems are more durable than endoskeletal systems; however, they may be heavier and have a fixed alignment, making adjustments difficult.

Socket

The socket contacts the residual limb and disperses pressure around it. A hard socket offers direct contact between the limb and the socket, resulting in decreased friction, no liner bulk, easy cleaning, and increased durability. It is, however, difficult to fit and adjust in response to residual limb changes. A soft socket includes a liner as a cushion between the socket and residual limb. This provides additional protection for the limb but may increase friction and bulk. Transtibial socket types include: patellar tendon-bearing (PTB), silicone suction, energy-storing, or bent-knee designs. Transfemoral socket types include: quadrilateral, ischial containment, and contoured adducted trochanteric-controlled alignment method (CAT-CAM) designs. A prosthetic sock is usually worn to help cushion the limb from forces and accommodate for volume changes. Prosthetic socks are available in a variety of materials and thickness, and may be worn in layers to achieve the most comfortable fit.

Suspension

Suspension devices should keep the prosthesis firmly in place during use and allow comfortable sitting. Several types of suspension exist, both for the transtibial and transfemoral amputation. Common transtibial suspensions include sleeve, supracondylar, cuff, belt and strap, thigh-lacer, and suction styles. Sleeves are made of neoprene, urethane, or latex and are used over the shank, socket and thigh. Supracondylar and cuff suspensions are used to capture the femoral condyles and hold the prosthesis on the residual limb. The belt and strap method uses a waist belt with an anterior elastic strap to suspend the prosthesis, while the thigh-lacer method uses a snug-fitting corset around the thigh. The suction method consists of a silicone sleeve with a short pin at the end. The sleeve fits over the residual limb and the pin locks into the socket. With a transfemoral prosthesis, suction and several types of belt suspension also are available.



A man wears an artificial leg. (Photograph by Andrew Holbrooke. Stock Market. Reproduced by permission.)

Transfemoral amputations also provide the additional challenge of incorporating a prosthetic knee unit. The knee unit must be able to bend and straighten smoothly during ambulation, in addition to providing stability during weightbearing on that limb. Knees are available as single-axis, polycentric, weight-activated, manual-locking, hydraulic, and pneumatic units. Technology using microprocessors in knee units is becoming a reality, although costs can be prohibitive.

Operation

Use of an actual prosthesis usually follows a period of postoperative management that includes addressing issues of **pain**, swelling, and proper positioning. In addition, **physical therapy** for range of motion, strength, bed mobility, transfers, and single limb ambulation often takes place during the initial rehabilitation period. In some cases, an individual may be fitted with an immediate post-operative prosthesis to allow for early double-

limb ambulation. Many individuals will be fitted with a temporary prosthesis when the wound has healed. A temporary prosthesis allows for ambulation and continued shrinkage of the residual limb until a definitive prosthesis is fit.

When evaluating a prosthesis before use, the prosthetist and physical therapist should ensure that the inside of the socket is smooth and that all joints move freely. The socket should fit securely on the residual limb, and the overall prosthesis length should match the length of the intact leg. The patient must learn how to properly put on the residual limb sock and the prosthesis itself. A variety of techniques are used, depending on the type of socket and suspension system.

Maintenance

The user should be aware of how to properly care for and maintain the prosthesis, liner, and socks. Most plastic sockets and liners can be wiped with a damp cloth and dried. Socks should be washed and changed daily. Due to the wide variety of componentry and materials used in the fabrication of prostheses, the prosthetist should be the source for instructions regarding proper care and maintenance for each individual. In general, the patient should return to the prosthetist for any repairs, adjustments or realignments.

Health care team roles

The patient's primary care physician, surgeon, neurologist, prosthetist, physical and occupational therapists, nurses, and social worker are all important players in the multidisciplinary health care team. Surveys of patients with amputations have shown that the physical therapist, along with the physician and prosthetist, plays one of the most valued roles in providing information and help both at the time of amputation and following amputation. The entire team's input, along with the patient's input, is vital in determining whether a prosthesis should be fit and the specific prescription for the prosthesis. Input should be provided regarding the patient's medical history, pre-morbid level of function, present level of function, body build, range of motion, strength, motivation, and availability of familial and social support.

The physical therapist usually plays a major role in training an individual to walk with a prosthesis, and also is the health care professional who can evaluate prosthetic function immediately and over time. The physical therapist is trained in gait assessment and should watch for compensations and gait deviations that may indicate a problem with the prosthesis.

Training

The main goal of prosthetic training usually is smooth, energy-efficient gait. This includes the ability of the individual to accept weight on either leg, balance on one foot, advance each leg forward and adjust to different types of terrain or environmental conditions. Principles of motor learning often are used in training, progressing from simple to complex tasks. Individuals begin with learning to keep their bodies stable in a closed environment with no manipulation or variability. An example may be practicing standing balance on one or both legs. Mobility, environmental changes, and task variability are added slowly to further challenge the individual as tasks are mastered. In the end, an example of a more complex task practiced may be the ability walk in a crowded hallway while carrying an object in one hand. In addition to ambulation training, the patient also should be taught how to transfer to and from surfaces, assume a variety of positions such as kneeling or squatting, and manage **falls**. Depending upon the individual's previous and present level of function, use of a traditional cane, quad cane, or crutches may be indicated. Patient motivation, comorbidity, level of amputation and level of function are all factors in determining the outcome of rehabilitation.

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Peggy Campbell Torpey, MPT

Lumbar puncture see **Cerebrospinal fluid (CSF) analysis**

Lumbosacral radiculopathy see **Sciatica**

Lung biopsy

Definition

Lung biopsy is a procedure by which a small sample of lung tissue is obtained for examination. Usually, it is examined under the **microscope** and also may be sent to the microbiological laboratory for culture. Microscopic examination is performed by pathologists.

Purpose

A lung biopsy is usually ordered to determine the cause of abnormalities that appear on chest x rays, such as nodules or infiltrates. Lung biopsies are performed to confirm a diagnosis of **cancer**, especially if malignant cells are detected in the patient's sputum or bronchial washing. In addition to evaluating lung tumors and their associated symptoms, lung biopsies may be used in the diagnosis of lung infections, especially **tuberculosis** and **Pneumocystis pneumonia**, drug reactions, and chronic diseases of the lung such as sarcoidosis.

A lung biopsy can be used for treatment as well as diagnosis. **Bronchoscopy**, a type of lung biopsy performed with a long slender instrument called a bronchoscope, can be used to clear a patient's air passages of secretions and to remove blockages from the airways. Today, flexible fiberoptic bronchoscopes, which are easier to use than rigid scopes, are used to perform most biopsies.

Precautions

As with any other biopsy, lung biopsies should not be performed on patients who have a tendency to bleed or abnormal **blood** clotting because of low platelet counts or prolonged prothrombin time (PT) or partial thromboplastin time (PTT). Platelets are small blood cells that play a role in the blood clotting process. PT and PTT measure how well blood clots. If they are prolonged, it might be unsafe to perform a biopsy because of the risk of bleeding. If the platelet count is lower than 50,000/cubic mm, the patient may be given a platelet transfusion as a temporary relief measure, and a biopsy can then be performed.

Description

Overview

The mediastinum separates the right and the left **lungs** from each other. The **heart**, the trachea, the lymph nodes, and the esophagus lie in the mediastinum. Lung

biopsies may involve **mediastinoscopy**, as well as the lungs themselves.

Types of lung biopsies

Lung biopsies can be performed using a variety of techniques. A bronchoscopy is ordered if a lesion identified on the x ray seems to be located in the periphery of the chest. If the suspicious area lies close to the chest wall, a needle biopsy can be done. If both these methods fail to diagnose the problem, an open lung biopsy may be performed. When there is a question about whether the **lung cancer** has spread to the lymph nodes in the mediastinum, a mediastinoscopy is performed.

NEEDLE BIOPSY. About an hour before the needle biopsy procedure, a sedative is administered to the patient. The patient is mildly sedated but fully awake. An X ray technician takes a computerized axial tomography (CT) scan to identify the location of the suspicious areas. Markers are placed on the overlying skin to mark the biopsy site. The skin is thoroughly cleansed with an antiseptic solution, and a local anesthetic is injected to numb the area.

The physician then makes a small incision, about half an inch (1.25 cm) in length. The patient is asked to take a deep breath and hold it while the physician inserts the biopsy needle through the incision into the lung. When enough tissue has been obtained, the needle is withdrawn. Pressure is applied at the biopsy site and a sterile bandage is placed over the cut. The entire procedure takes between 30 and 45 minutes.

The patient may feel a brief sharp **pain** or some pressure as the biopsy needle is inserted. Most do not experience severe pain.

OPEN BIOPSY. Open biopsies are performed in a hospital operating room under **general anesthesia**. As with needle biopsies, patients are sedated before the procedure. An intravenous line is placed to give medications or fluids as necessary. A hollow tube, called an endotracheal tube, is passed through the mouth, into the airway leading to the lungs. It is used to convey the general anesthetic.

Once the patient is anesthetized, the surgeon makes an incision over the lung area, a procedure called a thoracotomy. Some lung tissue is removed and the incision is closed with sutures. The entire procedure usually takes about an hour. A chest tube is sometimes placed with one end inside the lung and the other end protruding through the closed incision. Chest tube placement is done to prevent the lungs from collapsing by removing the air from the lungs. The tube is removed a few days after the biopsy.

A **chest x ray** is done following an open biopsy, to check for a pneumothorax (lung collapse). The patient may experience some grogginess for a few hours after the procedure. Patients also may experience tiredness and muscle aches for a day or two, because of the general anesthesia. The throat may be sore because of the placement of the endotracheal tube. The patient may also have some pain or discomfort at the incision site, which can be relieved by pain medication.

VIDEO-ASSISTED THOROSCOPIC SURGERY. A new technique, video-assisted thoroscopic surgery (VATS), also can be used to biopsy lung and mediastinal lesions. VATS may be performed on selected patients in place of open lung biopsy. To perform a VATS procedure, the surgeon makes several small incisions in the patient's chest wall. A thoroscope, a thin, hollow, lighted tube with a tiny video camera mounted on it, is inserted through one of the small incisions. The other incisions allow the surgeon to insert **surgical instruments** to retrieve tissue for biopsy.

MEDIASTINOSCOPY. The preparation for a mediastinoscopy is similar to that for an open biopsy. The patient is sedated and prepared for general anesthesia. The neck and the chest are cleansed with an antiseptic solution.

After the patient is anesthetized, an incision about two or three inches long is made at the base of the neck. A thin, hollow, lighted tube, called a mediastinoscope, is inserted through the incision into the space between the right and the left lungs. The surgeon removes any lymph nodes or tissues that look abnormal. The mediastinoscope is then removed, and the incision is sutured and bandaged. A mediastinoscopy takes about an hour.

Preparation

Before scheduling a lung biopsy, the physician performs a preoperative history and **physical examination**. An electrocardiogram (EKG) and laboratory tests may be performed before the procedure to check for clotting problems, anemia, and blood type, in case a transfusion becomes necessary.

Patient education

Patients who will undergo surgical diagnostic and treatment procedures should be encouraged to stop smoking. Patients able to stop smoking several weeks before surgical procedures have fewer postoperative complications.

Before any procedure is performed, the patient is asked to sign a consent form. The nurse may review the procedure and answer questions about the consent form or procedure. The nurse will advise the patient preparing

for general anesthesia to refrain from eating or drinking anything for at least 12 hours before the biopsy.

Aftercare

Needle biopsy

Following a needle biopsy, the patient is allowed to rest comfortably. The nurse checks the patient's status at two-hour intervals. If there are no complications after four hours, then the patient can go home.

Patient education

Prior to discharge to home, the nurse instructs the patient about resuming normal activities. Patients are advised to rest at home for a day or two before resuming regular activities, and to avoid strenuous activities for a week after the biopsy.

Open biopsy, VATS, or mediastinoscopy

After an open biopsy, VATS, or mediastinoscopy, patients are taken to the recovery room for observation. If no complications develop, they are returned to the hospital room. Nursing care includes monitoring temperature, pulse **blood pressure** and respiration. **Fever** may indicate **infection**, and decreased breath sounds may be symptoms of pneumothorax. Sutures are usually removed after seven to 14 days.

If the patient has extreme pain, light-headedness, or difficulty breathing after an open biopsy, the physician should be notified immediately. The sputum may be slightly bloody for a day or two after the procedure. Heavy or persistent bleeding requires evaluation by the physician.

Complications

Needle biopsy

Needle biopsy is associated with fewer risks than open biopsy, because it does not involve general anesthesia. Rarely, the lung may collapse because of air that leaks in through the hole made by the biopsy needle. If a pneumothorax (lung collapse) occurs, a chest tube is inserted into the pleural cavity to re-expand the lung. Some hemoptysis (coughing up of blood) occurs in 5% of needle biopsies. Prolonged bleeding or infection may also occur, although these are very rare.

Open biopsy

Possible complications of an open biopsy include infection or pneumothorax. Death occurs in about 1 in 3000 cases. If the patient has very severe breathing problems before the biopsy, then breathing may be further

KEY TERMS

Bronchoscopy—A medical test that enables the physician to see the breathing passages and the lungs through a hollow, lighted tube.

Endotracheal tube—A hollow tube that is inserted into the windpipe to administer anesthesia.

Lymph nodes—Small, bean-shaped structures scattered along the lymphatic vessels which serve as filters. Lymph nodes trap bacteria or cancer cells that are traveling through the lymphatic system.

Mediastinoscopy—A procedure that allows the physician to see the organs in the mediastinal space using a thin, lighted, hollow tube (a mediastinoscope).

Mediastinum—The area between the lungs, bounded by the spine, breastbone, and diaphragm.

Pneumothorax—A condition in which air or gas enters the pleura (area around the lungs) and causes a collapse of the lung.

Sputum—A mucus-rich secretion that is coughed up from the passageways (bronchial tubes) and the lungs.

impaired following the operation. For patients with normal lung function before the biopsy, the risk of respiratory problems resulting from or following the procedure is very small.

Mediastinoscopy

Complications due to mediastinoscopy are rare; death occurs in fewer than one in 3000 cases. More common complications include pneumothorax or bleeding caused by damage to the **blood vessels** near the heart. Mediastinitis, infection of the mediastinum, may develop. Injury to the esophagus or larynx may occur. If the nerves leading to the larynx are injured, the patient may be left with a permanently hoarse voice. All of these complications are rare.

Results

Abnormal results of needle biopsy, VATS, and open biopsy may be associated with diseases other than cancer. Nodular lesions, while frequently cancerous, can also be the result of active infections such as tuberculosis, or may be healed scars from a previous infection. In a third

of biopsies using a mediastinoscope, the lymph nodes that are biopsied prove to be cancerous. Abnormal results should always be considered in the context of the patient's medical history, physical examination, and other tests such as sputum examination, chest x rays, etc. before a definitive diagnosis is made.

Health care team roles

Fiberoptic bronchoscopy is performed by pulmonologists, physician specialists in pulmonary medicine. CT guided needle biopsy is done by interventional radiologists, physician specialists in radiological procedures. Thoracic surgeons perform open biopsy and VATS. Specially trained nurses, x ray, and laboratory technicians assist during the procedures and provide pre and postoperative education and supportive care.

Resources

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- American Lung Association. 1740 Broadway, New York, NY 10019-4374. (800)586-4872.
- Cancer Research Institute. 681 Fifth Avenue, New York, NY 10022. (800)992-2623.
- National Cancer Institute (National Institutes of Health). 9000 Rockville Pike, Bethesda, MD 20892. (800) 422-6237.

Barbara Wexler

Lung cancer

Definition

Lung **cancer** is a disease in which the cells of the lung tissues grow uncontrollably and form tumors. It is the leading cause of death from cancer among both men and women in the United States. The American Cancer

Society estimates that in 2001 at least 169,500 new cases of lung cancer will be diagnosed, and that lung cancer will account for 28% of all cancer deaths—approximately 157,400 people.

Description

Types of lung cancer

There are two kinds of lung cancers, primary and secondary. Primary lung cancer starts in the lung itself. Primary lung cancer is divided into small cell lung cancer and non-small cell lung cancer, depending on how the cells look under the **microscope**. Secondary lung cancer is cancer that starts somewhere else in the body (for example, the breast or urinary bladder) and metastasizes (spreads) to the **lungs**. Identifying the type of lung cancer is important because treatment varies by type. For example, small cell cancers generally are treated with surgery. On the other hand, surgery is not generally considered beneficial for non-small cell cancers; they are treated with **chemotherapy**.

Small cell cancer was formerly called oat cell cancer, because the cells resemble oats in their shape. About a fourth of all lung cancers are small cell cancers. This is a very aggressive cancer and spreads to other organs within a short time. It is generally diagnosed in people who are heavy smokers. Non-small cell cancers account for the remaining 75% of primary lung cancers. They can be further subdivided into three categories.

Nearly 30% of non-small cell cancers are squamous cell carcinomas. Squamous cell carcinoma is most often found near the bronchi of patients with a history of smoking. Forty percent of non-small cell cancers are adenocarcinomas, most often found in the outer region of the lung. The remaining 10% are large-cell undifferentiated carcinomas. These rapidly spreading carcinomas may be found throughout the lung.

Incidence of lung cancer

Lung cancer is rare among young adults. It is usually found in people who are 50 years of age or older, the average age at diagnosis is 60. While the incidence of the disease is decreasing among white men, it is steadily rising among African-American men, and among both white and African-American women. This change is probably due to the increase in the number of smokers in these groups. In 1987, lung cancer replaced **breast cancer** as the number one cancer killer among women. Lung cancer is responsible for more deaths than the combined totals for cancers of the colon, breast, and prostate.

Causes and symptoms

Causes

SMOKING. Tobacco smoking is the leading cause of lung cancer. Ninety percent of lung cancers can be prevented by giving up tobacco. Smoking **marijuana** cigarettes is considered yet another risk factor for cancer of the lung. These cigarettes have a higher tar content than tobacco cigarettes. In addition, they are inhaled very deeply—as a result, the carcinogens in the smoke are held in the lungs for a longer time.

EXPOSURE TO ASBESTOS AND TOXIC CHEMICALS. Exposure to asbestos fibers, either at home or in the workplace, is also considered a risk factor for lung cancer. Studies show that compared to the general population, asbestos workers are seven times more likely to die from lung cancer. Asbestos workers who smoke increase their risk of getting lung cancer by 50-100 times. Besides asbestos, mining industry workers exposed to coal products or radioactive substances such as uranium, and workers exposed to chemicals such as arsenic, vinyl chloride, mustard gas, and other carcinogens also have a higher than average risk of contracting lung cancer.

ENVIRONMENTAL CONTAMINATION. High levels of radon, a radioactive gas that cannot be seen or smelled, pose a risk for lung cancer. This gas is produced by the breakdown of uranium, and does not present any problem outdoors. In the basements of some houses that are built over soil containing natural uranium deposits, however, radon may accumulate to dangerous levels. Other forms of environmental pollution (e.g., auto exhaust fumes) may also slightly increase the risk of lung cancer.

CHRONIC LUNG INFLAMMATION AND SCARRING. Inflammation and scar tissue are sometimes produced in the lung by diseases such as silicosis and berylliosis, which are caused by inhalation of certain **minerals**; **tuberculosis**; and certain types of **pneumonia**. This scarring may increase the risk of developing lung cancer.

FAMILY HISTORY. Although the exact cause of lung cancer is not known, people with a family history of lung cancer appear to have a slightly higher risk of contracting the disease.

Symptoms

Because lung cancers tend to spread very early, only 15% are detected in their early stages. The chances of early detection, however, can be improved by seeking medical care at once if any of the following symptoms appear:

- a cough that does not go away
- chest **pain**

- shortness of breath
- persistent hoarseness
- swelling of the neck and face
- significant weight loss that is not due to dieting or vigorous **exercise**; fatigue and loss of appetite
- bloody or brown-colored phlegm (sputum)
- unexplained **fever**
- recurrent lung infections, such as bronchitis or pneumonia

Diseases other than lung cancer may cause these symptoms. It is vital, however, for patients to consult a physician to rule out the possibility that they are the presenting symptoms of lung cancer.

If the lung cancer has spread to other organs, the patient may have other symptoms such as headaches, bone **fractures**, pain, bleeding, or **blood** clots. Early detection and treatment can increase the chances of a cure for some patients; for others, it can at least prolong life.

Diagnosis

Physical examination and initial tests

If lung cancer is suspected, the physician will take a detailed medical history to document the symptoms and assess the risk factors. The history is followed by a complete **physical examination**. The physician will examine the patient's throat to rule out other possible causes of hoarseness or coughing, and listen to the patient's breathing and the sounds made when the patient's chest and upper back are percussed (tapped). The physical examination, however, is not conclusive.

If there is reason to suspect lung cancer—such as a history of heavy smoking or occupational exposure to substances known to irritate the lungs—the physician may order a **chest x ray** to see if there are any masses in the lungs. Special imaging techniques, such as **PET scans (positron emission tomography)**, CT (computerized axial tomography) scans or MRI (**magnetic resonance imaging**) may provide more precise information about the size, shape, and location of any tumors. X ray and other imaging techniques may be performed by a radiologic technician.

Sputum analysis

Sputum analysis involves microscopic examination of the cells that are either coughed up from the lungs, or are collected through a bronchoscope. Sputum analyses can diagnose at least 30% of lung cancers, some of which do not show up even on chest x rays. In addition, this lab-

oratory test can help detect cancer in its very early stages, before it metastasizes (spreads) to other regions. The sputum test does not, however, provide any information about the location of the tumor and must be followed by other diagnostic tests.

Lung biopsy

Lung biopsy is the definitive diagnostic tool for cancer. It can be performed in several different ways. The physician can perform a **bronchoscopy**, which involves the insertion of a slender, lighted tube, called a bronchoscope, down the patient's throat and into the lungs. In addition to viewing the passageways of the lungs, the physician can use the bronchoscope to obtain samples of the lung tissue. In another procedure known as a needle biopsy, the location of the tumor is first identified using a CT scan or MRI. The physician then inserts a needle through the chest wall and collects a sample of tissue from the tumor. In the third procedure, known as surgical biopsy, the chest wall is opened up and a part of the tumor, or all of it, is removed. A pathologist, a physician who specializes in the study of diseased tissue, examines the tumor samples to identify the cancer type and stage.

Patient education

Patients who will undergo surgical diagnostic and treatment procedures should be encouraged to stop smoking. Patients able to stop smoking several weeks before surgical procedures have fewer postoperative complications.

Treatment

Treatment for lung cancer depends on the type of cancer, its location, and its stage. Staging is a process that describes if the cancer has metastasized and the extent of its spread. Lung cancer is staged at the time of diagnosis; this is called clinical staging. It usually is staged again following surgical intervention; this is called pathologic staging. When determining a course of treatment, the patient's age, medical history, and general state of health are taken into account. The most commonly used modes of treatment are surgery, radiation therapy, and chemotherapy.

Surgery

Surgery is not usually an option for small cell lung cancers, because they have usually spread beyond the lung by the time they are diagnosed. Because non-small cell lung cancers are less aggressive, however, surgery can be used to treat them. The surgeon determines the type of surgery, depending on how much of the lung is

affected. Surgery may be the primary method of treatment, or radiation therapy and/or chemotherapy may be used to shrink the tumor before surgery is attempted.

Not all patients are candidates for surgery, especially the removal of an entire lung (pneumonectomy). For example, many smokers suffer from **emphysema** as well as lung cancer, and as a result have sharply reduced lung capacity. Spirometric testing may be performed to assess lung capacity. The forced expiratory volume in one second (FEV1) is a laboratory test that helps to determine whether patients will have adequate pulmonary function after resection.

There are three different types of surgical operations:

- **Wedge resection.** This procedure involves removing a small part of the lung. A wedge resection is done when the cancer is in a very small area and has not metastasized to any other chest tissues or other parts of the body.
- **Lobectomy.** A lobectomy is the removal of one lobe of the lung. The right lung has three lobes and the left lung has two lobes. If the cancer is limited to one part of the lung, the surgeon will perform a lobectomy.
- **Pneumonectomy.** A pneumonectomy is the removal of an entire lung. If the cancer cells have spread throughout the lung, and if the surgeon feels that removal of the entire lung is the best option for curing the cancer, a pneumonectomy will be performed.

Postoperative surgical nursing care includes monitoring temperature, pulse **blood pressure** and respiration. Fever may indicate **infection**; patients are vulnerable to bacterial and viral infections. Decreased breath sounds may be symptoms of pneumothorax. The pain that follows surgery can be relieved by medications. The tendency of surgical **stress** to weaken the patient's **immune system** is treatable with **antibiotics**, anti-viral medicines, and vaccines.

Patient education

Postoperative patient teaching encourages ambulation (walking), and reinforces patient and family understanding of surgical results and necessary follow-up.

Radiotherapy

Radiotherapy involves the use of high-energy rays to kill cancer cells. It is used either by itself or in combination with surgery or chemotherapy. Radiotherapy can be used to treat all types of cancer. The amount of radiation used depends on the size and the location of the tumor. There are two types of radiotherapy treatments, external beam radiation therapy and internal (or interstitial) radiotherapy. In external radiation therapy, the radi-



A normal lung (left) and the lung of a cigarette smoker (right). (Photograph by A. Glauber, Photo Researchers, Inc. Reproduced by permission.)

ation is delivered from a machine positioned outside the body. Internal radiotherapy uses a small pellet of radioactive materials placed inside the body in the area of the cancer.

Radiation therapy may produce such side effects as tiredness, skin rashes, upset **stomach**, and **diarrhea**. Dry or sore throats, difficulty in swallowing, and loss of hair in the treated area are all minor side effects of radiation. Some side effects diminish or disappear either during the course of the treatment or after the treatment is over.

Patient education

Patient education by nurses and radiologic technicians includes measures to identify and manage side effects such as fatigue or radiodermatitis (skin condition resulting from radiotherapy).

Chemotherapy

Chemotherapy uses anti-cancer medications that are either given intravenously or taken by mouth. These drugs enter the bloodstream and travel throughout the body, killing cancer cells that have spread to different organs. Chemotherapy is used as the primary treatment

for cancers that have spread beyond the lung and cannot be removed by surgery. It may also be used in addition to surgery or radiation therapy.

Chemotherapy is tailored to each patient's needs. The prescribed regimen depends on the type of cancer, the extent of its spread, and the patient's general state of health. Most patients are given a combination of several different drugs. Besides killing the cancer cells, these drugs also harm normal cells. Hence, the dose has to be carefully adjusted to minimize damage to normal cells. Chemotherapy often has severe side effects, including nausea, vomiting, hair loss, anemia, weakening of the immune system, and sometimes **infertility**. Most of these side effects end when the treatment is over. Other medications can be given to lessen the unpleasant side effects of chemotherapy.

Patient education

Patient teaching helps patients and families to distinguish between anticipated side effects such as alopecia (hair loss), nausea, and constipation and the more serious side effects that require medical attention. Examples of

KEY TERMS

Alopecia—Hair loss.

Biopsy—The surgical removal and microscopic examination of living tissue for diagnostic purposes.

Bronchoscope—A thin, flexible, lighted tube that is used to view the air passages in the lungs.

Carcinogen—Any substance capable of causing cancer.

Chemotherapy—Treatment of cancer with synthetic drugs that destroy the tumor either by inhibiting the growth of cancerous cells or by killing them.

Lobectomy—Surgical removal of an entire lobe of the lung.

Metastasize—The spread of cancer cells from a primary site to distant parts of the body.

Pathologist—A physician who specializes in the diagnosis of disease by studying cells and tissues under a microscope.

Pneumonectomy—Surgical removal of an entire lung.

Pneumothorax—Collapse of the lung.

Radiation therapy—Treatment using high energy radiation from X-ray machines, cobalt, radium, or other sources.

Sputum—Mucus or phlegm that is coughed up from the passageways of the lungs.

Stage—A term used to describe the size and extent of spread of cancer.

Wedge resection—Removal of only a small portion of a cancerous lung.

side effects that can not be managed at home include bleeding, fever, and confusion or hallucinations.

Prognosis

If the lung cancer is detected before it has had a chance to spread to other organs, and if it is treated appropriately, at least 49% of patients can survive five years or longer after the initial diagnosis. Only 15% of lung cancers, however, are found at this early stage.

Improvements in surgical technique and the development of new approaches to treatment have markedly improved the one-year survival rate for lung cancer.

Slightly more than 40% of patients survive for at least a year after diagnosis, as opposed to 30% 25 years ago. The five-year survival rate for all stages of lung cancer is 14%.

Health care team roles

Lung cancer treatment involves an multidisciplinary team of health care professionals. In addition to primary care physicians, such as a family practitioner or an internist, the treatment team may include a pulmonologist, pathologist, radiologist, and thoracic surgeon as well as specialized nurses, radiologic and laboratory technicians, respiratory therapists, and dieticians.

Patient education

Before, during and after treatment, nurses and allied health professionals should inform and educate patients and families about the risks and complications of any planned diagnostic test, intervention, or treatment. Patients and families should be taught about some of the common side effects of treatment, including weight loss, malnutrition, increased risk of infection, pain, fatigue, and depression.

Prevention

The best way to prevent lung cancer is never to smoke or to quit smoking if one has already started. Secondhand smoke from tobacco should be avoided. Appropriate precautions should be taken when working with carcinogens (cancer-causing substances). Promoting healthy lifestyles, testing houses for the presence of radon gas, and asbestos abatement are also useful preventive strategies.

Patient education

The objectives of education are to prevent patients, especially children and adolescents, from smoking, and to encourage smokers to quit. Participation in smoking cessation programs should be encouraged and patients should be informed about the health risks of passive (secondhand) smoking. Patient education also should describe the role of environmental carcinogens such as asbestos and radon in the development of lung cancer.

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American Lung Association. 1740 Broadway, New York, NY 10019-4374. (800)586-4872.

Cancer Research Institute. 681 Fifth Avenue, New York, NY 10022. (800)992-2623.

National Cancer Institute (National Institutes of Health). 9000 Rockville Pike, Bethesda, MD 20892. (800)422-6237.

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Lung function tests see **Pulmonary function test**

Lung perfusion and ventilation scan

Definition

A lung perfusion scan and ventilation study are two diagnostic imaging studies. A lung perfusion scan assesses **blood** flow to the **lungs**. A lung ventilation study reveals the distribution of air space within the lungs. These are two separate studies that are often performed sequentially. The tests are called by different names, including perfusion lung scan, aerosol lung scan, ventilation lung scan, xenon lung scan, ventilation/perfusion scanning (VPS), pulmonary scintiphotography, or most commonly, V/Q scan.

Purpose

Lung scans may be performed for patients with chest **pain**, for those coughing up blood (hemoptysis), or for those having difficulty breathing (dyspnea). A perfusion scan alone or both tests are frequently performed for patients with a suspected pulmonary embolism (blood clot in the lung) or for follow-up in patients with known pulmonary embolism. Lung scans are a sensitive method for demonstrating the presence of pulmonary disease but are not often specific for a certain disease. For example,

an abnormal scan may also be caused by chronic obstructive pulmonary disease (COPD), **asthma**, **pneumonia**, venous **hypertension**, pleural effusion, and cardiomegaly.

Precautions

The amount of radioactivity a person is exposed to during these tests is very low and is not harmful. However, if the patient has had other recent nuclear medicine tests, it may be necessary to wait until other radiopharmaceuticals have been cleared from the body so that they do not interfere with these tests.

Description

These tests are typically done in a hospital nuclear medicine department or out-patient radiology facility. Scans to diagnose pulmonary embolism are often done on an emergency basis. Most often, both studies are needed. Sometimes a perfusion scan is done without a ventilation scan. Rarely, a ventilation scan is done alone.

For a lung perfusion scan, the patient is injected intravenously with radioactive particles, known as Tc 99m MAA (macroaggregated albumin). The particles pass through the larger **blood vessels** and become temporarily trapped in small blood vessels. The images thus reflect blood perfusion in the lungs. Images are obtained anteriorly, posteriorly, laterally, and obliquely.

For a lung ventilation scan, the patient inhales a radioactive gas through a mask placed over the nose and mouth. Images of the ventilation lung scan show the distribution of the gas in the lungs. The test typically consists of three phases. The first stage is the initial, or ventilation stage, which reflects the rate of ventilation of the different lung segments. Second is the equilibrium stage, which represents gas volume of the lungs. The third stage is the wash-out phase, which demonstrates any gas trapping that may occur in obstructive diseases. Images are typically obtained posteriorly, although additional views may also be performed. Each test takes approximately 15 to 30 minutes. If possible, the patient usually sits up while the images are taken.

Preparation

To accompany the lung scan, the patient should have a **chest x ray** within 12 to 24 hours of the study. Otherwise, there is no special preparation needed for these tests. The patient may eat and drink normally before the procedure.

KEY TERMS

Pulmonary embolism—A blood clot or other blockage in the arteries leading to the lungs.

Aftercare

No special aftercare is needed. The patient may resume normal activities immediately.

Complications

There are no complications associated with these tests.

Results

Normally, there is a physiological relationship between the perfusion of the pulmonary blood vessels and their regional alveolar ventilation. An imbalance of this relationship as demonstrated by these studies reflect various respiratory diseases. Other diagnostic tests are often required to confirm a diagnosis.

Normal results for both tests show an even distribution of radioactive material in all parts of the lungs. For the lung perfusion scan, diminished or absent perfusion suggests decreased blood flow to that part of the lung, and possibly a pulmonary embolism. However, pneumonia, **emphysema**, or lung tumors can create readings on the lung perfusion scan that falsely suggest a pulmonary embolism is present. For the ventilation study, areas that show an increased accumulation of radioactive gas, particularly after the wash-out phase, suggests obstructive lung disease. Areas where there is decreased or absent radioactive gas flow suggests mechanical obstruction of air flow, such as an embolus. Certain combinations of abnormalities in lung perfusion and ventilation scans suggest pulmonary embolism.

Health care team roles

Both the lung perfusion and ventilation scans are performed by a nuclear medicine technologist. The technologist is trained to handle radioactive materials, operate the equipment, and process the data. The tests are interpreted by a radiologist who may specialize in nuclear medicine. Patients receive the results from their personal physician or the doctor who ordered the test.

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Lungs

Definition

The two lungs are spongy and highly elastic organs of respiration in the pulmonary cavities of the thorax, where the aeration of **blood** occurs.

Description

Each lung has an irregular conical shape with a blunt top, called the apex, extending into the root of the neck. They have concave bottoms resting on the arc of the diaphragm, a mostly concave inner mediastinal surface that follows the lines of the pericardium, and a convex outer (costal) surface. The right lung is larger than the left, and consists of three lobes (upper, middle, and basal or lower). The left lung consists of two lobes, an upper and a basal, or lower, lobe.

Each lung consists of an exterior plasma coat comprised of an organ coat which folds back to make an interior lining for the chest cavity. The inner lung contains sub-serous areolar tissue with elastic fibers interspersed over the surface of the organ. The parenchyma, or functional part of the organ, is composed of secondary lobules (alveolar ducts) that differentiate into primary lobules (alveoli) consisting of **blood vessels**, lymphatics, nerves, and an alveolar duct that connects with air space.

The lung, as it relates to inspiration and expiration, has two distinct zones in which the lung passages convey air to the alveolar sacs. The zones relate to the two functions of these passages. One is for conducting air, and the other is for respiration. The parts of the conducting zone do not participate in gas transfer, rather they convey air

to and from the respiratory zone. All of the parts of the respiratory zone can take part in gas transfer. However, the uppermost branches, such as the respiratory bronchioles, participate in respiration only in times of exertion.

The conducting zone starts at the trachea and branches out to the bronchi. The bronchi differentiate into bronchioles and then into terminal bronchioles. The respiratory zone starts after the terminal bronchioles at the respiratory bronchioles. These differentiate into the alveolar ducts, which terminate at the alveolar sacs. The lungs consist mainly of the tiny air containing alveolar sacs.

Function

The lung is the sole means of **gas exchange** in respiration. Air is brought into the body through the mouth or nose and trachea to the lung. There oxygen diffuses from the airspace of the alveoli into the blood stream and carbon dioxide diffuses from the blood into the alveoli's airspace.

The alveoli are small hollow sacs. Their ends connect to the lumens of the airways. The air adjacent to surfaces of the alveolar wall are lined by a single cell layer of flat epithelial cells called type I alveolar cells. In between type I cells are type II cells. They are thicker, and secrete a fluid called surfactant. In the alveolar walls this fluid and connective tissue fills the interstitial space and is interspersed with capillaries. In some places the interstitial space is nonexistent and the epithelial **cell membranes** are in direct contact with the capillaries. The blood in the capillaries is separated from the air by a single layer of flat epithelial cells. The surface area in a single alveoli is roughly the size of a small basketball court due to the undulating terrain of the type I and II epithelial cells. There are around 300 million alveoli in the adult male. Thus, there is a large surface area where the air and the blood stream are in close proximity. This large surface area is necessary for gas exchange to easily occur. The **respiratory system** also needs a continual supply of fresh air, which is supplied by the process of breathing.

The process of breathing is aided by the position of the lungs in the thorax (chest). The thorax is a closed chamber that extends from the neck muscles to the diaphragm. The diaphragm is a dome shaped sheet of skeletal muscle that separates the thorax from the abdomen. The sides of the thorax are bounded by connective tissue around the spine, ribs, intercostal muscles, and sternum.

A completely enclosed sac consisting of a thin sheet of cells, called the pleura, surround each lung. Between the pleura and the lung is interstitial fluid. As the

diaphragm expands and contracts the intra-pleural pressure placed on the lungs causes the lung to inflate and deflate. Breathing allows a fresh supply of air and oxygen to enter the lung upon inflation and carbon dioxide to exit the lung upon deflation. It also causes a change in the pressure of the lung.

The epithelial surface from the conducting zone to the respiratory bronchioles is lined with cilia that continually beat in the direction of the pharynx. There are epithelial cells and glands on this surface that secrete mucus. This mucus catches particulate and bacterial matter, and the material (and mucus) is slowly moved by the cilia toward the pharynx. There it is either swallowed or coughed up as sputum. The epithelial layer also secretes another viscous fluid that allows the cilia to move mucus easily out of the lung.

Toxic substances can inhibit ciliary action. Agents like cigarette smoke can paralyze the cilia for extended periods of time. This inhibits the movement of mucus and particles out of the lungs. The suspension of this process can inhibit gas exchange and eventually cause prolonged oxygen deficiency.

Respiration

Respiration is the process by which the body takes in oxygen and emits carbon dioxide. The following is a summary of the steps of respiration:

- ventilation
- interchange of CO₂ and O₂ between alveolar air and blood in lung capillaries
- transport of CO₂ and O₂ through the bloodstream
- interchange of CO₂ and O₂ between blood in lung capillaries and alveolar air by diffusion
- use of O₂ and production of CO₂ by cells in **metabolism**

Ventilation is the interchange of air between the atmosphere and the alveoli by bulk flow. Bulk flow is the movement of air from a region of high pressure to one of low pressure. Bulk flow may be thought of as occurring between the outside air, the air in most of the lung, and the air in the alveolar sacs. Flow of some gases (especially oxygen and carbon dioxide) also occurs between the alveolar air and the blood. It is important to note that the pressure of individual gases is different in different types of air. For example, air going into the lungs is rich in oxygen and low in carbon dioxide. Air leaving the lungs is rich in carbon dioxide and low in oxygen. The different concentrations (or pressures) of individual gases are known as the partial pressures, and the partial

KEY TERMS

Interstitial space—The spaces found within organs and tissues.

Metabolism—A series of chemical and physiological changes in the body that either build larger molecules out of smaller molecules (anabolism) or break down larger molecules into smaller ones (catabolism).

Parenchyma—The active portion of an organ that fulfills its function (as opposed to purely structural portions of the organ).

Proteolysis—The breaking down of proteins by cleaving or hydrolyzing peptide bonds (the bonds connecting amino acids within the protein).

pressure of each individual gas adds up to the total pressure of the gas.

When air is inspired (taken in), it has a higher partial pressure of oxygen than the air already in the lung, and a lower partial pressure of carbon dioxide. Therefore, inspired air allows oxygen to flow from the area of highest pressure (inspired air) to the alveolar sacs (that have a lower partial pressure of oxygen), and into the bloodstream. The same inspired air has a low partial pressure of carbon dioxide, so carbon dioxide leaves the bloodstream (where it has a high partial pressure), enters the alveolar air (where the pressure is lower), and is passed onto the inspired air (where the partial pressure is even lower). Thus, carbon dioxide gas and oxygen gas both move from areas of highest pressure to lowest pressure in an attempt to reach a pressure (or concentration) equilibrium. This process is called gas exchange. After gas exchange has taken place, the air is expired, or expelled to rid the body of air that has a high concentration (partial pressure) of carbon dioxide gas. Then the process begins again.

Lung expansion and contraction

The concept of bulk flow (explained above) and Boyle's law explain the expansion and contraction of the lung. Boyle's law states that, at constant temperature, an increase in the volume of a container (lung) lowers the pressure of a gas, and a decrease in the container (lung) volume raises the pressure. Thus, when the volume of the lung expands, the pressure inside the lung is lowered, and when the volume of the lung contracts, the pressure inside the lung rises.

Inspiration occurs when the muscles of inspiration increase the volume of the thoracic cavity. The decrease in pressure in the cavity causes the lungs to expand to fill the cavity, which lowers the pressure inside the lung. Since air flows from areas of high pressure to low pressure, air fills the lungs to equalize the air pressure inside the lungs with the outside air, and inspiration occurs. The difference between the internal pressure in the lung and the pressure of the outside air is called the transpulmonary pressure.

During expiration, the muscles of inspiration relax, and the lung contracts. The decreased volume causes increased pressure inside the lungs, which results in air being expired, or expelled. In normal adults, expiration does not require any effort.

Role in human health

The lungs ability to extract oxygen from the atmosphere and supply it to the body's tissues is essential for metabolism and therefore for life. Disease and disorder can interfere with the body's normal function and slow a normally healthy person. Serious interference with the lung's function can cause hypoxia and even death.

Common diseases and disorders

Asthma is an intermittent disease characterized by a chronic inflammation of the airways, causing smooth **muscle contraction** in the airway. The causes vary from person to person and can include **allergies**, viral infections, environmental pollutants, mold, dust, dander, cigarette smoke, overexertion, and naturally released bronchiorestrictors. Ingested items such as food coloring, preservatives, and medications can trigger an attack.

Chronic obstructive pulmonary disease (COPD) refers to **emphysema**, chronic bronchitis, or a combination of the two. This category of disease is one of the major causes of death and disability in the world. These diseases restrict ventilation and the oxygenation of the blood.

Chronic bronchitis is characterized by excessive mucus production in the bronchi and chronic inflammatory changes in the small airways. The accumulation of mucus and thickening of inflamed airways obstruct the flow of air. It is primarily a result of cigarette smoking, although pollution may also play a role.

Emphysema is a major cause of hypoxia and is characterized by the destruction of the alveolar walls, and the atrophy and collapse of the lower airways. The lungs self-destruct through the secretion of proteolytic enzymes by white blood cells. Cigarette smoke stimulates the release of harmful enzymes and destroys the

Lymphatic system

Definition

The lymphatic system is composed of a network of vessels that collects fluid and plasma **proteins** that leak out of capillaries and into the interstitial space. Lymphatic vessels return the lymph (fluid and plasma protein) back to the circulatory system through the veins.

Description

The lymphatic system is a secondary system of vessels that is distinct both in anatomy and function from the **blood** vessel capillaries of the circulatory system. Small lymphatic vessels (or “lymphatics”) called lymphatic capillaries are found in almost all organs of the body except superficial layers of the skin, the **central nervous system**, endomysium of muscles, and the bone. These exceptions have a system of smaller vessels called pre-lymphatics. Fluid from prelymphatics returns to nearby lymphatic vessels, or the cerebral spinal fluid in the case of the central nervous system.

Lymphatic capillaries are made up of a single layer of endothelial cells. They are anchored to the surrounding connective tissue by special filaments called anchoring filaments. The system begins as a series of sacs. Each sac has a low hydrostatic pressure relative to the outside of the sac. At the end of the lymphatic capillaries there are endothelial valves. The valves form as a result of the slight overlap of the endothelial cells, and the overlapping edge has the ability to open inward. The valves open enough to allow fluid and plasma protein to pass into the lymphatic capillary.

Inside the lymph vessels are valves that prevent the backflow of lymph, a general name for the slightly opalescent fluid picked up by the lymphatics. Surrounding the lymphatics are smooth muscles that contract involuntarily to assist in the movement of lymph through the system. The lymphatic capillaries converge into larger lymph vessels. The larger lymph vessels pass through swellings called lymph nodes and then empty into one of two large lymph ducts. The lymph ducts empty into the venous circulatory system through either the right or left subclavian veins. Lymph from the right side of the head, arm and chest empties into the right subclavian vein. Lymph collected from the lower part of the body, and lymph from the left side of the head, arm and chest empties into the left subclavian vein. Both subclavian veins are located within the thorax underneath the clavicles, the thin bones located on the top part of the chest.

enzymes that normally protect against proteolysis. The proteolytic enzymes cause the breakdown of the alveolar walls. The damaged alveoli fuse and a gradual decrease in the surface area available for gas exchange results. Emphysema increases the work of breathing and, when severe enough, causes hypoventilation (inadequate ventilation). The obstruction caused by the collapse of the lower airways is accompanied with destruction of the lung’s elastic tissues and the eventual collapse of the airways.

Pneumonia is normally caused by bacterial or viral **infection**. It can be triggered by the inhalation of toxic chemicals, chest trauma, yeast, rickettsiae, and **fungi**. It is the inflammation and compaction of the lung parenchyma. The alveolar spaces fill with mucus, inflammatory cells, and fibrin.

Tuberculosis is caused by the infection of *Mycobacterium tuberculosis*. It can affect most organs but is most commonly found in the lungs. The **bacteria** cause lesions to be formed on the lungs and spread to other tissues. Pulmonary tissue in motion will be chronically affected and may eventually be destroyed, if left untreated. The erosion of lung tissue into the blood vessels can result in life-threatening hemorrhages.

Other less common diseases of the lung include Legionnaire’s disease, **cystic fibrosis**, histoplasmosis, coccidiomycosis, and *Mycobacterium avium* complex.

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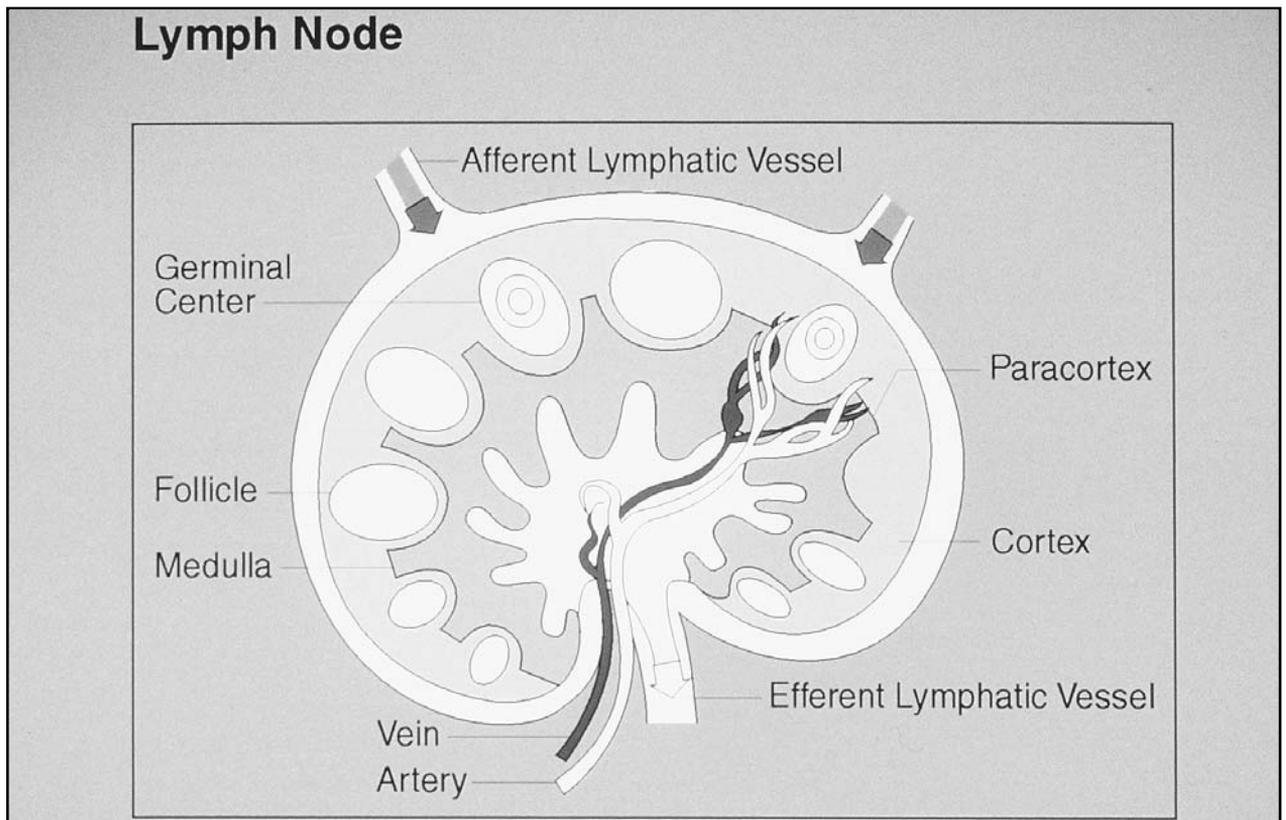
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Sally C. McFarlane-Parrott

Luteinizing hormone test see **Pituitary hormone tests**



Lymph nodes filter the flow of lymph in the lymphatic system. (National Institutes of Health. Reproduced by permission.)

At approximately 600 sites in the human body, lymphatic vessels converge into bundles of tissue called lymph nodes. The shape of a lymph node resembles a kidney bean and ranges in size from a few millimeters to a few centimeters. They are mostly found at the base of extremities such as the arms, legs and head. Many afferent lymphatics or vessels lead the lymph into the node at the larger curve of the bean shape and efferent lymphatics, fewer in number, take the lymph away from the node at the hilum, the depressed region of the bean shape. All nodes have a blood supply from the circulatory system running through them. The **blood vessels** enter and exit at the hilum. Inside the nodes are a honeycomb of lymph-filled sinuses that have macrophages and groupings of lymphocytes that produce antibodies.

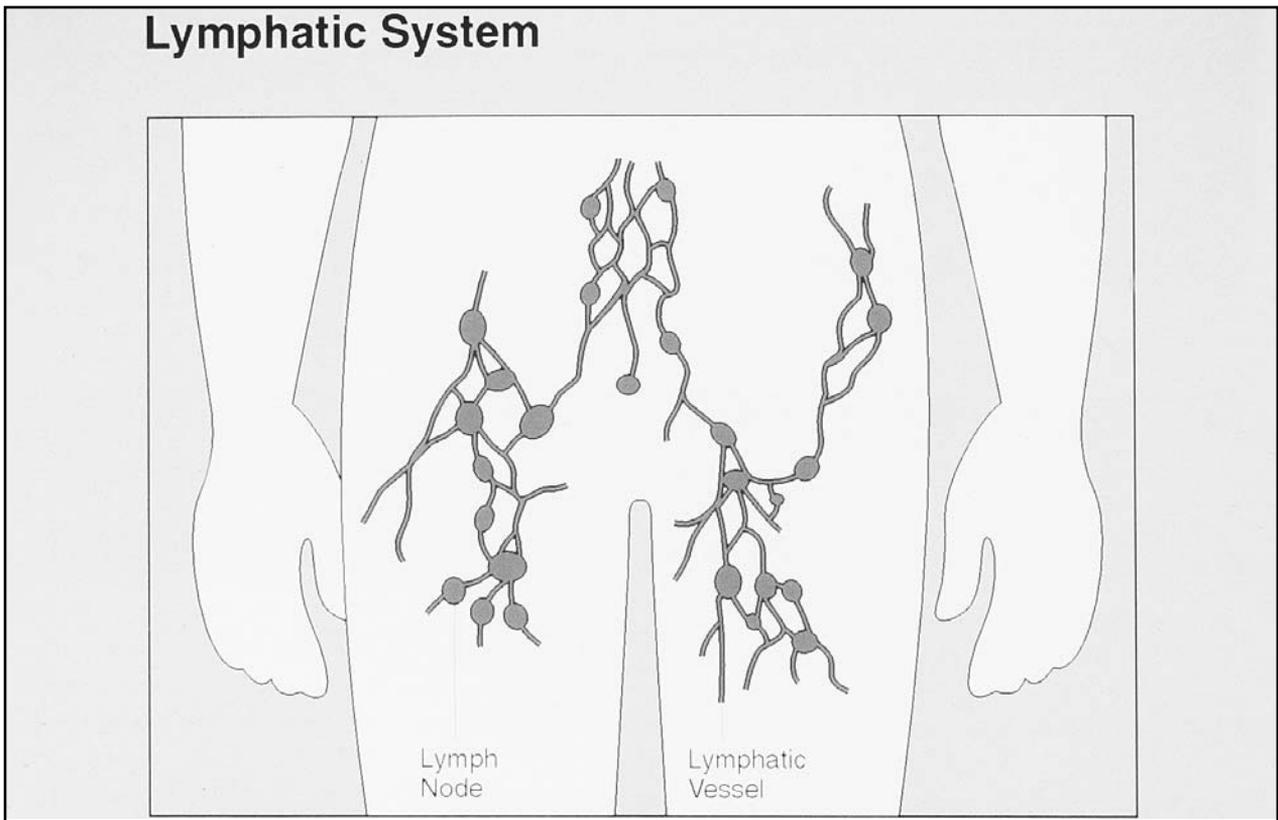
As mentioned, lymph is the fluid flowing through the lymphatic system and originates from the interstitial spaces of the organs and tissues. Another element of the lymph is a type of cell of the **immune system** called a lymphocyte, which is a type of white blood cell. Lymphocytes mature in either the thymus (T-lymphocytes) or the bone marrow (B-lymphocytes), which are primary lymphoid organs. The blood supply transports lymphocytes from their site of maturation (the thymus or

bone marrow) to secondary lymphoid organs such as the lymph nodes, spleen, and tonsils. All lymphocytes in the adult originate in the bone marrow.

Function

Fluid enters organs and tissues from the arterial capillaries, and is eventually reabsorbed by the venous capillaries. However, not all of the fluid is reabsorbed by blood capillaries. About one tenth of the fluid is returned to the blood vessels via the lymphatic system. The lymphatic system reabsorbs about 2–4 qt (l) of fluid per day. Lymph composition is different depending on the site of origin. For example lymph collected from the gastrointestinal tract is high in fat that has been absorbed during digestion, and lymph collected from the bone marrow and thymus is high in lymphocyte concentration.

Lymph is collected when the pressure of the interstitial fluid and plasma proteins increases in the organs and tissues. Lymph pushes against the outside of the lymphatic valves and flows into the lymphatic capillary. This is called bulk flow. Valves are located throughout the lymphatic system approximately 0.15 in (3.8 mm) apart. Backflow is not possible in the lymphatics because the



The lymph collected from the body's tissues is carried through the lymphatic vessels and lymph nodes. This illustration shows lymph nodes and vessels in the groin. (National Institutes of Health. Reproduced by permission.)

valves open in only one direction. Therefore, the lymphatic system runs in only one direction.

There are several factors that affect the rate at which lymph is collected. Interstitial fluid pressure affects the rate of flow of fluid into the lymphatic capillaries. Elevated capillary pressure, increased interstitial fluid pressure, and increased capillary permeability all contribute to an increase in the amount of interstitial pressure and the rate of lymph flow.

Smooth muscles around the lymphatic vessels act as lymphatic pumps, and their involuntary contractions affect the rate of lymph flow. As the lymphatic vessel swells with fluid, the smooth muscle around that portion senses the stretch and automatically contracts, pushing the lymph through the valve to the next chamber. The valve prevents backwards flow as the smooth muscle in the chamber contracts to send the lymph through the next valve into the next chamber. This process continues along the entire vessel until the lymph passes through the lymph nodes and into the subclavian vein.

Factors outside of the lymphatic system can also affect the rate of lymph flow by assisting in the pumping of lymph through the system. The following external fac-

tors can increase lymph flow: contraction of close **skeletal muscles**, movements made by other parts of the body, nearby arterial pulses, and compression of tissues by items outside of the body. Therefore, during periods of **exercise**, the lymphatic system is extremely active and the flow rate is high.

The terminal end of the lymphatic capillary also has a pump that can affect the rate of lymph flow. When the interstitial fluid pressure is high, the surrounding tissue expands. The anchoring filaments that are attached to the endothelial cells at the terminal end of the lymphatic capillary and to the connective tissue pull the capillary valves open, allowing inward flow of interstitial fluid. Then the internal lymphatic capillary pressure causes the valves to close and the smooth muscle in the first compartment to contract and push the lymph into the next chamber.

Contractile actomyosin filaments are also present in the end terminal of the lymphatic vessels. These filaments cause the rhythmic contraction of the terminal end of the lymphatic capillary. Therefore, they contribute to part of the initial pumping of lymph through the system.

KEY TERMS

B-lymphocytes (B-cells)—A type of white blood cell that originates in the bone marrow and recognizes foreign antigens (or proteins), secreting antibodies in an immune response.

Interstitial space—The spaces found within organs and tissues.

Lymph—The slightly opalescent fluid found within the lymphatic system.

Lymph nodes—Bean shaped swellings along the lymphatic vessels that contain macrophages and lymphocytes.

Lymphatics—The system of lymphatic vessels.

T-lymphocytes (T-cells)—A type of white blood cell that originates in the thymus and attaches themselves to foreign organisms, secreting lymphokines that kill the foreign organisms.

Tonsil—A collection of lymphocytes that form a mass in the back of the pharynx.

Role in human health

The lymphatic system has a variety of roles in human health ranging from returning fluid from organs back to the circulatory system, to an important part in the human **immune response**, to absorbing **lipids** from the intestines. The defining role of the lymphatic vessels is to return any fluid that has leaked from the capillaries and into the interstitial space back to the circulatory system through the veins. This is important because if fluid was retained in the tissues, the result in reduced blood volume and swelling of the tissues.

Another important role of the lymphatic system is the ability of plasma proteins to fit through the lymphatic valves and into the lymphatic capillary. Since most proteins have such a high molecular weight, they are unable to be reabsorbed by venous capillaries. Without the reabsorption of the plasma proteins, humans can die within 24 hours.

The lymphatic system also has an essential role in the process of digestion. Primarily, the lymphatic capillaries in the gastrointestinal tract are one of the main routes for **fats** to be absorbed. Fats enter the lymphatics before entering the blood stream.

High molecular weight proteins are not the only large substances that are absorbed. Microorganisms such as **bacteria** can also fit between the endothelial cells of

the terminal end of the lymphatic capillary. As this occurs and the bacteria are transported to the next lymph node, the meshwork of the node and sinuses within the node act as a filter, catching and trapping the foreign organisms. Once trapped, microorganisms can be attacked by the concentrated cells of the immune system. Macrophages may consume disease-causing bacteria, B-lymphocytes may come into contact with the antigens on the surface of the microorganism and stimulate antibodies, and T-lymphocytes called “killer” cells that attach themselves to the foreign organism and release a substance to destroy the organism. The destructive nature of the “killer” cells is enhanced by another T-lymphocyte called “helper” cells (T-helper cells also assist B-cells). If this system fails, then microorganisms are not destroyed, resulting in the spread of **infection** through the lymphatic system and extreme infection possibly leading to death.

Cancer cells that have lost adherence to, and break away from, the primary tumor are collected by the lymphatic system and filtered by latticework within the lymph nodes. Within the lymph node T-cells release substances called lymphokine (e.g. gamma interferon and interleukin 2) that may help destroy the cancer cells. Doctors use the lymph nodes as one factor of evaluation when determining the stage of the cancer. In other words, when determining how far the cancer has progressed at the time of diagnosis, the lymph nodes can be dissected to determine if cancer has spread (metastasized) from the original tumor or not. If cancer cells are present in the lymph nodes, then the cancer receives a higher stage and a less-optimistic diagnosis. In cancers that metastasize via the lymphatics, the lymph nodes where cancer cells are present are often removed. This is even more common when the lymph nodes in question are adjacent to the tumor, when the lymph nodes are located on the only lymphatic vessel present in the area of the tumor, or if no other lymphatics will be damaged during the removal.

Common diseases and disorders

Since the lymphatic system is responsible for draining excess fluid from tissues and organs, the most common symptom of diseases and disorders of the lymphatic system is swelling. For example, a disease known as elephantiasis, which is caused by a filarial worm infestation, involves the blockage of the lymphatics. When the lymphatics are blocked, fluid cannot be drained and swelling occurs in the affected areas. Administering ethyl-carbamazine drugs, elevating the area and wearing a compression stocking can treat elephantiasis.

Tonsillitis is another disease of the lymphatic system. Tonsillitis usually involves a bacterial or viral infec-

tion located within the tonsils. The tonsils are swollen, and the patient experiences a **fever, sore throat**, and difficulty swallowing. This can be treated by the use of **antibiotics** or through a surgical procedure called a tonsillectomy.

A condition common among individuals following surgery for **breast cancer** or **prostate cancer** is lymphedema. It is caused by blockage of lymph vessels or lymph nodes located near the surgical site and can result in swollen arms or legs. If microorganisms cause the swelling, then antibiotics are used as treatment. If microorganisms are not the cause, then compression garments and massage therapy are used as treatment.

There are also cancers called lymphosarcomas and cancers of the lymph nodes that can affect the lymphatic system. The causes of these cancers are not known and there is not a consensus on what preventative measures can be taken to reduce the risk of developing these cancers. Symptoms of cancers affecting the lymphatic system include loss of appetite, energy, and weight, as well as swelling of the glands. As with many cancers, treat-

ment includes surgical removal followed by adjuvant radiation and **chemotherapy**.

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Sally C. McFarlane-Parrott

Lymphocyte typing see **Flow cytometry analysis**

Lymphomas see **Malignant lymphomas**

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M

Macular degeneration

Definition

Macular degeneration is the progressive deterioration of a critical region of the retina called the macula. The macula is 3–5 mm and is responsible for central **vision**. This disorder leads to irreversible loss of central vision, although peripheral vision is retained. In the early stages, vision may be gray, hazy, or distorted.

Description

Macular degeneration is the most common cause of legal blindness in people over 60, and accounts for approximately 11.7% of blindness in the United States. About 28% of the population over age 74 is affected by this disease.

Age-related macular degeneration (ARMD) is the most common form of macular degeneration. It is also known as age-related maculopathy (ARM), aged macular degeneration, and senile macular degeneration. Approximately ten million Americans have some vision loss due to ARMD.

ARMD is subdivided into a dry (atrophic) and a wet (exudative) form. The dry form is more common and accounts for 70–90% of cases of ARMD. It progresses more slowly than the wet form and vision loss is less severe. In the dry form, the macula thins over time as part of the aging process and the pigmented retinal epithelium (a dark-colored cell layer at the back of the eye) is gradually lost. Words may appear blurred or hazy, and colors may appear dim or gray.

With wet ARMD, new **blood vessels** grow underneath the retina and distort the retina. These **blood vessels** can leak, causing scar tissue to form on the retina. The wet form may cause visual distortion and make straight lines appear wavy. A central blind spot develops.

The wet type progresses more rapidly and vision loss is more pronounced.

Less common forms of macular degeneration include:

- Cystoid macular degeneration: Vision loss in the macula due to fluid-filled areas (cysts) in the macular region. This may be a result of other disorders, such as aging, inflammation, or high myopia.
- Diabetic macular degeneration: Deterioration of the macula due to diabetes.
- Senile disciform degeneration (Kuhnt-Junius macular degeneration): A severe type of wet ARMD that involves hemorrhaging in the macular region. It usually occurs in people over 40 years old.

Causes and symptoms

Age-related macular degeneration is intrinsic to aging for some individuals, but not all. People with an ARMD-affected family member have an increased the risk for its development. A slightly higher incidence occurs in females, although males and females are considered to be equally at risk. Whites and Asians are more susceptible to developing ARMD than blacks, in whom the disorder is rare.

The cause of ARMD is thought to be arteriosclerosis in the blood vessels supplying the retina. Certain risks for the **heart** are considered similar risks to those that contribute to the development of macular degeneration. Smoking increases the risk of developing wet-type ARMD, and may increase the risk of developing dry-type as well. Dietary fat also increases the risk. In one study of older (age 45–84) Americans, signs of early ARMD were 80% more common in the group who ate the most saturated fat compared to those who ate the least. Low consumption of antioxidants, such as foods rich in **vitamin A**, is associated with a higher risk. It is generally believed that exposure to ultraviolet (UV) light may con-

tribute to disease development, but this has not been proven conclusively.

A study reported in *Ophthalmology* in 2000 concluded that **hypertension**, thyroid hormones, and **antacids** are associated with certain types of ARMD. The issue of antacids is not widely recognized since no determination has yet been made regarding whether the antacids themselves lead to the disease, or whether it is the **stomach** problems that are a contributing factor. **Obesity** was also found to be a factor in this study.

The main symptom of macular degeneration is a central vision change. The patient may experience blurred central vision or a blank spot on the page when reading, visual distortion such as bending of straight lines, and images might appear smaller than is the actual object. Some patients notice a change in color perception, or abnormal light sensations. These symptoms can emerge suddenly and become progressively worse. Patients should be advised that a sudden onset of symptoms, particularly vision distortion, is an indication for immediate evaluation.

Diagnosis

Optometrists and ophthalmologists, with assistance from ophthalmic assistants, technicians and nurses, should carefully screen patients who are at risk for macular degeneration. These include patients older than 60; patients with hypertension or cardiovascular disease; cigarette smokers; patients with a first-degree family (sibling or maternal) history of vision loss from ARMD regardless of age; patients with aphakia or pseudophakia; or someone with a cataract, and patients with a history that indicates significant cumulative light exposure.

The ophthalmic assistant will take a careful history and log these risk factors. The patient then should have a complete ocular examination. Vision tests, performed by the physician or a skilled ophthalmic assistant, examine best corrected visual acuity, as well as near monocular visual acuity; refraction; biomicroscopy; tonometry; and stereoscopic fundus examination with pupillary dilation. Though rarely used even if ARMD is suspected, a central 10-degree computerized automated perimetry might be utilized along with fundus photography and laser ophthalmoscope scanning.

After preliminary testing, specific tests are performed to determine macular degeneration. To make the diagnosis, the doctor dilates the pupil with eye drops and examines the interior of the eye, examining the retina for the presence of drusen, small white-yellow spots in the macular area, and for gross changes in the macula such as thinning. The doctor also administers a visual field test to

search for blank spots in the central vision. The doctor might order fluorescein **angiography** (intravenous injection of fluorescent dye followed by visual examination and photography of the back of the eye) to determine if blood vessels in the retina are leaking. Retinal pigmented epithelium (RPE) mottling that occurs, like the drusen, due to atherosclerotic changes of the macula decreasing the blood supply, can also be indicated through a thorough examination.

A central visual field test called an Amsler grid is usually given to patients who are suspected of having ARMD. It is a grid printed on a sheet of paper (also presented for home use every week). When viewing a central dot on the page, the patient should note if any of the lines appear to be wavy or missing. This could be an indication of fluid and the onset of wet ARMD. High-risk patients particularly will be urged to schedule more frequent checkups.

Although ophthalmologists and optometrists can accurately diagnose macular degeneration, attending physicians may want to consult with a retinal specialist for the best treatment protocols.

Treatment

While vision loss cannot be reversed, early detection is important because treatments are available that may halt or slow the progression of the wet form of ARMD. Some treatments for the dry form were still in early clinical trials in 2001.

In wet-type ARMD and in senile disciform macular degeneration, new capillaries grow in the macular region and leak. This leaking of blood and fluid causes a portion of the retina to detach. Blood vessel growth, called neovascularization, can be treated with laser photocoagulation in some cases, depending upon the location and extent of the growth. Argon or krypton lasers can destroy the new tissue and flatten the retina. This treatment is effective in about half the cases but results may be temporary. A concern exists that laser therapy causes the laser to destroy the photoreceptors in the treated area. If the blood vessels have grown into the fovea (a region of the macula responsible for fine vision), treatment may be impossible. Because capillaries can grow quickly, this form of macular degeneration should be handled as an emergency and treated immediately.

Photodynamic therapy (PDT) is a promising new treatment approved by the Food and Drug Administration in 2000. With PDT, the patient is given a light-activated drug intravenously with no damage to the retina. The drug, Visudyne, is absorbed by the damaged blood vessels. The affected area on the retina is exposed to a non-

thermal laser light that activates the drug exactly 15 minutes after the infusion begins. It must be exactly 15 minutes for the treatment to be successful. The light chemically alters the drug, and any leakage from choroidal neovascularization (CNV) ceases. Patients require treatment every three months during the first year of therapy, and should be advised to avoid bright light or sun exposure for several days after therapy.

Another form of treatment for the wet form of ARMD is radiation therapy with either x rays, or a proton beam. Growing blood vessels are sensitive to treatment with low doses of ionizing radiation. The growth of nerve cells in the retina is stunted. They are insensitive and thus are not harmed by this treatment. External beam radiation treatment has shown promising results at slowing progression in limited, early trials.

Other therapies that are under study include treatment with alpha-interferon, thalidomide, and other drugs that slow the growth of blood vessels. Subretinal surgery also has shown promise in rapid-onset cases of wet ARMD. This surgery carries the risk of retinal detachment, hemorrhage, and acceleration of cataract formation. A controversial treatment called rheotherapy involves pumping the patient's blood through a device that removes some **proteins** and **fats**. As of 2001, this had not been proven to be safe or effective.

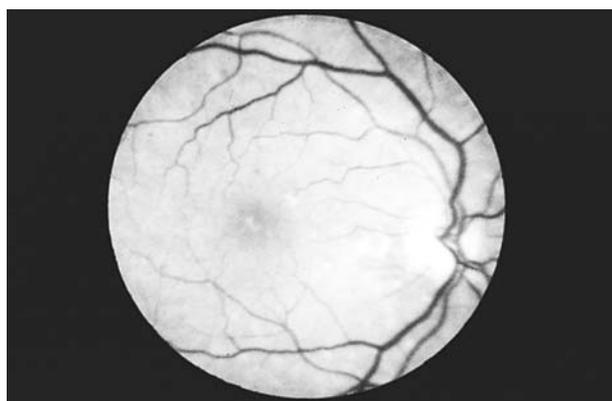
Consumption of a diet rich in antioxidants (beta carotene and the mixed carotenoids that are precursors of vitamin A, **vitamins** C and E, selenium, and **zinc**), or antioxidant nutritional supplements, may help prevent macular degeneration, particularly if started early in life. Research has shown that nutritional therapy can prevent ARMD or slow its progression once established.

Researchers also are working on therapies to treat the dry form of macular degeneration. Low-energy laser treatment for drusen is currently in clinical trials as of 2001. In this treatment the ophthalmologist uses a diode laser to reduce the drusen level. Some ophthalmologists were already performing this procedure "off-label," without FDA approval.

Another treatment, approved overseas but not in the United States, treats dry ARMD by implanting a miniaturized telescope to magnify objects in the central field of vision. This does not treat the disease, but aids the patient's vision in only the very severe cases of ARMD.

Prognosis

The dry form of ARMD is self-limiting and eventually stabilizes, with permanent vision loss. The vision of patients with the wet form of ARMD often stabilizes or improves even without treatment, at least temporarily.



A slit-lamp view showing macular degeneration of the eye.
(Custom Medical Stock Photo. Reproduced by permission.)

However, after a few years, patients with this type are usually left without acute central vision.

Many macular degeneration patients lose their central vision permanently and may become legally blind. However, macular degeneration rarely causes total vision loss. Peripheral vision is retained. Patients can compensate for central vision loss, even when macular degeneration renders them legally blind. Improved lighting and low-vision aids can help even if visual acuity is poor. Vision aids include special magnifiers allowing patients to read, and provide telescopic aids for long-distance vision. The use of these visual aids plus the retained peripheral vision assist in maintaining patient independence.

Health care team roles

Ophthalmic assistants, technicians, and nurses assist optometrists and ophthalmologists in testing for macular degeneration. Skilled ophthalmic staff take patient history and perform refraction; biomicroscopy; tonometry; stereoscopic fundus examination with pupillary dilation, only rarely; computerized automated perimetry; and fundus photography.

Registered ophthalmic nurses also play an important role in preparing patients for PDT. Only registered nurses and physicians are allowed to mix the drug used for PDT. RNs familiar with infusion are best-suited for this task. Nurses and ophthalmic staff also play an important role in PDT follow-up care. They are critical in issuing patient instructions to stay out of bright light and sunlight after treatment, and to wear sun-protective clothing for each treatment.

Patient education

Ophthalmic staff should reinforce the physician's instructions when assessing macular degeneration. They

KEY TERMS

Drusen—Tiny yellow dots on the retina that can be soft or hard and that usually do not interfere with vision.

Fovea—A tiny pit in the macula that is responsible for sharp vision.

Neovascularization—Growth of new capillaries.

Photoreceptors—Specialized nerve cells (rods and cones) in the retina that are responsible for vision.

Retina—The light-sensitive membrane at the back of the eye that images are focused on. The retina sends the images to the brain via the optic nerve.

should emphasize the importance of the Amsler grid and regular check-ups to monitor the progression of the disease.

Staff should also reaffirm doctor's orders with patients being treated with PDT. They should review that PDT is not a cure, but a slowing of the disease, and that retreatment is necessary for its success. Staff should also reinforce restrictions on patients' activities, such as staying out of direct sunlight or bright light for several days after PDT. They should also make follow-up calls to patients to ensure they are returning for PDT on time and to see if they have any questions about retreatment. Ophthalmic personnel should also be considerate of the age of most macular degeneration patients and provide large, easy-to-read instructions, and not rush them through the therapy or aftercare.

Prevention

Avoiding the risk factors for macular degeneration may help prevent it. This includes avoiding tobacco smoke and eating a diet low in saturated fat and rich in antioxidants. Some doctors suggest that wearing UV-blocking sunglasses reduces risk. Use of estrogen in postmenopausal women is associated with a lower risk of developing ARMD.

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- American Optometric Association. 243 North Lindbergh Blvd., St. Louis, MO 63141. (314) 991-4100. <<http://www.aoanet.org>>.
- National Eye Institute. National Institutes of Health. Bethesda, Maryland. <<http://www.nei.nih.gov/publicaations/armd.htm>>.
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Mary Bekker

Mad cow disease see **Creutzfeldt-Jakob disease**

Magnesium hydroxide see **Antacids**

Magnetic resonance angiography see **Magnetic resonance imaging**

Magnetic resonance imaging

Definition

Magnetic resonance imaging (MRI) is a unique and versatile medical imaging modality. Doctors can obtain highly refined images of the body's interior using MRI.

By using strong magnetic fields and pulses of radio waves to manipulate the natural magnetic properties in the body, this technique produces images not possible with other diagnostic imaging methods. MRI is particularly useful for imaging the **brain** and spine, as well as the soft tissues of joints and the interior structure of bones. The entire body can be imaged using MRI, and the technology poses few known health risks.

Purpose

MRI was developed in the 1980s. The latest additions to MRI technology are **angiography** (MRA) and spectroscopy (MRS). MRA was developed to study **blood** flow, while MRS can identify the chemical composition of diseased tissue and produce color images of brain function. The many advantages of MRI include:

- **Detail.** MRI creates precise images of the body based on the varying proportions of magnetically polarizable elements in different tissues. Very minor fluctuations in chemical composition can be determined. MRI images have greater subject contrast than those produced with standard x rays, computed tomography (CT), or ultrasound, all of which depend on the differing physical properties of tissues. This contrast sensitivity lets MRI distinguish fine variations in tissues deep within the body. It also is particularly useful for spotting and distinguishing diseased tissues (tumors and other lesions) early in their development. Often, doctors prescribe an MRI scan to more fully investigate earlier findings of the other imaging techniques.
- **Scope.** The entire body can be scanned, from head to toe and from the skin to the deepest recesses of the brain. Moreover, MRI scans are not adversely affected by bone, gas, or body waste, which can hinder other imaging techniques. (Although the scans can be degraded by motion such as breathing, heartbeat, and normal bowel activity.) MRI process produces cross-sectional images of the body that are as sharp in the middle as on the edges, even of the brain through the **skull**. A close series of these two-dimensional images can provide a three-dimensional view of a targeted area.
- **Safety.** MRI does not depend on potentially harmful ionizing radiation, as do standard x-ray and **CT scans**. There are no known risks specific to the procedure, other than for people who might have metal objects in their bodies.

Given all the advantages, doctors would undoubtedly prescribe MRI as frequently as ultrasound scanning, but the MRI process is complex and costly. The process requires large, expensive, and complicated equipment; a

highly trained operator; and a doctor specializing in radiology. Generally, MRI is prescribed only when serious symptoms and/or negative results from other tests indicate a need. Many times an alternative imaging procedure is more appropriate for the type of diagnosis needed.

Doctors may prescribe an MRI scan of different areas of the body.

- **Brain and head.** MRI technology was developed because of the need for brain imaging. It is one of the few imaging tools that can see through bone (the skull) and deliver high quality pictures of the brain's delicate soft tissue structures. MRI may be needed for patients with symptoms of a **brain tumor**, stroke, or **infection** (like **meningitis**). MRI also may be needed when cognitive and/or psychological symptoms suggest brain disease (like Alzheimer's or Huntington's diseases, or **multiple sclerosis**), or when developmental retardation suggests a birth defect. MRI can also provide pictures of the sinuses and other areas of the head beneath the face.
- **Spine.** Spinal problems can create a host of seemingly unrelated symptoms. MRI is particularly useful for identifying and evaluating degenerated or herniated intervertebral discs. It can also be used to determine the condition of nerve tissue within the **spinal cord**.
- **Joint.** MRI scanning is often used to diagnose and assess joint problems. MRI can provide clear images of the bone, cartilage, ligaments, and tendons that comprise a joint. MRI can be used to diagnose joint injuries due to sports, advancing age, or arthritis. It can also be used to diagnose shoulder problems, like a torn rotator cuff. MRI can detect the presence of an otherwise hidden tumor or infection in a joint, and can be used to diagnose the nature of developmental joint abnormalities in children.
- **Skeleton.** The properties of MRI that allow it to see through the skull also allow it to view the interior of bones. It can be used to detect bone **cancer**, inspect the marrow for leukemia and other diseases, assess bone loss (**osteoporosis**), and examine complex **fractures**.
- **The rest of the body.** While CT and ultrasound satisfy most chest, abdominal, and general body imaging needs, MRI may be needed in certain circumstances to provide more detailed images or when repeated scanning is required. The progress of some therapies, like **liver cancer** therapy, need to be monitored, and the effect of repeated x-ray exposure is a concern.

Precautions

MRI scanning should not be used when there is the potential for an interaction between the strong MRI mag-



Magnetic resonance imaging (MRI) uses magnets and radio waves to make images of the body's organs, soft tissue, bone, and even blood flow. (Jon Meyer/Custom Medical Stock Photo. Reproduced by permission.)

netic field and metal objects that might be imbedded in a patient's body. The force of magnetic attraction on certain types of metal objects (including surgical steel and clips used to pinch off **blood vessels**) could move them within the body and cause serious injury. The movement would occur when the patient is moved into and out of the magnetic field. Metal may be imbedded in a person's body for several reasons.

- **Medical.** People with implanted cardiac **pacemakers**, metal aneurysm clips, or who have had broken bones repaired with metal pins, screws, rods, or plates must tell their radiologist prior to having an MRI scan. In some cases (like a metal rod in a reconstructed leg) the difficulty may be overcome.
- **Injury.** Patients must tell their doctors if they have bullet fragments or other metal pieces in their body from old **wounds**. The suspected presence of metal, whether from an old or recent wound, should be confirmed before scanning.
- **Occupational.** People with significant work exposure to metal particles (working with a metal grinder, for example) should discuss this with their doctor and radiologist. The patient may need prescan testing—usually

a single, standard x ray of the eyes to see if any metal is present.

Chemical agents designed to improve the image and/or allow for the imaging of blood or other fluid flow during MRA may be injected. In rare cases, patients may be allergic to or intolerant of these agents, and these patients should not receive them. If these chemical agents are to be used, patients should discuss any concerns they have with their doctor and radiologist.

The potential side effects of magnetic and electric fields on human health remain a source of debate. In particular, the possible effects on an unborn baby are not well known. Any woman who is, or may be, pregnant should carefully discuss this issue with her doctor and radiologist before undergoing a scan.

As with all medical imaging techniques, **obesity** greatly interferes with the quality of MRI.

Description

In essence, MRI produces a map of hydrogen atoms distributed in the body. Hydrogen is the simplest element known, the most abundant in biological tissue, and one

that can be magnetically polarized. It will align itself within a strong magnetic field, like the needle of a compass. The earth's magnetic field is not strong enough to polarize a person's hydrogen atoms, but the superconducting magnet of an MRI machine can. The strength of the Earth's magnetic field is approximately 1 gauss. Typical field strength of an MRI unit, with a superconducting magnet is 1,500 gauss expressed as 1.5 kilogauss or 1.5 Tesla units. This comprises the "magnetic" part of MRI.

Once a patient's hydrogen atoms have been aligned in the magnet, pulses of very specific radio wave frequencies are used to jolt them out of alignment. The hydrogen atoms alternately absorb and emit radio wave energy, vibrating back and forth between their resting (polarized) state and their agitated (radio pulse) state. This comprises the "resonance" part of MRI.

The MRI equipment detects the duration, strength, and source location of the signals emitted by the atoms as they relax and translates the data into an image on a television monitor. The amount of hydrogen in diseased tissue differs from the amount in healthy tissue of the same type, making MRI particularly good at identifying tumors and other lesions. In some cases, chemical agents such as gadolinium can be injected to improve the contrast between healthy and diseased tissue.

A single MRI exposure produces a two-dimensional image of a slice through the entire target area. A series of these image slices closely spaced (usually less than half an inch) makes a virtual three-dimensional view of the area.

Magnetic resonance spectroscopy (MRS) is different from MRI because MRS uses a continuous band of radio wave frequencies to excite hydrogen atoms in a variety of chemical compounds other than water. These compounds absorb and emit radio energy at characteristic frequencies, or spectra, which can be used to identify them. Generally, a color image is created by assigning a color to each distinctive spectral emission. This comprises the "spectroscopy" part of MRS. MRS is still experimental and is available in only a few research centers.

Doctors primarily use MRS to study the brain and disorders, like epilepsy, **Alzheimer's disease**, brain tumors, and the effects of drugs on brain growth and **metabolism**. The technique is also useful in evaluating metabolic disorders of the muscles and nervous system.

Magnetic resonance angiography (MRA) is a variation on standard MRI. MRA, like other types of angiography, looks specifically at blood flow within vascular system, but does so without the injection of contrast agents or radioactive tracers. Standard MRI cannot detect blood flow, but MRA uses specific radio pulse sequences

to capture usable signals. The technique is generally used in combination with MRI to obtain images that show both vascular structure and flow within the brain and head in cases of stroke, or when a blood clot or aneurysm is suspected.

Regardless of the exact type of MRI planned, or area of the body targeted, the procedure involved is basically the same and occurs in a special MRI suite. The patient lies back on a narrow table and is made as comfortable as possible. Transmitters are positioned on the body and the cushioned table that the patient is lying on moves into a long tube that houses the magnet. The tube is as long as an average adult lying down, and the tube is narrow and open at both ends. Once the area to be examined has been properly positioned, a radio pulse is applied. Then a two-dimensional image corresponding to one slice through the area is made. The table then moves a fraction of an inch and the next image is made. Each image exposure takes several seconds and the entire exam will last anywhere from 30-90 minutes. During this time, the patient is not allowed to move. If the patient moves during the scan, the picture will not be clear.

Depending on the area to be imaged, the radio-wave transmitters will be positioned in different locations.

- For the head and neck, a helmet-like hat is worn.
- For the spine, chest, and abdomen, the patient will be lying on the transmitters.
- For the knee, shoulder, or other joint, the transmitters will be applied directly to the joint.

Additional probes will monitor **vital signs** (like pulse, respiration, etc.).

The process is very noisy and confining. The patient hears a thumping sound for the duration of the procedure. Since the procedure is noisy, music supplied via earphones is often provided. Some patients get anxious or panic because they are in the small, enclosed tube. This is why vital signs are monitored and the patient and medical team can communicate between each other. If the chest or abdomen are to be imaged, the patient will be asked to hold his/her breath as each exposure is made. Other instructions may be given to the patient, as needed. In many cases, the entire examination will be performed by an MRI operator who is not a doctor. However, the supervising radiologist should be available to consult as necessary during the exam, and will view and interpret the results sometime later.

Open MRI units

Many adult patients and, especially children, become extremely claustrophobic when placed inside the confines of a full strength (1.5 Tesla) superconducting

KEY TERMS

Angiography—Any of the different methods for investigating the condition of blood vessels, usually via a combination of radiological imaging and injections of chemical tracing and contrasting agents.

Gadolinium—A very rare metallic element useful for its sensitivity to electromagnetic resonance, among other things. Traces of it can be injected into the body to enhance the MRI pictures.

Hydrogen—The simplest, most common element known in the universe. It is composed of a single electron (negatively charged particle) circling a nucleus consisting of a single proton (positively charged particle). It is the nuclear proton of hydrogen that makes MRI possible by reacting resonantly to radio waves while aligned in a magnetic field.

Ionizing radiation—Electromagnetic radiation that can damage living tissue by disrupting and destroying individual cells. All types of nuclear decay radiation (including x rays) are potentially ionizing. Radio waves do not damage organic tissues they pass through.

Magnetic field—The three-dimensional area surrounding a magnet, in which its force is active. During MRI, the patient's body is permeated by the force field of a superconducting magnet.

Radio waves—Electromagnetic energy of the frequency range corresponding to that used in radio communications, usually 10,000 cycles per second to 300 billion cycles per second. Radio waves are the same as visible light, x rays, and all other types of electromagnetic radiation, but are of a higher frequency.

magnet. This problem is often severe enough to prevent them from having an MRI scan performed. An alternative design, to the standard MRI unit is one where the magnet is comprised of two opposed halves with a large space in between. Units designed this way are known as open MRI machines. The advantage is, they can be used for patients who are claustrophobic. The disadvantage is, the field strength of the magnets is lower than with standard full strength machines, usually somewhere in the range of 0.2–0.5 Tesla. Lower strength magnetic fields require more time for image acquisition increasing the risks of

motion artifacts because patients need to remain still for longer periods of time.

Preparation

In some cases (such as for MRI brain scanning or an MRA), a chemical designed to increase image contrast may be given by the radiologist immediately before the exam. If a patient suffers from **anxiety** or claustrophobia, drugs may be given to help the patient relax.

The patient must remove all metal objects (watches, jewelry, **eye glasses**, hair clips, etc). Any magnetized objects (like credit and bank machine cards, audio tapes, etc.) should be kept far away from the MRI equipment because they can be erased. The patient cannot bring their wallet or keys into the MRI machine. The patient may be asked to wear clothing without metal snaps, buckles, or zippers, unless a medical gown is worn during the procedure. The patient may be asked to remove any hair spray, hair gel, or cosmetics that may interfere with the scan.

Aftercare

No aftercare is necessary, unless the patient received medication or had a reaction to a contrast agent. Normally, patients can immediately return to their daily activities. If the exam reveals a serious condition that requires more testing and/or treatment, appropriate information and counseling will be needed.

Complications

MRI poses no known health risks to the patient and produces no physical side effects. Again, the potential effects of MRI on an unborn baby are not well known. Any woman who is, or may be, pregnant, should carefully discuss this issue with her doctor and radiologist before undergoing a scan.

Results

A normal MRI, MRA, or MRS result is one that shows the patient's physical condition to fall within normal ranges for the target area scanned.

Generally, MRI is prescribed only when serious symptoms and/or negative results from other tests indicate a need. There often exists strong evidence of a condition that the scan is designed to detect and assess. Thus, the results will often be abnormal, confirming the earlier diagnosis. At that point, further testing and appropriate medical treatment is needed. For example, if the MRI indicates the presence of a brain tumor, an MRS may be prescribed to determine the type of tumor so that aggres-

sive treatment can begin immediately without the need for a surgical biopsy.

Health care team roles

The MRI examination is conducted by an MRI technologist and a radiologist. The MRI technologist is responsible for preparing the patient for the examination by making sure that all metallic objects have been removed and that the patient does not have any metallic implants that will be affected by the examination. It is recommended that a prescreening MRI questionnaire be developed and that all patients be required to complete the form prior to having an MRI. If necessary for the area being imaged, an intravenous contrast agent will be administered by either the technologist or a nurse. Nursing staff may also be present during the examination, depending on the medical condition of the patient. The radiologist oversees the selection of MRI imaging sequences and protocols and reviews the acquired images to be sure image quality is appropriate for diagnosis. The radiologist also provides the final interpretation of images and provides a report for any referring physicians.

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Center for Devices and Radiological Health. United States Food and Drug Administration. 1901 Chapman Ave., Rockville, MD 20857. (301) 443-4109. <<http://www.fda.gov/cdrh>>.

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Magnetic resonance imaging unit

Definition

A **magnetic resonance imaging** (MRI) unit uses a magnetic field, radiofrequency waves, and computerized image processing to produce cross-sectional images of the anatomy.

Purpose

An MRI unit has several diagnostic clinical applications, including:

- diagnosing diseases of the **central nervous system**, **brain**, and spine
- detecting musculoskeletal disorders and injuries
- identifying infectious diseases such as those associated with acquired **immunodeficiency** syndrome (AIDS)
- detecting metastatic **liver** disease
- imaging the cardiovascular system
- staging prostate, bladder, and uterine cancers
- studying bone marrow diseases
- imaging the breast adjunctive to conventional mammography

Some MRI units can perform magnetic resonance **angiography** (MRA), which is used to image vascular and arteriovenous malformations, thromboses, stenoses, and other vascular abnormalities. In particular, MRA is used for evaluating the carotid artery and cerebral vasculature in patients with suspected or known stroke. An MRI unit can also be used in conjunction with other imaging modalities such as computed tomography (CT) for localizing the treatment target for radiation treatment planning and prior to surgical treatment of tumors, including stereotactic radiosurgery and image-guided surgery. It is also possible to evaluate brain function associated with certain tasks such as language or **vision** using functional MRI.

MRI provides images with excellent contrast that allow clinicians to clearly see details of soft tissue, bone, joints, and ligaments. Because MRI does not use ionizing radiation to produce images, like radiography and CT, it is often the examination of choice for imaging the male and female reproductive systems, pelvis and hips, and urinary tract and bladder.



Magnetic resonance imaging system. (Photograph by Mason Morfit. FPG International Corp. Reproduced by permission.)

Description

MRI units are used in the radiology department and outpatient imaging centers for diagnostic imaging, in the emergency care and critical care settings to diagnose acute conditions such as stroke in the clinical research setting (especially for brain research), and in orthopedic practices. Large hospitals usually have one or more MRI units that are typically located in the radiology department or in a separate annex near the radiology and emergency departments.

An MRI unit consists of a magnet system, a radiofrequency (RF) transmitter/receiver system, a gradient system, a patient table, a computer workstation, and operator console. The magnetic strength of the magnet is measured in teslas (T), a unit of magnetic field strength, and ranges from 0.064–4 T, depending on the type of system. The magnetic field generated during an MRI examination is approximately 8,000 times stronger than the Earth's magnetic field. Principles of image production are based on the magnetic spin properties of hydrogen atoms in the body's tissues and fluids and how they behave in a magnetic field. Basically, hydrogen protons (particles located in the atom's nucleus) will align with an applied magnetic field and will spin perpendicular to

the magnetic field when a radiofrequency pulse is added. When the pulse is terminated, protons relax back into alignment with the magnetic field, and this generates a radiofrequency signal that is received by the antenna coil. Different tissues such as those high in water and in fat will produce different signals that are then processed by the computer and converted into anatomical images. MRI protocols and imaging sequences are based on the different signals produced by different types and physiologic states of tissue.

The magnet system is contained in the gantry, which is a large square or round unit with a hole in the center (the bore) through which the patient table is moved. Magnets may be of three types: permanent magnet, resistive or superconducting electromagnet, and iron-core electromagnet. Permanent magnets are extremely heavy and thus require special construction; however, they do not require electrical power or cooling because they are constructed of magnetic alloys. They also have almost no fringe field (the magnetic field outside the magnet itself). Permanent magnets are limited to field strengths of 0.3 T or less. Resistive electromagnets use electrical coils to generate a magnetic field and thus require cooling water. Resistive magnets are limited to field strengths of 0.5 T.

Superconducting magnets use titanium alloy coils that require cooling with liquid helium or liquid nitrogen (cryogenics). They can have field strengths of up to 2 T. Iron-core electromagnets use a combination of permanent and electromagnet technology, and require cooling water for operation. Field strengths are usually 0.3 or 0.4 T.

An MRI unit with a field strength less than 0.2 T is considered low field, an MRI unit with a field strength of 0.2 T to 1 T is considered mid field, and an MRI unit with a field strength greater than 1 T is considered high field. In general, high-field MRI units are capable of shorter imaging times and higher image quality and are preferred for many clinical applications.

The radiofrequency system transmits and receives signals using a coil that acts as an antenna. Separate coils are used for head and body imaging, and specially designed coils are used for imaging the spine, face, knee, breast, shoulder, and extremities. The gradient system produces magnetic fields in the direction of the primary field and perpendicular to the primary field in order to select the area for imaging and to register the location of signals received from the area imaged. The radiofrequency and gradient systems are turned on and off (pulsed) to control image contrast; these pulse patterns are called a pulse sequence. There are several different types of pulse sequences used, and they vary according to the duration, frequency, and timing of the pulses. Different pulse sequences are used to image different anatomic areas, and the pulse sequence is chosen based on the characteristics of the tissue being imaged such as fat content, water content, and anatomic area.

There are several different types of MRI units and MRI imaging methods:

- Conventional MRI units have long, closed bores that surround most of the patient's body during imaging.
- Short-bore MRI units were developed in response to patient claustrophobia and to retain the image-quality benefits of conventional systems, and have bore lengths that allow patients of average height to have much of their body outside the bore during imaging. The patient's head can then be outside the bore for exams not involving the brain and neck, thereby reducing claustrophobic reactions.
- Open MRI units were also developed in response to patient claustrophobia and to facilitate interventional procedures. They have bores that are open on most sides (sometimes columns are used to support the gantry). Open MRI units usually have low-field strengths.
- Dedicated extremity/head/breast MRI units have very small bores designed to accommodate imaging of

limbs, joints, or the head, and are primarily used for orthopedic applications. A dedicated breast MRI system is also available.

- Mobile MRI units are installed in a specially designed trailer and driven to hospitals that do not have an MRI unit. Mobile MRI services are used frequently in rural areas.
- Functional MRI is an imaging technique that rapidly acquires images that display changes in cerebral **blood** flow in response to visual or auditory stimuli or motor tasks. This technique is used primarily for research to map the functional organization of the brain.
- Interventional and intraoperative MRI is a developing field that involves performing interventional procedures such as catheterization or guidewire insertion, and intraoperative guidance such as during neurosurgery, using a specially designed MRI unit. Open MRI units are being used for these applications due to their open-bore design, which facilitates patient access.
- MRI spectroscopy is an imaging technique used primarily in research that measures metabolites in the brain to evaluate brain tissue.
- Echoplanar MRI is an imaging technique that uses rapidly oscillating magnetic field gradients for image acquisition in less than 30 milliseconds. It is used to evaluate real-time cardiac and brain function, as well as muscle activity.
- MRI angiography is an imaging technique used to evaluate the **blood vessels**, for example, to detect aneurysms or atherosclerosis. Injection of a contrast agent is required.
- Diffusion tensor MRI is a relatively new imaging technique that tracks water molecules in the brain to detect abnormalities associated with stroke, **multiple sclerosis**, and other conditions.

Operation

An MRI unit is operated by the MRI technologist who prepares the patient for the examination, including administering any necessary intravenous contrast agents and positioning the patient on the table. Some examinations require the use of special surface coils (e.g., for head, knee, etc.) to focus the radiofrequency pulses on the area of interest. The MRI technologist places or attaches the appropriate coil and helps the patient onto the table. After the patient is properly positioned, the MRI technologist goes to the control room, which is adjacent to but separated from the MRI unit by a window, and initiates the imaging sequences selected by the radiologist. Usually, two to six imaging sequences are per-

formed, each lasting approximately two to 15 minutes. The technologist instructs the patient via an intercom system when the scanning sequence is to begin and whether holding of breath or stillness is required. While the images are being acquired, the MRI technologist and radiologist review them on the computer workstation to make sure the image quality is sufficient for diagnosis.

Image artifacts may occur during image acquisition, and the technologist and radiologist should monitor acquired images for artifacts. Patient motion, respiratory motion, implants, signal loss, and improper unit settings can all cause artifacts to occur. Constantly occurring artifacts related to the unit's operation or magnetic field may require a service call from the manufacturer or testing by a medical physicist.

With regard to patient safety, there are no side effects associated with the magnetic field during an MRI examination, but, in general, MRI is not recommended for pregnant women. Patients with a pacemaker, cochlear implants, aneurysm clips, and other metallic implants must check with a physician before undergoing MRI due to the possible effects of the magnetic field on the implants. Patients who have been exposed to shrapnel or metal shavings (especially in the eye) may not be able to have an MRI; instances where the magnetic field caused movement of metal fragments in the body and subsequent patient injury have been reported. Because eyeshadow may contain metallic substances, patients undergoing MRI should not wear make-up during the examination.

Several incidents have occurred where patients undergoing MRI examinations received serious skin **burns** from contact with surface coils or monitoring cables. Therefore, the United States Food and Drug Administration (FDA) has issued precautions to prevent burns during MRI, including removal of unnecessary coils, cables, and leads before the scan is begun; frequent checking of coils, cables, and leads for frayed insulation or exposed wires; and a thorough check that cables and leads do not form loops, touch the sides of the magnet bore, or directly touch the patient.

The magnetic field requires that all medical equipment used in the MRI suite be MRI-compatible. For example, patient monitoring equipment, intravenous poles, **ventilators**, and contrast media injectors should have been tested and certified by the manufacturer as MRI-compatible. If interventional procedures are performed in the MRI suite, anesthesia units, surgical instrumentation, patient monitoring systems, and resuscitation equipment should all be MRI-compatible. The operation and performance of equipment that is not MRI-compatible may be affected by the magnetic field, or if the equip-

ment contains certain metals, it may be attracted to the magnet, causing equipment damage and presenting a safety problem. Because patients may be brought into the MRI suite on wheelchairs or with oxygen canisters, MRI staff should be sure that the magnetic field is not on during patient transfer. There have been several hazard reports of injury to patients and staff by oxygen canisters, wheelchairs, and other metal items when they were rapidly drawn to the magnet.

During the MRI examination, all patients, but particularly those under sedation or anesthesia or in critical condition, should be monitored using physiologic monitoring equipment, intercom systems, and video. Some patients may be claustrophobic during the examination or may experience **anxiety**. To alleviate these discomforts, an MRI-compatible music system and increased ventilation in the magnet bore can be installed.

Depending on the type of magnet, different types of shielding are required for the MRI suite. The performance of the MRI unit depends on the homogeneity, or uniformity, of the magnetic field, which may be disturbed by surrounding hospital equipment, metallic structures, and environmental factors. A process called **shimming** is used to improve the uniformity of the magnetic field, and is accomplished by using shim coils or ferromagnetic materials around the magnet. Shimming is usually done during installation or testing by physicists. The entire MRI suite may need to be shielded with different materials to insulate the magnet from outside interference or to prevent the magnet's fringe field from interfering with the operation of medical equipment in adjacent areas.

Maintenance

Because of the complexity of an MRI unit, a service contract covering parts replacement, preventive maintenance, and emergency repairs is usually purchased from the manufacturer or a third-party service organization. The **biomedical engineering** staff and/or the MRI technologist conduct periodic performance testing of image quality and other parameters. Surface coils should be cleaned and maintained according to manufacturer instructions. Many MRI units have special cooling system requirements, and storage and replenishment of cryogenics (chemicals used for cooling the magnet system) is necessary. This is generally performed by the service provider or biomedical engineering staff.

Health care team roles

The MRI examination is conducted by an MRI technologist and a radiologist. The MRI technologist is responsible for preparing the patient for the examination

by making sure that all metallic objects have been removed and that the patient does not have any metallic implants that will be affected by the examination. It is recommended that a prescreening MRI questionnaire be developed and that all patients be required to complete the form prior to having an MRI. If necessary for the area being imaged, an intravenous contrast agent will be administered by either the technologist or a nurse. Nursing staff may also be present during the examination, depending on the medical condition of the patient. The radiologist oversees the selection of MRI imaging sequences and protocols and reviews the acquired images to be sure image quality is appropriate for diagnosis. The radiologist also provides the final interpretation of images and provides a report for any referring physicians. For **cancer** cases, oncologists may also be involved in image review for treatment planning purposes. If interventional MRI procedures are performed, specialists such as a gastroenterologist, orthopedic surgeon, neurologist, or neurosurgeon may perform the procedures while the MRI unit is operated by the technologist.

Training

MRI technologists have completed special education programs in MRI physics, operation, and safety. All manufacturers of MRI units provide on-site, and sometimes off-site, training on the technical features and clinical applications of their systems. The American College of Radiology has developed an MRI site accreditation program, which requires that the MRI system, quality control procedures, MRI technologists, and radiologists be evaluated according to certain standards of performance. As of 2001, this accreditation was not mandatory, but many facilities undergo the process to demonstrate quality performance.

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KEY TERMS

Aneurysm—Localized enlargement of an artery or vein.

Artifact—An artificial feature in an acquired MRI image.

Atherosclerosis—Hardening of the arteries, a form of heart disease.

Metabolites—Byproducts of metabolism that accumulate in brain tissue that is measured by MRI spectroscopy.

Teslas (T)—A unit of magnetic field strength.

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American Society of Radiologic Technologists (ASRT). 15000 Central Avenue SE, Albuquerque, NM 87123-2778. (800) 444-2778. <<http://www.asrt.org>>.

Clinical Magnetic Resonance Society. 2825 Burnet Avenue, Suite 2, Cincinnati, OH 45219. (800) 823-2677. <<http://www.cmrs.com>>.

International Society for Magnetic Resonance in Medicine. 2118 Milvia Street, Suite 201, Berkeley, CA 94704. (510) 841-1899. <<http://www.ismrm.org>>.

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Magnetic resonance spectroscopy *see*
Magnetic resonance imaging

Malabsorption syndrome

Definition

Malabsorption syndrome is an alteration in the ability of the intestine to absorb nutrients adequately into the bloodstream.

Causes and symptoms

Protein, **fats**, and **carbohydrates** (macronutrients) normally are absorbed in the **small intestine**; the small bowel also absorbs about 80% of the 8.4–10.5 qt (8–10 l) of fluid ingested daily. There are many different conditions that affect fluid and nutrient absorption by the intestine. A fault in the digestive process may result from failure of the body to produce the enzymes needed to digest certain foods. Congenital structural defects or diseases of the **pancreas**, gall bladder, or **liver** may alter the digestive process. Inflammation, **infection**, injury, or surgical removal of portions of the intestine may also result in absorption problems; reduced length or surface area of intestine available for fluid and nutrient absorption can result in malabsorption. Radiation therapy may injure the mucosal lining of the intestine, resulting in **diarrhea** that may not become evident until several years later. The use of some **antibiotics** can also affect the **bacteria** that normally live in the intestine and affect intestinal function.

Risk factors for malabsorption syndrome include:

- family history of malabsorption or **cystic fibrosis**
- use of certain drugs such as mineral oil or other laxatives
- travel to foreign countries, which may introduce parasites into the body
- intestinal surgery
- excess alcohol consumption

Individuals may experience symptoms of malabsorption, the most common of which include:

- anemia, with weakness and fatigue due to inadequate absorption of **vitamin B₁₂**, **iron**, and **follic acid**
- diarrhea (sometimes explosive diarrhea with greasy, foul-smelling stools), steatorrhea (excessive amount of fat in the stool), and abdominal distention with cramps, bloating, and gas due to impaired water and carbohy-

drate absorption, and irritation from unabsorbed fatty acids

- **edema** (fluid retention in the body's tissues) due to decreased protein absorption
- malnutrition and weight loss due to decreased fat, carbohydrate, and protein absorption; weight may be 80–90% of usual weight despite increased oral intake of nutrients
- muscle cramping due to decreased **vitamin D**, **calcium**, and potassium levels
- muscle wasting and atrophy due to decreased protein absorption and metabolism
- perianal skin burning, itching, or soreness due to frequent loose stools

Irregular **heart** rhythms may also result from inadequate levels of potassium and other electrolytes. **Blood** clotting disorders may occur due to a **vitamin K** deficiency. Children with malabsorption syndrome often exhibit a failure to grow and thrive.

Several disorders can lead to malabsorption syndrome, including cystic fibrosis, chronic **pancreatitis**, lactose intolerance, and celiac disease (gluten enteropathy, non-tropical sprue).

Tropical sprue is a malabsorptive disorder that is uncommon in the United States, but seen more often in people from the Caribbean, India, or southeast Asia. Although its cause is unknown, the disorder is thought to be related to environmental factors, including infection, intestinal parasites, or possibly the consumption of certain food toxins. Symptoms often include a sore tongue, anemia, weight loss, along with diarrhea and passage of fatty stools.

Celiac disease, also known as non-tropical sprue, gluten enteropathy, or celiac sprue, is an inherited disorder resulting in malabsorption because of an allergic reaction after consumption of a protein called gluten. Gluten is found in wheat, rye, barley, and oats.

Whipple's disease is a relatively rare malabsorptive disorder that affects mostly middle-aged men. The cause of the disorder is possibly related to bacterial infection, resulting in nutritional deficiencies, chronic low-grade **fever**, diarrhea, joint **pain**, weight loss, and darkening of the skin's pigmentation. Other organs of the body may be affected, including the **brain**, heart, **lungs**, and eyes.

Short bowel syndromes—which may be present at birth (congenital) or the result of surgery—reduce the surface area of the bowel available to absorb nutrients and can also result in malabsorption syndrome.

Bacterial overgrowth that is triggered by intestinal diverticulosis, intestinal disorders, blind loops, fistulas,

and strictures may cause malabsorption, resulting in fat malabsorption and flatulence.

Intestinal lymphangiectasia, also called idiopathic hypoproteinemia, is a disorder affecting children and young adults in which the lymph vessels supplying the lining of the small intestine become enlarged. Lymph vessel enlargement may be a birth defect or may have been due to inflammation of the pancreas, called pancreatitis or a condition called constrictive pericarditis, which is characterized by a stiffening of the sac around the heart (constrictive pericarditis). These conditions increase pressure on the **lymphatic system**. Symptoms of intestinal lymphangiectasia are severe edema, and perhaps nausea, vomiting, mild diarrhea, fatty stools, and abdominal pain. The number of lymphocytes in the blood may decrease. As well, cholesterol and protein levels in the blood are low.

Diagnosis

Doctors often suspect malabsorption syndromes when weight loss, diarrhea, and nutritional deficiencies occur despite eating a healthy and adequate diet. The diagnosis of malabsorption syndrome and identification of the underlying cause can require extensive diagnostic testing.

The first phase of diagnosis involves a thorough medical history and **physical examination** by a physician, who will then determine the appropriate laboratory studies and x rays. A 72-hour stool collection may be ordered for fecal fat measurement; increased fecal fat in the stool indicates malabsorption. A biopsy of the small intestine may be done to assist in differentiating between malabsorption syndrome and small bowel disease. Pancreatic function tests are often conducted since pancreatic disorders are a common cause of malabsorption syndromes. Ultrasound, computed tomography scan (CT scan), **magnetic resonance imaging (MRI)**, **barium enema**, or other x rays to identify abnormalities of the gastrointestinal tract and pancreas may also be ordered.

To diagnose intestinal lymphangiectasia, an intravenous injection of radioactive-labeled albumin may be ordered. Excessive protein is lost if abnormal amounts of the radioactive substance appear in the stool. Enlarged lymph vessels are indicated by a biopsy of the small intestine.

Laboratory studies of the blood may include:

- Serum cholesterol: May be low due to decreased fat absorption and digestion.
- Serum sodium, potassium, and chloride: May be low due to electrolyte losses with diarrhea.

- Serum calcium: May be low due to vitamin D and amino acid malabsorption.
- Serum protein and albumin: May be low due to protein losses.
- Serum **vitamin A** and carotene: May be low due to bile salt deficiency and impaired fat absorption.
- D-xylose test: Decreased excretion may indicate malabsorption.
- Schilling test: May indicate malabsorption of vitamin B₁₂.

Treatment

Fluid and nutrient monitoring and replacement is essential for any individual with malabsorption syndrome. Hospitalization may be required when severe fluid and electrolyte imbalances occur. Consultation with a dietitian to assist with nutritional support and meal planning is helpful. If the patient is able to eat, the diet and supplements should provide bulk and be rich in carbohydrates, **proteins**, fats, **minerals**, and **vitamins**. The patient should be encouraged to eat several small meals throughout the day, avoiding fluids and foods that promote diarrhea. Intake and output should be monitored, along with the number, color, and consistency of stools.

The individual with malabsorption syndrome must be monitored for **dehydration**, including dry tongue, mouth, and skin; increased thirst; low, concentrated urine output; or feeling weak or dizzy when standing. Pulse and **blood pressure** should be monitored for increased or irregular pulse rate, or hypotension (low blood pressure). The individual should also be alert for signs of nutrient, vitamin, and mineral depletion, including nausea or vomiting; fissures at corner of mouth; fatigue or weakness; dry, thinning hair; easy bruising; tingling in fingers or toes; and numbness or burning sensation in legs or feet. Fluid volume excess, as a result of diminished protein stores, may require fluid intake restrictions. The physician should also be notified of any shortness of breath.

Other specific medical management for malabsorption syndrome is dependent upon the cause. Treatment for tropical sprue consists of folic acid supplements and long-term antibiotics. Depending on the severity of the disorder, this treatment may be continued for six months or longer. Whipple's disease also may require long-term use of antibiotics such as tetracycline. Management of some individuals with malabsorption syndrome may require injections of vitamin B₁₂ and oral iron supplements. The doctor may also prescribe enzymes to replace missing intestinal enzymes, or antispasmodics to reduce abdominal cramping and associated diarrhea. People with cystic fibrosis and chronic pancreatitis require pan-

KEY TERMS

Anemia—A decrease in the number of red blood cells in the bloodstream, characterized by pallor, loss of energy, and generalized weakness.

Atrophy—A wasting away of a tissue or organ, often caused by insufficient nutrition.

Biopsy—A tissue sample removed from the body for examination under the microscope.

Constrictive pericarditis—A condition that is characterized by a stiffening of the sac around the heart, which leads to increased pressure on the lymphatic system.

Cystic fibrosis—A hereditary genetic disorder that occurs most often in Caucasians. Thick, sticky secretions from mucus-producing glands cause blockages in the pancreatic ducts and the airways.

Edema—An excessive accumulation of fluid in the tissue spaces.

Gluten enteropathy—A hereditary malabsorption disorder caused by sensitivity to gluten, a protein found in wheat, rye, barley, and oats; also called non-tropical sprue or celiac disease.

Intestines—Also known as the bowels; intestines are divided into the large and small intestines, extending from the stomach to the anus.

Short bowel syndrome—A condition in which the bowel is not as long as normal, either because of surgery or because of a congenital defect.

Steatorrhea—An excessive amount of fat in the stool.

creatic supplements. Those with lactose intolerance or gluten enteropathy will have to modify their diets to avoid foods that they cannot properly digest.

Intestinal lymphangiectasia is treated by correcting the cause of the lymph vessel enlargement. For instance, treating constrictive pericarditis may relieve pressure on the lymph vessels. Some people improve by eating a low-fat diet and taking supplements of certain triglycerides, which are absorbed directly into the blood and not through the lymph vessels. If only a small part of the intestine is affected, it can be removed surgically.

Prognosis

The expected course for the individual with malabsorption syndrome varies, depending on the cause. The

onset of symptoms may be slow and difficult to diagnose. Treatment may be long, complicated, and changed often for optimal effectiveness. Patience and a positive attitude are important in controlling or curing the disorder.

Health care team roles

The health care team should familiarize patients with their condition and the methods of dealing most effectively with their malabsorption syndrome. Physicians will typically take charge of the patient's care, ordering tests and medications. Nurses are involved in the daily care of the patient, including administering medicines. Clinical laboratory scientists and medical technologists perform laboratory tests on blood or fecal samples. Radiologic technologists perform many of the imaging studies used in diagnosis.

Prevention

Many malabsorption syndromes are hereditary. Genetic screening may prevent passing on the genes to unborn children. For infants or children, the best means of prevention of some of these hereditary conditions are by early detection at routine well-baby examinations and periodic follow-ups with school-aged and adolescent children. In some cases, however, prevention of malabsorption syndromes can consist of simply avoiding foods or substances that cause the patient an allergic reaction and/or gastrointestinal distress. Careful monitoring is necessary to prevent additional illnesses caused by nutritional deficiencies. Impure water sources should be avoided when traveling to prevent parasitic infection.

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Malabsorption tests

Definition

Malabsorption tests are done to determine if a patient has dietary malabsorption or maldigestion and to help differentiate between these two conditions. Malabsorption occurs when the gastrointestinal (GI) tract cannot take up a dietary compound. This is caused by the loss of function of the cells responsible for absorption. Maldigestion occurs when an important digestive enzyme or tissue is lacking or not functioning correctly. This may be caused by genetic disorders, injury to the tissue that provides the enzyme (i.e. the **pancreas**), alterations in pH that make the enzymes inactive, or to surgery. In general, clinicians speak of both disorders as malabsorption disorders since they both result in a lack of absorption of nutrients.

Purpose

Malabsorption tests are generally used to determine why someone is malnourished or is experiencing gastrointestinal upset. Some malabsorption tests are used as a last resort because the testing procedures are complicated. The physician first needs to rule out other disorders such as ulcers in the **stomach** and intestine. In the population, the elderly are at the greatest risk for developing malabsorption disorders. Before ordering malabsorption tests, physicians may do a general screen for malnutrition. This can include tests for **proteins** that reflect nutritional status such as serum albumin and prealbumin (transthyretin); tests for serum **calcium**, **vitamin B₁₂**, folate, **iron**, and **vitamin D** to detect a deficiency of **vitamins** or **minerals**; and a peripheral **blood** smear to detect anemia, which may have a related cause.

The absorptive capacity of the gastrointestinal tract is staggering. In general, we absorb hundreds of grams of **carbohydrates**, over 100 grams of fat and 50-100 grams of amino acids per 24-hour period. This is accomplished by the mucosal cells lining the intestine. These surfaces contain many villi, small projections that increase the surface area of the intestinal wall. It is estimated the average adult human intestine has the absorptive surface area of a tennis court. Different parts of the GI tract have different functions and nutrients are broken down and absorbed in different parts.

Carbohydrate digestion begins in the mouth with salivary amylase and continues in the stomach via the action of the stomach and low pH. In the **small intestine**, pancreatic amylase and intestinal enzymes such as lactase complete carbohydrate hydrolysis, forming simple sugars that are absorbed. Any undigestible carbohydrate (fiber) is excreted in the feces. Fat digestion and absorption is very efficient, with very little fat found in the feces. Pancreatic and gastric lipases are the enzymes most responsible for the breakdown of triacylglycerides (triglycerides) into small glycerides and free fatty acids. The action of lipase requires bile salts and bile acids that are also needed to emulsify the **fats**. The free fatty acids and small glycerides produced by the hydrolysis of triglycerides are absorbed in the intestine and converted by the mucosal cells into chylomicrons. Protein digestion begins in the stomach with the action of hydrochloric acid and pepsin, and continues in the intestine via the activity of pancreatic and intestinal proteases such as trypsin, chymotrypsin, and carboxypeptidase. The dipeptides and amino acids produced from protein hydrolysis are absorbed via complex mechanisms by the intestinal epithelial cells.

Malabsorption of nutrients can cause painful GI symptoms and over time cause malnutrition. Patients lose

vitamins and minerals along with basic nutrients. Some malabsorption syndromes can cause **dehydration** since they produce **diarrhea**. Diagnosing the cause of malabsorption is difficult, and doctors will try many different testing approaches. Malabsorption can be caused by many things including:

- Pancreatic insufficiency, caused by inflammation of the pancreas (**pancreatitis**), obstruction of the pancreatic duct, pancreatic **cancer**, inherited deficiency of pancreatic enzymes.
- Defective stimulation of the stomach due to illness or surgery. Muscles in the stomach need to contract to mix up the food with digestive enzymes and acid.
- Elevated pH of stomach acid (hypoacidity or achlorhydria).
- Lack of bile acids due to obstruction (gallstones or tumors) or due to **liver** disease.
- Bacterial overgrowth in the lower intestine.
- Food **allergies** such as celiac disease.
- Inflammation of the intestines or colon, such as colitis, **Crohn's disease**, inflammatory bowel syndrome.
- Parasitic infections, such as Whipple's disease or tropical sprue.
- Lack of enzymes in the intestine. For example, lactase deficiency causes lactose intolerance, a very common cause of malabsorption in adults.
- Surgical removal of parts of the intestine due to disease, or surgery to decrease the size of the stomach to promote weight loss.
- Diseases such as diabetes, **AIDS**, **cystic fibrosis**, thyroid disease, and alcoholism.

Symptoms of malabsorption are varied because the disorder affects so many systems. General symptoms may include loss of appetite (anorexia), weight loss, fatigue, shortness of breath, dehydration, low **blood pressure**, and swelling (**edema**). Nutritional disorders may cause anemia (lack of iron, folate and vitamin B₁₂), bleeding tendency (lack of **vitamin K**), or bone disease (lack of vitamin D). Gastrointestinal symptoms include flatulence, stomach distention, borborygmi (rumbling in the bowels), discomfort, diarrhea, steatorrhea (excessive fat in stool) and frequent bowel movements.

Precautions

Most malabsorption tests require a blood sample collected by venipuncture. The nurse or phlebotomist must follow **universal precautions** for the prevention of transmission of bloodborne pathogens. Most of the tests done to measure malabsorption are relatively safe but do

require some effort on the patient's part. Many require an overnight fast. Some patients who need malabsorption tests may be malnourished or dehydrated. Clinicians should watch for low blood pressure, weakness, thirst, concentrated urine (dehydration), and dizziness. Some tests require ingestion of highly concentrated nutrients that may be difficult for the patient to digest. Asking patients to collect urine or feces over a long time period can cause problems with compliance. It is important to make sure the patient understands the test and why he or she must comply. Clinical laboratories will reject any samples that appear to have been collected or stored incorrectly.

Description

Breath hydrogen test

The breath hydrogen test is used to measure two things, carbohydrate malabsorption such as lactose intolerance and bacterial overgrowth. Hydrogen is produced by bacterial fermentation of unabsorbed carbohydrates in the intestines. Bacterial overgrowth can occur in this situation because there is a large food supply. The hydrogen produced goes into the blood stream and is excreted through the **lungs**. The test is done using a gas chromatograph, an apparatus that can separate compounds from one another based on their chemical composition. The patient is asked to fast overnight, and his or her breath is collected in a plastic syringe at the start of the test. The patient is then given something to eat depending on what is being evaluated. If the doctor suspects that the patient has trouble absorbing carbohydrates, then he or she may be given rice, glucose or fructose. If lactose intolerance is suspected, the patient is given a food containing lactose such as milk. For general bacterial overgrowth tests, the patient will be given glucose. The patient's breath will be collected in a plastic syringe every thirty minutes for the next two to five hours, depending on the test. The syringe will be capped and sent to the laboratory for analysis. The test is simple and non-invasive and while not diagnostic, it gives the doctor an idea of what may be wrong.

D-xylose absorption test

D-xylose is a sugar that is not normally found in the blood. It can be easily absorbed by healthy intestinal cells without the aid of pancreatic enzymes, and is poorly metabolized so that at least 50% of the dose is excreted in the urine within 24 hours. This test is a good general screen for malfunction of absorption, and helps to differentiate intestinal malabsorption syndromes (reduced D-xylose absorption) from pancreatitis (normal D-xylose absorption). Adults are given an oral dose (usually 25

grams) of D-xylose. A five-hour timed urine sample is collected, and a blood sample is collected two hours after the dose is given. Children are given a 5 gram dose of D-xylose, and a blood sample is collected one hour after the dose is given. Adults should excrete at least 25% of the dose in the five-hour urine sample, and have a two-hour blood level of at least 25 mg/dL. Children should have a one-hour blood level of at least 20 mg/dL. The D-xylose test will be normal if the patient has normal absorptive capacity in the intestine, or if the patient has malabsorption that is caused by a pancreatic problem. It will be low if the patient has celiac disease, tropical sprue, Crohn's disease, advanced AIDs, or pellegra (**niacin** deficiency).

Tests for celiac disease

Celiac disease is a disorder characterized by antibodies to gluten, a protein found in wheat. The disease produces lesions in the intestine and decreases the tissue's ability to absorb many different nutrients. Patients have diarrhea and lose weight over time. The lesions will improve when foods containing gluten are removed from the diet. Tests for this disease involve drawing the patient's blood and testing for the presence of three antibodies, antigliadin, antiendomysium, and antireticulin antibodies. Patients with celiac disease are followed closely by their doctors, even after dietary changes, because they are more prone to developing intestinal cancers and intestinal ulcerations.

Stool fat testing

Stool fat testing, measuring fats in the feces, is a sensitive way to determine if the patient has fat malabsorption but the test does not differentiate between pancreatic and intestinal causes. Fat is normally absorbed very efficiently by the intestinal cells. High levels of fat in the feces causes steatorrhea, a type of feces that appears pale in color and greasy. Before the test, the patient is put on a high fat diet, consuming between 50-150 g/day of fat for three days. The patient must collect their feces over the next 72 hours using a 1-gallon paint can that can be well sealed. The fecal sample must be refrigerated to prevent any bacterial action. Fecal fat analysis is performed by first weighing the sample and then extracting the **lipids** with an organic solvent. The extraction solvent is evaporated and the dry weight of the fat that remains is measured. Normal absorption of fat is indicated by a fecal fat level of less than or equal to 7 grams per day.

A more simple but less accurate way to measure fat absorption is to count the fat droplets in a well mixed sample of the stool specimen using a **microscope** and a neutral fat stain. Another simplified screening test is the fat tolerance test called the butterfat or the fatty meal test.

The patient is asked to fast overnight and is given 1 gram of fat per kg of body weight. This is a substantial amount of fat and usually is given as 1 gram of butter per Kg spread on a piece of toast or as 6 ounces of corn oil. Blood is drawn before the dose and again three and six hours afterwards. The fasting, three-hour and six-hour plasma samples are analyzed for triglyceride concentration. Normal absorption is indicated by at least a 50% increase in triglycerides over the fasting level.

Preparation

The patient should be advised about the test he or she is taking and what the testing procedure involves. It is important with all tests, except the celiac antibody tests, that the patient fasts overnight. This allows the clinician to determine a "baseline" or starting value. Patients who are required to collect a 72-hour fecal sample must seal the sample well and keep it refrigerated to prevent any degradation.

Aftercare

Some patients may feel sick after the procedures since they are being exposed to compounds that they may have trouble absorbing. Nurses should be careful to discuss any side effects with the patient beforehand, and the patient should be given the smallest amount of substance possible to avoid problems. In addition, patients may be malnourished and need something to eat and drink once the procedure is over.

Complications

The hydrogen breath test may not be accurate if the patient is a smoker, has pulmonary disease, is not fasting or is hyperventilating. Patients being measured for bacterial overgrowth must not only fast overnight, but avoid fiber-rich foods for three days before the test. Patients taking the fecal fat test must remain on a high fat diet before and during the test.

Falsely low results with the D-xylose test will be seen if the patient has been vomiting, has gastric stasis, fluid build up (ascites), fluid retention (edema) or bacterial overgrowth. There is a decrease in urinary excretion of D-xylose with aspirin, colchicine, digitalis, MAO inhibitors, food consumption, neomycin and opiates. In addition, excretion is lower in those with impaired renal function and in elderly patients.

Results

D-xylose absorption should be greater than 1.2 g/5 hours with a 5 g dose of D-xylose and 4.0 g/5 hours in an

KEY TERMS

Absorption—Process of taking up digested food substances into the cells and blood stream of the body.

Carbohydrate—A macromolecule (large molecule) that is made of sugars or starch.

Diarrhea—Excessive production of feces. This is usually due to a large amount of water in the stool.

Fats—A macromolecule that is not soluble in water. Fats are also called lipids.

Gastrointestinal—Having to do with the stomach and intestines.

Gluten—One of the proteins found in wheat products.

Lactase—An enzyme that breaks down lactose.

Lipase—An enzyme that breaks down fats.

Mucosa—The cells lining the digestive tract. These cells secrete mucus to protect themselves from digestion.

Protease—An enzyme that breaks down proteins.

Protein—A macromolecule that is made of amino acids.

Steatorrhea—Feces that contain a high level of fat due to poor fat absorption in the GI tract.

Villi—Projections of tissue into the intestine that increase the surface area.

adult given a 25 g dose of D-xylose. Fecal fat should be less than 7 g/day in adults and less than 2 g/day in a child. Hydrogen breath test results are based on the baseline value, which in most people should be extremely low. The results are measured in parts per million and the actual numbers depend on the sugar or carbohydrate given. Abnormal results with the celiac tests are any antibodies measured since healthy people do not generate antibodies to gluten protein.

Health care team roles

Malabsorption tests are ordered by a physician. The malabsorption tests call for a skilled team of nurses and dieticians who administer the tests. Clinical laboratory scientists/medical technologists perform malabsorption tests, and the physician interprets the result.

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Malaria

Definition

Malaria is a serious, infectious disease spread by certain mosquitoes. It is most common in tropical climates. It is characterized by recurrent symptoms of chills, **fever**, and an enlarged spleen. The disease can be treated with medication, but it often recurs. Malaria is endemic (occurs frequently in a particular locality) in many third world countries. Isolated, small outbreaks sometimes occur within the boundaries of the United States.

Description

Malaria is not a serious problem in the United States. Within the last decade, only about 1,200 cases have been reported each year in this country, mostly by people who were infected elsewhere. Locally transmitted malaria has occurred in California, Florida, Texas, Michigan, New Jersey, and New York City. While malaria can be transmitted in **blood**, the American blood supply is not screened for malaria. Widespread malarial epidemics are far less likely to occur in the United States, but small, localized epidemics could return to the western world.

The picture is far more bleak outside the territorial boundaries of the United States. A recent government panel warned that disaster looms over Africa from the disease. Malaria infects between 300 and 500 million people every year in Africa, India, southeast Asia, the Middle East, Oceania, and Central and South America. About 2 million of the infected die each year. Most of the cases and almost all of the deaths occur in sub-Saharan Africa. At the present time, malaria kills about twice as many people each year as does **AIDS**. As many as half a billion people worldwide are left with chronic anemia due to malaria **infection**. In some parts of Africa, people battle up to 40 or more separate episodes of malaria in their lifetimes. The spread of malaria is becoming even

more serious as the parasites that cause malaria develop resistance to the drugs used to treat the condition.

Causes and symptoms

Human malaria is caused by four different species of a parasite called plasmodium: *Plasmodium falciparum* (the most deadly), *P. vivax*, *P. malariae*, and *P. ovale*. The last two are fairly uncommon. Many animals can get malaria but human malaria does not spread to animals. In turn, animal malaria does not spread to humans.

A person gets malaria when bitten by a female mosquito who is looking for a blood meal and is infected with the malaria parasite. The parasites enter the blood stream and travel to the **liver**, where they multiply. When they re-emerge into the blood, symptoms appear. By the time a person shows symptoms, the parasites have reproduced very rapidly, clogging **blood vessels** and rupturing blood cells.

Malaria cannot be casually transmitted directly from one person to another. Instead, a mosquito bites an infected person and then passes the infection on to the next human it bites. It is also possible to spread malaria via contaminated needles or in blood transfusions. This is why all blood donors are carefully screened with questionnaires for possible exposure to malaria.

The amount of time between the mosquito bite and the appearance of symptoms varies, depending on the strain of parasite involved. The incubation period is usually between eight and 12 days for falciparum malaria, but it can be as long as a month for the other types. Symptoms from some strains of *P. vivax* may not appear until eight to 10 months after the mosquito bite occurred.

The primary symptom of all types of malaria is the “malaria ague” (chills and fever). In most cases, the fever has three stages, beginning with uncontrollable shivering for an hour or two, followed by a rapid spike in temperature (as high as 106°F, or 41.1°C), which lasts for three to six hours. Then, just as suddenly, the affected person begins to sweat profusely, which will quickly bring down the fever. Other symptoms may include fatigue, severe headache, or nausea, and vomiting. As the sweating subsides, an individual typically feels exhausted and falls asleep. In many cases, this cycle of chills, fever, and sweating occurs every other day, or every third day, and may last for between a week and a month. Those with the chronic form of malaria may have a relapse as long as 50 years after the initial infection.

Falciparum malaria is far more severe than other types of malaria because the parasite attacks all red blood cells, not just the young or old cells, as do other types. It causes the red blood cells to become very “sticky.” A per-

son with this type of malaria can die within hours of the first symptoms. The fever is prolonged. So many red blood cells are destroyed that they block the blood vessels in vital organs (especially the **kidneys**), and the spleen becomes enlarged. There may be **brain** damage, leading to **coma** and convulsions. The kidneys and liver may fail.

Malaria in **pregnancy** can lead to premature delivery, **miscarriage**, or stillbirth.

Certain kinds of mosquitoes (called anopheles) can pick up the parasite by biting an infected human. (The more common kinds of mosquitoes in the United States do not transmit the infection.) This is true for as long as that human has parasites in the blood. Since strains of malaria do not protect against each other, it is possible to be re-infected with the parasites again and again. It is also possible to develop a chronic infection without developing an effective **immune response**.

Diagnosis

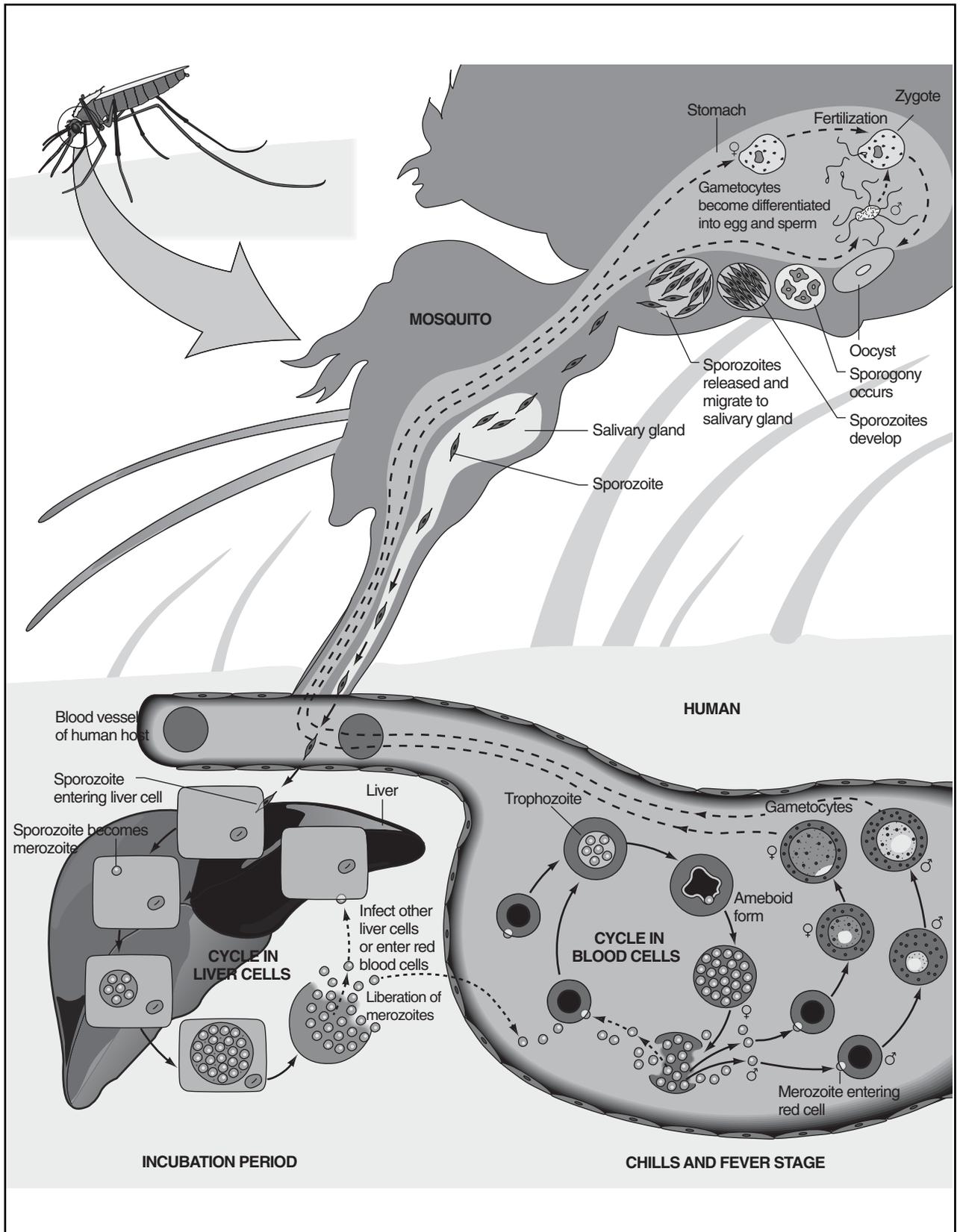
Malaria is diagnosed by examining blood under a **microscope**. The parasite can be seen in the blood smears on a slide. These blood smears may need to be repeated over a 72-hour period to make an accurate diagnosis. Antibody tests are not usually helpful because many people developed antibodies from past infections, and the tests may not be readily available.

Anyone who becomes ill with chills and fever after being in an area where malaria exists must see a doctor and mention the recent travel to endemic areas. A person with the above symptoms who has been in a high-risk area should insist on a blood test for malaria. The doctor may believe the symptoms are just the common flu virus. Malaria is often misdiagnosed by North American doctors who are not used to seeing the disease. Delaying treatment of falciparum malaria can be fatal.

Treatment

Falciparum malaria is a medical emergency that must be treated in a hospital. The type of drugs, the method of giving them, and the length of the treatment depend on where the malaria was contracted and how sick is the affected person.

For all strains except falciparum, the treatment for malaria is usually chloroquine (Aralen) by mouth for three days. Those falciparum strains suspected to be resistant to chloroquine are usually treated with a combination of quinine and tetracycline. In countries where quinine resistance is developing, other treatments may include clindamycin (Cleocin), mefloquin (Lariam), or sulfadoxone/pyrimethamine (Fansidar). Most persons



The life cycle of *Plasmodium vivax*, the parasite that causes malaria. (Illustration by Hans & Cassidy.)

receive an antibiotic for seven days. Those who are very ill may need intensive care and intravenous (IV) malaria treatment for the first three days.

Anyone who acquired falciparum malaria in the Dominican Republic, Haiti, Central America west of the Panama Canal, the Middle East, or Egypt can still be cured with chloroquine. Almost all strains of falciparum malaria in Africa, South Africa, India, and southeast Asia are now resistant to chloroquine. In Thailand and Cambodia, there are strains of falciparum malaria that have some resistance to almost all known drugs.

A person with falciparum malaria needs to be hospitalized and given antimalarial drugs in different combinations and doses depending on the resistance of the strain. The individual may need IV fluids, red blood cell transfusions, **kidney dialysis**, and assistance breathing.

A drug called primaquine may prevent relapses after recovery from *P. vivax* or *P. ovale*. These relapses are caused by a form of the parasite that remains in the liver and can reactivate months or years later.

Another new drug, halofantrine, is available abroad. While it is licensed in the United States, it is not marketed in this country and it is not recommended by the Centers for Disease Control and Prevention in Atlanta, Georgia.

Preventing mosquito bites while in the tropics is an important way to avoid malaria.

Alternative treatment

The Chinese herb qinghaosu (the western name is artemisinin) has been used in China and southeast Asia to fight severe malaria, and became available in Europe in 1994. Because this treatment often fails, it is usually combined with another antimalarial drug (mefloquine) to boost its effectiveness. It is not available in the United States and other parts of the developed world due to fears of its toxicity, in addition to licensing and other issues.

A western herb called wormwood (*Artemisia annua*) that is taken as a daily dose can be effective against malaria. Protecting the liver with herbs like goldenseal (*Hydrastis canadensis*), Chinese goldenthrad (*Coptis chinensis*), and milk thistle (*Silybum marianum*) can be used as preventive treatment.

Prognosis

If treated in the early stages, malaria can be cured. Those who live in areas where malaria is epidemic, however, can contract the disease repeatedly, never fully recovering between bouts of acute infection.

Health care team roles

Physicians, assisted by laboratory technicians, usually make a diagnosis of malaria. Nurses may provide prevention education and support during recovery from malaria ague.

Prevention

Several researchers are currently working on a malarial vaccine, but the complex life cycle of the malaria parasite makes it difficult. A parasite has much more genetic material than a virus or bacterium. For this reason, a successful vaccine has not yet been developed.

Malaria is an especially difficult disease to vaccinate against because the parasite goes through several separate stages. One recent, promising vaccine appears to have protected up to 60% of people exposed to malaria. This was evident during field trials for the drug that were conducted in South America and Africa. It is not yet commercially available.

The World Health Association (WHO) has been trying to eliminate malaria for the past 30 years by controlling mosquitoes. Their efforts were successful as long as the pesticide DDT killed mosquitoes and antimalarial drugs cured those who were infected. Today, however, the problem has returned a hundredfold, especially in Africa. Because both the mosquito and parasite are now extremely resistant to the insecticides designed to kill them, governments are now trying to teach people to take antimalarial drugs as a preventive medicine and avoid being bitten by mosquitoes.

Travelers to high-risk areas should use insect repellent containing DEET for exposed skin. Because DEET is toxic in large amounts, children should not use a concentration higher than 35%. DEET should not be inhaled. It should not be rubbed onto the eye area, on any broken or irritated skin, or on children's hands. It should be thoroughly washed off after coming indoors.

Individuals who use the following preventive measures get fewer infections than those who do not:

- Between dusk and dawn, remain indoors in well-screened areas.
- Sleep inside pyrethrin or permethrin repellent-soaked mosquito nets.
- Wear clothes over the entire body.

Anyone visiting endemic areas should take anti-malarial drugs starting a day or two before leaving the United States. The drugs used are usually chloroquine or mefloquine. This treatment is continued through at least four weeks after leaving the endemic area. However,

KEY TERMS

Artemisininins—An antimalarial family of products derived from an ancient Chinese herbal remedy. Two of the most popular varieties are artemether and artesunate, used mainly in southeast Asia in combination with mefloquine.

Chloroquine—This antimalarial drug was first used in the 1940s, until the first evidence of quinine resistance appeared in the 1960s. It is now ineffective against falciparum malaria almost everywhere. However, because it is inexpensive, it is still the antimalarial drug most widely used in Africa. Native individuals with partial immunity may have better results with chloroquine than a traveler with no previous exposure.

Mefloquine—An antimalarial drug that was developed by the United States Army in the early 1980s. Today, malaria resistance to this drug has become a problem in some parts of Asia (especially Thailand and Cambodia).

Quinine—One of the first treatments for malaria, quinine is a natural product made from the bark of the Cinchona tree. It was popular until being superseded by the development of chloroquine in the 1940s. In the wake of widespread chloroquine resistance, however, it has become popular again. It or its close relative quinidine can be given intravenously to treat severe falciparum malaria.

Sulfadoxone/pyrimethamine (Fansidar)—This antimalarial drug developed in the 1960s is the first drug tried in some parts of the world where chloroquine resistance is widespread. It has been associated with severe allergic reactions due to its sulfa component.

even those who take antimalarial drugs and are careful to avoid mosquito bites can still contract malaria.

International travelers are at risk for becoming infected. Most Americans who have acquired falciparum malaria were visiting sub-Saharan Africa. Travelers in Asia and South America are less at risk. Travelers who stay in air conditioned hotels on tourist itineraries in urban or resort areas are at lower risk than backpackers, missionaries, and Peace Corps volunteers. Some people in western cities where malaria does not usually exist may acquire the infection from a mosquito carried onto a jet. This is called airport or runway malaria.

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- Pan American Health Organization, 525 Twenty-third Street, NW, Washington, D.C. 20037. (202)974-3000. Fax: (202)974-3663. <<http://www.paho.org/>>; webmaster@paho.org.

World Health Organization, Communicable Diseases, 20 Avenue Appia, 1211 Geneva 27, Switzerland. +41 (22) 791 4140. Fax: +41 (22) 791 4268. <<http://www.who.int/gtb/>>, tuberculosis@who.org.

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Male infertility *see* **Infertility**

Male reproductive system *see* **Reproductive system, male**

Malignant lymphomas

Definition

Malignant lymphomas are a group of cancers in which cells of the **lymphatic system** become abnormal and start to grow uncontrollably and spread (metastasize) throughout the body. Because lymph tissue is in many parts of the body, lymphomas can start in almost any organ of the body. Lymphomas are classified as being either non-Hodgkin's lymphoma or Hodgkin's disease.

Description

The lymph system is made up of ducts or tubules that carry lymph to all parts of the body. Lymph is a milky fluid that contains the lymphocytes or white **blood** cells, as well as protein and waste products. These are the infection-fighting cells of the blood. Small pea-shaped organs are found along the network of lymph vessels. These are called the lymph nodes, and their main function is to make and store lymphocytes. Clusters of lymph nodes are found in the pelvis region, underarm, neck, chest, and abdomen. The spleen, the tonsils, and the thymus are part of the lymphatic system.

The lymphocyte is the main cell of the lymphoid tissue. There are two main types of lymphocytes: the T lymphocyte and the B lymphocyte. Lymphomas develop from these two cell types. B cell lymphomas are more common among adults; while among children, the incidence of T and B cell lymphomas is almost equal.

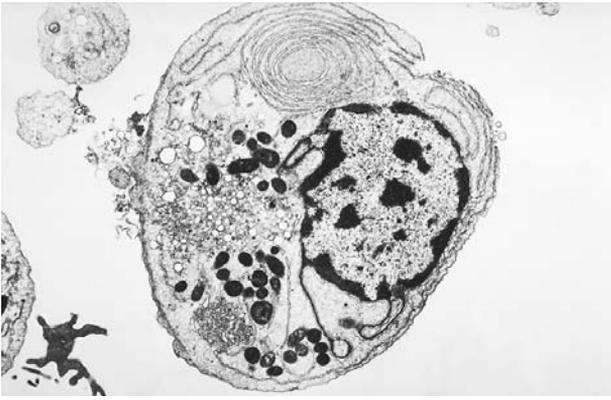
The T and the B cell perform different jobs within the **immune system**. When an infectious bacterium enters the body, the B cell makes **proteins** called “antibodies.” These antibodies attach themselves to the **bacteria** and flag them for destruction by other immune cells. The T cells help protect the body against **viruses**. When a virus enters the cell, it generally produces certain proteins that are projected on the surface of the infected cell. T cells recognize these proteins and produce certain substances (cytokines) that destroy the infected cells. Some of the cytokines made by the T cells attract other cell types, which are capable of digesting the virus-infected cell. The T cells can also destroy some types of cancerous cells.

Lymphomas can be divided into two main types: Hodgkin's lymphoma or Hodgkin's disease, and non-Hodgkin's lymphomas. The two are distinguished by cell type and have similar symptoms. Non-Hodgkin's lymphomas are more common, with at least 30 different types. Hodgkin's primarily affects individuals 15–40 years of age, while Non-Hodgkin's occurs mainly in persons between the ages of 30–70.

Lymphomas are grouped (staged) by how aggressively they grow—slow growing (low grade, mostly found in B-cell types), intermediate growing (seen in both B-cell and T-cell types), and rapidly growing (high grade, seen in both B-cell and T-cell types)—and how far they spread. Lymphomas are also staged by the Roman numerals I, II, III, and IV. These stages indicate the following:

- Stage I. There is only one **cancer** site. No bone marrow involvement found.
- Stage II. Two sites are found, either above or below the diaphragm. There is no bone marrow involvement.
- Stage III. Sites are found above and below the diaphragm, but there is still no bone marrow involvement.
- Stage IV. The bone marrow is involved and the cancer cells have metastasized beyond the lymphatic system.

A majority of non-Hodgkin's lymphomas begin in the lymph nodes. About 20% start in other organs, such as the **lungs**, **liver**, or the gastrointestinal tract. Malignant lymphocytes multiply uncontrollably and do not perform their normal functions. Hence, the body's ability to fight infections is affected. In addition, these malignant cells may crowd the bone marrow and, depending on the stage,



A close-up view of a malignant lymph cell. (Custom Medical Stock Photo. Reproduced by permission.)

prevent the production of normal red blood cells, white blood cells, and platelets. A low red blood cell count causes anemia, while a reduction in the number of platelets makes the person susceptible to excessive bleeding. Cancerous cells can also invade other organs through the circulatory system of the lymph, causing those organs to malfunction.

In 2001, an estimated 56,200 Americans received a diagnosis of non-Hodgkin's lymphoma, and approximately 16,300 people died from malignant lymphomas. It is the fifth most common cancer in the country (not including nonmelanoma skin cancers). The incidence of non-Hodgkin's lymphoma has nearly doubled since the 1970s; however, during the 1990s the rate began to decline. The increase was related both to an actual increase in the number of cases as well as improved methods of detecting the disease. Over 95% of non-Hodgkin's lymphomas occur in adults, with the average age at diagnosis being in the early 40s. The disease more commonly occurs in men than women, and whites are affected to a greater extent than Asian Americans or African Americans.

Causes and symptoms

The exact cause of non-Hodgkin's lymphomas is not known. However, the incidence has increased significantly in recent years. Part of the increase is due to the **AIDS** epidemic. Individuals infected with the AIDS virus have a higher likelihood of developing non-Hodgkin's lymphomas.

People exposed to certain pesticides and ionizing radiation have a higher than average chance of developing this disease. For example, an increased incidence of lymphomas has been seen in survivors of the atomic bomb explosion in Hiroshima, and in people who have undergone aggressive radiation therapy. People who suf-

fer from immune-deficient (**immunodeficiency**) disorders and those who have been treated with immune suppressive drugs for transplants or for conditions such as rheumatoid arthritis and autoimmune diseases are at an increased risk for this disease.

Some studies have shown a loose association between retroviruses, such as HTLV-I, and some rare forms of lymphoma. The Epstein-Barr virus has been linked to Burkitt's lymphoma in African countries. However, a direct cause-and-effect relationship has not been established.

The symptoms of lymphomas are often vague and non-specific. The signs and symptoms may differ, depending on the location of the involvement. Patients may experience loss of appetite, weight loss, nausea, vomiting, abdominal discomfort, and indigestion. The patient may complain of a feeling of fullness, which is a result of enlarged lymph nodes in the abdomen. Sometimes the abdomen can become so swollen it may resemble **pregnancy** in a woman. Pressure or **pain** in the lower back is another symptom. In the advanced stages, the patient may have bone pain, headaches, constant coughing, and abnormal pressure and congestion in the face, neck, and upper chest. Some may have fevers and night sweats. In most cases, patients go to the doctor because of the presence of swollen glands in the neck, armpits, or groin area. Since all the symptoms are common to many other illnesses, it is essential to seek medical attention if any of the conditions persist for two weeks or more. Only a qualified physician can correctly diagnose whether the symptoms are due to lymphoma or some other ailment.

Diagnosis

Like all cancers, lymphomas are best treated when found early. However, it is often difficult to diagnose lymphomas. There are no screening tests available; and, since the symptoms are non-specific, lymphomas are rarely recognized in their early stages. Detection often occurs by chance during a routine **physical examination**.

When the doctor suspects lymphoma, a complete medical history is taken and a thorough physical examination is performed. Enlargement of the lymph nodes, liver, or spleen may suggest lymphomas. Blood tests will determine the cell counts and obtain information on how well the organs, such as the kidney and liver, are functioning.

A biopsy of the enlarged lymph node is the most definitive diagnostic tool for staging purposes. The doctor may perform a bone marrow biopsy. During the biop-

sy, a cylindrical piece of bone and marrow fluid is removed. They are generally taken out of the hipbone. These samples are sent to the laboratory for examination. In addition to diagnosis, the biopsy may also be repeated during the treatment phase of the disease to see if the lymphoma is responding to therapy.

Once the exact form of lymphoma is known, it is then staged to determine how aggressive it is, and how far it has spread. Staging is necessary to plan appropriate treatment.

Conventional imaging tests, such as x rays, computed tomography scans (**CT scans**), **magnetic resonance imaging** (MRI), and abdominal sonograms, are used to determine how far the disease has spread.

Rarely, a lumbar puncture or a spinal tap is performed to check if malignant cells are present in the fluid surrounding the **brain**. In this test, the physician inserts a needle into the epidural space at the base of the spine and collects a small amount of spinal fluid for microscopic examination.

Treatment

Much progress has been made in the treatment of non-Hodgkin's lymphoma. Treatment options for lymphomas depend on the type of lymphoma and its present stage. In most cases, treatment consists of **chemotherapy**, **radiotherapy**, or a combination of the two methods.

Chemotherapy is the use of anti-cancer drugs to kill cancer cells. In non-Hodgkin's lymphomas, combination therapy, which involves the use of multiple drugs, has been found more effective than single drug use. The treatment may last about six months, but in some cases may last as long as a year. The drugs may either be administered intravenously or given orally in the form of pills. If cancer cells have invaded the **central nervous system**, then chemotherapeutic drugs may be injected, through a needle in the brain or back, into the fluid that surrounds the brain. This procedure is known as intrathecal chemotherapy.

Radiation therapy, where high-energy ionizing rays are directed at specific portions of the body, such as the upper chest, abdomen, pelvis, or neck, is often used for treatment of lymphomas. External radiation therapy, where the rays are directed from a source outside the body, is the most common mode of radiation treatment.

Stem cell transplantation is used in cases where the lymphomas do not respond to conventional therapy, or in cases where the patient has had a relapse or suffers from recurrent lymphomas. However, one study done in the Netherlands suggested that patients may do just as well

with a standard chemotherapy regimen rather than the transplant.

There are two ways of performing stem cell transplantation. In a procedure called "allogeneic stem cell transplant," a donor is found whose cells match that of the patient. The donor can be a twin (best match), a sibling, or a person who is not related at all. High-dose chemotherapy or radiation therapy is given to eradicate the lymphoma. The donor stem cells are then given to replace those destroyed by the therapy.

In "autologous stem cell transplantation," some of the patient's own stem cells are collected, "purged" of lymphoma cells, and frozen. High-dose chemotherapy and radiation therapy are given. The stem cells that were taken and frozen are then thawed and put back into the patient's body to replace the destroyed marrow. One of the serious risks of autologous stem cell transplants is that it is possible for some of the lymphoma cells to remain even after purging the stem cells.

There are no proven alternative treatments for non-Hodgkin's lymphoma. However, many complementary therapies, including **vitamins** and herbal remedies, massage, and acupuncture, may help persons going through treatment to better cope with the side effects they might experience. Because many of these therapies have not been studied thoroughly, it is not known which ones may be potentially harmful or helpful. Therefore, the patient with lymphoma should be advised to speak with their health care professional prior to trying any alternative or complementary treatment.

Prognosis

Like all cancers, the prognosis for lymphoma depends on the stage of the cancer, and the patient's age and general health. When all the different types and stages of lymphoma are considered together, only 50% of patients survive five years or more after initial diagnosis. This is because some types of lymphoma are more aggressive than others. Patients with T-cell lymphomas generally have a worse prognosis than those with B-cell types.

The five-year survival rate for those with non-Hodgkin's lymphoma rose from 31% in 1960 to 51% in 1994. The overall survival rate among children, 78%, is definitely better than among older people. About 90% of the children diagnosed with early stage disease survive five years or more, while only 60%–70% of adults diagnosed with low grade lymphomas survive for five years or more.

KEY TERMS

Antibodies—Proteins made by the B lymphocytes in response to the presence of infectious agents such as bacteria or viruses in the body.

Autoimmune disease—A disease caused by a person's own antibodies or T cells that attack molecules, cells, or tissues.

Biopsy—The surgical removal and microscopic examination of living tissue for diagnostic purposes.

Growth factors (cytokines)—Chemicals made by the cells that act on other cells to stimulate or inhibit their function. Cytokines that stimulate growth are called “growth factors.”

Metastasize—The spread of a disease, such as a cancer, from its original site to another part of the body.

Health care team roles

Many members of the health care team will work with the lymphoma patient. The primary physician may initially suspect lymphoma and order the appropriate diagnostic workup. The surgeon performs the biopsy, and the pathologist confirms the cellular diagnosis. Various x-ray and lab technicians will perform other imaging studies. Specially trained nurses administer chemotherapy and will instruct the patient on all aspects of his diagnosis and treatment. The patient may see both a medical and radiation oncologist, depending upon the specifics of the treatment ordered. Registered nurses also provide part-time family education.

Prevention

Although many cancers may be prevented by making diet and life style changes which reduce risk factors, there is currently no known way to prevent lymphomas. Protecting oneself from developing AIDS, which may be a risk factor for lymphomas, is the only preventive measure that can be practiced.

No special tests are available for early detection of non-Hodgkin's lymphomas. Paying prompt attention to the signs and symptoms of this disease and seeing a doctor if the symptoms persist are the best strategies for an early diagnosis of lymphoma. Early detection affords the best chance for a cure.

Resources

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American Cancer Society. (800) ACS-2345. <<http://www.cancer.org>>.

The Leukemia and Lymphoma Society of America, Inc. 1311 Mamaroneck Ave, White Plains, NY 10605. (914)949-5213. <<http://www.leukemia-lymphoma.org>>.

Lymphoma Research Foundation. 8800 Venice Boulevard, Suite 207, Los Angeles, CA 90034. (310)204-7040. <<http://www.lymphoma.org>>.

National Cancer Institute. Building 31, Room 10A31, 31 Center Drive, MSC 2580, Bethesda, MD 20892-2580. (800)4CANCER. <<http://www.nci.nih.gov>>.

Deanna Swartout-Corbeil, R.N.

Malignant melanoma

Definition

Malignant melanoma is a type of skin tumor that is characterized by the cancerous growth of melanocytes, which are cells that produce a dark pigment called melanin.

Description

Overview

Cancer of the skin is the most common type of cancer and continues to grow in incidence. Skin cancer starts in the top layer of skin (the epidermis) but can grow down into the lower layers, the dermis and the subcutaneous layer. There are three main types of cells located in the epidermis, each of which can become cancerous. Melanocytes are the pigmented cells that are scattered throughout the skin, providing protection from ultraviolet (UV) light. Basal cells rest near the bottom of the epidermis and the layer of cells that continually grow to replace skin. The third type of epidermal cell is the squa-

mous cells which make up most of the cells in human skin.

Melanoma

Malignant melanoma is the most serious type of skin cancer. It develops from melanocytes. Although melanoma is the least common skin cancer, it is the most aggressive. It spreads (metastasizes) to other parts of the body—especially the **lungs** and liver—as well as invading surrounding tissues. Melanomas in their early stages resemble moles. In Caucasians, melanomas appear most often on the trunk, head, and neck in men and on the arms and legs in women. Melanomas in African Americans, however, occur primarily on the palms of the hand, soles of the feet, and under the nails. Melanomas appear only rarely in the eyes, mouth, vagina, or digestive tract. Although melanomas are associated with exposure to the sun, the greatest risk factor for developing melanoma may be genetic. People who have a first-degree relative (parent, sibling or child) with melanoma have an increased risk up to eight times greater of developing the disease.

Basal cell cancer

Basal cell cancer is the most common type of skin cancer, accounting for about 75% of all skin cancers. It occurs primarily on the parts of the skin exposed to the sun and is most common in people living in equatorial regions or areas of high ozone depletion. Light-skinned people are more at risk of developing basal cell cancer than dark-skinned people. This form of skin cancer is primarily a disease of adults; it appears most often after age 30, peaking around age 70. Basal cell cancer grows very slowly. If it is not treated, however, it can invade deeper skin layers and cause disfigurement. This type of cancer can appear as a shiny, translucent nodule on the skin or as a red, wrinkled and scaly area.

Squamous cell cancer

Squamous cell cancer is the second most frequent type of skin cancer. It arises from the outer keratinizing layer of skin, so named because it contains a tough protein called keratin. Squamous cell cancer grows faster than basal cell cancer; it is more likely to metastasize to the lymph nodes as well as to distant sites. Squamous cell cancer most often appears on the arms, head, and neck. Fair-skinned people of Celtic descent are at high risk for developing squamous cell cancer. This type of cancer is rarely life-threatening but can cause serious problems if it spreads and can also cause disfigurement. Squamous cell cancer usually appears as a scaly, slightly elevated area of damaged skin.

Other skin cancers

Besides the three major types of skin cancer, there are a few other relatively rare forms. The most serious of these is Kaposi's sarcoma (KS), which occurs primarily in persons who have **AIDS** or older males of Mediterranean descent. When KS occurs with AIDS it is usually more aggressive. Other types of skin tumors are usually nonmalignant and grow slowly. These include:

- Bowen's disease. This is a type of skin inflammation (dermatitis) that sometimes looks like squamous cell cancer.
- Actinic or solar keratosis. This is a sunlight-damaged area of skin that sometimes develops into cancer.
- Keratoacanthoma. A keratoacanthoma is a dome-shaped tumor that can grow quickly and appear like squamous cell cancer. Although it is usually benign, it should be removed.

Risk factors

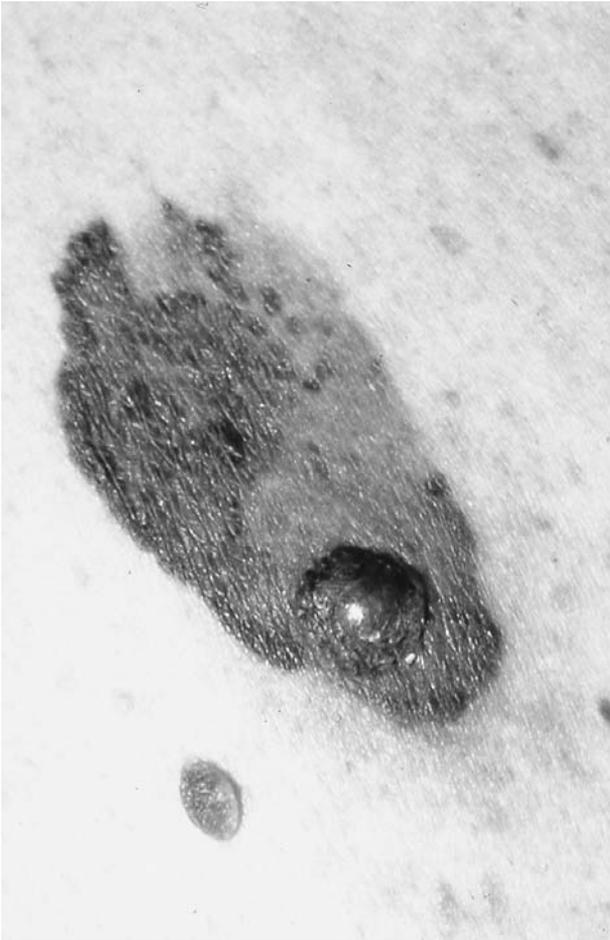
SUN EXPOSURE. Most skin cancers are associated with the amount of time that a person spends in the sun and the number of sunburns received, especially if they occurred at an early age. Skin cancer typically does not appear for 10-20 years after the sun damage has occurred. Because of this time lag, skin cancer rarely occurs before **puberty** and occurs more frequently with age.

MOLES. The number of moles (nevi) on a person's skin is related to the likelihood of developing melanoma. There are three types of nevi: not cancerous (benign); atypical (dysplastic); or birthmark (congenital). All three types of nevi have been associated with a higher risk of developing melanoma. Sometimes the moles themselves can become cancerous. Usually, however, the cancer is a new growth that occurs on normal skin.

HEREDITY. The tendency to develop skin cancer also tends to run in families. As has already been mentioned, there appears to be a significant genetic factor in the development of melanoma.

Causes and symptoms

Skin cancer begins to develop when a change or mutation occurs in one of the cells of the skin, causing it to grow without control. This mutation can be caused by ultraviolet (UV) light; most skin cancers are thought to be caused by overexposure to UV light from the sun. The incidence of severe, blistering sunburns is particularly closely related to skin cancer, more so when these **burns** occur during childhood. Exposure to ionizing radiation, arsenic, or polycyclic hydrocarbons in the workplace also



A close-up image of a malignant melanoma on patient's back. (Custom Medical Stock Photo. Reproduced by permission.)

appears to stimulate the development of skin cancers. The use of psoralen for treatment of psoriasis may be associated with the development of squamous cell cancer. Skin cancers are also more common in immunocompromised persons, such individuals with AIDS or those who have undergone organ transplants.

The first sign of skin cancer is usually a change in an existing mole, the presence of a new mole, or a change in a specific area of skin. Any change in a mole or skin lesion, including changes in color, size, or shape, tenderness, scaliness, or itching should be suspected of being skin cancer. Areas that bleed or are ulcerated may be signs of more advanced skin cancer. By doing a monthly self-examination, a person can identify abnormal moles or areas of skin and seek evaluation from a qualified health professional. The ABCD rule provides an easy way to remember the important characteristics of moles when one is examining the skin:

- **Asymmetry.** A normal mole is round, whereas a suspicious mole is unevenly shaped.
- **Border.** A normal mole has a clear-cut border with the surrounding skin, whereas the edges of a suspect mole are often irregular.
- **Color.** Normal moles are uniformly tan or brown, but cancerous moles may appear as mixtures of red, white, blue, brown, purple, or black.
- **Diameter.** Normal moles are usually less than 0.20 in (5 mm) in diameter. A skin lesion greater than 0.25 in (0.6 cm) across may be suspected as cancerous.

There are two systems used in staging melanomas. The first is Clark's, which bases staging on the level of invasion, or which tissues the tumor has penetrated (i.e. which skin layer). The other is the American Joint Committee on Cancer. The second system is sometimes called the TNM system, which stands for tumor-nodes-metastasis, after the three major phases in cancer progression. Most experts generally agree that the thickness of the tumor is more accurate than the level of invasion for predicting prognosis (the outcome of the disease and estimated chance of recovery) and choosing an appropriate treatment.

Diagnosis

A person who has a suspicious-looking mole or area of skin should consult a doctor. In many cases, the person's primary care physician will make a referral to a doctor who specializes in skin diseases (a dermatologist). The dermatologist will carefully examine the lesion for the characteristic features of skin cancer. If further testing seems necessary, the dermatologist will perform a skin biopsy by removing the lesion under **local anesthesia**. Because melanomas tend to grow in diameter, as well as downwards into the epidermis and fatty layers of skin, a biopsy sample that is larger than the mole will be taken. This tissue is then analyzed under a **microscope** by a specialist in diseased organs and tissues (a pathologist). The pathologist makes the diagnosis of cancer and determines how far the tumor has grown into the skin. The evaluation of the progression of the cancer is called staging. Staging refers to how advanced the cancer is and is determined by the thickness and size of the tumor. Additional tests will also be done to determine if the cancer has moved into the lymph nodes or other areas of the body. These tests might include **chest x ray**, computed tomography scan (CT scan), **magnetic resonance imaging** (MRI), and **blood** tests.

Treatment

Surgery

The primary treatment for skin cancer is to cut out (excise) the tumor or diseased area of skin. Surgery usually involves a simple excision using a scalpel to remove the lesion and a small amount of normal surrounding tissue. A procedure known as microscopically controlled excision can be used to examine each layer of skin as it is removed to ensure that the proper amount is taken. Depending on the amount of skin removed, the cut is either closed with stitches or covered with a skin graft. When surgical excision is performed on visible areas, such as the face, cosmetic surgery may also be performed to minimize the scar. Other techniques for removing skin tumors include burning, freezing with dry ice (cryosurgery), or **laser surgery**. For skin cancer that is localized and has not spread to other areas of the body, excision may be the only treatment needed.

Nonsurgical approaches

Although **chemotherapy** is the normal course of therapy for most other types of advanced cancer, it is not usually effective and not usually used for advanced skin cancer. For advanced melanoma that has moved beyond the original tumor site, the local lymph nodes may be surgically removed. Immunotherapy in the form of interferon or interleukin is being used more often with success for advanced melanoma. There is growing evidence that radiation therapy may be useful for advanced melanoma. Other treatments under investigation for melanoma include **gene therapy** and **vaccination**. Recent studies have shown that the use of a vaccine prepared from a person's own cancer cells may be useful in treating advanced melanoma. For people previously diagnosed with skin cancers, the chances of getting additional skin cancers are high. Therefore, regular monthly self-examination, as well as frequent examinations by a dermatologist, are essential.

Alternative treatment

There are no established alternative treatments for skin cancer. Immunotherapy, which strengthens the **immune system**, is an approach that may prove valuable in the future. Preventive measures that can be helpful include minimizing exposure to the sun and sunburn, eating a diet high in antioxidants and supplementation with antioxidant nutrients.

Prognosis

The prognosis for skin cancer depends on several factors, the most important of which are the invasiveness

of the tumor and its location. The prognosis is good for localized skin cancers that are diagnosed and treated early. For basal cell cancer and squamous cell cancer, the cure rate is close to 100%, although most people with these forms will have recurrent skin cancer. For localized melanoma, the cure rate is approximately 95%. The prognosis worsens with larger tumors. Melanoma that has spread to the lymph nodes has a 5-year survival rate of 54%; advanced melanoma has a survival rate of only 13%. When melanoma has spread to other parts of the body, it is generally considered incurable. The median length of survival is six months.

Health care team roles

A physician makes an initial diagnosis. A dermatologist and pathologist may confirm the diagnosis. A surgeon removes most lesions. A plastic and reconstructive surgeon may repair or minimize surgical scars. Nurses and nurse practitioners will participate in prevention education with patients.

Prevention

Prevention is the best way to approach skin cancer. Avoiding unnecessary sun exposure, from such sources as sun lamps and tanning salons, is relatively simple. Parents of small children should protect them against the risk of sunburn. Precautions include avoiding high sun, when the rays of the sun are most intense (between 11 A.M. and 1 P.M.). In addition, persons living at high elevations need to take extra precautions because the intensity of UV radiation increases by 4% with every 1,000-ft (305-m) rise above sea level. When outdoors protective clothing should be worn, covering exposed skin. Sunglasses with UV protective coating should also be worn.

There is presently some debate about the ability of sunscreen to protect against skin cancer. Some scientists believe that gradual exposure to the sun, in order to develop a mild tan, may offer the best protection from skin cancer. Skin cancer has also been related to diets that are high in fat. Decreasing the amount of fat consumed may also help to decrease the risk of skin cancer.

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KEY TERMS

Biopsy—Removal of a small piece of tissue for examination. This is done under local anesthesia and removed by either using a scalpel or a punch, which removes a small cylindrical portion of tissue.

Cryosurgery—The use of extreme cold to destroy tissue in treating skin cancer.

Dermatologist—A doctor who specializes in skin diseases.

Epidermis—The outermost layer of skin.

Interferon—A group of proteins that have an effect on immune function and appear to have an anti-tumor effect in some persons.

Melanin—A dark pigment that is found in certain skin cells and helps to protect the skin from ultraviolet light.

Melanocyte—A specialized skin cell that produces melanin.

Metastasis—The movement of cancer cells from one area of the body to another through the blood or the lymph vessels.

Pathologist—A specialist in diseased organs and tissues.

Staging—The process of classifying and evaluating the progression of a cancer.

TNM staging—A staging system for classifying cancers developed by the American Joint Committee on Cancer. The initials stand for tumor, nodes, and metastasis.

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ORGANIZATIONS

American Academy of Dermatology, 930 N. Meacham Road, PO Box 4014, Schaumburg, IL 60168-4014. (847) 330-0230. Fax: (847) 330-0050. <<http://www.aad.org>>.

American Melanoma Foundation, 3914 Murphy Canyon Road, Suite A132, San Diego, CA 92123. (858) 277-4426. <<http://www.melanomafoundation.org/homepage.html>>. sunsmartz@melanomafoundation.org.

Melanoma Education Foundation, 7 Jones Road, Peabody, MA 01960. <<http://www.skincheck.com/#Site%20Content>>. MEF@skincheck.org.

Melanoma Research Foundation, 23704-5 El Toro Rd., #206, Lake Forest, CA 92630. Phone/Fax: (800) 673-1290. mrf@melanoma.org.

National Cancer Institute, Building 31, Room 10A31, 31 Center Drive, MSC 2580, Bethesda, MD 20892-2580. (800) 422-6237 or (301) 435-3848. <http://www.nci.nih.gov/>.

Skin Cancer Foundation, 245 5th Avenue Suite 1403, New York, NY 10016. (800) 754-6490. Fax: (212) 725-5751. <<http://www.skincancer.org/melanoma/>>, info@skincancer.org.

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American Academy of Dermatology. <<http://www.aad.org/SkinCancerNews/WhatIsSkinCancer/ABCDMe1.html>>.

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Malocclusion

Definition

Malocclusion is an abnormality in the way the upper and lower teeth fit together in biting or chewing. The word malocclusion literally means “bad bite.” The condition may also be referred to as an irregular bite, cross-bite, or overbite.

Description

Malocclusion may be seen as crooked, crowded, or protruding teeth, or disproportionately smaller or larger jaws. Malocclusion can affect a person’s appearance, speech, and ability to eat. Usually by age seven, enough of the permanent teeth have come in for dentists to identify current malocclusion and anticipate future problems if teeth and bone are left untreated. Adults and children can be successfully treated for most problems related to malocclusion.

Causes and symptoms

Malocclusions are most often inherited, but may be acquired. Inherited conditions include too many or too few teeth; too much or too little space between teeth; irregular mouth, jaw size, and shape; and atypical formations of the jaws and face, such as a cleft palate. Malocclusions may be acquired from habits like finger or thumb sucking, tongue thrusting, premature loss of teeth from an accident or dental disease, and medical conditions such as enlarged tonsils and adenoids that lead to mouth breathing.

Malocclusions may not have symptoms, or they may produce **pain** from increased stress on the oral structures.



A close-up of person’s mouth and teeth. The teeth are misarranged due to excessive thumb sucking. (Custom Medical Stock Photo. Reproduced by permission.)

Teeth may show abnormal signs of wear on the chewing surfaces or decay in areas of tight overlap. Chewing may be difficult. Left untreated, crooked or crowded teeth can become worse, sometimes requiring costly treatment to correct serious problems that develop over time. Orthodontic problems can contribute to conditions that cause tooth decay and gum disease. They can also help cause abnormal wear of tooth surfaces, inefficient chewing function, excessive stress on gum tissue and supporting bone, as well as jaw misalignment, resulting in headaches and face or neck pain.

Diagnosis

Malocclusion is most often found during a **dental examination** or screening. A dentist or dental hygienist checks a patient’s occlusion by watching how the teeth make contact when the patient bites down normally. The dentist asks the patient to bite down on a piece of coated paper placed between the upper and lower teeth; this paper will leave colored marks at the points of contact. When malocclusion is suspected, photographs and x rays of the face and mouth may be taken for further study. To confirm the presence and extent of malocclusion, the dentist makes a plaster study model of the patient’s teeth from impressions. These models duplicate the fit of the teeth and are very useful in treatment planning.

KEY TERMS

Braces—An orthodontic appliance consisting of brackets cemented to the surface of each tooth and wires of stainless steel or nickel titanium alloy. Braces treat malocclusion by gradually changing the position of the teeth.

Impression—An imprint of the upper or lower teeth made in a pliable material that sets. When this material has hardened, it may be filled with plaster, plastic, or artificial stone to make an exact model of the teeth.

Occlusion—The way the upper and lower teeth fit together in biting or chewing.

Retainer—An orthodontic appliance worn to stabilize teeth in a new position.

Space maintainer—An orthodontic appliance worn to prevent adjacent teeth from moving into the space left by an unerupted or prematurely lost tooth.

Treatment

Malocclusion may be remedied by orthodontic treatment. Orthodontics is a specialty of dentistry that manages the growth, prevention, and correction of abnormal dental and facial relationships. Braces are the most commonly used **orthodontic appliances** in the treatment of malocclusion.

Braces apply constant gentle force to slowly change the position of the teeth, straightening them and properly aligning them with the opposing teeth. Braces consist of removable or fixed (cemented or bonded to the teeth) brackets, made of metal, ceramic, or plastic.

In most cases, braces are not removable for daily tooth brushing, so the patient must be especially diligent about keeping the mouth clean and removing bacterial plaque that is easily trapped, in order to prevent tooth decay. Foods that are crunchy should be avoided to minimize the risk of breaking the appliance. Hard fruits, vegetables, and breads must be cut into bite-sized pieces before eating. Foods that are sticky, including chewing gum, should be avoided because they may pull off the brackets or weaken the cement. Carbonated beverages may also weaken the cement, as well as contribute to tooth decay. Teeth should be brushed immediately after eating sweet foods. Special floss threaders are available to make flossing easier.

If overcrowding is creating malocclusion, one or more teeth may be extracted (surgically removed), giving other teeth room to move. If a tooth has not yet erupted or is prematurely lost, the orthodontist may insert an appliance called a space maintainer to keep the other teeth from moving out of their natural position. In severe cases of malocclusion, surgery may be necessary and the patient would be referred to yet another specialist, an oral or maxillofacial surgeon.

Once the teeth have been moved into their new position, the braces are removed and a retainer is worn until the teeth stabilize in that position. Retainers do not move teeth, they only hold them in place.

Orthodontic treatment is the only effective treatment for malocclusion not requiring surgery. However, depending on the cause and severity of the condition, an orthodontist may be able to suggest other appliances as alternatives to braces. Experts recommend early treatment, which can help to guide the growth of the jaw, regulate the widths of the dental arches, correct thumb, finger, and other sucking habits, enhance swallowing and speech, and improve personal appearance and self-esteem. Adults are candidates for orthodontics to correct malocclusion, as well. Healthy teeth can be moved to more desirable positions at any age.

Alternative treatment

There are some techniques of craniosacral therapy that can alter structure. This therapy may allow correction of some cases of malocclusion. If surgery is required, pre- and post-surgical care with natural remedies, as well as vitamin and mineral supplements, may enhance recovery. Night guards and stress management are sometimes recommended to ease the strain on the jaw and to limit teeth grinding.

Prognosis

Depending on the cause and severity of the malocclusion and the appliance used in treatment, a patient should expect correction of the condition to take one to three years. Interceptive, or early treatment procedures, might take months or more. The time required to correct malocclusion depends on the growth of the patient's mouth and face, patient cooperation, and the extent of the problem.

Health care team roles

The general dentist or dental hygienist, during preventive oral care, is often the first health professional to see evidence of a malocclusion. The general dentist usually determines a patient's need to have the problem

looked at by a specialist, such as an orthodontist. Dental assistants are ancillary personnel used in dentists' or orthodontists' offices to assist in the procedures.

Prevention

Malocclusion is preventable at times. It can be prevented by space maintenance and may be minimized by controlling habits such as finger or thumb sucking. Initial consultation with an orthodontist before a child is seven years old may lead to appropriate management of the growth and development of the child's dental and facial structures, circumventing many of the factors contributing to malocclusion.

Resources

ORGANIZATIONS

Academy of General Dentistry. 211 East Chicago Ave., Chicago, IL 60061. (312) 440-4800. <<http://www.agd.org>>.

American Association of Oral and Maxillofacial Surgeons. 9700 West Bryn Mawr Avenue, Rosemont, IL 60018-5701. (847) 678-6200. <<http://www.aaoms.org>>.

American Association of Orthodontists. 401 N. Lindbergh Blvd. St. Louis, MO 63141-7816. (314) 993-1700. <<http://www.aaortho.org>>.

OTHER

OrthoFind. (310) 328-2020. <<http://www.orthofind.com>>.

Interview with Dr. Leslie Seldin, practicing general dentist and spokesperson for the American Dental Association. Office address: 40 Central Park. New York, NY 10019-1413. (212) 246-2398.

Lisette Hilton

Malpractice

Definition

Malpractice is defined as improper or negligent practice by a lawyer, physician, or other professional who injures a client or patient. The fields in which a judgment of malpractice can be made are those that require training and skills beyond the level of most people's abilities. Medical malpractice is defined as a wrongful act by a physician, nurse, or other medical professional in the administration of treatment—or at times, the omission of medical treatment, to a patient under his or her care. Although dentists, architects, accountants, and engineers are also liable to malpractice suits, most lawsuits of this type in the United States involve medical malpractice.

Negligence can result from a lack of knowledge or skill, or from failure to exercise reasonable judgment in the application of professional knowledge or skill. Lack or failure is determined by comparing the action in question with what a similar practitioner would reasonably be expected to do in the same circumstances.

In law, malpractice is classified as a tort, which is a wrongful act resulting in injury to another's person, property, or reputation. In a tort, the injured party is entitled to seek compensation for the injury. All torts, including malpractice, have three features:

- a person who has a duty of care toward others
- a failure to exercise due care
- an injury or financial damages caused by the failure

Description

The American Nurses Association estimates that there are 1–3 million health care errors in United States hospitals per year. In the past, only physicians were sued for malpractice, but as of 2001, nurses and other allied health professionals are being named with increasing frequency as defendants in lawsuits. This focus on shared responsibility can be attributed to a number of factors.

The responsibilities of nurses and allied health professionals are continually expanding to include more risk and more patient contact without a physician present. In some clinic settings, **advanced practice nurses** have prescriptive authority and can perform many of the same functions as a physician. This expansion increases the likelihood of lawsuits against nonphysician health care providers.

In 2001, limits on staffing and a shortage of qualified nurses have increased demands on the time and attention of health care professionals. Even conscientious workers may find themselves making mistakes when under increased pressure to do more with fewer resources. This pressure leads to errors resulting from breakdowns in communication as well.

In addition, the advent of the Internet has produced a patient population that is more knowledgeable about health care and more aware of the risks and benefits of treatment. Health care providers are no longer regarded as “always knowing what's best.” Easy access to health care information enables patients to judge for themselves if they are receiving reasonable care or not.

The legal process of malpractice suits

When a patient wishes to sue a medical professional for malpractice, he or she must first consult an attorney. Most malpractice attorneys work on a contingent fee

KEY TERMS

Contingent fee—A method of compensation in which an attorney is paid only if damages are awarded to the client. Contingent fees are usually a percentage of the gross amount of the award.

Defendant—The party sued or accused in a court of law.

Plaintiff—The party initiating a lawsuit in a court of law.

Prescriptive authority—Legal authority granted to advanced practice nurses to prescribe medication.

Tort—A wrongful act that causes injury to another person's body, property, or reputation, for which the injured party is entitled to seek compensation. Malpractice is classified as a tort in the legal system of the United States.

basis. This term means that the attorney is paid only if the patient recovers damages from the professional. The attorney usually receives a percentage of the gross award—sometimes as high as 30–40%.

The attorney will obtain a detailed medical history from the patient, including the names of all physicians and hospitals who have treated him or her. The most important step is securing a medical expert. The attorney will consult someone certified in the relevant medical specialty in order to determine whether there is sufficient evidence that the defendant medical professional did indeed injure the patient.

If the medical expert concludes that there is evidence of malpractice, a lawsuit is filed. If the plaintiff and the defendant cannot resolve their differences outside of court, the case will go to trial before a judge and jury.

Proving medical malpractice

Four elements must be proven in court in order for a verdict of malpractice, or negligence, to be issued. These include legal duty; breach of duty; causation; and damages.

Legal duty to the patient is initiated upon establishment of a provider-patient relationship. For example, if treatment is begun, a contract is implied to exist between the health care provider and the patient. If health care professionals assist at the scene of an accident, they are covered under Good Samaritan law if the assistance is given freely and in a situation where other medical personnel and equipment are not immediately available. In most states, there is no legal duty to assist in such a situ-

ation, although there may be an ethical or moral duty. Good Samaritan law offers protection against litigation for simple negligence in order to encourage health care professionals to stop at accident scenes, but any action considered gross negligence is not protected.

Breach of duty is determined by comparing the action in question with the established standard of care. These standards are developed by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and State Nurse Practice Acts, and are communicated by professional associations, professional journals and textbooks, job descriptions, and organization policies and procedures.

Proving causation requires evidence that the health care provider's negligence directly caused injury or harm to the patient. Even if breach of duty can be established, malpractice is not proven unless causation is confirmed.

The last step in proving malpractice is verifying that the patient suffered disability, disfigurement, **pain**, suffering, or financial loss as a result of negligence. In some states, any of the defendants may be required to pay 100% of the award, even if they were only slightly negligent in comparison to the other defendants. This rule is gradually being abolished, however, and usually liability is distributed based on degree of fault.

Viewpoints

Since there has been a trend to include nurses and allied health professionals in medical malpractice suits, the question of liability insurance must be addressed. Nurses and allied health professionals are usually covered by liability insurance provided by their employer, and many professionals consider this coverage sufficient. Others, however, encourage purchasing a personal policy as well for the following reasons:

- The employer's policy may not cover the total award.
- Employer coverage may not apply after job termination.
- Agency workers are not usually covered by hospital policies.
- Personal policies may also cover attorney fees, transportation, and paid time off from work.

Some professionals may think that having personal liability insurance makes them more likely to be sued; however, this is not true. If a health care worker is involved in a negligent situation in any way, they can be named in the lawsuit. The plaintiff's lawyer may not investigate the defendants for personal insurance; and even if the lawyer does make an investigation, the jury is not allowed to have that information.

Some nurses and allied health professionals may decide not to have personal liability insurance “because it costs too much.” The average yearly cost of a nursing policy with a liability limit of \$1,000,000 is approximately \$90. That’s relatively inexpensive protection from having to pay out of one’s own pocket for damages awarded in a lawsuit.

Professional implications

The obvious professional implications of malpractice include the reasons for lawsuits against nurses and allied health professionals; and ways to avoid being named in a suit.

Reasons for lawsuits against nurses and allied health professionals

Nurses and allied health care professionals have a duty to question physician orders that are inappropriate or unclear. If they do not ask such questions, and a patient is harmed as a result of an inappropriate order, the nurse or allied health professional is just as liable for damages as the physician. The same is true for verbal orders. Verbal orders should be accepted only in emergency situations, and the physician should write and sign the order immediately afterwards. Telephone orders can be accepted by a **registered nurse** or pharmacist, but should be signed by the physician as soon as possible.

If a patient’s status changes and the physician is not notified, the nurse is liable for damages that may occur. These changes include change in physical status, critical laboratory values, and critical information that the physician should ask for but doesn’t. If a medical resident is managing the patient, the attending physician must still be notified.

Documentation is crucial. Specifics should be documented about the patient’s condition, who was notified and what was said, the interventions implemented, and the outcomes of care. A favorite phrase in health care is “If it wasn’t documented, it wasn’t done,” and that’s exactly how the court will view the patient’s chart in a lawsuit.

Other common reasons for lawsuits against nurses include:

- failure to secure the patient’s safety
- failure to properly assess the patient
- failure to perform a procedure according to established standards of care
- failure to administer medication properly

Ways to avoid being named in a lawsuit

Nurses and allied health care professionals who are conscientious and who exercise good judgment are usually successful at avoiding negligent practice. Not every situation can be completely controlled, however, especially when other physicians or health care professionals are involved. The American Nurses Association is a strong advocate for patient safety and has proposed whistle-blower protection for nurses and allied health care professionals who report unsafe patient care practices. Whistle-blower protection legislation has been addressed at the state and federal levels.

There is another simple way to lessen the chance of being included in a lawsuit: give compassionate care. It’s been established that patients who file lawsuits tend to sue people who have made them angry. Often, the real issue for patients is that they feel they have not been heard or treated with respect. One study (Beckman, et al., 1994) reviewed 45 malpractice cases against a large medical center and found that in 71% of the cases, plaintiffs stated that they had a negative relationship with the caregivers. The issues included feelings of abandonment; feeling that discomfort had been ignored; not receiving explanations about the care given or expected outcomes; and feeling that the patient’s or family’s opinions were discounted.

In another situation, a defense attorney for health care providers found that a plaintiff refused to name a certain nurse in the lawsuit, even though the nurse was clearly negligent. The plaintiff felt that this nurse was the only one who gave compassionate care.

Effective communication, compassionate care, and treating patients with dignity increases both patient and professional satisfaction. The end result is patients who are less likely to initiate lawsuits, and health care workers who are less likely to end up in court.

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ORGANIZATIONS

American Bar Association (ABA). 750 North Lake Shore Drive, Chicago, IL 60611. (312) 988-5000 or (800) 964-4253.

American Nurses Association. 600 Maryland Ave. SW, 100 W., Washington, DC 20024. (800) 274-4ANA. <<http://www.nursingworld.org>>.

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Mammography

Definition

Mammography is the study of the breast using x-rays. The actual test is called a mammogram. It is an x-ray of the breast which shows the fatty, fibrous and glandular tissues. There are two types of mammograms. A screening mammogram is ordered for women who have no problems with their breasts. It consists of two x-ray views of each breast: a craniocaudal (from above) and a mediolateral oblique (from the sides). A diagnostic mammogram is for evaluation of abnormalities in either men or women. Additional x rays from other angles, or special coned views of certain areas are taken.

Purpose

The purpose of screening mammography is **breast cancer** detection. A screening test, by definition, is used for patients without any signs or symptoms, in order to detect disease as early as possible. Many studies have shown that having regular mammograms increases a woman's chances of finding breast **cancer** in an early stage, when it is more likely to be curable. It has been estimated that a mammogram may find a cancer as much as two or three years before it can be felt. The American Cancer Society (ACS) guidelines recommend an annual screening mammogram for every woman of average risk beginning at age 40. Radiologists look specifically for the presence of microcalcifications and other abnormalities that can be associated with malignancy. New digital mammography and computer aided reporting can automatically enhance and magnify the mammograms for easier finding of these tiny calcifications.

The highest risk factor for developing cancer is age. Some women are at an increased risk for developing

breast cancer, such as those with a positive family history of the disease. Beginning screening mammography at a younger age may be recommended for these women.

Diagnostic mammography is used to evaluate an existing problem, such as a lump, discharge from the nipple, or unusual tenderness in one area. It is also done to evaluate further abnormalities that have been seen on screening mammograms. The radiologist normally views the films immediately and may ask for additional views such as a magnification view of one specific area. Additional studies such as an ultrasound of the breast may be performed as well to determine if the lesion is cystic or solid. Breast-specific **positron emission tomography (PET)** scans as well as in MRI (**magnetic resonance imaging**) may be ordered to further evaluate a tumor, but mammography is still the first choice in detecting small tumors on a screening basis.

Precautions

Screening mammograms are not usually recommended for women under age 40 who have no special risk factors and a normal physical breast examination. A mammogram may be useful if a lump or other problem is discovered in a woman aged 30-40. Below age 30, breasts tend to be "radiographically dense," which means the breasts contain a large amount of glandular tissue which is difficult to image in fine detail. Mammograms for this age group are controversial. An ultrasound of the breasts is usually done instead since it gives no radiation to the patient.

Description

A mammogram may be offered in a variety of settings. Hospitals, outpatient clinics, physician's offices, or other facilities may have mammography equipment. In the United States only places certified by the Food and Drug Administration (FDA) are legally permitted to perform, interpret, or develop mammograms. Mammograms are taken with dedicated machines using high frequency generators, low kvp, molybdenum targets and specialized x-ray beam filtration. Sensitive high contrast film and screen combinations along with prolonged developing enable the visualization of minute breast detail.

In addition to the usual paperwork, a woman will be asked to fill out a questionnaire asking for information on her current medical history. Beyond her personal and family history of cancer, details about menstruation, previous breast surgeries, child bearing, birth control, and hormone replacement therapy are recorded. Information about breast self-examination (BSE) and other breast health issues are usually available at no charge.

At some centers, a technologist may perform a **physical examination** of the breasts before the mammogram. Whether or not this is done, it is essential for the technologist to record any lumps, nipple discharge, breast **pain** or other concerns of the patient. All visible scars, tattoos and nipple alterations must be carefully noted as well.

Clothing from the waist up is removed, along with necklaces and dangling earrings. A hospital gown or similar covering is put on. A small self-adhesive metal marker may be placed on each nipple by the x-ray technologist. This allows the nipple to be viewed as a reference point on the film for concise tumor location and easier centering for additional views.

Patients are positioned for mammograms differently, depending on the type of mammogram being performed:

- **Craniocaudal position (CC):** The woman stands or sits facing the mammogram machine. One breast is exposed and raised to a level position while the height of the cassette-holder is adjusted to the same level. The breast is placed mid-film with the nipple in profile and the head turned away from the side being x-rayed. The shoulder is relaxed and pulled slightly backward while the breast is pulled as far forward as possible. The technologist holds the breast in place and slowly lowers the compression with a foot pedal. The breast is compressed between the film holder and a rectangle of plastic (called a paddle). The breast is compressed until the skin is taut and the breast tissue firm when touched on the lateral side. The exposure is taken immediately and the compression released. Good compression can be uncomfortable, but it is very necessary. Compression reduces the thickness of the breast, creates a uniform density and separates over-lying tissues. This allows for a detailed image with a lower exposure time and decreased radiation dose to the patient. The same view is repeated on the opposite breast.
- **Mediolateral oblique position (MLO):** The woman is positioned with her side towards the mammography unit. The film holder is angled parallel to the pectoral muscle, anywhere from 30-60 degrees depending on the size and height of the patient. The taller and thinner the patient the higher the angle. The height of the machine is level with the axilla (armpit). The arm is placed at the top of the cassette-holder with a corner touching the armpit. The breast is lifted forward and upward and compression is applied until the breast is held firmly in place by the paddle. The nipple should be in profile and the opposite breast held away if necessary by the patient. This procedure is repeated for the



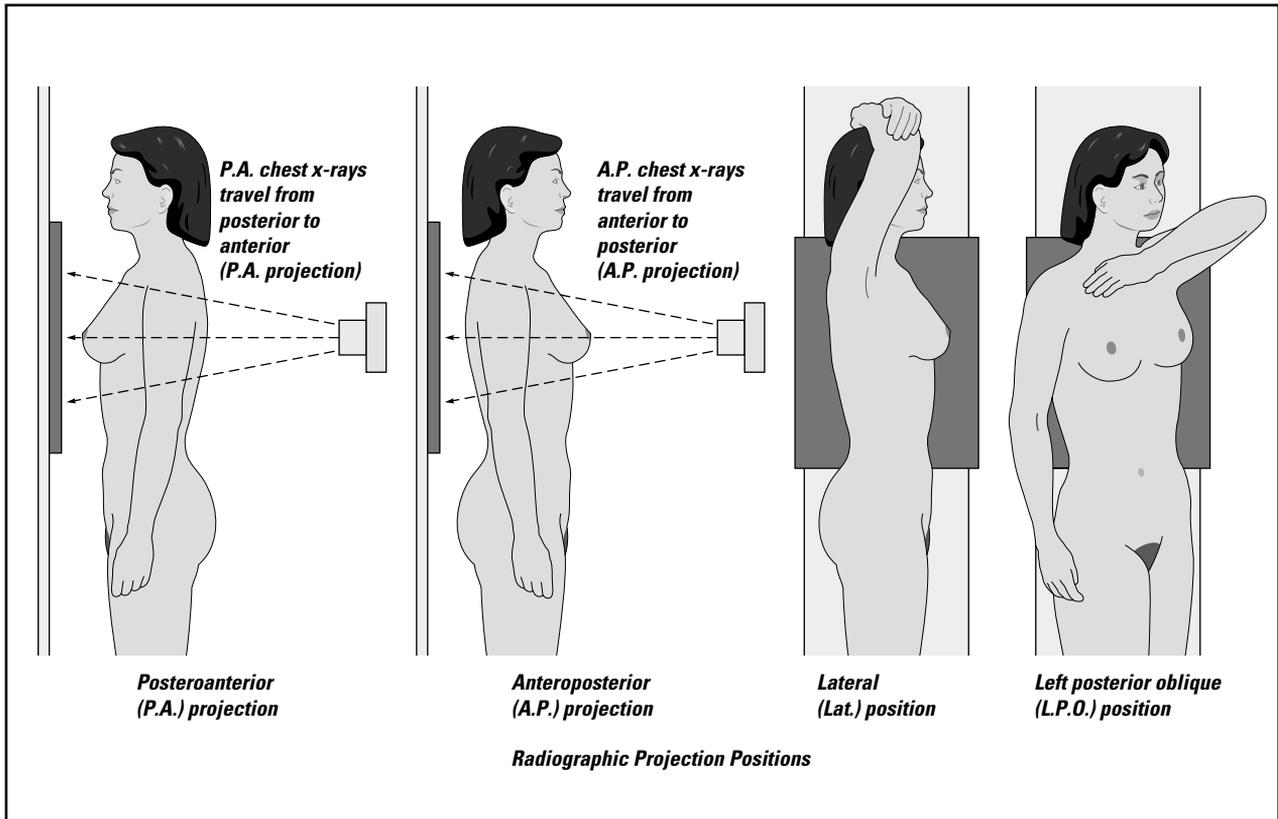
Mammography can detect breast cancer before it can be felt, increasing the chances that it can be treated successfully. (D. Weinstein/Custom Medical Stock Photo. Reproduced by permission.)

other breast. A total of four x-rays, two of each breast, are taken for a screening mammogram. Additional x-rays, using special paddles, different breast positions, or other techniques may be taken for a diagnostic mammogram.

The mammogram may be seen and interpreted by a radiologist right away, or it may not be reviewed until later. If there is any questionable area or abnormality, extra x-rays may be recommended. These may be taken during the same appointment. More commonly, especially for screening mammograms, the woman is called back on another day for these additional films.

A screening mammogram usually takes approximately 15-30 minutes. A woman having a diagnostic mammogram can expect to spend up to an hour for the procedure.

The cost of mammography varies widely. Many mammography facilities accept "self referral." This means women can schedule themselves without a physician's referral. However, some insurance policies do require a doctor's prescription to ensure payment. **Medicare** will pay for annual screening mammograms for all women over age 39.



Positioning for breast x rays. (Delmar Publishers, Inc. Reproduced by permission.)

Preparation

The compression or squeezing of the breast necessary for a mammogram is a concern of many women. Mammograms should be scheduled when a woman's breasts are least likely to be tender. One to two weeks after the first day of the menstrual period is usually best. Some women with sensitive breasts also find that stopping or decreasing **caffeine** intake from coffee, tea, colas, and chocolate for a week or two before the examination decreases any discomfort. Women receiving hormone therapy may also have sensitive breasts. Over-the-counter pain relievers are recommended an hour before the mammogram appointment when pain is a significant problem.

Women should not put deodorant, powder, or lotion on their upper body on the day the mammogram is performed. Particles from these products can get on the breast or film holder and may show up as abnormalities on the mammogram. Most facilities will have special wipes available for those patients who need to wash before the mammogram.

Aftercare

No special aftercare is required.

Complications

The risk of radiation exposure from a mammogram is considered minimal and not significant. Experts are unanimous that any negligible risk is by far outweighed by the potential benefits of mammography. Patients who have breast implants must be x-rayed with caution and compression is minimally applied so that the sac is not ruptured. Special techniques and positioning skills must be learned before a technologist can x-ray a patient with breast implants.

Some breast cancers do not show up on mammograms, or "hide" in dense breast tissue. A normal (or negative) study is not a guarantee that a woman is cancer-free. The false-negative rate is estimated to be 15-20%, higher in younger women and women with dense breasts.

False positive readings are also possible. Breast biopsies may be recommended on the basis of a mammogram, and find no cancer. It is estimated that 75-80% of all breast biopsies resulted in benign (no cancer pres-

ent) findings. This is considered an acceptable rate, because recommending fewer biopsies would result in too many missed cancers.

Results

A mammography report describes details about the x-ray appearance of the breasts. It also rates the mammogram according to standardized categories, as part of the Breast Imaging Reporting and Data System (BIRADS) created by the American College of Radiology (ACR). A normal mammogram may be rated as BIRADS 1 or negative, which means no abnormalities were seen. A normal mammogram may also be rated as BIRADS 2 or benign findings. This means there are one or more abnormalities but they are clearly benign (not cancerous), or variations of normal. Some kinds of calcifications, enlarged lymph nodes or obvious cysts might generate a BIRADS 2 rating.

Many mammograms are considered borderline or indeterminate in their findings. BIRADS 3 means either additional images are needed, or an abnormality is seen and is probably (but not definitely) benign. A follow-up mammogram within a short interval of six to twelve months is suggested. This helps to ensure that the abnormality is not changing, or is “stable.” Only the affected side will be x-rayed at this time. Some women are uncomfortable or anxious about waiting, and may want to consult with their doctor about having a biopsy. BIRADS 4 means suspicious for cancer. A biopsy is usually recommended in this case. BIRADS 5 means an abnormality is highly suggestive of cancer. A biopsy or other appropriate action should be taken.

Health care team roles

The mammographic x-ray technologist works closely with the radiologist. Films of high quality must be taken so the radiologist can make an accurate diagnosis. The technologist also assists the radiologist when performing biopsies or fine needle aspirations. Analysis of the specimen will be carried out in the laboratory by the medical laboratory technician. It is important for the technologist to fill out the proper laboratory forms. Biopsies performed in the operating room will sometimes require a magnified x-ray of the specimen itself. The technologist must work in conjunction with the surgeon and operating room nurses to make sure the specimen is x-rayed immediately and then returned for further analysis.

All radiology technologists must be certified according to a recognized standard such as that of the American Society of Registered Radiology Technologists. The MQSA, or Mammography Quality Standards Act,

KEY TERMS

Breast biopsy—A procedure where suspicious tissue is removed and examined by a pathologist for cancer or other disease. The breast tissue may be obtained by open surgery, or through a needle.

Craniocaudal—Head to tail, x-ray beam directly overhead the part being examined.

Radiographically dense—An abundance of glandular tissue, which results in diminished film detail.

enforced by the FDA, ensures that all mammographic x-ray technologists receive adequate training and continued education to perform special techniques such as mammography of patients with breast implants. It is also part of the technologist’s or nurse’s job to perform quality assurance and to keep statistics to ensure FDA compliance.

Patient education

The mammography technologist must be empathetic to the patient’s modesty and **anxiety**. He or she must explain that compression is necessary to improve the quality of the image but does not harm the breasts. Patients will be very anxious when additional films are requested. Explaining that an extra view will give the radiologist more information will help to ease the patient’s tension. One in eight women in North America will develop breast cancer. Educating the public on monthly breast self-examinations and yearly mammograms will help in achieving an early diagnosis and therefore a better cure.

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31, Room 10A16, Bethesda, MD 20892. (800) 4-CAN-CER (800) 422-6237. Fax: (800) 624-2511 or (301) 402-5874. <<http://cancernet.nci.nih.gov>>, cancermail@cips.nci.nih.gov.

Lorraine K. Ehresman

Managed care plans

Definition

Managed care plans are health care delivery systems that integrate the financing and delivery of health care. Managed care organizations generally negotiate agreements with providers to offer packaged health care benefits to covered individuals.

Description

A majority of insured Americans belong to a managed care plan, a health care delivery system that applies corporate business practices to medical care in order to reduce costs and streamline care. The managed care era began in the late 1980s in response to skyrocketing health care costs, which stemmed from a number of sources. Under the fee-for-service, or indemnity, model that preceded managed care, doctors and hospitals were financially rewarded for using a multitude of expensive tests and procedures to treat patients. Other contributors to the high cost of health care included the **public health** advances after World War II that lengthened the average life span of Americans—putting increased pressure on the health care system, and efforts by providers to adopt state-of-the-art diagnostic and treatment technologies as they became available.

Managed care companies attempted to reduce costs by negotiating lower fees with clinicians and hospitals in exchange for a steady flow of patients, developing standards of treatment for specific diseases, requiring clinicians to get plan approval before hospitalizing a patient (except in the case of an emergency), and encouraging clinicians to prescribe less expensive medicines. Many plans offer financial incentives to clinicians who minimize referrals and diagnostic tests, and some even apply financial penalties, or disincentives, on those deemed to have ordered unnecessary care. The primary “watchdog” and accreditation agency for managed care organizations is the National Committee for Quality Assurance (NCQA), a non-profit organization that also collects and disseminates health plan performance data.

Three basic types of managed care plans exist: health maintenance organizations (HMOs), preferred provider organizations (PPOs), and point-of-service (POS) plans.

- HMOs, in existence for over 50 years, are the best known and oldest form of managed care. Participants in HMO plans must see a primary care provider, who may be a physician or an advanced practice **registered nurse** (APRN) in order to receive care from a specialist. Four types of HMOs exist: the Staff Model, Group Model, Network Model, and the Independent Practice Association (IPA). The Staff Model hires clinicians to work on site. The Group Model contracts with group practice physicians on an exclusive basis. The Network Model resembles the group model except participating physicians can treat patients who are not plan members. The Independent Practice Association (IPA) contracts with physicians in private practice to see HMO patients at a prepaid rate per visit as a part of their practice.
- PPOs are more flexible than HMOs. Like HMOs, they negotiate with networks of physicians and hospitals to get discounted rates for plan members. But, unlike HMOs, PPOs allow plan members to seek care from specialists without being referred by a primary care practitioner. These plans use financial incentives to encourage members to seek medical care from providers inside the network.
- POSs are a blend of the other types of managed care plans. They encourage plan members to seek care from providers inside the network by charging low fees for their services, but they add the option of choosing an out-of-plan provider at any time and for any reason. POS plans carry a high premium, a high deductible, or a higher co-payment for choosing an out-of-plan provider.

Viewpoints

Several managed care theories, such as those stressing continuity of care, prevention, and early intervention are applauded by health care practitioners and patients alike. But managed care has come under fire by critics who feel patient care may be compromised by managed care cost-cutting strategies, such as early hospital discharge and use of financial incentives to control referrals, which may make clinicians too cautious about sending patients to specialists. In general, the rise of managed care has shifted decision-making power away from plan members, who are limited in their choices of providers, and away from clinicians, who must concede to managed-care administrators regarding what is a medically necessary procedure. Many people would like to see managed care restructured to remedy this inequitable dis-

tribution of power. Such actions would maximize consumer choice and allow health care practitioners the freedom to provide the best care possible. According to the American Medical Association, rejection of care resulting from managed care stipulations should be subjected to an independent appeals process.

Professional implications

The health care industry today is dominated by corporate values of managed care and is subject to corporate principles such as cost cutting, mergers and acquisitions, and layoffs. To thrive in such an environment, and to provide health care in accordance with professional values, health care practitioners must educate themselves on the business of health care, including hospital operations and administrative decision-making, in order to influence institutional and regional health care policies. A sampling of the roles available for registered nurses in a managed care environment include:

- *Primary care provider.* The individual responsible for determining a plan of care, including referrals to specialists.
- *Case manager.* This person tracks patients through the health care system to maintain continuity of care.
- *Triage nurse.* In a managed care organization, triage nurses help direct patients through the system by determining the urgency and level of care necessary and advising incoming patients on self care when appropriate.
- *Utilization/Resource reviewer.* This individual helps manage costs by assessing the appropriateness of specialized treatments.

According to an American Nursing Association statement, it is difficult to predict the effect of the managed care revolution on the nursing profession, but the profession will benefit from building broad nursing coalitions at the state and federal levels to publicize nursing's views on patient care issues, and to monitor developing trends in the industry, including the impact of proposed mergers and acquisitions of health care institutions on the provision of care.

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Ann Quigley

Manic depression see **Bipolar disorder**

Manual therapy see **Joint mobilization and manipulation**

Marijuana

Definition

Marijuana is prepared from the leaves and flowering tops of *Cannabis sativa*, the hemp plant, which contains a number of pharmacologically active principles, called cannabinoids.

Description

Marijuana is most popularly used for its euphoric properties. Its many nicknames include grass, pot, Mary Jane, reefer, and cannabis, which is derived from *Cannabis sativa*, the scientific name for hemp.

The beneficial effects of marijuana's most active ingredient, tetrahydrocannabinol (THC), include the lowering of intraocular pressure, which may help control

glaucoma, and the relief of **pain**, nausea, and appetite loss among **chemotherapy** and **AIDS** patients.

Marijuana's short-term effects are psychological and physical, usually lasting for three to five hours after a person has smoked marijuana. The psychological reaction, more commonly known as a high, involves changes in the user's feelings and thoughts. These changes are primarily caused by THC, which affects **brain** function.

The effects of marijuana's high vary for each individual. In most cases the high consists of a dreamy, relaxed state in which users seem more aware of their senses and feel that time is moving slowly. Sometimes, however, marijuana produces feelings of panic and dread. Reactions vary according to the concentration of THC, the setting in which marijuana is used, and the user's expectations, personality, and mood.

Marijuana's short-term physical effects include reddening of the eyes and rapid heartbeat. The drug interferes with the individual's judgment, coordination, and short-term **memory**.

Long-term effects are not completely known. Marijuana use affects memory and motivation. Some chronic users experience bronchitis, coughing, and chest pains. Among males marijuana use can reduce sperm production and testosterone level. Among females it can cause menstrual irregularity and reduced fertility. Extended marijuana use often has a psychological impact and may result in the loss of interest in, for example, school, work, and social activities. Some regular marijuana users become dependent on it.

Marijuana affects psychomotor performance. The effects depend on the nature of the task and the individual's experience with marijuana. Cannabinoids, especially THC, can impact **immune response**, either enhancing or diminishing it.

Human volunteers performing auditory attention tasks while smoking marijuana show impaired performance, which is associated with substantial reduction in **blood** flow to the brain's temporal lobe. However, marijuana smoking increases blood flow in other brain regions, such as the frontal lobes and lateral cerebellum. Although some studies purported to show structural changes in the brains of heavy marijuana users, these results have not been replicated with more sophisticated techniques. Nevertheless, some studies have found subtle defects in the performance of cognitive tasks among heavy marijuana users.

THC narrows bronchi and bronchioles and produces inflammation of the mucous membranes. Marijuana smoke contains many of the same chemicals and tars of

tobacco smoke and therefore increases the risk of **lung cancer**.

Although a distinctive marijuana withdrawal syndrome has been identified, it is mild and short-lived. Symptoms include restlessness, irritability, mild agitation, insomnia, sleep disturbance, nausea, and cramping.

Viewpoints

Marijuana has been used as a medicine and intoxicant for thousands of years. In the United States, marijuana use has been prohibited by state and local laws since the early 1900s, and by federal law since 1937. In spite of these laws, use of the drug became widespread during the 1960s and 1970s. Between 1969 and 1978, the federal and many state governments reduced the criminal charge for possession of small amounts of marijuana from a felony to a misdemeanor. Some states even substituted fines for jail sentences. Use of marijuana in the United States declined from the mid-1970s through the early 1990s. In the mid-1990s, however, marijuana use again began to rise.

The Institute of Medicine recently released its findings on the medical merits of marijuana. Initially commissioned by the Office of National Drug Control Policy in 1997, the study concluded that cannabinoids, marijuana's active components, can be useful in treating pain, nausea and appetite loss caused by advanced **cancer** and **AIDS**. For very ill patients with no other treatment options, investigators recommended short-term use of smoked marijuana under strict medical oversight. However, the Institute of Medicine found that the drug's benefits were hampered by the toxicity of smoking, and that marijuana's future lay in the development of synthetic cannabinoids and in smokeless delivery systems—ideally an asthma-type inhaler. Finally, researchers found no conclusive evidence that recommending marijuana medicinally would increase general use.

Proponents of medical marijuana cite scientific research indicating the potential therapeutic value of cannabinoid drugs, primarily THC, for pain relief, control of nausea and vomiting, and appetite loss that often accompany cancer and AIDS. However, proponents lament the fact that the emphasis on pharmaceutical research will delay treatment because research and development for new drugs can cost \$300 million and only about one in five are approved.

In 1985, the U.S. Food and Drug Administration approved Marinol, a capsule containing THC, as a prescription drug. However, Marinol takes from one to several hours to take effect and many patients experience severe side effects. Since 1996, voters in Arizona,

California, Oregon, several other states, and the District of Columbia have passed laws allowing medical use of marijuana.

Opponents focus their arguments on marijuana's addictive potential and other health problems.

Professional implications

Because marijuana is a crude THC delivery system that also delivers harmful substances, smoked marijuana should generally not be recommended for medical use. Nevertheless, marijuana is widely used by certain patient groups, which raises both safety and efficacy issues. Marijuana's future as a medicine lies in its isolated components, the cannabinoids and their synthetic derivatives. Isolated cannabinoids provide more reliable effects than crude plant mixtures.

The accumulated data suggest a variety of indications, particularly for pain relief, antiemesis, and appetite stimulation. For patients such as those with AIDS or who are undergoing chemotherapy, and who suffer simultaneously from severe pain, nausea, and appetite loss, cannabinoid drugs might offer broad-spectrum relief not found in any other single medication. The therapeutic effects of cannabinoids are most well established for THC, marijuana's primary psychoactive ingredient. Although marijuana smoke delivers THC and other cannabinoids it also delivers harmful substances, including most of those found in tobacco smoke. In addition, plants contain a variable mixture of biologically active compounds and cannot be expected to provide a precisely defined drug effect. For those reasons there seems to be little future in smoked marijuana as a medically approved medication.

While clinical trials are the route to developing approved medications, they are also valuable for other reasons. For example, the personal medical use of smoked marijuana to treat certain symptoms is sufficient reason to advocate clinical trials to assess the degree to which the symptoms or course of diseases are affected. Trials testing the safety and efficacy of marijuana use are an important component to understanding the course of a disease, particularly diseases such as AIDS. The argument against the future of smoked marijuana for treating any condition is not that there is no reason to predict efficacy but that there is risk. That risk could be overcome by the development of a non-smoked rapid-onset delivery system for cannabinoid drugs.

In addition to smoking, there are other means of cannabinoid delivery. Inhalers eliminate smoke toxicity while maintaining quick bloodstream entry. Pills are legal and smokeless, however, they can take over an hour

to enter bloodstream and some patients cannot tolerate the concentrated dose.

The psychological effects of cannabinoids, such as **anxiety** reduction, sedation, and euphoria can influence their potential therapeutic value. Those effects are potentially undesirable for certain patients, although they may be beneficial for others. In addition, marijuana's psychological effects can complicate the interpretation of other aspects of the drug's effect.

Since marijuana smoke contains many of tobacco smoke's harmful components, it is important to consider the relationship between habitual marijuana smoking and lung disease. Given a cigarette of comparable weight, as much as four times the amount of tar can be deposited in the **lungs** of marijuana smokers as in the lungs of tobacco smokers. Marijuana smoke's carcinogenicity is an important concern.

Alveolar macrophages protect lungs against infectious microorganisms, inhaled foreign substances, and tumor cells. Marijuana smoking reduces the ability of alveolar macrophages to kill **fungi**, pathogenic **bacteria**, and tumor target cells. The reduction in ability to destroy fungal organisms is similar to that observed in tobacco smokers.

Marijuana smoke and oral THC can cause tachycardia (fast **heart** beat). In some cases **blood pressure** increases while a person is in a reclining position but decreases inordinately on standing, resulting in postural hypotension or decreased blood pressure, which may cause dizziness and faintness.

Advances in cannabinoid science have revealed a wealth of new opportunities for the development of medically useful cannabinoid-based drugs. The accumulated data suggest a variety of indications, particularly for pain relief, antiemesis, and appetite stimulation. For patients such as those with AIDS or who are undergoing chemotherapy, and who suffer simultaneously from severe pain, nausea, and appetite loss, cannabinoid drugs might offer broad-spectrum relief not found in any other single medication.

The risks of smoking marijuana should be considered before recommending its use to any patient with pre-existing immune deficits, including AIDS patients, cancer patients, and those receiving immunosuppressive therapies.

The argument against the future of smoked marijuana for treating any condition is not the absence of efficacy but the risk. That risk could be overcome by the development of a non-smoked, rapid-onset delivery system for cannabinoid drugs.

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Maslow's hierarchy of needs

Definition

Maslow's hierarchy of needs is a theory of motivation and personality developed by the psychologist Abraham H. Maslow (1908-1970). Maslow's hierarchy explains human behavior in terms of basic requirements for survival and growth. These requirements, or needs, are arranged according to their importance for survival and their power to motivate the individual. The most basic physical requirements, such as food, water, or oxygen, constitute the lowest level of the need hierarchy. These needs must be satisfied before other, higher needs become important to individuals. Needs at the higher levels of the hierarchy are less oriented towards physical survival and more toward psychological well-being and growth. These needs have less power to motivate persons, and they are more influenced by formal education and life experiences. The resulting hierarchy of needs is often depicted as a pyramid, with physical survival needs

located at the base of the pyramid and needs for self-actualization located at the top.

Description

Maslow's hierarchy specifies the following levels:

- *Physiological needs*: These are the basic requirements for human physical survival. They include such essentials as food, water, shelter, oxygen, and sleep. When these needs are unmet, human beings will focus on satisfying them and will ignore higher needs.
- *Safety needs*: Once the individual's basic physical needs are met, his or her needs for safety emerge. These include needs for a sense of security and predictability in the world. The person tries to maintain the conditions that allow him or her to feel safe and avoid danger. Maslow thought that inadequate fulfillment of these needs might explain neurotic behavior and other emotional problems in some people.
- *Love and belonging needs*: When the individual's physiological and safety needs are met, needs for love and belongingness emerge. These needs include longings for an intimate relationship with another person as well as the need to belong to a group and to feel accepted. Maslow emphasized that these needs involve both giving and receiving love.
- *Esteem needs*: Esteem needs include both self-esteem and the esteem of others. Self-esteem is the feeling that one is worthwhile, competent, and independent. The esteem of others involves the feeling that other people respect and appreciate the person. Once the person has satisfied his or her basic needs, concerns about worthiness emerge. The focus becomes not just surviving, but doing well according to meaningful communal standards.
- *Self-actualization needs*: These are the needs associated with realizing one's full potential. As these needs emerge, the person focuses on doing what he or she is meant to do in life—developing his or her talents and abilities to their fullest extent.

Other human needs

Maslow described other needs that did not fit into his hierarchy. These included cognitive needs, such as curiosity and scientific interest, as well as aesthetic needs, which include the need for beauty and order. As Maslow studied self-actualizing individuals, he also discovered a range of needs that extend beyond self-actualization. He called these needs transcendence needs or B-values. They refer to needs to contribute to human welfare and to find higher meanings in life. Although transcendence needs are usually described as lying

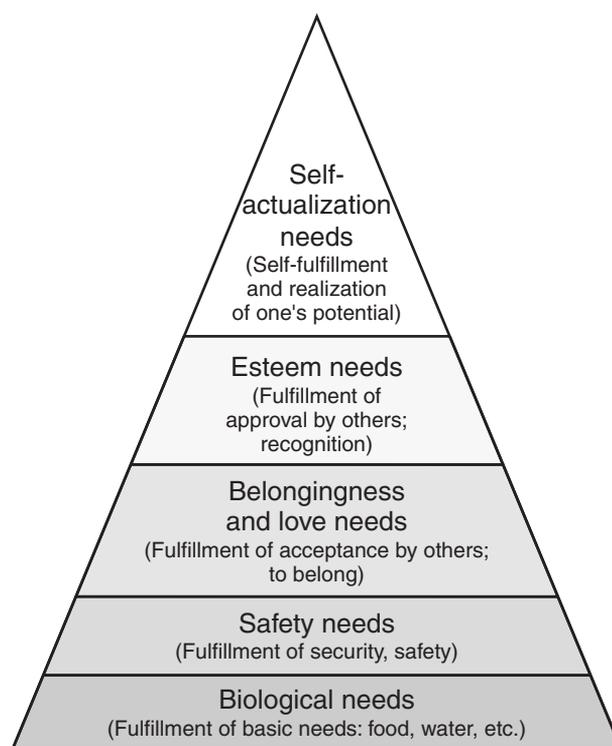
somewhere beyond the need for self-actualization, these needs are not included in most formulations of Maslow's needs hierarchy.

While Maslow described human needs as a hierarchy, he allowed for some departures from the strict order of his needs hierarchy. He stated that lower needs must be reasonably well satisfied in order for the person to focus on higher needs, but he noted that complete satisfaction of a given need may not be possible or necessary. He indicated that most people would show a range of need satisfaction levels at any given time. For example, a person might be 85% satisfied in the area of physiological needs, 60% satisfied in the area of safety needs, 45% satisfied in the area of love and belongingness needs, and so on. Maslow also noted situations in which lower needs might be ignored in favor of higher needs, as when an artist sacrifices comfort and security in order to pursue aesthetic goals, or when a student postpones looking for a romantic partner in order to earn high grades and get into a prestigious graduate program. Maslow thought, however, that these departures from a strict hierarchy did not invalidate his general theory.

The historical context of Maslow's theories

At the time Maslow developed his theory in the early 1960s, psychology was dominated by two views of human behavior, the psychoanalytic and the behaviorist. The psychoanalytic view emphasized unconscious conflicts and drives, drawing many of its concepts from case studies of neurotic people. The behaviorist view emphasized the role of learning and derived many of its principles from observations of animal behavior. Maslow pointed out that the psychoanalysts had failed to consider the behavior of healthy human beings, while the behaviorists were too mechanistic and largely ignored subjective experience. He thought that no theory of human personality could be complete without a thorough study of healthy functioning, so he set out to examine the conscious motivations and experiences of healthy individuals. One important finding was that psychologically healthy people were more likely to report what Maslow called "peak experiences." A peak experience, according to Maslow, is one in which the individual loses a sense of time and place and experiences a momentary feeling of unity with the universe. It is a particularly intense form of growth experience.

Maslow's perspective, together with similar approaches proposed by Carl Rogers, Gordon Allport, and others, came to be known as the "third force" in psychology. Because of their focus on the positive, growth-oriented aspects of human behavior, these views are also described as humanistic theories of behavior. They stim-



Maslow's hierarchy of needs. (EPD Photos. Courtesy Gale Group.)

ulated the emergence and rapid growth of the human potential movement of the late 1960s and early 1970s.

Viewpoints

Maslow's theory and the other humanistic theories have had an important impact on psychology as well as in other fields. By emphasizing positive aspects of human behavior, these theories provide a framework for understanding human behavior outside the context of mental illness and dysfunction. Humanistic approaches to behavior allow for the possibility of growth and achievement, in addition to providing useful explanations for some forms of maladjustment that do not fit the traditional understanding of neurosis and mental illness. The humanistic viewpoint has been very influential on **psychotherapy** and counseling, and many therapists identify themselves as humanistic in orientation.

Maslow's need hierarchy provides a helpful way to understand human motivation in many settings. Maslow proposed many changes in business management in order to make workplaces more responsive to the needs of workers. He called his ideas "eupsychian management," emphasizing the potential for human growth in the workplace. A small body of research has shown modest support for some of Maslow's concepts. Maslow's hierarchy

KEY TERMS

Behaviorism—The theory that human or animal psychology can be accurately studied only through analysis of objectively observable and quantifiable behaviors, in contrast to subjective mental states.

Humanistic psychology—An approach to psychology that emphasizes the special qualities and potential of human beings. It emphasizes the positive qualities in people, rather than the characteristics of maladaptive or unhealthy individuals.

Peak experience—An awe-inspiring emotional experience, characterized by a sense of timelessness, unity, and wonder. Maslow found that self-actualizing people were more likely to have peak experiences, but that ordinary individuals could have these experiences as well.

Self-actualization—The development of one's full potential as a person through creativity, independence, spontaneity, and a grasp of the real world.

Self-esteem—A sense of competence, achievement, and self-respect. Maslow felt that the most stable source of self-esteem is genuine accomplishment rather than public acclaim or praise.

Transcendence needs—Needs or values that go beyond the need for self-actualization. These values involve a higher purpose and concern for the good of the community rather than personal welfare.

of needs is also used in medical and social welfare settings, providing a set of theoretical guidelines for understanding the concerns of people suffering from physical illness, disabilities, or other life problems. In addition to these settings, the theory is frequently applied in educational and career counseling, in which it is used to help clients select appropriate goals for their lives.

Maslow's theory has been criticized because it is difficult to evaluate objectively. Many of the phenomena that Maslow describes are subjective and difficult to quantify. Most studies rely on self-reported data, which are notoriously subject to distortion and inaccuracies. Because studies based on Maslow's concepts often focus on value-laden topics, it is also difficult for researchers to remain objective. Maslow acknowledged these difficulties himself, but thought that human potential was so important that it should be explored without regard to current limitations of scientific accuracy.

The field of personality theory has changed considerably over the 30 years since Maslow's death in 1970. The cognitive behaviorist approach has become increasingly influential, answering some of Maslow's criticisms of earlier psychoanalytic and behaviorist theories. Humanistic theories have become less popular in academic and research settings, with newer approaches generating more research topics. Nonetheless, Maslow's theory, with its positive emphasis, remains influential, particularly in such applied settings as counseling, industrial management, and health care.

Professional implications

Maslow's understanding of human motivation has had an important influence in the fields of nursing and allied health. The needs hierarchy provides a useful framework for understanding patients, and this framework has been incorporated into several important theories of medical and nursing care. One major approach to nursing theory has been described as a "needs" approach, and it relies on Maslow's need hierarchy as well as the developmental theories of Erik Erikson. Needs-oriented theories emphasize the nurse's role in helping the patient to meet his or her physiological and psychosocial needs. Although more recent theories have moved away from this position, the needs hierarchy has been useful in helping care providers look for the "big picture" of a given patient's situation. A description of Maslow's needs hierarchy is still included in many textbooks for students of nursing and allied health.

As the realities of health care in a managed care environment have affected medical professionals, Maslow's theory has also found a role in human resource management for health care. The needs hierarchy offers one approach to such human resource issues as quality assurance, employee burnout, and job satisfaction. By understanding the larger set of needs that health care providers bring to their professions, human resource managers can do a better job of coping with and planning for problems that arise in the medical workplace. Maslow's ideas remain influential because they make sense of a certain range of human behavior.

On the other hand, Maslow's emphasis on a strict hierarchical ordering of human needs has not held up well in other respects because it has never been empirically substantiated. The connections between motivation and external behavior in human beings are more complex than Maslow's theory allows. People strive to satisfy simultaneous needs for love, safety, self-esteem, etc. Moreover, people who have their "lower" needs met in a satisfactory fashion do not invariably seek the fulfillment of "higher" needs, as the behavior of many wealthy or

famous individuals indicates. In addition, the drive to satisfy “higher” needs takes precedence over “lower” needs more frequently than Maslow thought. In sum, human beings are influenced by a wide range of needs and motives. For some people, love, safety, and security are paramount values, while others are motivated by desires for power and dominance. Lastly, human beings are shaped to a considerable extent by their cultures, and cultures differ widely in the sets of values that they emphasize and transmit to their members. For example, the very notion of a “self” is more consistently individualistic in Western societies, whereas it incorporates family relationships in Eastern cultures. Maslow’s hierarchy of needs reflects the values of twentieth-century Western middle-class males; it is not culture-neutral and is therefore not universally applicable to all periods of human history or to all contemporary societies.

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Massage therapy

Definition

Massage therapy is the scientific manipulation of the soft tissues of the body for the purpose of normalizing those tissues and consists of manual techniques that include applying fixed or movable pressure, holding, and/or causing movement of or to the body.

Origins

Massage therapy is one of the oldest health care practices known to history. References to massage are found in Chinese medical texts more than 4,000 years old. Massage has been advocated in Western health care practices at least since the time of Hippocrates, the “Father of Medicine.” In the fourth century B.C. Hippocrates wrote, “The physician must be acquainted with many things and assuredly with rubbing” (the ancient Greek term for massage was rubbing).

The roots of modern, scientific massage therapy go back to Per Henrik Ling (1776–1839), a Swede, who developed an integrated system consisting of massage and active and passive exercises. Ling established the Royal Central Gymnastic Institute in Sweden in 1813 to teach his methods.

Modern, scientific massage therapy was introduced in the United States in the 1850s by two New York physicians, brothers George and Charles Taylor, who had studied in Sweden. The first clinics for massage therapy in the United States were opened by two Swedish physicians after the Civil War period. Doctor Baron Nils Posse operated the Posse Institute in Boston and Doctor Hartwig Nissen opened the Swedish Health Institute near the Capitol in Washington, D.C.

Although there were periods when massage fell out of favor, in the 1960s it made a comeback in a different way as a tool for **relaxation**, communication, and alternative healing. Today, massage is one of the most popular healing modalities. It is used by conventional, as well as alternative, medical communities and is now covered by some health insurance plans.

Benefits

Generally, massage is known to affect the circulation of **blood** and the flow of blood and lymph, reduce muscular tension or flaccidity, affect the nervous system through stimulation or sedation, and enhance tissue healing. These effects provide a number of benefits:

- reduction of muscle tension and stiffness

- relief of muscle spasms
- greater flexibility and range of motion
- increase of the ease and efficiency of movement
- relief of **stress** and aide of relaxation
- promotion of deeper and easier breathing
- improvement of the circulation of blood and movement of lymph
- relief of tension-related conditions, such as headaches and eyestrain
- promotion of faster healing of soft tissue injuries, such as pulled muscles and sprained ligaments, and reduction in **pain** and swelling related to such injuries
- reduction in the formation of excessive scar tissue following soft tissue injuries
- enhancement in the health and nourishment of skin
- improvement in posture through changing tension patterns that affect posture
- reduction in stress and an excellent stress management tool
- creation of a feeling of well-being
- reduction in levels of **anxiety**
- increase in awareness of the mind-body connection
- promotion of a relaxed state of mental awareness

Massage therapy also has a number of documented clinical benefits. For example, massage can reduce anxiety, improve pulmonary function in young **asthma** patients, reduce psycho-emotional distress in persons suffering from chronic inflammatory bowel disease, increase weight and improve motor development in **premature infants**, and may enhance **immune system** functioning. Some medical conditions that massage therapy can help are: **allergies**, anxiety and stress, arthritis, asthma and bronchitis, **carpal tunnel syndrome** and other repetitive motion injuries, chronic and temporary pain, circulatory problems, depression, digestive disorders, **tension headache**, insomnia, myofascial pain, **sports injuries**, and temporomandibular joint dysfunction.

Description

Massage therapy is the scientific manipulation of the soft tissues of the body for the purpose of normalizing those tissues and consists of a group of manual techniques that include applying fixed or movable pressure, holding, and/or causing movement of or to the body. While massage therapy is applied primarily with the hands, sometimes the forearms or elbows are used. These techniques affect the muscular, skeletal, circulatory, lym-

phatic, nervous, and other systems of the body. The basic philosophy of massage therapy embraces the concept of *vis Medicatrix naturae*, which is aiding the ability of the body to heal itself, and is aimed at achieving or increasing health and well-being.

Touch is the fundamental medium of massage therapy. While massage can be described in terms of the type of techniques performed, touch is not used solely in a mechanistic way in massage therapy. One could look at a diagram or photo of a massage technique that depicts where to place one's hands and what direction the stroke should go, but this would not convey everything that is important for giving a good massage. Massage also has an artistic component.

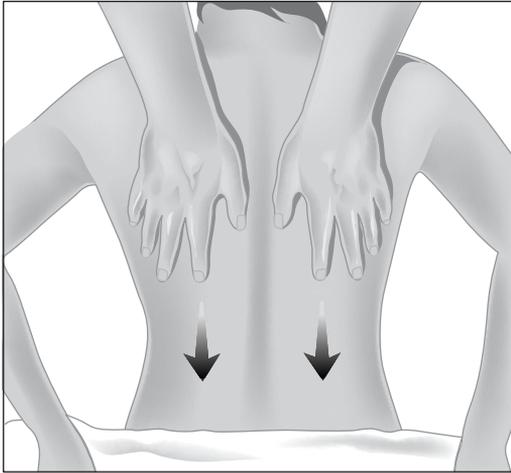
Because massage usually involves applying touch with some degree of pressure and movement, the massage therapist must use touch with sensitivity in order to determine the optimal amount of pressure to use for each person. For example, using too much pressure may cause the body to tense up, while using too little may not have enough effect. Touch used with sensitivity also allows the massage therapist to receive useful information via his or her hands about the client's body, such as locating areas of muscle tension and other soft tissue problems. Because touch is also a form of communication, sensitive touch can convey a sense of caring—an essential element in the therapeutic relationship—to the person receiving massage.

In practice, many massage therapists use more than one technique or method in their work and sometimes combine several. Effective massage therapists ascertain each person's needs and then use the techniques that will meet those needs best.

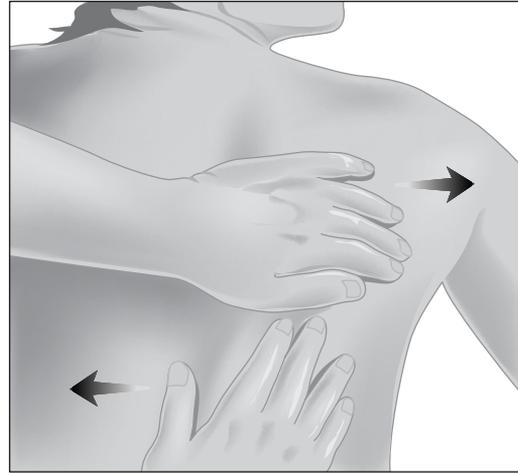
Swedish massage uses a system of long gliding strokes, kneading, and friction techniques on the more superficial layers of muscles, generally in the direction of blood flow toward the **heart**, and sometimes combined with active and passive movements of the joints. It is used to promote general relaxation, improve circulation and range of motion, and relieve muscle tension. Swedish massage is the most commonly used form of massage.

Deep tissue massage is used to release chronic patterns of muscular tension using slow strokes, direct pressure, or friction directed across the grain of the muscles. It is applied with greater pressure and to deeper layers of muscle than Swedish, which is why it is called deep tissue and is effective for chronic muscular tension.

Sports massage uses techniques that are similar to Swedish and deep tissue, but are specially adapted to deal with the effects of athletic performance on the body and



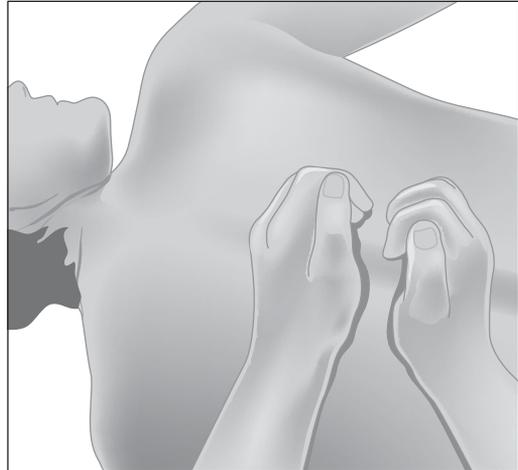
Basic Effleurage



Rolling Petrissage



Circular Friction



Beating Percussion

Four basic massage techniques. In basic effleurage, keep firm contact with the skin as you stroke down your partner's back. In rolling petrissage, push the heel of one hand across your partner's back, while you pull and lift the skin with the fingers of the other. In circular friction, rotate your thumb in small circles on the ropelike tissues of your partner's back. In beating percussion, use a loose fist to gently beat the fleshy areas of the body. (Illustration by Electronic Illustrators Group.)

the needs of athletes regarding training, performing, and recovery from injury.

Neuromuscular massage is a form of deep massage that is applied to individual muscles. It is used primarily to release trigger points (intense knots of muscle tension that refer pain to other parts of the body), and also to increase blood flow. It is often used to reduce pain. Trigger point massage and myotherapy are similar forms.

Acupressure applies finger or thumb pressure to specific points located on the acupuncture meridians (channels of energy flow identified in Asian concepts of anatomy) in order to release blocked energy along these meridians that causes physical discomforts, and re-balance the energy flow. **Shiatsu** is a Japanese form of acupressure.

The cost of massage therapy varies according to geographic location, experience of the massage therapist, and length of the massage. In the United States, the average range is from \$35–60 for a one hour session. Massage therapy sessions at a client's home or office may cost more due to travel time for the massage therapist. Most sessions are one hour. Frequency of massage sessions can vary widely. If a person is receiving massage for a specific problem, frequency can vary widely based on the condition, though it usually will be once a week. Some people incorporate massage into their regular personal health and fitness program. They will go for massage on a regular basis, varying from once a week to once a month.

The first appointment generally begins with information gathering, such as the reason for getting massage therapy, physical condition and medical history, and other areas. The client is asked to remove clothing to one's level of comfort. Undressing takes place in private, and a sheet or towel is provided for draping. The massage therapist will undrape only the part of the body being massaged. The client's modesty is respected at all times. The massage therapist may use an oil or cream, which will be absorbed into the skin in a short time.

To receive the most benefit from a massage, generally the person being massaged should give the therapist accurate health information, report discomfort of any kind (whether it's from the massage itself or due to the room temperature or any other distractions), and be as receptive and open to the process as possible.

Insurance coverage for massage therapy varies widely. There tends to be greater coverage in states that license massage therapy. In most cases, a physician's prescription for massage therapy is needed. Once massage therapy is prescribed, authorization from the insurer may be needed if coverage is not clearly spelled out in one's policy or plan.

Preparations

Going for a massage requires little in the way of preparation. Generally, one should be clean and should not eat just before a massage. One should not be under the influence of alcohol or non-medicinal drugs. Massage therapists generally work by appointment and usually will provide information about how to prepare for an appointment at the time of making the appointment.

Precautions

Massage is comparatively safe. However, it is generally contraindicated, i.e., it should not be used if a person has one of the following conditions: advanced heart diseases, **hypertension** (high **blood pressure**), phlebitis, thrombosis, embolism, kidney failure, **cancer** if massage would accelerate metastasis (i.e., spread a tumor) or damage tissue that is fragile due to **chemotherapy** or other treatment, infectious diseases, contagious skin conditions, acute inflammation, infected injuries, unhealed **fractures**, dislocations, frostbite, large hernias, torn ligaments, conditions prone to hemorrhage, and psychosis.

Massage should not be used locally on affected areas for the following conditions: rheumatoid arthritis flare up, eczema, goiter, and open skin lesions. Massage may be used on the areas of the body that are not affected by these conditions.

In some cases, precautions should be taken before using massage for the following conditions: **pregnancy**, high fevers, **osteoporosis**, diabetes, recent postoperative cases in which pain and muscular splinting (i.e., tightening as a protective reaction) would be increased, apprehension, and mental conditions that may impair communication or perception. In such cases, massage may or may not be appropriate. The decision on whether to use massage must be based on whether it may cause harm. For example, if someone has osteoporosis, the concern is whether bones are strong enough to withstand the pressure applied. If one has a health condition and has any hesitation about whether massage therapy would be appropriate, a physician should be consulted.

Side effects

Massage therapy does not have side effects. Sometimes people are concerned that massage may leave them too relaxed or too mentally unfocused. To the contrary, massage tends to leave people feeling more relaxed and alert.

Research and general acceptance

Before 1939, more than 600 research studies on massage appeared in the main journals of medicine in English. However, the pace of research was slowed by medicine's disinterest in massage therapy.

Massage therapy research picked up again in the 1980s, as the growing popularity of massage paralleled the growing interest in complementary and alternative medicine. Well designed studies have documented the benefits of massage therapy for the treatment of acute and chronic pain, acute and chronic inflammation, chronic lymphedema, nausea, muscle spasm, various soft tissue dysfunctions, anxiety, depression, insomnia, and psycho-emotional stress, which may aggravate mental illness.

Premature infants treated with daily massage therapy gain more weight and have shorter hospital stays than infants who are not massaged. A study of 40 low-birth-weight babies found that the 20 massaged babies had a 47% greater weight gain per day and stayed in the hospital an average of six days less than 20 infants who did not receive massage, resulting a cost savings of approximately \$3,000 per infant. Cocaine-exposed, preterm infants given massage three times daily for a 10 day period showed significant improvement. Results indicated that massaged infants had fewer postnatal complications and exhibited fewer stress behaviors during the 10 day period, had a 28% greater daily weight gain, and demonstrated more mature motor behaviors.

A study comparing 52 hospitalized depressed and adjustment disorder children and adolescents with a control group that viewed relaxation videotapes, found massage therapy subjects were less depressed and anxious, and had lower saliva cortisol levels (an indicator of less depression).

Another study showed massage therapy produced relaxation in 18 elderly subjects, demonstrated in measures such as decreased blood pressure and heart rate and increased skin temperature.

A combination of massage techniques for 52 subjects with traumatically induced spinal pain led to significant improvements in acute and chronic pain and increased muscle flexibility and tone. This study also found massage therapy to be extremely cost effective, with cost savings ranging from 15–50%. Massage has also been shown to stimulate the body's ability to naturally control pain by stimulating the **brain** to produce endorphins. **Fibromyalgia** is an example of a condition that may be favorably affected by this effect.

A pilot study of five subjects with symptoms of tension and anxiety found a significant response to massage

therapy in one or more psycho-physiological parameters of heart rate, frontalis and forearm extensor electromyograms (EMGs) and skin resistance, which demonstrate relaxation of muscle tension and reduced anxiety.

Lymph drainage massage has been shown to be more effective than mechanized methods or diuretic drugs to control lymphedema secondary to radical mastectomy, consequently using massage to control lymphedema would significantly lower treatment costs. A study found that massage therapy can have a powerful effect upon psycho-emotional distress in persons suffering from chronic inflammatory bowel disease. Massage therapy was effective in reducing the frequency of episodes of pain and disability in these patients.

Massage may enhance the immune system. A study suggests an increase in cytotoxic capacity associated with massage. A study of chronic fatigue syndrome subjects found that a group receiving massage therapy had lower depression, emotional distress, and somatic symptom scores, more hours of sleep, and lower epinephrine and cortisol levels than a control group.

Training and certification

The generally accepted standard for training is a minimum of 500 classroom hours. Training should include anatomy, physiology, pathology, massage theory and technique, and supervised practice. Most massage therapists also take additional courses and workshops during their careers.

In the United States, massage therapists are currently licensed by 29 states, the District of Columbia, and a number of localities. Most states require 500 or more classroom hours of training from a recognized training program and passing an examination.

A national certification program was inaugurated in June 1992 by the National Certification Board for Therapeutic Massage and Bodywork (NCBTMB). The NCBTMB program is accredited by the National Commission for Certifying Agencies, the chief outside agency for evaluating certification programs. Those certified can use the title Nationally Certified in Therapeutic Massage and Bodywork (NCTMB). Most states use the NCBTMB exam for their licensing exams.

A national accreditation agency, the Commission on Massage Therapy Accreditation, designed according to the guidelines of the U.S. Department of Education, currently recognizes about 70 training programs. The Accrediting Commission of Career Schools and Colleges of Technology and the Accrediting Council for Continuing Education and Training also accredit massage training programs.

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- American Massage Therapy Association. <<http://www.amta-massage.org>>.

Elliot Greene

Mastitis

Definition

Mastitis is an **infection** of the ducts of the breast. It usually only occurs in women who are breastfeeding their babies.

Description

In the process of breastfeeding, the unaccustomed pull and tug by the infant suckling at the breast may



Mastitis is usually caused by bacterial infection through damaged nipples during breastfeeding. Mastitis can also be caused by a hormone imbalance and usually occurs at puberty or in the newborn. (Photograph by Dr. P. Marazzi, Photo Researchers, Inc. Reproduced by permission.)

result in the mother's nipples may becoming sore, cracked, or slightly abraded. This creates a tiny opening in the breast, through which **bacteria** can enter. The presence of milk, with high sugar content, gives the bacteria an excellent source of **nutrition**. Under these conditions, the bacteria are able to multiply, until they are plentiful enough to cause an infection within the breast.

Mastitis is most likely to occur in the fifth and sixth week of the postpartum period. Studies indicate an incidence of mastitis from 6–33% of all women who have a history of breastfeeding.

Causes and symptoms

The most common bacteria causing mastitis is *Staphylococcus aureus*, but sometimes *Escherichia coli* is responsible. In rare instances, *Streptococcus* can also induce an episode of mastitis. In 25–30% of people, *Staphylococcus aureus* is present on the skin, lining normal, uninfected nostrils. It is probably this bacteria, clinging to the baby's nostrils, that is available to create infection when an opportunity (i.e., a crack in the nipple) presents itself. A sluggish flow of milk and trauma to the nipples are the main contributing factors to the development of mastitis. Fatigue, **stress**, and returning to work may also predispose a nursing mother to developing the condition.

Diagnosis

The clinic, midwife, or office of the physician will most likely receive a call from the mother at home. The condition rarely occurs in the hospital. She will likely report general malaise, fatigue, headache, chills, an increased **heart** rate, and flu-like symptoms. Usually, only one breast is involved. An area of the affected breast

becomes swollen, red, hard, and painful. A red streak may be evident. Often, the location of the infection is in the upper, outer quadrant, which is the location of most of the glandular tissue.

Lumps in the breasts may result from plugged milk ducts. Plugged ducts can contribute to mastitis. If the mother describes **pain** in both breasts, then the condition might be engorgement of the breasts, as opposed to mastitis, which almost always occurs unilaterally.

A definitive diagnosis of the offending pathogen involves obtaining a sample of breast milk from the infected breast. A culture is done to identify the pathogen. In practice, however, laboratory studies are done infrequently because antibiotic therapy is initiated before results are returned, and insurance companies may not cover the cost of the tests.

Treatment

A penicillinase-resistant penicillin or a cephalosporin, for six to 10 days, can both be used to treat mastitis. Low doses of erythromycin or trimethoprim-sulfamethoxazole over an extended period of time have been used to treat chronic mastitis. Breastfeeding should be continued, because the rate of **abscess** formation in the infected breast increases sharply among women who stop breastfeeding during a bout of mastitis. Some symptoms of mastitis respond solely to frequent breastfeeding and pumping, without requiring antibiotic therapy. Most practitioners allow women to take acetaminophen while nursing, to relieve both **fever** and pain. Since almost all drugs the mother takes appear in her breast milk, any medication taken by breastfeeding women must also be safe for the baby. Warm, moist compresses applied to the affected breast can be soothing. Increasing fluid intake and bed rest are also recommended.

Prognosis

Prognosis for uncomplicated mastitis is excellent. A small percentage of women with mastitis will end up with an abscess within the affected breast. This complication will require a surgical procedure to drain the pus. In the case of a small abscess, aspiration with a needle under the direction of ultrasound may be the preferred method of treatment. A larger abscess requires an incision be made into the affected area, so that drainage can occur. A drain in the wound may be placed to facilitate further drainage. Manual expression of the site allows for elimination of pus and milk. The wound normally heals in one to two weeks.

KEY TERMS

Abscess—A persistent pocket of pus.

Lactation consultant—A health care provider who is certified in managing the breastfeeding concerns of mothers.

Health care team roles

The **registered nurse** (R.N.) and **lactation consultant** are frequently the first to speak with the mother who has mastitis. Rapid diagnosis, followed by treatment, can prevent the formation of an abscess. It is imperative to help the mother understand that continuation of breastfeeding is part of successful management of mastitis. It should be emphasized to her that abrupt cessation will actually worsen the problem.

Patient education

When counseling a mother who has mastitis, the health care provider should encourage her to breastfeed frequently and to use a breast pump if the baby does not adequately empty the breast. The mother should be instructed to start each nursing session by breastfeeding her baby on the breast that is not affected, because the baby's initial sucks will be the most vigorous ones. Once the baby switches to the affected breast, the milk will have already started to flow in "letdown reflex," and the baby's sucking will be less painful. The health care provider should instruct the mother to rest, increase her fluid intake, and take medications as prescribed.

Prevention

To prevent mastitis, mothers should breastfeed frequently, ensuring adequate emptying of each breast at least every other nursing session. Handwashing is important in decreasing the chance of spreading bacteria to the breasts. Mothers should also be instructed to avoid wearing tight bras, skipping feedings, and becoming overly tired.

Resources

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ORGANIZATIONS

LaLeche League International. 1400 N. Meacham Rd.,
Schaumburg, IL 60173-4048. (847) 519-7730 or (800)
LALECHE. <<http://www.lalecheleague.org>>.

Nadine M. Jacobson

MD *see* **Muscular dystrophy**

Mean corpuscular hemoglobin *see* **Red blood cell indices**

Mean corpuscular volume *see* **Red blood cell indices**

Mechanical circulation support

Definition

Mechanical circulatory support is used to treat patients with advanced **heart failure**. A mechanical pump is surgically implanted to provide pulsatile or non-pulsatile flow of **blood** to supplement or replace the blood flow generated by the native **heart**. Types of circulatory support pumps include pneumatic and electromagnetic pumps. Rotary pumps, which are also available, propel blood by axial or centrifugal force, or by the use of positive displacement roller pumps.

Purpose

Heart failure causes low cardiac output, which results in inadequate **blood pressure** and reduced blood flow to the **brain**, **kidneys**, heart, and/or **lungs**. Pharmaceutical and palliative surgical treatments are typically exhausted before mechanical circulatory support is initiated. The extent of failure exhibited by one or both ventricles of the heart determines if univentricular or biventricular support is required. In either case, blood flow is supplemented or replaced by a mechanical circulatory support device. The device works by removing blood from the inlet of the ventricle(s) and reinjecting it at the outlet of the ventricle(s) in order to increase blood pressure and blood flow to the brain, kidneys, heart, and lungs.

The Abiomed and Thoratec devices along with the intra-aortic balloon pump (IABP), centrifugal pump, and extracorporeal membrane oxygenation (ECMO) are systems that are meant to sustain the patient until the heart recovers. If recovery does not occur, or is not expected,

then heart transplantation becomes the desired course of treatment. In this case intermediate- to long-term mechanical circulatory support devices are available. These longer-term devices include ECMO, Thoratec, Novacor, HeartMate, and Cardiowest products.

Description

Tertiary care facilities have the staff and equipment to provide treatment for heart failure patients, with the use of mechanical circulatory support devices. Short-, intermediate-, and long-term support requires bedside monitoring of the equipment and patient throughout treatment. The specialized nature of the equipment and intensive patient care requires dedicated staff who are able to provide continuous bedside treatment.

In most instances, patients receive pharmaceuticals that anticoagulate the blood by blocking the clotting factors from interacting with the foreign surfaces of the device and each other. Frequent laboratory testing determines the proper amount of medication required to prevent blood clots. To mimic the lining of **blood vessels**, some surfaces of the device attract native cells, which stick to the device surface, thereby eliminating the need for anticoagulation.

Blood flow generated by these devices is able to sustain blood pressure and flow to the heart, kidneys, **liver**, and brain. Temporary assist devices sustain vital organ tissues in situations where recovery of the heart function is anticipated. Long-term support devices sustain patients until a donor heart is available for transplantation.

Venoarterial ECMO circulatory support provides cardiopulmonary bypass. Both cardiac and pulmonary function can be supplemented with this device. The complexity of care and highly trained staff with specialized equipment limit the availability of ECMO to tertiary care facilities. Surgical cannulation is venoarterial, using the femoral or intrathoracic vessels. **Postoperative care** in the critical care unit requires dedicated bedside staffing.

Short- to intermediate-term devices

VENOARTERIAL ECMO. The positive displacement roller head pump provides pulsatile or non-pulsatile blood flow to the systemic circulation. Tubing connected to the venous cannula carries blood to the roller pump. The roller assembly rotates and engages the tubing, which is then compressed against the pump's housing, propelling blood ahead of the roller head. Rotational frequency and tubing inner diameter determine blood flow. Blood flow to the lungs is reduced as blood is drained from the venous circulation. Blood pumped by the left ventricle is also reduced as blood is returned directly to

the systemic circulation. The heart is allowed to rest, pumping less blood than needed to maintain pressure and flow to the vital organs. An oxygenator is placed after the roller pump in the circuit. **Gas exchange** occurs prior to return of the blood to the arterial circulation.

As cardiac function improves, flow from ECMO support is reduced, allowing the heart to gradually resume normal function. The cannulae are surgically removed from the patient once the heart can maintain adequate cardiac output. Systemic anticoagulation is required throughout the length of support, and often leads to complications of stroke and coagulopathies. Long-term use of ECMO is limited since the patient is immobilized and sedated during treatment.

IABP. Ease of insertion for placement in the aorta makes the IABP the most often used univentricular assist device. Tertiary care centers provide this service in the **cardiac catheterization** laboratory, operating room, critical care unit, and emergency room. Secondary care level hospitals can also employ this technology. Well-trained staff are required to monitor equipment at regular intervals and troubleshoot problems.

Left ventricular support with the IABP reduces the workload of the heart and increases blood flow to the vital organs. Once in position, the IABP times the inflation and deflation of the balloon catheter to the electrocardiogram or arterial blood pressures waveform. Helium or carbon dioxide gases are used to fill the balloon, although low molecular weight helium is preferred because it can be transported rapidly. Carbon dioxide has the advantage that it is highly soluble in the blood in case of balloon rupture. The balloon inflates during diastole to deliver increased oxygen saturated blood to the heart. Blood flow is also increased to the arteries distal to the balloon, since flow is not occluded in either direction. Deflation of the balloon occurs prior to systole. Less contractile force is required for the heart to eject blood against a decreased afterload.

With recovery of the heart, the device is timed to inflate with every second or third heart beat. The catheter is removed, non-surgically, when the heart can sustain blood pressure and systemic blood flow. Therapeutic anticoagulation is achieved with minimal pharmaceutical anticoagulant throughout the treatment. The device can be in place up to several weeks, but duration is limited because the patient must be immobilized during the treatment.

CENTRIFUGAL PUMPS. Centrifugal pumps are able to provide uni-ventricular or bi-ventricular support to the ventricles. Blood is removed from the left or right atrium and returned to the aorta or pulmonary artery, respectively, therefore surgery is required to place the device.

Tertiary care facilities have the staff and equipment to provide treatment to heart failure patients with the use of mechanical circulatory support devices. Post-operative care in critical care units requires continuous monitoring by dedicated staff.

The cannulae are passed through the chest wall to attach to a pump that is magnetically coupled to the control unit, which is kept at the patient's bedside during treatment. The centrifugal force draws blood into the device and propels it to the arterial cannula. Rotational speed determines the amount of blood flow, which is measured by a flowmeter. If rotational frequency is too low, blood may flow in the wrong direction since the system is non-occlusive in nature.

As the heart recovers, flow is decreased from the centrifugal pump until the device can be removed. The native heart is then able to maintain blood pressure and flow. Anticoagulant is delivered continuously during treatment with a centrifugal pump, and patient immobilization limits the length of support to several weeks.

Intermediate- to long-term devices

When short-term support devices, such as ECMO, IABP, and the centrifugal pump are ineffective to sustain the patient to recovery or organ transplantation, a medium or long-term device is required. An advantage of treatment with a medium to long-term device is that it allows the patient to be mobile. In some instances patients have been able to leave the hospital for continued treatment at home with the implanted device. Complete recovery of the heart has been demonstrated in 5–15% of patients being supported as a bridge to organ transplantation.

PNEUMATIC PULSATILE. Pneumatically driven pulsatile paracorporeal mechanical circulatory support devices provide pulsatile support for the left or right ventricle, or both. Devices implanted in at least 100 patients by January 2001 include Abiomed, Thoratec, HeartMate, and Cardiowest brands. Staff are trained to monitor and troubleshoot equipment, thus limiting use to tertiary care facilities.

Cannulation of the left or right atrium, along with the aorta or pulmonary artery, respectively, requires a surgical approach. The cables that connect to the control center are tunneled out of the chest wall and the housing is typically implanted in the chest cavity, except Abiomed, which remains extracorporeal. The rigid outer housing encloses two compartments separated by a flexible boundary. Valves located at the inlet and outlet of the device direct the path of blood flow from high to low pressure, preventing back flow after ejection. Inflation of the gas chamber creates pressure in the blood chamber,

KEY TERMS

Anticoagulant—Pharmaceuticals to prevent clotting proteins and platelets in the blood to be activated to form a blood clot.

Cannulae—Tubes that provide access to the blood once inserted into the heart or blood vessels.

Cardiac—Of or relating to the heart.

Cardiac output—The liter per minute blood flow generated by contraction of the heart.

Cardiopulmonary bypass—Diversion of blood flow away from the right atrium and return of blood beyond the left ventricle, to bypass the heart and lungs.

Console—A freestanding device that monitors, measures, and controls parameters associated with the mechanical circulatory support device it operates.

Extracorporeal—Circulation of blood outside of the body.

Intracorporeal—Circulation of blood inside the body.

Paracorporeal—Circulation of blood near or close to the body.

which opens the outlet valve. Blood is then ejected until the chamber empties and pressure in the chamber decreases, closing the outlet valve. The inlet valve opens when the pressure is low enough in the blood chamber. Blood fills from the atrium and the inlet valve closes once the blood volume has increased the pressure. The cycle repeats itself when the controller fills the gas chamber again. The ejection is not typically timed to that of the native heart. The heart is emptied of blood by the assist device so there is little ejection from the native heart.

Removal of the device occurs at the time of cardiac transplant, unless the native heart has healed during support. Anticoagulation is achieved by low doses of pharmaceuticals. Some patients regain mobility while assisted by these devices.

ELECTRICAL PULSATILE. Novacor and HeartMate make devices that run electrically. Pusher plates activate the compression of the blood chamber for pulsatile blood flow. Cannulation and cable positioning are the same as for pneumatic devices. Valves are required for direction of blood flow and operation is the same as for pneumatic mechanical circulatory support. Electronic connections that use magnetic induction to cross the skin barrier,

rather than cables tunneled through the chest wall decrease the risk of **infection**.

DESTINATION THERAPIES. Destination therapies intended to supplement or permanently replace the native heart are provided by chronic implantation of the mechanical circulatory support system. The Nimbus/TCI IVAS, the Jarvik 2000 IVAS, and DeBakey Micromed IVAS axial flow pumps are expected to achieve “first generation” chronic device trials in the United States. Low volume centrifugal pump technology includes the AB-180 Circulatory Support System, the HeartMate III LVAD, and the CorAide centrifugal blood pump. Pulsatile assist devices include the Thoratec Intracorporeal Ventricular Assist Device (IVAD), the Novacor II, the Worldheart HeartSaver VAD, and the Arrow Lionheart VAD. Total artificial hearts (TAH), made by Abiomed (AbioCor) and Penn State/3M, will replace the native heart. Upon removal of the native heart the TAH will be attached to the major blood vessels, thereby supplying blood pressure and flow to both the pulmonary and systemic circulation. No blood contact will be required with the Abiomed Heart Booster. The next five years, beyond 2001, expect to find these products in clinical trials, offering patients not eligible for organ transplantation a promising future.

Operation

The operator powers up the control console as equipment in the surgical field is inserted into the patient. Any tubing that will be connected to the patient is filled with crystalloid solution, which displaces any air that would be harmful to the patient if it entered the bloodstream. Once all sterile connections are complete, the physician will request that mechanical circulatory support be initiated. Rotational frequency is then increased or pneumatic pumping commences. Initial adjustments may be frequent, but decrease as the patient stabilizes.

Maintenance

Electrical maintenance is performed biannually to check consoles for leakage currents exceeding 100 mAmps. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) requires documentation of all electrical and mechanical maintenance activities. Specific manufacturer maintenance protocols must be followed to prevent mechanical failure. Physician orders provide the nursing and allied health staff with specific treatment instructions for maintenance of the patient on the support device.

Health care team roles

The physician, nursing, and allied health staff work as a team when patients are treated with mechanical circulatory support. Support initiation requires clear communication by the device operator of changes in device status that will alert the team to the changing condition of the patient. Once stable, the patient is transported to the intensive care unit (ICU). Any change in patient status is reported to the physician. Around-the-clock bedside care is provided by nursing staff trained to operate the mechanical circulatory support, or by nursing staff and an allied health professional trained in the operation of the particular mechanical circulatory support device in use.

Training

A circulation technologist earns a certificate of completion from a program accredited by the Commission on Accreditation of Allied Health Education Programs (CAAHEP). A bachelor's degree is required before entering the certification program, or is achieved by the time of completion of the certificate-granting program. Registered nurses usually receive in-service training from a circulation technologist, an experienced nurse, or a manufacturer representative. A respiratory therapist can pursue additional training as an ECMO specialist. Those who receive on-the-job training may also provide support services. Electrical and mechanical maintenance of the control unit is provided by biomedical engineers, who hold an associates or undergraduate degree in engineering.

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ORGANIZATIONS

- Commission on Accreditation of Allied Health Education Programs. 1740 Gilpin Street, Denver, CO 80218. (303) 320-7701. <<http://www.caahep.org>>.
- Extracorporeal Life Support Organization (ELSO). 1327 Jones Drive Suite 101, Ann Arbor, MI 48105. (734) 998-6600. <<http://www.else.med.umich.edu/>>.

Joint Commission on Accreditation of Health Organizations. One Renaissance Boulevard, Oakbrook Terrace, IL 60181. (630) 792-5000. <<http://www.jcaho.org/>>

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Allison Spiwak

Mechanical traction see **Spinal traction**

Mechanical ventilation see **Ventilation assistance**

Median nerve entrapment see **Carpal tunnel syndrome**

Mediastinoscopy

Definition

Mediastinoscopy is a surgical procedure that allows physicians to view areas of the mediastinum, the cavity behind the breastbone that lies between the **lungs**. The organs in the mediastinum include the **heart** and its vessels, the lymph nodes, trachea, esophagus, and thymus.

Mediastinoscopy is most commonly used to detect or stage **cancer**. It is also ordered to detect **infection**, and to confirm diagnosis of certain conditions and diseases of the respiratory organs. The procedure involves insertion of an endotracheal tube, followed by a small incision in the chest. A mediastinoscope is inserted through the incision. The purpose of this equipment is to allow the physician to directly see the organs inside the mediastinum, and to collect tissue samples for laboratory study.

Purpose

This procedure allows direct visualization of the tissues and organs in the chest cavity behind the sternum (breastbone) and is used to detect or evaluate infections and various types of cancers. Originally the aim of mediastinoscopy was to retrieve tissue samples for microscopic analysis. Other indications for the procedure are diagnosing pulmonary lesions and predicting the benefit of surgery. Mediastinoscopy is often the diagnostic method of choice for detecting lymphoma, including Hodgkin's disease. Diagnosis of sarcoidosis (a chronic

lung disease) and the staging of **lung cancer** can also be accomplished through mediastinoscopy. The lymph nodes in the mediastinum are likely to show if lung cancer has spread beyond the lungs (metastasis). Mediastinoscopy allows a physician to observe and extract a sample from the nodes for further study. Involvement of these lymph nodes can indicate the diagnosis and staging of lung cancer.

Alternatives to mediastinoscopy, such as computed tomography (CT), **magnetic resonance imaging** (MRI), and new developments in ultrasonography, have resulted in a decrease in the number of mediastinoscopies performed. In addition, fine-needle aspiration and core-needle biopsy procedures coupled with new techniques in thoracoscopy have brought alternative possibilities in examining mediastinal masses. As of 2000, the choice of procedures is one of the most controversial issues in the staging of lung cancer.

Precautions

Since mediastinoscopy is a surgical procedure, it should only be performed when the benefits of the exam's findings outweigh the risks of surgery and anesthesia. Patients who previously had mediastinoscopy should not receive it again if there is scarring present from the first exam.

Mediastinoscopy is contraindicated in those patients who have a superior vena cava obstruction, due to the risk of hemorrhage. The procedure is also contraindicated for patients with a **tracheotomy**.

Description

Mediastinoscopy is usually performed in a hospital under **general anesthesia**. An endotracheal tube is inserted first, after **local anesthesia** is applied to the throat. Once the patient is under general anesthesia, a small incision is made usually just below the neck. The surgeon may clear a path and feel the patient's lymph nodes first to evaluate any abnormalities within the nodes. Next, the physician will insert the mediastinoscope through the incision. The scope is a narrow, hollow tube with an attached light, which allows the surgeon to see inside the area. The surgeon can insert tools through the hollow tube to help perform the exam. A sample of tissue from the lymph nodes or one of the organs can be extracted and sent for study under a **microscope** or on to a laboratory for further testing.

In some cases, analysis of the tissue sample that shows malignancy will suggest the need for immediate surgery while the patient is already prepared and under anesthesia. In other cases, the surgeon will complete the

visual study and tissue extraction and stitch the small incision closed. The patient will remain in the surgery recovery area until it is determined that the effects of anesthesia have lessened and it is safe for the patient to leave the area. The entire procedure should take about an hour, not counting preparation and recovery time. Studies have shown that mediastinoscopy is a thorough and cost-effective diagnostic tool with less risk than some other procedures. Mediastinoscopy has been shown to be an effective and safe technique for biopsy of mediastinal masses in the pediatric population.

Preparation

Patients should sign a consent form after having reviewed the risks of mediastinoscopy and known risks or reactions to anesthesia. The patient should have nothing to eat or drink after midnight the day of the procedure, or at least 8 hours before the exam. A local anesthetic may be applied to the throat to ease discomfort during placement of the endotracheal tube.

Aftercare

Following mediastinoscopy, patients will be carefully monitored for changes in **vital signs** or indications of complications of the procedure or the anesthesia. A patient may have a **sore throat** from the endotracheal tube and temporary chest **pain**, soreness, or tenderness at the site of incision.

Complications

Complications from the actual mediastinoscopy procedure are relatively rare. Risks to internal organs consist of puncture of the esophagus, trachea, or the **blood vessels** in the area. Air leaks from the lung can also occur and occasionally require additional treatment. Infection and hemorrhage are other rare complications. The usual risks associated with general anesthesia apply to this procedure. General anesthesia is safe for most patients, but it is estimated to cause major or minor complications in 3–10% of those having surgery of all types.

Results

In the majority of procedures performed to diagnose cancer, a normal result would involve evidence of normal lymph nodes and no tumors. In the case of lung cancer staging, results are related to the severity and progression of the cancer.

If the lymph nodes are malignant, this indicates that a cancer such as lymphoma (including Hodgkin's disease), lung cancer, or esophageal cancer are present.

Health care team roles

Either a surgeon or a trained pulmonary specialist performs this procedure. An anesthesiologist will obtain a medical history and supervise the anesthesia for the procedure. A Certified **Registered Nurse Anesthetist** (CRNA) may work under the direction of the anesthesiologist. Operating room personnel include the scrub person and a circulator. Depending on the facility, there may be unlicensed assistive personnel (UAPs) in attendance, as well.

Patient education

After the procedure, the patient will experience some pain and soreness at the incision site, and possibly a sore throat from the endotracheal tube. Pain at the incision site may last for up to two weeks after the procedure. Patients should be instructed that there will be a small scar wherever the instruments were inserted. There will be a small dressing over the incision. The incision site must be kept clean and dry for 48 hours, and then patients may shower.

Patients should notify their health care provider if they develop any of these symptoms:

- redness at the incision site
- drainage of **blood** or pus from the incision site
- fever more than 101°F (38.3 °C)
- progressive swelling at the incision site

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KEY TERMS

Endotracheal—Within the trachea, which is commonly known as the windpipe.

Hodgkin's disease—A malignant disorder of lymph tissue (lymphoma) that appears to originate in a particular lymph node and later spreads to the spleen, liver, and bone marrow.

Mediastinum—The mass of organs and tissues separating the lungs. It contains the heart and large vessels, trachea, esophagus, thymus, lymph nodes, and connective tissue.

Sarcoidosis—A chronic disease known for development of nodules in the lungs, skin, lymph nodes, and bones.

Superior vena cava—The principal vein that drains the upper portion of the body.

Tracheotomy—Incision of the trachea through the skin and muscles of the neck.

ORGANIZATIONS

American Cancer Society. 1599 Clifton Rd. NE, Atlanta, GA 30329. (800) ACS-2345. <<http://www.cancer.org>>.

American College of Chest Physicians. 3300 Dundee Rd, Northbrook, IL 60062-2348. (800) 343-2227. <<http://www.chestnet.org>>.

American Lung Association. 1740 Broadway, New York, NY 10019-4374. (800) LUNG-USA. <<http://www.lungusa.org>>.

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Medicaid

Definition

Medicaid is a federal-state entitlement program for low-income citizens of the United States. The Medicaid program is part of Title XIX of the Social Security Act that became law in 1965. Medicaid offers federal matching funds to states for costs incurred in paying healthcare providers for serving covered individuals. State partici-

KEY TERMS

Categorically needy—A term that describes certain groups of Medicaid recipients who qualify for the basic mandatory package of Medicaid benefits. There are categorically needy groups that states participating in Medicaid are required to cover, and others that the states have the option to cover.

DHHS—The Department of Health and Human Service. It is a federal agency that distributes funds for Medicaid.

Entitlement—A program that creates a legal obligation on the federal government to any person, business, or government entity that meets the legally defined criteria. Medicaid is an entitlement both for eligible individuals and for the states that decide to participate in it.

Federal poverty level (FPL)—The federal government's definition of poverty used as the reference point for Medicaid eligibility for certain groups of beneficiaries. The FPL is adjusted every year to allow for inflation.

HCFA—Health Care Financing Administration. A federal agency that provides guidelines for the Medicaid program.

Medically needy—A term that describes a group whose coverage is optional with the states because of high medical expenses. These persons meet Medicaid's category requirements (they are children or parents or elderly or disabled) but their income is too high to qualify them for "categorically needy" coverage.

Supplemental Security Income (SSI)—A federal entitlement program that provides cash assistance to low-income blind, disabled, and elderly people. In most states, people receiving SSI benefits are eligible for Medicaid.

pation is voluntary, but since 1982 all 50 states have chosen to participate in Medicaid.

Description

Medicaid benefits

Medicaid benefits cover basic health care and long-term care services for eligible persons. About 59% of Medicaid spending covers hospital and other acute care

services. The remaining 41% pays for nursing home and long-term care.

States that choose to participate in Medicaid must offer the following basic services:

- hospital care, both inpatient and outpatient
- nursing **home care**
- physicians' services
- laboratory and diagnostic x-ray services
- immunizations and other screening, diagnostic, and treatment services for children
- family planning
- health center and rural health clinic services
- nurse midwife and nurse practitioner services

Participating states may offer the following optional services and receive federal matching funds for them:

- prescription medications
- institutional care for the mentally retarded
- home- or community-based care for the elderly, including case management
- personal care for the disabled
- dental and **vision** care for eligible adults

Because the participating states are allowed to design their own benefits packages as long as they meet federal minimum requirements, Medicaid benefits vary considerably from state to state. About half of all Medicaid spending covers groups of people and services above the federal minimum.

Eligibility for Medicaid

Medicaid covers three major groups of low-income Americans:

- **Parents and children.** In 1997 Medicaid covered 21 million low-income children—one-fifth of all children in the United States—and 8.6 million low-income adults in families with children. Most of these low-income adults are women.
- **The elderly.** In 1997 Medicaid covered 4 million adults over the age of 65. Medicaid is the largest single purchaser of long-term and nursing home care in the United States. In 1997, Medicaid paid for 38% of the \$115 billion spent on long-term care and 47% of the \$83 billion spent on nursing home care.
- **The disabled.** About 17% of Medicaid recipients are blind or disabled. Most of these are eligible for Medicaid because they receive assistance through the Supplemental Security Income (SSI) program.

All Medicaid recipients must have incomes and resources below specified eligibility levels. These levels vary from state to state depending on the local cost of living and other factors. For example, in 1999 the federal poverty level (FPL) was determined to be \$13,880 for a family of three on the mainland of the United States, but \$15,970 in Hawaii and \$17,360 in Alaska.

In most cases, persons must be citizens of the United States to be eligible for Medicaid, although legal immigrants may qualify in some circumstances depending on their date of entry. Illegal aliens are not eligible for Medicaid except for emergency care.

A person must fit into an eligibility category to receive Medicaid even if their income is low. Childless couples and single childless adults who are not disabled or elderly are not eligible for Medicaid.

Medicaid costs

Medicaid is by far the government's most expensive general welfare program. In 1966, Medicaid accounted for 1.4% of the federal budget, but by 2001 its share had risen to nearly 9%. Combined federal and state spending for Medicaid takes nearly 20 cents of every tax dollar. The federal government covers about 57% of Medicaid's costs, with the states paying for the remaining 43%.

As of 2001, Medicaid's costs rise at an average annual rate of 7.9%. The federal government spent \$107 billion on Medicaid in fiscal year (FY) 1999, a sum that is expected to rise to \$159 billion in 2004. The states spent \$81 billion to cover Medicaid costs in FY 1999. These costs are projected to increase to \$120 billion by FY 2004.

Although 50% of all Medicaid beneficiaries are children, most of the money (72%) goes for services for the elderly and disabled. The single largest portion of Medicaid money pays for long-term care for the elderly. Only 17% of Medicaid funds are spent on services for children.

There are several factors involved in the steep rise of Medicaid costs:

- The rise in the number of eligible individuals. As the life span of most Americans continues to increase, the number of elderly individuals eligible for Medicaid also rises. The fastest-growing age group in the United States is people over 85.
- The price of medical and long-term care. Advances in medical technology, including expensive diagnostic imaging, keep these costs high.
- The increased use of services covered by Medicaid.

- The expansion of state coverage from the minimum benefits package to include optional groups and optional services.

Viewpoints

The need to contain Medicaid costs is considered one of the most problematic policy issues that legislators will face in the coming years. In addition, the complexity of the Medicaid system, its vulnerability to billing fraud and other abuses, the confusing variety in the benefits packages available in different states, and the time-consuming paperwork are other problems that disturb taxpayers and legislators alike.

Professional implications

Medicaid has increased the demand for health care services in the United States without greatly improving the **quality of health care** for low-income Americans. On the one hand, Medicaid's position as the largest health insurer in the United States means that it affects the employment of several hundred thousand health care workers. In 1997, Medicaid payments went to over 5,000 hospitals, 3,000 **nursing homes**, 7,000 homes for the mentally retarded, 670 community health clinics, and 550 managed care plans—all of which provide employment for thousands of health care providers, administrators, and support staff. On the other hand, participation in Medicaid is optional for physicians and nursing homes. Many do not participate in the program because the reimbursement rates are low. As a result, many low-income people who are dependent on Medicaid must go to overcrowded facilities where they often receive substandard health care.

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Health Care Financing Administration. United States Department of Health and Human Services. 200 Independence Avenue SW, Washington, D.C. 20201. <<http://www.hcfa.gov>>.

Kaiser Commission on Medicaid and the Uninsured. 1450 G Street NW, Suite 250, Washington, DC 20005. (202) 347-5270. Fax: (202) 347-5274. <<http://www.kff.org>>.

National Center for Policy Analysis. 655 15th Street NW, Suite 375, Washington, DC 20005. (202) 628-6671. Fax: (202) 628-6474. <<http://www.ncpa.org>>.

United States Department of Health and Human Services. 200 Independence Avenue SW, Washington, D.C. 20201. <<http://www.hhs.gov>>.

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Peggy Elaine Browning

Medical assisting

Definition

Medical assisting involves supporting physicians and other health care staff in a variety of administrative and clinical duties.

Description

Medical assistants are not to be confused with physician assistants who examine, diagnose, and treat patients under the supervision of a physician. Medical assistants support physicians and other health care staff through administrative and clinical duties. The scope of their duties varies according to the size of the facilities in which they work. For example, in a large office, the medical assisting duties may be divided among a number of staff, one arranging for hospital or outside laboratory testing for patients, another scheduling appointments, with still others handle only insurance forms, keep patient records, do the bookkeeping, or are involved with direct care of the patient. Small offices may require the medical assistant to do most of these duties or to share them with one other administrative person.

Clinical duties are subject to the state laws in which the medical assistant works. Some of these duties include taking patient medical histories, preparing patients for medical exams and other procedures, taking patients' **vital signs**, taking x rays, taking and preparing laboratory specimens such as drawing **blood**, and performing basic lab tests in the office. Medical assistants may also be responsible for disposing of contaminated supplies and sterilizing equipment. They may prepare and administer medications, authorize drug refills, remove sutures, and change dressings.

Specialists may employ medical assistants who have training in their specific fields. Among these are podiatrists, ophthalmologists, and chiropractors. Podiatric medical assistants take x rays, make casts of feet, and assist podiatrists in surgery. Ophthalmic medical assistants administer **vision** tests, test eye function, adminis-

KEY TERMS

Chiropractor—A specialist who treats disorders by manipulating the spine and bones.

Medical assistant—A professional who supports physicians and other health care staff in a variety of administrative and clinical duties.

Ophthalmologist—A physician who treats vision problems and diseases of the eye.

Physician assistant—A professional who examines, diagnoses, and treats patients under the supervision of a physician.

Podiatrist—A physician who treats foot disorders.

ter eye-drops, maintain **surgical instruments**, and assist ophthalmologists in surgery.

All medical assistants deal with the public, and many directly with patients. They must be neat and well groomed and have a pleasant manner. They must be able to put patients at ease and explain to them medical procedures and medication requirements.

Medical assistants may advance to office manager or other administrative support positions. They may also qualify to teach medical assisting.

Work settings

Medical assistants work in clean, well-lit offices and hospitals, interacting with patients, co-workers, and supervisors daily. Most medical assistants (about 65% in 1998) are employed in physicians' offices, while about 20% work in hospitals, **nursing homes**, and other related health care facilities. All others work in the offices of chiropractors, ophthalmologists, and podiatrists.

Education and training

There is no formal licensing for medical assistants, and on-the-job training was considered the norm in the past. In 2001, employers are beginning to require that medical assistants have formal training. Medical assisting programs can be found in vocational/technical high schools, technical colleges, community and junior colleges, and in universities and colleges. Most technical programs offer a certificate or diploma after one year of study. Two-year programs offer an associate degree.

The course of study incorporates two main areas: administrative and clinical. The administrative emphasis

is on computer technology, accounting, record keeping, medical transcription, and insurance processing. The clinical area involves course work on laboratory techniques, clinical procedures, pharmaceuticals, medication administration, **first aid**, and universal sterilization precautions.

Accredited programs are certified by the Commission on Accreditation of Allied Health Education Programs and the Accrediting Bureau of Health Education Schools. In 1999, there were 590 schools accredited by these organizations. The Committee on Accreditation for Ophthalmic Medical Personnel accredited 14 others.

Among the certificates that verify a standard of competency for medical assistants are the Certified Medical Assistant (the American Association of Medical Assistants), Registered Medical Assistant (the American Medical Technologists), and the Podiatric Medical Assistant Certified (the American Society of Podiatric Medical Assistants). The Joint Commission on Allied Health Personnel in Ophthalmology offers three certificates: Ophthalmic Medical Assistant, Certified Ophthalmic Technician, and Certified Ophthalmic Medical Technologist.

Advanced education and training

With additional training, medical assistants may enter other related health fields such as medical technology.

Future outlook

The employment outlook for medical assistants will be increasing over the next decade. Demand for medical assistants is expected to increase faster than the average for all occupations through 2008. It is expected to be one of the 10 fastest growing occupations in the United States. This is due to the increased number of group medical practices, clinics, and related health care facilities that will require assistants. Due to the flexibility of the medical assistant's job focus, medical assistants will be highly sought after. Private outpatient settings will experience the most growth. Formally trained medical assistants will be in high demand.

Currently, earnings range from \$14,000 to \$24,000, with the average being around \$21,000 annually. Private medical practices and hospitals have the highest salary range. This is expected to increase with demand.

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ORGANIZATIONS

The American Association of Medical Assistants. 20 North Wacker Dr., Suite 1575, Chicago, IL 60606-2903. <<http://www.aama-ntl.org>>.

Registered Medical Assistants of American Medical Technologists. 710 Higgins Rd., Park Ridge, IL. 60068-5765. <<http://www.amtl.com>>.

Janie F. Franz

Medical billing

Definition

Medical billing is the process of collecting fees for medical services. A medical bill is called a claim.

Purpose

The purpose of medical billing is to ensure that the provider receives fair payment for services rendered. Payment should reflect the services performed and should be received in a timely manner.

Precautions

There are laws regarding medical billing procedures. Staff members involved in collecting fees must be aware of these regulations.

Some of these laws are:

- The Fair Debt Collection Act. This federal law dictates how and when to collect a debt. It protects patients and consumers from unlawful threats.
- The Health Insurance Portability and Accountability Act of 1996 (HIPAA) contains an administrative portion that increases the efficiency of data exchange for healthcare financial transactions and protects the privacy of electronic data transmission. This protection is especially important for confidential patient records. Violators are subject to financial penalties.

Description

Medical billing may be handled directly by the physician and his or her staff, or it may be administered

by a third party. The third party is an independent contractor or company that specializes in handling medical billing.

Physician fees

A physician sets fees for his or her services. There are some important concepts in fee-setting. One is usual, reasonable, and customary (UCR). Usual fees represent the fair value of a service; customary rates are similar to those of other physicians; and reasonable rates meet the criteria for the other two factors.

Another method used in setting fees is the Resource-Based Relative Value Scale (RBRVS), which examines the relative value of a service and relates it to geographic peculiarities. This method considers the time and skills needed to perform a service, intensity of the service, office (overhead) expenses, and the **malpractice** insurance premiums that the physician pays. The geographic differences allow for consideration of health care cost variations around the nation.

It is recommended that fees be discussed with the patient in advance of treatment. Often, the medical office personnel are called upon to do this. If any co-payments are due, they are collected at the time of service.

Fees may be adjusted for certain payors, such as managed care companies (HMOs, PPOs, etc.). In these cases, physicians and managed care companies negotiate fees for various services. Sometimes certain patients receive discounts. This practice may be enforced when the patient works in the health care field.

Basic bookkeeping

There are a few systems that help physician office staffs keep records. A day sheet is a record of all transactions that occurred in one day. This information is placed into a board called a pegboard. Each patient's card, called a ledger card, is also inserted into the peg board. It contains a record of his or her charges, credits, and payments. This legal document should be held as long as the patient's medical record. The information, including patient's name, diagnosis, treatments, charges, payments, and credits, are entered into a pre-printed bill called a superbill.

The medical claim

When a service such as an office visit is complete, the staff begins preparing the claim or sends the patient information to a third party for billing. A physician's office will send out a claim if that physician accepts assignment of benefits. To accept assignment of benefits, the physician must receive the patient's signature allow-

ing his or her office to receive payment directly from the insurance company.

Claim preparation begins with proper coding. Medical procedures and diagnoses have codes. The Current Procedural Terminology (CPT), developed in 1966 by the American Medical Association, lists medical procedures and corresponding codes. Each medical procedure has a code that is listed in a CPT manual. The book is divided into sections so that similar procedures appear in the same area.

The major sections of the CPT book are:

- evaluation/management
- anesthesia
- surgery
- radiology
- pathology and laboratory
- medicine

In addition to procedure codes, there are codes for diagnoses, called ICD-9 codes. This practice was established in 1983 when **Medicare** began using diagnosis-related groups (DRGs). An ICD-9 book lists each diagnosis within the DRGs. Each DRG corresponds to a fee.

Coding must be accurate because it determines reimbursement.

Health plans issue identification numbers to providers. This number is placed on claim forms so that payors can quickly and accurately identify providers.

The medical claim also contains important information, such as:

- provider name, address, telephone number, and ID number
- name of insurance plan and group number
- ID number of insurance holder
- patient's name, date of birth
- insured person's name, date of birth
- patient's address and telephone number
- insured person's address and telephone number
- relationship between patient and insured person
- other health insurance the patient may have
- patient's medical condition, and whether it was related to a job automobile accident, or other type of accident
- other information, such as the patient's history of related illness, may need to appear on the claim

The use of computer software allows medical offices to submit claims electronically. This method shortens the time between filing the claim and reimbursement.

Payment

Medical bills may be paid by the patient or by third party payors, such as private insurance company, a managed care company, or a government insurance program such as Medicare. Often, the patient pays for a portion of the care (co-payment or deductible), and an insurance or managed care company is billed for the remaining fees. In some cases, patients may ask to pay their portion over time, and credit may be extended to them. The medical office may charge interest as long as the patient has been informed. This practice is called truth-in-lending. Credit laws vary by state.

Payment received from an insurance or managed care company contains a document called the explanation of benefits (EOB). This statement explains what was paid and what services were not covered and is sent to the provider and the patient. A service may not be covered if a patient has not met his or her yearly deductible. In this case, the provider bills the patient for his or her fee. It is common to bill patients once a month.

When a payment arrives, it is important to endorse it right away. This can be done with a rubber stamp that contains the name of the provider and the bank account number. Endorsing is a form of protection because only the provider who endorsed it can cash the check in the event it is lost or stolen. The provider should have a deposit procedure.

Complications

Complications impact bill collection. Accurate coding, standard office procedures, and good communication within a provider group minimize complications.

Overdue payments

In some cases, a patient may not pay his or her bill within a month or by the claim's due date. A document called an aging schedule lists overdue accounts. The information includes the patient's name, amount due, payments received, and comments. An account is aged beginning with the billing date rather than the date the procedure was performed. Eighty percent of fees should be collected within a month of billing. If this number falls to 50% or less, collection procedures should be examined.

A patient must be reminded of an overdue bill. This can be done with a written notice, phone call, or during the next office visit.

KEY TERMS

Adjustment—Changes to a standard fee. Changes may be made because of managed care agreements or other discounts.

Aging schedule—A list of overdue medical accounts calculated from date of original bill to current date.

Claim—Medical bill.

Diagnostic related groups (DRGs)—Diagnosis categories that are used when doing physician or hospital billing. Each diagnosis is placed into the appropriate category.

Managed care—A type of health plan with a network of providers and pre-arranged fee schedule. Examples include a health maintenance organization (HMO) or preferred provider organization (PPO).

Payor—One who pays a medical claim. A third party payor is an entity other than the patient, such as the insurance company.

Provider—Health team professional or entity (hospital) that offers care.

Denied claims

If the insurance or managed care company's EOB indicates that the claim is denied, it is important to determine why this happened. The claim should be double-checked to determine if an error has occurred. If the patient is not entitled to coverage, he or she is billed when the monthly billings are sent out.

Fraud

Medicare has the right to audit a physician's office and examine its billing practices. Errors in claims are checked to determine the presence of fraudulent practices. A medical office must not bill for services that were not performed and must not inaccurately code a service to receive a higher level of payment. These practices are examples of fraud.

Health care professionals who report fraud are called whistle-blowers. The Federal Claims Act protects and reward these individuals when they report Medicare fraud. States also have anti-fraud regulations.

Collecting fees after a patient's death

If a patient has died, the physician may collect fees from his or her estate. Since death is followed by a period of grief, it is recommended that the physician's office wait before sending a final statement to the patient's next of kin as indicated on the chart.

Health care team roles

Clear communication within a provider group helps ensure that claims are properly coded, patients are informed of fees, and fair reimbursement is billed and received. The physician must be questioned if there is any doubt that a service was performed or if the diagnosis is not clear.

The team involved in billing includes the physician, office manager, nurse, receptionist, medical assistant, and insurance clerk, with these billing-related duties:

- Performs billable service: physician, nurse, medical assistant.
- Explains fees/billing: physician, receptionist, nurse, medical assistant, insurance clerk.
- Prepares day sheet, ledger, superbill: nurse, medical assistant, insurance clerk.
- Files (sends out) claim: insurance clerk.
- Reminds patient of overdue payment: receptionist, nurse, medical assistant, insurance clerk.
- Communicates with insurance companies: receptionist, medical assistant, nurse, insurance clerk.

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Rhonda Cloos, R.N.

Medical chart

Definition

The medical chart is a confidential document that contains detailed and comprehensive information on the individual patient and their care experience.

Purpose

The purpose of the medical chart is to serve as both a medical and legal record of patient clinical status, care, history, and caregiver involvement. The detailed information contained in the chart is intended to provide a of the patient's clinical condition by detailing diagnoses, treatments, tests and response to treatment, as well as any other factors that may affect the clinical state of the patient.

Description

The term medical chart or medical record is a general description of a collection of information on a patient. However, different clinical settings and systems utilize different forms of documentation to achieve this purpose. As technology progresses, more institutions are adopting computerized systems that aid in clear documentation, enhanced access, and efficient storage of patient records.

New uses of technology have also raised concerns about confidentiality. Confidentiality, or patient privacy, is an important principle related to the chart. Whatever system may be in place, it is essential that the health care provider protect the patient's privacy by limiting access to authorized individuals only. Generally, physicians and nurses write most frequently in the chart. The documentation by the clinician who is leading treatment decisions (usually the physician) often focuses on diagnosis and prognosis, while the documentation by the nursing team generally focuses on patient responses to treatment and details of day-to-day progress. In many institutions the medical and nursing staff may complete separate forms or areas of the chart specific to their disciplines.

Other on-staff health care professionals that have access to the chart include physician assistants; social workers; psychologists; nutritionists; physical, occupational, speech, or respiratory therapists; and consultants. It is important that the various disciplines view the notes written by other specialties in order to form a complete picture of the patient and provide continuity of care. Quality assurance and regulatory organizations, legal bodies, and insurance companies may also have access to the chart for specific purposes such as documentation, institutional audits, legal proceedings, or verification of

information for care reimbursement. It is important to know the institution's policies regarding chart access in order to ensure the privacy of the patient.

The medical record should be stored in a predesignated, secure area and discussed only in appropriate and private clinical areas. The patient has a right to view and obtain copies of his or her own record. Special state statutes may cover especially sensitive information such as psychiatric, communicable disease (i.e., HIV), or substance abuse records. Institutional and government policies govern what is contained in the chart, how it is documented, who has access, and policies for regulating access to the chart and protecting its integrity and confidentiality. In cases where chart contents need to be accessed by individuals outside of the immediate care system, the patient or patient representative is asked for written permission to release records. Patients are often asked to sign these releases so that caregivers in new clinical settings may review their charts.

Operation

Documentation in the medical record begins when the patient enters the care system, which may be a specific place such as a hospital or a program such as a home health care service. Frequently the facility will request permission to obtain copies of previous records so that they have complete information on the patient. Although chart systems vary from institution to institution, there are many aspects of the chart that are universal. Frequently used chart sections include:

- Admission paperwork: includes legal paperwork such as living will or health care proxy, consents for admission to the facility or program, demographics, and contact information.
- History and physical: contains comprehensive review of patient's medical history and physical exam.
- Orders: contains medication and treatment orders by the doctor, nurse practitioner, physician assistant, or other qualified health care team members.
- Medication record: records all medication administered.
- Treatment record: documents all treatments received, such as dressing changes or respiratory therapy.
- Procedures: summarizes diagnostic or therapeutic procedures, i.e., **colonoscopy** or open-heart surgery.
- Tests: provides reports and results of diagnostic evaluations, such as laboratory tests and **electrocardiography** or radiography images or summaries.
- Progress notes: includes regular notes on the patient's status by the interdisciplinary care team.
- Consultations: contains notes from specialized diagnosticians or care providers.
- Consents: includes permissions signed by patient for procedures, tests, or access to chart. May also contain releases, such as the release signed by the patient when leaving the facility against medical advice (AMA).
- Flow records: tracks specific aspects of patient care that occur on a routine basis, using tables or chart format.
- Care plans: documents treatment goals and plans for future care within the facility or following discharge.
- Discharge: contains final instructions for the patient and reports by the care team before the chart is closed and stored following patient discharge.
- Insurance information: lists health care benefit coverage and insurance provider contact information.

These general categories may be further divided for the individual facility's purposes. For example, a psychiatric facility may use a special section for psychometric testing, or a hospital may provide sections specifically for operations, x-ray reports, or electrocardiograms. In addition, certain details such as **allergies** or do not resuscitate orders may be displayed prominently (i.e., on large colored stickers or special chart sections) on the chart in order to communicate uniquely important information. It is important for the health care provider to become familiar with the charting systems in place at his or her specific facility or program.

It is important that the information in the chart be clear and concise, so that those utilizing the record can easily access accurate information. The medical chart can also aid in clinical problem solving by tracking the patient's baseline, or status on admission; orders and treatments provided in response to specific problems; and patient responses. Another reason for the standard of clear documentation is the possibility of the legal use of the record, when documentation serves as evidence in exploring and evaluating the patient's care experience. When medical care is being referred to or questioned by the legal system, the chart contents are frequently cited in court. For all of these purposes, certain practices that protect the integrity of the chart and provide essential information are recommended for adding information and maintaining the chart. These practices include:

- Include date and time on all records.
- Include full patient name and other identifiers (i.e., medical record number, date of birth) on all records.
- Mark continued records clearly (i.e., if note continued on reverse of page).
- Sign each page of documentation.

KEY TERMS

Consultation—Evaluation by an expert or specialist.

Continuity—Consistency or coordination of details.

Discipline—In health care, a specific area of preparation or training, i.e., social work, nursing, or nutrition.

Documentation—The process of recording information in the medical chart, or the materials in a medical chart.

Interdisciplinary—Consisting of several interacting disciplines that work together to care for the patient.

Objective—Not biased by personal opinion

Prognosis—Expected outcome of an illness or injury.

Regulatory organization—Organization designed to maintain or control quality in health care, such as the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), Department of Health (DOH), or the Food and Drug Administration (FDA).

Subjective—Influenced by personal opinion or experience.

- Use blue or black non-erasable ink on handwritten records.
- Keep records in chronological order.
- Prevent disposal or obliteration of any records.
- Note documentation errors and correct clearly, i.e., by drawing one line through the error and noting presence of error, initialing the area.
- Avoid excess empty space on the page.
- Avoid abbreviations or use only universally accepted abbreviations.
- Avoid other unclear documentation, such as illegible penmanship.
- Avoid including contradictory information. For example, if a nurse documents that a patient has complained of abdominal **pain** throughout the shift, while the physician documents that the patient is free of pain, these discrepancies should be discussed and clarified.
- Provide objective rather than subjective information. For example, do not allow personality conflicts

between staff to enter into the notes. All events involving the patient should be described as objectively as possible, i.e., describe a hostile patient by simply stating the facts, such as what the patient said or did and surrounding circumstances or response of staff, without using derogatory or judgmental language.

- Document any occurrence that might affect the patient. Only documented information is considered credible in court. Undocumented information is considered questionable since there is no written record of its occurrence.
- Always use current date and time with documentation. For example, if adding a note after the fact, it can be labeled “addendum” and inserted in correct chronological order, rather than trying to insert the information on the date of the actual occurrence.
- Record actual statements of patients or other individuals in quotes.
- Never leave the chart in an unprotected environment where unauthorized individuals may read or alter the contents.

Several methods of documentation have arisen in response to the need to accurately summarize the patient experience. In the critical care setting, flow records are often used to track the frequent patient evaluations, checks of equipment, and changes of equipment settings that are required. Flow records also offer the advantages of displaying a large amount of information in a relatively small space and allowing for quick comparison. Flow records can also save time for the busy clinician by allowing completion of checklists versus narrative notes.

Narrative progress notes, while more time consuming, are often the best way to capture specific information about the patient. Some institutions require only charting by exception (CBE), which requires notes for significant or unusual findings only. While this method may decrease repetition and lower required documentation time, most institutions that use CBE notes also require a separate flow record that documents regular contact with the patient. Many facilities or programs require notes at regular intervals even when there no significant occurrence, i.e., every nursing shift. Frequently used formats in patient notes include SOAP (Subjective, Objective, Assessment, Plan) notes. SOAP notes use a subjective patient statement to capture an important aspect of care, then follow with a key objective statement regarding the patient’s status, a description of the patient assessment, and a plan for how to address patient problems or concerns. Focus charting and PIE (problem-intervention-evaluation) charting use similar systems of notes that begin with a particular focus such as a patient concern or a **nursing diagnosis**. Nursing diagnoses are often used as

guides to nursing care by focusing on individual patient needs and responses to treatment. An example of a nursing diagnosis would be “Fluid volume deficit” for a patient that is dehydrated. The notes would then focus on assessment for **dehydration**, interventions to address the problem, and a plan for continued care, such as measurement of input and output and intravenous therapy.

Maintenance

Current medical charts are maintained by the health care team and usually require clerical assistance, such as the unit clerk in the hospital setting. No alterations should be made to the record unless they are required to clarify or correct information and are clearly marked as such. After patient discharge, the **medical records** department of a facility checks for completeness and retains the record. Sometimes the record will be made available in another format, i.e., recording paper charts on microfilm or computer imaging. Institutional and state laws govern storage of charts on- and off-site and length of storage time required.

Health care team roles

All members of the health care team require thorough understanding of the medical chart and documentation guidelines in order to provide thorough care and maintain a clear, concise, and pertinent record. Health care systems often employ methods to guarantee thorough and continuous use and review of charts across disciplines. For example, nursing staff may be required to sign below every new physician order to indicate that this information has been communicated, or internal quality assurance teams may study groups of charts to determine trends in missing or unclear documentation. In legal settings, health care team members may be called upon to interpret or explain chart notations as they relate to the individual legal case.

Training

Thorough training is essential prior to independent use of the medical chart. Whenever possible, the new clinician should spend time reviewing the chart to get a sense of organization and documentation format and style. Training programs for health care professionals often include practice in writing notes or flow charts in mock medical records. Notes by trainees are often initially cosigned by supervisors to ensure accurate and relevant documentation and document appropriate supervision.

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Medical codes and oaths see **Ethical codes and oaths**

Medical electrodes

Definition

The medical electrode transfers the energy of ionic currents in the body into electrical currents that can be amplified, studied, and used to help make diagnoses.

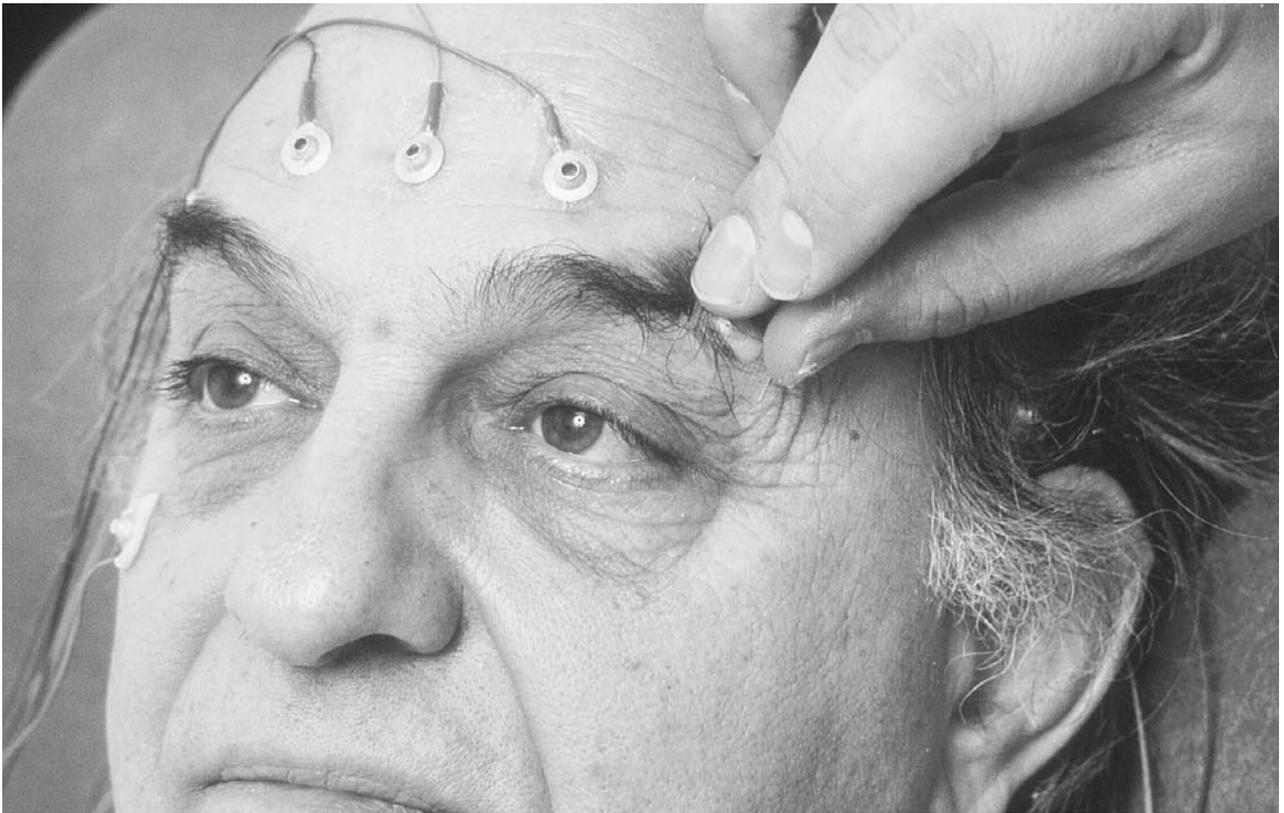
Purpose

Medical electrodes permit surface quantification of internal ionic currents, yielding an ordinarily non-invasive test for a variety of nervous, muscular, ocular, cardiac, and other disorders that might otherwise have required surgical means to verify their presence. For instance, muscular exams using electrodes may produce evidence of diminished muscle strength and can discriminate between primary muscle disorders and neurologically-based disorders, in addition to detecting if a muscle is truly weak or seems so due to other reasons. The electrodes are typically easy to use, fairly cheap, disposable (or easily sterilizable), and often unique in the tasks they help to perform. The essential role of the electrode is to provide ideal electrical contact between the patient and the apparatus used to measure or record activity.

Description

Medical electrodes are generally comprised of a lead (for conduction of electrical current), a metal electrode, and electrode-conducting paste or gel for surface electrodes. There is also often a metal (for good electrical contact) snap for the lead to snap into place so that the electrode can be disposable while the lead can be reused.

Electrodes can be classified into many groupings; those useful for EEG, for example, follow:



Electrodes are placed to monitor this man's brain activity for Alzheimer's research. (SIU BioMed/Custom Medical Stock Photo. Reproduced by permission.)

- disposable electrodes (both types, without gel and pre-gelled)
- reusable disc electrodes (gold, silver, stainless steel, or tin)
- headbands
- saline-based electrodes, which include various kinds

Electromyography requires more specialized needle electrodes that must be capable of piercing the skin.

Electrodes are used for diverse procedures and check-ups in the health setting. Combined with monitoring systems, they can be powerful predictors of disease and disorders. Some of the main types of exams utilizing medical electrodes include:

- **Electrocardiography (ECG/EKG):** Evaluates the electrical activity of the **heart**. It may be used to assess heart rate and regularity, in addition to damage, effects of drugs, and devices. ECG is also popularly used to determine the size and position of the chambers of the heart as they relate to the onset of various forms of heart disease. Diagnostic ECG may require 12 to 15 surface electrodes, while monitoring ECG usually employs three to five.
- **Electroencephalography (EEG):** Helps to identify specific irregularities in the **brain**. Brain wave patterns can be recorded and observed by positioning typically 10 to 20 electrodes upon the scalp of the patient in different areas and measuring ionic, electrical waves of neuronal activity.
- **Electromyography (EMG):** Assesses muscular response to electrical activity in innervated muscle. Utilizes needle electrodes that are inserted through the skin into relevant muscle fibers.
- **Electronystagmography (ENG):** Records eye movements graphically by placing metal electrodes above, below, and to the side of the appropriate eye, in addition to a ground electrode on the forehead. Eye motion is then recorded relative to the ground electrode location. Testing is usually performed to verify the presence of nystagmus.
- **Electroretinography (ERG):** Operates with an electrode positioned onto the cornea of the eye to record the electrical response of retinal rods and cones. Electrodes measure retinal electrical response to the impingement of light in order to assess a probable retinal disorder

(both hereditary and acquired) and whether it may require surgery.

Offshoot technologies of electrodes, as of July 2001, are veering toward multi-functional processes. One original electrode application boasts hands-free defibrillator capabilities in addition to its normal electrode functions in ECG. It should also be noted that, using a voltage or current generator, electrical stimulation can be applied to precise areas of the body using medical electrodes (in addition to their more conventional utility in measuring ionic currents).

Operation

Prior to performing EMG, ENG, and ERG tests, adults need not take any special precautions, except to inform their medical provider of any medications they take. EEG patients should thoroughly wash their hair the night before and use nothing in their hair (such as hair spray, lotions, or oils) on the day of the test. Discontinuance of medications may be necessary and patients should avoid **caffeine** for at least eight hours prior to the test. ECG patients should inform the provider of any medications taken, in addition to refraining from ingesting cold water and from exercising immediately before the test. Removal of all jewelry is also required.

Since the role of medical electrodes is generally for monitoring of electrical impulses, there is no risk of shock. Electrical stimulation using electrodes carries more risk because electricity is delivered to the body and should thus only be performed by personnel with an understanding of the risks involved (especially electrical) and how to avoid them. Knowledge of the ground electrodes and how to use them is strictly required and differs for different systems.

Maintenance

Maintenance of electrodes, if they are not disposable, involves sterilization and checking to ensure that the electrode is electrically viable by following the manufacturer's instructions.

Health care team roles

Doctors, nurses, or other technicians may need to perform tests involving medical electrodes. Often the technician or nurse applies the electrodes in patterns conforming to testing standards (i.e., Einthoven's triangle).

Training

Electrode placement is essential and thus must be known well enough to position electrodes correctly to

KEY TERMS

Einthoven's triangle—An ECG reference system with the subject's heart presumed to be the center of an equilateral triangle (both physically, in that electrodes are placed in form of a triangle on the body, and figuratively, in the mathematical measurement techniques used to assess a patient's cardiac health) formed by three bipolar limb leads. Can be used to diagnose various disorders of the heart. Named after Wilhelm Einthoven, the Dutch electrocardiographer who advanced these recording techniques.

Nystagmus—Rapid, repetitive involuntary movements of the eyes.

Retinal rods and cones—The two types of light-sensitive photoreceptor cells in the retina.

Saline—Containing a salt, or of the nature of a salt.

obtain viable data on many different types of patients. Since each procedure is unique, training must be appropriate to the specific procedure being performed. Electrode impedances may be checked to ensure superior electrical contact; the optimal values should be listed in the manufacturer's manual.

In using electrodes, the technician should follow the guidelines set in the manufacturer's manual, because electrode handling is not conserved over all electrode types and applications. The following general guidelines have been adapted from Biomedical Life Systems (as of July 2001), a major manufacturer of medical electrodes, but do not apply to all types of electrodes:

- Electrodes, gel, and tape (for securing the electrode) should not be applied over broken skin.
- Body hair should be trimmed or shaved where electrodes are going to be applied.
- Carbon electrodes should be cleaned with mild soap and water to remove skin oils, gel, and dirt.
- Skin should be cleaned before and after applying electrodes.
- Cleaning lead wires with mild soap and water will prevent them from becoming brittle.

Resources

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Bryan Ronain Smith

Medical emergency kit see **First aid kit**

Medical ethics

Definition

Medical ethics refers to the discussion and application of moral values and responsibilities in the areas of medical practice and research. While questions of medical ethics have been debated since the beginnings of Western medicine in the fifth century B.C., medical ethics as a distinctive field came into prominence only since World War II. This change has come about largely as a result of advances in medical technology, scientific research, and telecommunications. These developments have affected nearly every aspect of clinical practice, from the confidentiality of patient records to end-of-life issues. Moreover, the increased involvement of government in medical research as well as the allocation of health care resources brings with it an additional set of ethical questions.

Description

The Hippocratic tradition

Medical ethics generally traces its origins to the ancient Greek physician Hippocrates (460–377 BC), who is credited with defining the first ethical standard in medicine: “Do no harm.” The oath attributed to Hippocrates was traditionally recited by medical students as part of their medical school’s graduation ceremonies. A modernized version of the Hippocratic Oath that has been approved by the American Medical Association (AMA) reads as follows:

You do solemnly swear, each by whatever he or she holds most sacred

That you will be loyal to the Profession of Medicine and just and generous to its members

That you will lead your lives and practice your art in uprightness and honor

That into whatsoever house you shall enter, it shall be for the good of the sick to the utmost of your power,

your holding yourselves far aloof from wrong, from corruption, from the tempting of others to vice

That you will exercise your art solely for the cure of your patients, and will give no drug, perform no operation, for a criminal purpose, even if solicited, far less suggest it

That whatsoever you shall see or hear of the lives of men or women which is not fitting to be spoken, you will keep inviolably secret

These things do you swear. Let each bow the head in sign of acquiescence

And now, if you will be true to this your oath, may prosperity and good repute be ever yours; the opposite, if you shall prove yourselves forsworn.

Religious traditions and medical ethics

Ancient Greece was not the only premodern culture that set ethical standards for physicians. Both Indian and Chinese medical texts from the third century B.C. list certain moral virtues that practitioners were to exemplify, among them humility, compassion, and concern for the patient’s well-being. In the West, both Judaism and Christianity gave extensive consideration to the importance of the physician’s moral character as well as his duties to patients. In Judaism, medical ethics is rooted in the study of specific case histories interpreted in the light of Jewish law. This case-based approach is known as casuistry. In Christianity, ethical reflection on medical questions has taken the form of an emphasis on duty, moral obligation, and right action. In both faiths, the relationship between the medical professional and the patient is still regarded as a covenant or sacred bond of trust rather than a business contract. In contemporary Buddhism, discussions of medical ethics reflect specifically Buddhist understandings of suffering, the meaning of human personhood, and the significance of death.

The Enlightenment and the nineteenth century

The eighteenth century in Europe witnessed a number of medical as well as general scientific advances, and the application of scientific principles to medical education led to a new interest in medical ethics. The first book on medical ethics in English was published by a British physician, Thomas Percival, in 1803. In the newly independent United States, Benjamin Rush—a signer of the Declaration of Independence as well as a physician—lectured to the medical students at the University of Pennsylvania on the importance of high ethical standards in their profession. Rush recommended service to the poor as well as the older Hippocratic virtues of honesty and justice.

In the middle of the nineteenth century, physicians in the United States and Canada began to form medical societies with stated codes of ethics. These codes were drawn up partly because there was no government licensing of physicians or regulation of medical practice at that time. The medical profession felt a need to regulate itself as well as set itself apart from quacks, faith healers, homeopaths, and other practitioners of what would now be called alternative medicine. The AMA, which was formed in 1847, has revised its Code of Ethics from time to time as new ethical issues have arisen. The present version consists of seven principles. The Canadian Medical Association (CMA) was formed in 1867 and has a Code of Ethics with 40 guidelines for the ethical practice of medicine.

Viewpoints

Theoretical approaches to medical ethics

PHILOSOPHICAL FRAMEWORKS. Since the early Middle Ages, questions of medical ethics have sometimes been discussed within the framework of specific philosophical positions or concepts. A follower of Immanuel Kant (1724–1804), for example, would test an ethical decision by the so-called categorical imperative, which states that one should act as if one's actions would serve as the basis of universal law. Another philosophical position that sometimes appears in discussions of medical ethics is utilitarianism, or the belief that moral virtue is based on usefulness. From a utilitarian perspective, the best decision is that which serves the greatest good of the greatest number of people. An American contribution to philosophical approaches to medical ethics is pragmatism, which is the notion that practical results, rather than theories or principles, provide the most secure basis for evaluating ethical decisions.

CASUISTRY. Casuistry can be defined as a case-based approach to medical ethics. An ethicist in this tradition, if confronted with a complicated ethical decision, would study a similar but simpler case in order to work out an answer to the specific case under discussion. As has already been mentioned, casuistry has been used as a method of analysis for centuries in Jewish medical ethics.

THE “FOUR PRINCIPLES” APPROACH. Another approach to medical ethics was developed in the 1970s by a philosopher, Tom Beauchamp, and a theologian, James Childress, who were working in the United States. Beauchamp and Childress drew up a list of four principles that they thought could be weighed against one another in ethical decision-making in medicine. The four principles are:

- the principle of autonomy, or respecting each person's right to make their own decisions
- the principle of beneficence, or doing good as the primary goal of medicine
- the principle of nonmaleficence, or refraining from harming people
- the principle of justice, or distributing the benefits and burdens of a specific decision fairly

One limitation of the “Four Principles” approach is that different persons involved in an ethical decision might well disagree about the relative weight to be given to each principle. For example, a patient who wants to be taken off a life-support system could argue that the principle of autonomy should be paramount, while the clinical staff could maintain that the principles of beneficence and nonmaleficence are more important. The principles themselves do not define or imply a hierarchical ranking or ordering.

Current issues in medical ethics

One well-known writer in the field of medical ethics has recently written an article listing what he considers “cutting-edge” topics in medical ethics. While space does not permit discussion of these subjects here, they serve as a useful summary of the impact of technology and globalization on medical ethics in the new millennium:

- **End-of-life care.** Medical advances that have led to a dramatic lengthening of the life span for adults in the developed countries and a corresponding increase in the elderly population have made end-of-life care a pressing issue.
- **Medical error.** The proliferation of new medications, new surgical techniques, and other innovations means that the consequences of medical errors are often very serious. All persons involved in health care have an ethical responsibility to help improve the quality of care.
- **Setting priorities.** The fair allocation of health care resources is one example of setting priorities.
- **Biotechnology.** Medical ethicists are still divided over the legitimacy of stem cell research, cloning, and other procedures that advances in biotechnology have made possible.
- **“eHealth.”** The expansion of the Internet and other rapid changes in information technology have raised many questions about the confidentiality of electronic **medical records** as well as the impact of online education on medical training.
- **Global bioethics.** Global bioethics represents an attempt to consider the ethical problems confronting the poorer countries of the world, rather than concen-

KEY TERMS

Casuistry—A case-based approach to medical ethics.

Categorical imperative—The principle that one should act in such a way that one's deeds could become universal rules of conduct.

Ethics—A system or set of moral principles; also, the study of values relating to human conduct.

Hippocratic Oath—The ethical oath attributed to Hippocrates that is used as a standard for care by physicians worldwide.

Pragmatism—A philosophical position that regards practical results, rather than abstract principles or theories, as the essential criterion of moral value.

Utilitarianism—An ethical position based on the premise that usefulness is the best measure of moral worth, and that ethical decisions should promote the good of the largest number of persons.

trating on medical issues from the perspective of the wealthy countries. Of the 54 million deaths that occur each year around the world, 46 million occur in low- and middle-income countries.

Professional implications

One implication for physicians is the importance of studying ethical issues during one's professional education. Many medical, dental, and nursing schools now include courses in their curricula that deal with such topics as moral decision-making, definitions of life and death, the ethical complexities of professional-patient relationships, and the moral safeguards of medical research. As of 2000, more than 25 universities in the United States and Canada offer graduate degrees in medical ethics.

A second implication is recognizing the necessity of interdisciplinary conversation and cooperation. Physicians can benefit from the insights of scholars in the social sciences, philosophy, theology, law, and history. At the same time, they have much to offer professionals in other fields on the basis of their clinical experience.

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American Nurses Association. 600 Maryland Ave. SW, Ste. 100 West, Washington, DC 20024. (800) 274-4262. <<http://www.nursingworld.org>>.

American Society of Bioethics and Humanities. 4700 W. Lake, Glenview, IL 60025. (847) 375-4745. <<http://www.asbh.org>>.

Canadian Medical Association. 1867 Alta Vista Drive, Ottawa ON K1G 3Y6. (613) 731-8610 x2307 or (888) 855-2555. Fax (613) 236-8864. <cmamsc@cma.ca>.

Institute for Jewish Medical Ethics. Hebrew Academy of San Francisco, San Francisco, CA. (415) 752-7333 or (800) 258-4427. <<http://www.ijme.org>>.

National Bioethics Advisory Commission. 6705 Rockledge Drive, Suite 700, Rockville, MD 20892. (310) 402-4242. <<http://www.bioethics.gov>>.

OTHER

Canadian Medical Association. *Code of Ethics of the Canadian Medical Association*. Policy statement approved by the CMA Board of Directors, October 15, 1996.

Ken R. Wells

Medical gases

Definition

A medical gas is defined as one that is manufactured, packaged, and intended for administration to a patient in

anesthesia, therapy, or diagnosis. Title 21 of the Code of Federal Regulations (CFR) designates medical gases as drugs, and mandates the Secretary of the Treasury and the Secretary of Health and Human Services to promulgate regulations for the efficient enforcement of the Federal Food, Drug, and Cosmetic Act (FDA)(drug portion of 21 CFR). Such other regulatory bodies as the Department of Transportation (DOT) and national organizations [e.g., the Compressed Gas Association (CGA) and the National Fire Protection Association (NFPA)] write regulations and standards for compressed gases. Medical gases are considered prescription drugs because their use as drugs is unsafe without the supervision of a licensed practitioner or by properly instructed emergency personnel. Regulations regarding the purity of these substances are established by the United States Pharmacopeia/National Formulary (USP/NF).

Purpose

Medical gases are used within hospital settings for many purposes. They include the following elements and compounds:

- Oxygen, used to provide supplemental oxygen to the **respiratory system**; in dentistry in combination with **nitrous oxide**; and as an emergency standby.
- Nitrous oxide, used as an anesthetic agent in surgery; mixed with oxygen to help patients relax during dental procedures; and in cryosurgery (the use of extreme cold to destroy tissue).
- Nitrogen, used to provide pneumatic pressure in medical equipment; to prevent combustion and other chemical reactions; and as a component of many gas mixtures.
- Carbon dioxide, used to inflate areas of the body for “keyhole” surgery (small incisions made to accommodate **surgical instruments**); mixed with air or oxygen to stimulate breathing; and in cryosurgery or testing tooth sensitivity in dentistry.
- Medical air, used in administering breathing treatments and as a mixing component for other respiratory gases.
- Helium, used in breathing mixtures for patients with impaired lung functions.

Since medical gases are the most frequently administered drugs in the United States, the FDA is attempting to heighten both consumer and industry awareness about this specialized category of regulated products. Such related delivery hardware as regulators and tubing is also regulated as medical devices.

Description

Cylinder markings

For the transport and delivery of a cylinder of compressed gas to a provider, the cylinder must have designated markings permanently affixed to its neck to identify the regulatory body governing the use of the cylinder; the service pressure; the serial number; the date of manufacture; the last test date; a stick-on label identifying its contents; its hazard class and color code (green for oxygen, blue for nitrous oxide, yellow for air). The cylinder is equipped with a valve threaded into it that is specifically designed only for the specific type of medical gas the cylinder is designated to contain.

Pin index safety system

The pin index safety system is used to prevent a cylinder of compressed gas from being filled with the wrong gas, or to prevent the connection of the wrong cylinder to a yoke on an anesthesia machine or to a pipeline within an institution. This system consists of three holes drilled in the valve of the gas cylinder that mate with matching pins on the yoke of the pipeline or anesthesia machine. The large central opening is the gas outlet of the cylinder. The other two holes are drilled to comply with the specifications of the safety system for the gas the cylinder is designed to contain. Despite the design of the safety system, it is not completely proof against mixups. Incidents have been reported of hospital personnel removing an oxygen fitting from an empty vessel, installing it on a nitrogen vessel and attaching it to the oxygen supply system in an institution. Patient deaths have been reported as resulting from such incidents.

Safety of hospital employees

In addition to concerns about patient safety, medical gases pose safety hazards to hospital personnel as well. The National Safety Council (NSC) has stated that hospital employees are 41% more likely to lose time from work because of injury or illness than employees in other fields. Hospital employees who work in or around laboratories or operating rooms are more likely to be injured by exposure to medical gases than workers in other areas. The highest risks are related to waste anesthetic gases, which result from inadequate maintenance of anesthesia machines or from poor work practices during the administration of anesthesia. The symptoms of acute exposure to waste anesthetic gases include drowsiness, depression, headaches, nausea, irritability, and loss of coordination. Chronic exposure can result in **liver** or kidney disease, **cancer**, or **miscarriage**.

KEY TERMS

Compressed medical gas—Any liquefied or vaporized gas alone or in combination with other gases.

Cryogenic vessel—A metal container designed to hold liquefied compressed medical gases at extremely low temperatures.

Cylinder—A metal container designed to hold compressed medical gases at a high pressure.

Manifold—A pipe or chamber with several openings for funneling the flow of liquids or gases.

Regulator—A mechanism that controls the flow of a medical gas.

Operation

Storage and transport of liquid oxygen

Pipelines serve as a convenient and economical method for the distribution of medical gases throughout a health care institution by reducing the number of gas cylinders required. This reduction contributes to the cleanliness of the facility, simplifies gas delivery, decreases the cost of the gas, and serves to decrease the number of personnel injuries related to the movement of heavy gas tanks. Liquid oxygen, stored at a temperature between -230 – -283°F (-150° – -175°C) in double-walled stainless steel containers built to withstand a pressure of 250 lb per square inch gauge (psig), is the system used by most health care facilities for the main supply of this gas. Since liquid oxygen can vaporize rapidly with an abrupt rise in temperature to create dangerously high pressure, the bulk oxygen container must be located away from the institution for safety reasons. An underground pipeline, fitted with protective casings in areas of high surface loads, is used to transport the oxygen to the main facility's distribution system. Alarm systems are used to monitor the condition and operation of the liquid oxygen container. To avoid misfillings of oxygen containers, hose connections must be noninterchangeable. A high-pressure cylinder manifold system with an automatic switch-over valve serves as a reserve supply of liquid oxygen.

Storage and transport of liquid nitrous oxide

Cylinders of liquefied nitrous oxide connected to a gas manifold usually serve as the supply of this medical gas for facilities. The manifold controls the release of nitrous oxide from each tank. The gas is reduced to a working pressure of 45–55 psig before entering the main

pipeline. Like liquid oxygen, liquid nitrous oxide has an automatic switch-over valve for a reserve bank of cylinders. These banks of gas cylinders are located in a designated storage room, which is usually adjacent to the facility's loading dock. To prevent cross-filling of tanks or rupture of the pipeline, a system of check valves, shutoff valves and pressure relief valves is employed.

Installation and inspection specifications

Pipelines in health care facilities must be constructed from hard-drawn seamless medical gas type tubing. All pipelines delivered to these facilities must also be cleaned for oxygen service, permanently labeled, and capped. Supports for the pipelines must have a copper finish if the support is to make contact with the copper tubing. Only qualified technicians should undertake all welding of medical pipelines. Shutoff valves are required throughout a facility's pipeline system; in particular, those that service a patient area should also have a pressure gauge. A newly installed pipeline system must be cleaned in accordance with set regulations before it is tested. The NFPA requires that both the installer and the user corroborate the findings of the pipeline testing before it is used with patients; and a record of these test results must be kept on file by the facility. Although this testing is designed to ensure the medical gas pipeline system is safe for patients, regulations addressing the requirements for the companies that perform the testing and the certification of pipeline systems have not been established. The American Hospital Association, however, does provide recommendations and verifications for the choice of a company to perform the inspection.

Operating rooms

Noninterchangeable outlets for medical gases located in operating rooms may be placed on the ceilings or walls. Each one must be color-coded and labeled with the name or chemical symbol of the medical gas it delivers. Automatic closing mechanisms in the outlet of each pipeline will prevent the leakage of gas when the mating end of the transfer hose is absent. The end of each hose used to connect the pipelines to an anesthesia machine must be color-coded and provided with a gas-specific noninterchangeable connection. Three gas sources supply an anesthesia machine:

- a storage container of liquid oxygen backed up by a reserve supply of oxygen in a cylinder
- liquid nitrous oxide in a cylinder
- medical air, supplied by gas cylinders or generated on site by compressors

Building codes

States regulate and enforce building codes regarding these pipelines but the variability of these codes are extreme. Some states have separate codes for each county or even for different regions within a large city. The NFPA has updated standards for the pipelines of health care facilities. In addition, the American Welding Society, the Manufacturers' Standardization Society of the Valve and Fittings Industry, the American Society of Mechanical Engineers, and the American National Standard Institute (ANSI) all have set standards for their installation, design and testing. With such varied coding, an enforcement mechanism is quite difficult. National standardization may come about only through the issue of medical liability.

Maintenance

Written procedures must be established for the testing intervals and maintenance of the pipelines as well as policies indicating procedures to be instituted for a shutdown. The American Hospital Association and the NFPA should be contacted regarding maintenance recommendations. The tests and procedures performed by the pipeline installer include:

- Pressurizing the pipeline to 1.5 times the working pressure for 24 hours, with each joint being checked for leaks.
- Blowing out the pipelines with oil-free nitrogen, pressurizing the pipelines to 1.2 times the working pressure for 24 hours and rechecking for leaks.
- Placing a white cloth over the outlets of the pipeline and intermittently purging it until the cloth is no longer discolored.
- Checking each pipeline with nitrogen and every outlet for the delivery of the labeled gas.

System users must repeat most of these tests and continue to ensure that each outlet is delivering the labeled medical gas. Further inspections of the manifolds, medical air compressors and alarms should be routinely performed. FDA inspectors are mandated to inspect gas liquefaction and container plants every other year.

Health care team roles

Biomedical technicians are the primary caretakers of medical gas pipelines within a health care facility. They are usually responsible for accepting medical gas deliveries and validating the contents of the delivery as well as its date and source. They should conduct scheduled shutdowns; establish protocol; maintain written policies and

procedures; and remain informed of new standardized recommendations within the medical gas supply industry. They must also ensure that persons working under them have the proper training to identify medical gas cylinders, connection valves, regulators, and the distribution system within a facility.

Respiratory therapists primarily utilize oxygen from outlets within patient areas or from individual cylinders. They are responsible for checking the labels on any cylinders they use. They should also be aware of their duties in the event of a shutdown.

Certified **registered nurse** anesthetists and anesthesiologists should be aware of the location of the banks of gas cylinders and know the personnel responsible for changing them. They should also be knowledgeable about the workings of the cylinder bank and be able to troubleshoot the system with the biomedical technicians. Lastly, they should know the symptoms of exposure to waste anesthetic gases and the proper methods of treatment.

Training

All employees handling medical gases should be alerted to the possible hazards associated with their use. These personnel should be trained to recognize the various medical gas labels and to examine all labels carefully. Personnel who receive medical gas deliveries should be trained to store medical grade products separately from industrial grade products. The storage area for these medical grade products should be well defined, with one area for receiving full cryogenic vessels and another area for storing empty vessels. All personnel responsible for changing or installing cryogenic vessels must be trained to connect medical gas vessels properly. They must understand how vessels are connected to the oxygen supply system and be alerted to the serious consequences of altering the connections. Emphasis must be placed on the fact that the fittings on these vessels should not be changed under any circumstances. If a cryogenic vessel fitting does not form a good connection with the oxygen supply system fitting, the supplier should be contacted immediately. The vessel should be returned to them for correction of the problem. Finally, before the medical gas is introduced into the system, a knowledgeable person should ensure that the correct vessel has been connected properly. Every opportunity should be taken to promote the importance of properly handling medical gases to all personnel and especially those who are directly involved with handling them.

Resources

ORGANIZATIONS

Food and Drug Administration. 5630 Fishers Lane, Room 1061, Rockville, MD 20852. <<http://www.fda.gov>>.

National Fire Protection Association (NFPA). 1 Batterymarch Park, Quincy, MA 02269-9101. (617) 770-3000 or (800) 344-3555. Fax: (617) 770-0700. <<http://www.nfpa.org>>.

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FDA Public Health Advisory. *Guidance for Hospitals, Nursing Homes, and Other Health Care Facilities*. March 2001.

Occupational Safety and Health Administration (OSHA). *OSHA Technical Manual*, Section VI, Chapter 1, "Hospital Investigations: Health Hazards." Washington, DC: United States Department of Labor, 2001.

United States Food and Drug Administration. <<http://www.fda.gov/cder/dmpq/freshair.htm>>.

Linda K. Bennington, CNS

Medical history see **Health history**

Medical laboratories

Definition

The medical laboratory, also called the clinical laboratory or the pathology laboratory, provides diagnostic testing services for physicians to help identify the cause of disease and changes produced in the body by disease conditions. Medical laboratories are classified as either clinical pathology laboratories, which analyze **blood**, urine, culture products, and other body fluids; or anatomical (or surgical) pathology laboratories, which analyze tissue or organ samples obtained during surgery or **autopsy** and cervical and body fluid samples obtained by biopsy or lavage. A typical hospital medical laboratory will be called the Department of Pathology (investigation of disease-related processes) and will offer both types of testing. Medical laboratories of various sizes, offering a variety of testing services, can be found in acute-care hospitals, medical centers, doctor's offices and group practices, skilled nursing facilities, and long-term care facilities. Commercial medical laboratories operate as independent businesses and serve as testing facilities for physicians and for companies engaged in medical or pharmaceutical research. Additional commercial laboratories that specialize in a specific type of testing such as genetic, drug, and fertility testing also serve the medical community. Reference laboratories are often established by universities, state governments, organizations, and

companies to provide more comprehensive testing or to perform more difficult tests not needed routinely.

Purpose

Medical laboratory science, or medical technology, is an important part of diagnostic medicine. It uses sophisticated instruments and methods to evaluate hundreds of body processes that occur constantly as body organs do their work. Combinations of laboratory tests are needed to help diagnose a patient's condition. Clinical pathology evaluates disease by identifying (qualitative testing) and measuring (quantitative testing) chemical substances found in blood, urine, spinal fluid, sputum, feces, and other body fluids. **Bacteria** and sometimes **viruses** are grown and identified in culture products (samples of blood, urine, sputum, **wounds**, etc. that are transferred onto culture media and incubated until they grow enough to be identified). Biochemical substances such as hormones, enzymes, **minerals**, and other chemicals produced in the body can be measured, as well as chemicals ingested (eaten with food or consumed as medications or poisons) or produced as waste products.

Normal levels or reference levels of these substances are determined by performing the tests on large numbers of people and establishing a typical range of results expected in the absence of disease. These reference ranges are often gender and age specific and will vary from laboratory to laboratory depending upon the methods used. A level that is higher or lower than normal gives physicians information about a patient's condition at the time of testing and may help physicians diagnose a disorder or disease in that patient. Measuring changes in the levels of chemicals may also help to monitor changes in the patient's condition during and after treatment. For example, a substance produced by the prostate gland called prostate specific antigen is used to screen for **prostate cancer**. Following treatment, the physician will request that this test be performed because complete removal of the tumor will cause the blood level to return to normal. Following demonstration of successful treatment, the test will be performed at regular intervals to detect any recurrence of the tumor.

Anatomical pathology identifies either the cause of disease or, through autopsy, the consequences of disease (cause of death). Samples of cells, tissues, or organs obtained during surgery or autopsy are examined macroscopically (by the naked eye) and microscopically (by powerful microscopes). Advances in the relatively new sciences of genomics (study of DNA and RNA) and proteomics (study of molecular **proteins**), cell genetics, and molecular analysis may also be performed to better understand the origins of disease in individuals.

Anatomical pathology gives doctors the most definitive information on the disease process causing a patient's symptoms, illness, or death. Results of anatomical pathology depend upon the qualified opinion of a pathologist, a physician trained and experienced in identifying the causes of disease and changes in body chemistry or tissues in the presence of disease. The anatomical pathology report is written in appropriate detail for the testing physician, and will be used along with clinical data to determine the stage (extent) and prognosis (outlook) of the disease.

Doctors order laboratory tests to make, confirm, or rule out a diagnosis, to select or monitor therapy (drugs, **physical therapy**, surgery, etc.), to monitor a patient's progress during therapy and help determine a prognosis for the patient. A single test is usually not enough to confirm a diagnosis. Combinations of laboratory tests are used along with the patient's history, **physical examination**, and diagnostic imaging exams (such as x ray, MRI, CAT scans, and ultrasound) to make a definitive diagnosis. Laboratory screening tests are often performed on apparently healthy patients to make sure they have no underlying disease. Test profiles are also designed that combine a series of related tests (such as a hematology profile or chemistry profile) or organ-related tests (such as a cardiac profile, **liver** profile, or thyroid profile) to get a broad view of a patient's condition. More specific testing is usually required to make a definitive diagnosis.

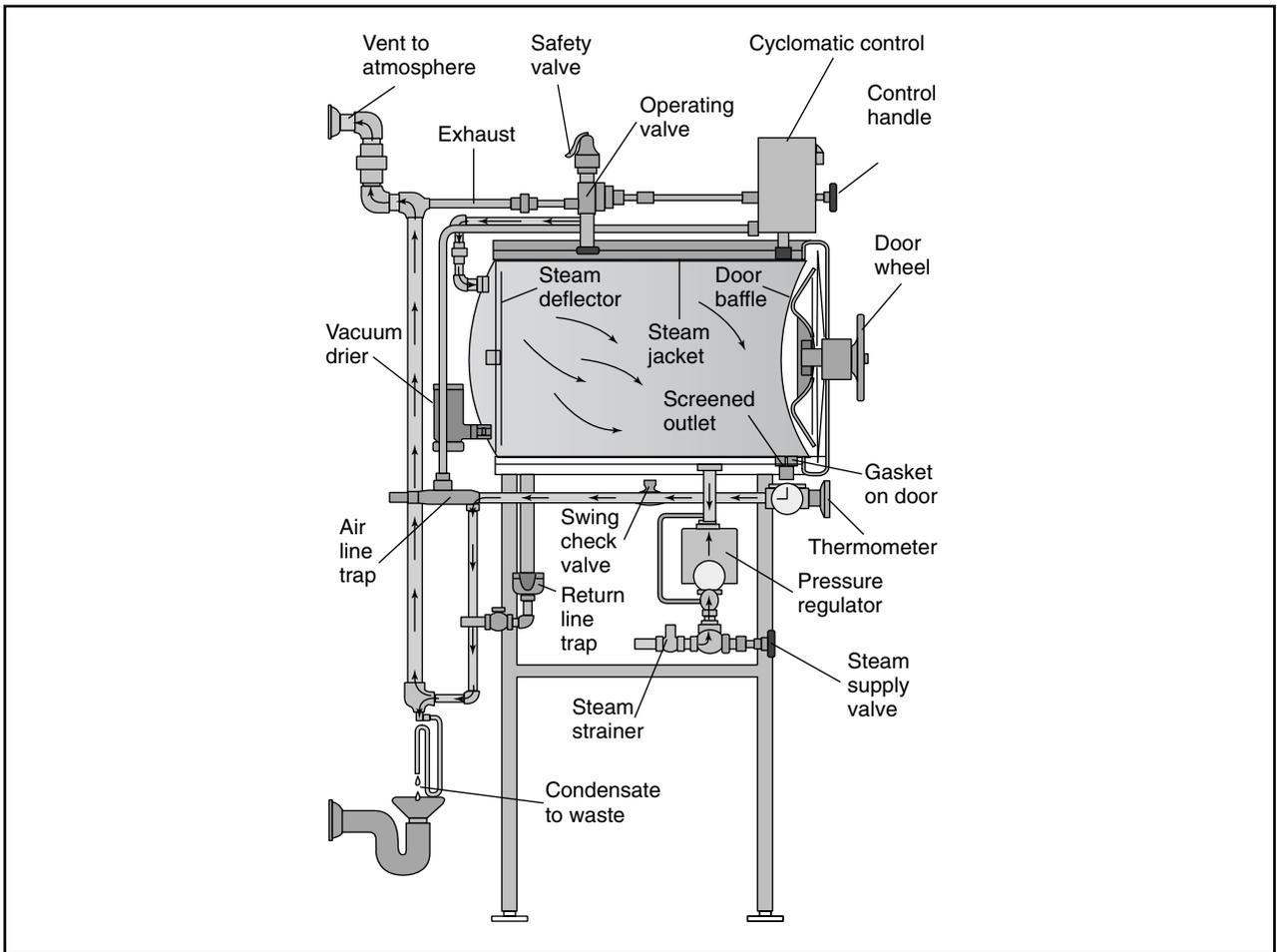
Description

Testing laboratories rely on well defined technical procedures, complex precise instruments, and a variety of automated and electronic equipment to do diagnostic testing. Tests are performed by medical technologists, technicians, and laboratory assistants. The technical staff works under the direction of a pathologist, who interprets the results of the laboratory tests. Laboratories, laboratory equipment, and testing personnel are evaluated and accredited by national scientific organizations and government agencies, including the American Society of Clinical Pathologists (ASCP) and the Joint Commission on Accreditation of Healthcare Organizations (JCAHO). This accreditation process helps to standardize lab procedures, establish quality control standards, and ensure that labs provide physicians with accurate and timely test results.

The medical laboratory is typically divided into sections that perform related groups of tests. The standard laboratory sections include, but are not limited to:

- **Clinical chemistry:** the study of body chemistry and the detection and measurement of chemicals such as hormones, enzymes, proteins, **fats**, **vitamins**, minerals, metals, and drugs. The chemistry department has subspecialties that include enzymology, **toxicology**, and immunochemistry.
- **Hematology:** the study of red and white blood cells, including their concentration and morphology (appearance and stages of growth), and the measurement of hemoglobin (iron-bearing protein in the blood) and other substances in the blood that may help diagnose bleeding and coagulation problems, anemia, **infection**, and various other illnesses including **cancer**. In large laboratories it is common practice to combine the automated components of both clinical chemistry and hematology into one section that is staffed by personnel who are skilled in both disciplines.
- **Microbiology:** the study of microorganisms, and the isolation and identification of disease-causing bacteria, yeasts, **fungi**, parasites, and viruses. Microbiologists also determine the antibiotic susceptibility of pathogenic bacteria that are grown from clinical specimens.
- **Immunology:** the study of the body's **immune system** and immune processes that mediate and regulate the body's defense against bacteria, viruses, and foreign cells or antigens (proteins). Immunology is also the section of the laboratory that tests for organ transplant compatibility, a specialized area called histocompatibility testing, and autoimmune disease (i.e., an immunological response to one's own tissues). In addition, a branch of immunology called serology measures the concentration of specific antibodies that indicate infectious disease, previous exposure to a pathogen, or immunity resulting from **vaccination**.
- **Urinalysis:** the examination of urine and the study of waste products that are eliminated by the **kidneys** may indicate or help explain metabolic or kidney disease processes and monitor treatment with therapeutic drugs. Urinalysis also includes the analysis of cells, crystals, and other objects that enter the urine or are formed by the kidney or urinary tract.
- Every clinical laboratory will offer testing capabilities within these categories. All hospitals that perform surgery will also have an immunohematology department, which comprises the blood bank and those tests that are used to determine whether blood from a donor will be compatible with the intended recipient. In addition, the blood bank technologists perform tests to detect antibodies on red blood cells, store blood and blood products, and prepare blood products for transfusion. The blood bank also performs therapeutic bleeding or removal of specific blood components for some patients.

Smaller laboratories, such as those in doctors' offices, will perform routine testing and screening tests



A steam autoclave is used to disinfect lab equipment. (Delmar Publishers, Inc. Reproduced by permission.)

related to the physician's specialty, usually testing blood and urine samples only, and will still need the hospital or independent testing laboratories for special diagnostic tests. Smaller laboratories generally use state-of-the-art equipment and automated instruments that are designed for less testing volume and that are less complex than those used in larger laboratories.

While some tests are performed manually, medical laboratories depend upon computer-controlled automated equipment for as many tests as possible to keep up with the volume and variety of tests ordered. Multichannel analyzers are commonly used to perform clinical chemistry tests. These large, complicated instruments are computer-controlled to perform many separate chemistry tests simultaneously (often called a chemistry panel or profile) on each patient's sample. The goal of such automation is to reduce the amounts of sample required; reduce the amount of chemicals (reagents) needed per test; reduce the time of analysis; eliminate contamination and error that results from excessive sam-

ple handling; and reduce the number of technologists needed to perform the testing. The precise operation of automated systems provides a higher degree of precision avoiding the differences in operator technique that increases the variance of manual testing methods. Computer-calculated results have been shown to be far more reliable than results subject to human manipulation, which is more likely to introduce transcription and random computational errors. Cost savings achieved through automation are important to both the testing facility and the patient. Time savings are important to the testing physicians and unit nurses who are waiting for test results to make critical patient-care decisions.

Laboratory computerization also includes laboratory information systems (LIS) that can access patient information and allow reporting of test results directly to the patient's record. Patient orders and test results can be viewed on a terminal or printed out in a comprehensive record, showing daily or hourly results side by side for comparison. This is especially valuable to physicians

and nurses who are monitoring the patient's treatment. Results may be reported more quickly when the LIS interfaces with the healthcare facility's medical information system (MIS), which displays results on computer terminals in point-of-care nursing units, or transfers the information to the testing physician's office.

Hundreds of different types of tests are performed daily in the medical laboratory using different methods on a variety of special instruments. The demand for both rapid and reliable results has led to increased reliance on automation and to new portable testing methods that can be performed at the bedside or other point-of-care. Some of the most common automated testing methods are:

- Automated general chemistry analyzer (automated spectrophotometry). Most automated tests performed on multichannel analyzers use this technique. The instrument consists of components that perform all of the steps of a manual procedure. Robotic arms may be used to convey the samples from the centrifuge to the analyzer and bar code readers are used to input test order and patient information directly to the analyzer's computer. Sample and reagents are added to reaction cells in precise amounts, mixed mechanically, and incubated at constant temperature for a specific period of time. The chemical reaction typically results in production of a colored product. The color intensity (absorbance) is determined by the instrument's optical system or spectrophotometer. The instructions for how to perform each different test (i.e., sample volume, reagent volume, incubation time, wavelengths for analysis) are stored in the computer's **memory**. The computer also stores calibration information needed to calculate results, and quality control data that is needed to validate instrument performance. Reaction cells may be disposable or cleaned and reused by an automated wash system on the analyzer. In addition to optical analysis, these instruments usually have electrochemical sensors for analysis of electrolytes such as sodium and potassium. The test menu is usually large, for example 40 to 60 different analytes that can be measured in any order or combination. Smaller, single-channel spectrophotometers are also used in doctor's offices, clinics, and nursing units to perform a more restrictive number of procedures. Another type of light measuring instrument called a reflectance photometer is often used to read dry reagent strip urine or dry slide chemistry tests.
- Immunoassays. This comprises a wide range of laboratory methods that utilize specific antibodies to facilitate a measurement. Immunoassay platforms are incorporated into several large autoanalyzers (automated chemistry analyzers), and are used to identify minute amounts of analytes (substances analyzed in blood, urine or body fluids), which include hormones, drugs,

tumor markers, specific proteins, and cardiac markers. Some systems also support immunological tests to identify bacterial and viral antigens and allergens (responsible for **allergies**). The technology is based upon the measurement of antigen-antibody complexes and usually involves the use of a label such as an enzyme, radioactive isotope, or fluorescent molecule to measure the amount of immune complexes formed. New technology allows the selection of individual tests in any order or combination without the need to change reagents or instrument settings manually.

- Electrophoresis. Electrically charged particles of varying size and electrical charge, will move at different rates under the influence of an electric field. These differences can be measured by a technique called electrophoresis. The process permits separation of similar molecules such as proteins with different net charges or of different sizes. Serum protein electrophoresis separates proteins found in blood serum, the clear portion of a blood sample after it clots. It is used as an aid to the diagnosis of diseases such as multiple myeloma, acute and chronic inflammation, kidney disease, liver disease, and nutritional disorders. Immunofixation electrophoresis uses the separation of proteins in conjunction with specific antibodies to help diagnose multiple myeloma (a malignant disease) and **immunodeficiency** states that occur in disorders such as **AIDS**. Hemoglobin electrophoresis separates the red pigment in blood cells to diagnose certain **anemias** and blood disorders.
- Chromatography. Substances can be separated and identified on the basis of their molecular size or chemical properties (how they interact). High performance liquid chromatography (HPLC), thin-layer chromatography, and gas-liquid chromatography each use a different type of medium to separate drugs, certain proteins, amino acids, **lipids**, organic acids, and hormones in blood or urine. Various detectors can be used to measure the quantity of the analytes following their separation.
- Mass spectrometry. This technology is coupled to gas chromatography in order to conclusively identify a compound based upon its unique chemical structure. The mass spectrometer is most often used to confirm positive **drug tests** performed by immunoassay. Mass spectrometry equipment is highly specialized and the testing is more likely offered by an independent laboratory specializing in this technique than by a hospital laboratory. Pharmaceutical companies often requires this type of testing on thousands of samples in the research and development of therapeutic drugs.

KEY TERMS

Analyte—A chemical substance in body fluids, cells, or tissues that is the subject of laboratory investigation.

Biochemistry—The study of biochemical origins of humans in health, growth, nutrition, and disease.

Clinical chemistry—A broad field of analytical techniques that detect and measure chemicals in body fluids, cells, or tissues, such as enzymes, hormones, proteins, drugs, or other naturally occurring chemicals or those either ingested or used to treat disease.

Diagnostic medicine—Diagnostic medicine is the scientific study of body fluids, tissues, and organs to diagnose disease, monitor the course of disease, and monitor the response to treatment, particularly drug therapy.

Enzymes—Important naturally occurring biological catalysts present in the body. They enhance all body processes, including growth, maturation, and reproduction, and can be detected and measured in body fluids to diagnose and monitor disease. Synthetic enzyme reagents (not manufactured in the body) can be used as markers or labels in tests for other analytes.

Fluorescence—A phenomenon exhibited by molecules that absorb light energy and then give off the energy as light of a longer wave length. Fluorescent technology is a measurement technique used in clinical laboratory procedures and equipment.

Immunoassay—This type of assay is a measurement technique that uses binding reactions between different types of proteins, one protein being an antigen, the other an antibody that attaches to it. Known amounts of either antigen or antibody are combined with a blood sample or other body fluid to attract the analyte of interest and allow it to be detected and measured. Antigen-antibody reactions can be measured using enzyme technology, fluorescence, or radioisotopes.

Immunology—The scientific study of the immune system, which the body's defense system against bacteria, viruses, foreign cells (as in transfusion or transplantation). Immune reactions in the body involve antigen-antibody reactions that can be detected and evaluated using similar antigen-antibody technology.

Markers—Also called labels or tags. They attach to analytes in patient samples and allow them to be detected and measured by various measurement techniques using light, heat, or radioactivity. The term also refers to analytes that signal the presence of a specific disease. For example, troponin I is a marker for a heart attack because it is liberated from myocardial cells following infarction.

Pathology—The scientific study of the causes and consequences of disease.

Reagents—Reagents are chemical preparations (compounds) used to perform laboratory tests or used in the operation of laboratory equipment.

- Atomic absorption and ion-selective electrodes. These techniques are used to measure trace metals and electrolytes, respectively. Atomic absorption spectrophotometry is an optical method that converts ions to atoms and then measures the absorbance of a wavelength of light by the atoms. Metals most commonly measured are lead, **zinc**, mercury, selenium, and **copper**. Ion selective electrodes are sensors that produce a small potential difference (voltage) in response to specific ions. This technique is accurate but not as sensitive as atomic absorption spectrophotometry. Therefore, it is used for measuring ions that are relatively abundant in blood such as sodium, potassium, chloride, hydrogen ions, magnesium, **calcium**, and lithium.
- Automated blood cell counters. Hematology laboratories count red and white blood cells, measure hemoglobin (the iron-bearing protein in blood), and determine the hematocrit (the volume percentage of blood occupied by the red cells), as well as other tests reported in a **complete blood count (CBC)**. These tests can all be performed on an automated hematology system. Some automated systems can also identify each type of white cell in what is called a differential blood test. This automated system and its results are useful in diagnosing anemias, infections, leukemia and other blood disorders related to various types of cancer, and for general health screening.
- Flow cytometry. A flow cytometer is a more specialized type of cell counter that can differentiate, count, and in some cases sort specific subpopulations of cells. Flow cytometers make use of some of the rapidly expanding tools and molecular diagnostics. Fluorescent labeled antibodies are used to tag the cells of interest and these cells are counted as they flow in single file past through

an aperture into which a laser is focused. The laser stimulates the fluorochrome to emit light of a specific color. Light filters and detectors respond to the specific colors and the instrument's computer processes the resulting electrical signals to determine the cell count. Two rapidly advancing biosciences, genomics and proteomics, are being applied to flow cytometry to permit measurement of the DNA content of cells to determine if they are benign or cancerous.

Operation

Clinical instruments use a variety of measuring technologies to evaluate patient samples, but the principles of operation between analyzers share some fundamental characteristics. All methods on all instruments must undergo a preliminary evaluation of precision and accuracy to demonstrate that they meet the manufacturer's claims for analytical performance. All methods must be calibrated on a regular basis by analyzing samples of known concentration to which the measured signals from patient samples are compared. All methods must be validated using quality control specimens on a daily basis. The quality control sample is made of the same composition as patient samples and has an expected concentration that is specific for the method of assay. When results for quality control samples do not fall within the expected range, the operator must institute correction actions before patient specimens can be analyzed and reported. Automated instruments have intricate computerized monitoring systems and software codes that signal the operator when results are likely to be invalid. The operator must troubleshoot these problems and perform whatever steps are required to facilitate successful measurement of affected patient samples. Every test result is reviewed and evaluated with respect to quality control performance and its reasonableness before it is electronically transferred to the LIS for reporting.

Maintenance and safety

Laboratory personnel often are trained in the operation and maintenance of new equipment by the manufacturers of each type of instrument. Technologists are responsible for calibrating measuring devices such as pipets, equipment such as centrifuges, as well as all instruments. In addition, all incubators, refrigerators, and freezers are monitored for temperature accuracy and electrical lines are checked for current leakage and unstable voltage. All reagents are dated, examined for contamination, and stored in a manner that complies with safety regulations and manufacturer specifications. Instruments, equipment, glassware, and work surfaces are regularly cleaned and disinfected. Gloves, leak-proof

gowns, and other forms of barrier protection are utilized to reduce the risk of transmission of bloodborne pathogens and exposure to chemical and physical agents that may be harmful. While large hospitals may rely on staff biomedical engineers to perform some maintenance and instrument repairs, the laboratory personnel are responsible for day-to-day operation, cleaning and maintenance procedures. Each laboratory must maintain records of equipment calibration, cleaning and maintenance, and a manual of all laboratory procedures and policies. Laboratory operations, facilities, and services are inspected by external accrediting agencies that evaluate compliance by the laboratory with the Clinical Laboratory Improvement Act of 1988 (CLIA 88) as well as their own standards.

Health care team roles

Physicians order diagnostic tests from the medical laboratory to help diagnose and treat their patients. When an order is received by the laboratory, either on a manual lab request form or through the hospital MIS, the lab will first obtain the proper type of sample. This may involve drawing blood (venipuncture), which is typically performed by a phlebotomist (person who specializes in venipuncture). Samples such as urine, feces, sputum, or tissue usually are obtained by nurses or physicians in the nursing unit. Surgical samples will be delivered to the lab by surgical technicians. Some samples, such as single or 24-hour urine samples, are brought to the lab by patients themselves (if they are outpatients). Laboratory personnel are responsible for checking all specimens received in order to determine that they are properly labeled and collected in the proper container. Personnel responsible for specimen processing will separate the blood components if required and store the sample at the proper temperature prior to testing. Technologists or technicians perform the analysis, evaluate the test system using quality control procedures, and review each result before reporting it. Inappropriate specimens are rejected, and suspicious results may require repeat testing using a new sample. Critical values and stat requests must be called immediately to the ordering physician. Some physicians have issued a written request for follow-up testing when results are abnormal. Timely communication between the laboratory staff and the primary care provider is essential for effective utilization of laboratory tests and results.

Training

Laboratory medicine is a well developed field based upon natural and physical sciences that requires education in medical science, techniques and research methods. Pathologists are physicians (MDs) who have completed

four years of medical school, followed by a residency in a pathology laboratory. Medical laboratory technologists, technicians, and assistants who work in all fields of medical laboratory science are educated and trained at various levels. Those with more education will have greater technical and administrative decision-making responsibilities in the laboratory. Some may have advanced degrees (Ph.D. or M.S.) in sciences such as biochemistry or immunology. Certified technologists are required to have a Bachelor of Science degree and to have successfully completed an accredited laboratory training program. Their course of study typically includes anatomy, physiology, molecular biology, organic and biochemistry, immunology, microbiology, mathematics and statistics. Professional laboratory training includes courses in hematology, diagnostic and pathogenic microbiology, clinical immunology, immunohematology, and clinical biochemistry and urinalysis. A clinical practicum (internship) is typically required either as part of the baccalaureate degree or afterwards. After this training, graduates will be eligible for certification by examination by the American Society of Clinical Pathologists (ASCP) or National Certification Agency for Clinical Laboratory Personnel (NCA). Certified clinical laboratory technicians earn an associate degree from an accredited medical laboratory technician program. The program will include a clinical practicum as part of the training. Following this graduates are eligible for certification by examination by the American Society of Clinical Pathologists (ASCP) or National Certification Agency for Clinical Laboratory Personnel (NCA). Some vocational schools offer basic education and training for medical laboratory assistants, allowing graduates to perform some laboratory procedures and assist more skilled laboratory personnel.

Resources

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L. Lee Culvert

Medical laboratory technology

Definition

Medical laboratory technology is the branch of medical science responsible for performing laboratory investigations relating to the diagnosis, treatment, and prevention of disease.

Description

Laboratory scientists (medical and clinical technologists as well as medical and clinical laboratory technicians) facilitate the diagnosis of diseases, as well as the implementation and monitoring of therapies to treat disease. Laboratory scientists are responsible for examining and analyzing **blood**, body fluids, tissues, and cells in an effort to help clinicians determine the underlying cause of an illness, the stage of a disease, or the effectiveness of therapy. To accomplish their objectives, laboratory scientists perform a wide variety of laboratory tests, often with the aid of complex, computerized, and automated instrumentation.

Tests performed by laboratory scientists include:

- Microbiology tests that isolate and identify pathogenic **bacteria**, yeast, **fungi**, parasites, and **viruses** and determine antibiotic sensitivity.
- Chemistry tests that measure the chemical content of plasma, body fluids and cells including electrolytes, glucose, **lipids**, **proteins**, hormones, enzymes, trace metals, drugs, and toxins.
- Blood banking tests, such as typing, antibody screening, and cross matching, that are used to identify and prepare blood components that are compatible for transfusion.
- Immunology tests that are used to determine a person's ability to resist infections, diagnose autoimmune diseases, **allergies**, and infectious diseases, and determine tissue compatibility for organ transplantation.
- Hematology tests that count and classify blood cells, diagnose blood diseases, diagnose **bleeding disorders**, and monitor anticoagulant therapy.
- Histology procedures that prepare specimens for microscopic examination by pathologists.
- Cytology procedures such as the Pap smear test, which identify cancerous changes within cells.
- Cytogenetic procedures which identify abnormal chromosome counts, morphology, and disease genes.

Over the past few decades the proliferation of laboratory automation has significantly decreased the hands-on nature of the work. Today, many experienced laboratory scientists spend more time analyzing results, developing and modifying procedures, and establishing and monitoring quality control programs than they do performing tests.

Work settings

An article published in the July 1999 issue of *Medical Laboratory Observer* reported that “in general, medical technologists and medical laboratory technicians are stable professionally.” Laboratory scientists in their study, which was conducted in 1998 and 1999, had been employed at their current lab for 12 years and had been in the lab profession for 21 years. This job stability may be due in part to job flexibility. Because many large hospitals and reference laboratories operate 24 hours a day, seven days a week, they offer opportunities for laboratory scientists to work full or part-time, days, evenings, or nights. However, smaller hospitals with a more limited staff often require their laboratory scientists to rotate shifts, while others place laboratory workers on call several nights a week or on weekends to ensure coverage during an emergency situation. Working an occasional weekend and holiday is also quite common.

Clinical laboratories are well lit and clean, and the work is not physically demanding or particularly dangerous. That said, in a typical day most laboratory scientists will spend a significant portion of their day on their feet and be exposed to odiferous reagents and specimens, some of which will be infectious.

Wages for laboratory personnel are rising and correlate with the level of education and training. According to a survey conducted by the American College of Clinical Pathologists, the median annual salary for a staff medical technician in 2000 was \$29,120, an increase of 8.5% since 1998. In contrast, the median annual salary for a staff medical technologist in 2000 was \$37,232, an increase of 11.9% since 1998. For both technicians and technologists, salaries on the coasts were higher than elsewhere in the United States.

As the MLO article and others have reported, the majority of laboratory scientists work full-time in hospitals, reference and physician office laboratories. However, there are also numerous employment opportunities for laboratory scientists in forensic, environmental and food industry laboratories. In addition, manufacturers of home diagnostic testing kits and laboratory equipment and supplies seek experienced technologists to work in product development, marketing, and sales.



Medical laboratory technologists perform a variety of tests on body fluids and tissues to help physicians determine diagnoses and evaluate therapies. (Custom Medical Stock Photo. Reproduced by permission.)

Education and training

The Clinical Laboratory Improvement Act of 1988 (CLIA '88) sets minimum standards for testing personnel who work in clinical laboratories. For labs performing high complexity tests, the minimum requirement for testing personnel is an associate's degree in laboratory science. Persons who hold an associate degree from an accredited training program and certification are referred to as technicians. Persons who hold a bachelor's degree and certification in a clinical laboratory field are referred to as technologists. Certification is a prerequisite for most jobs, and some states require laboratory scientists to be licensed. Those holding a bachelor's degree with a major in medical technology or in one of the life sciences typically earn more money and receive more opportunities for advancement. While both technicians and technologists perform laboratory procedures, the technologist has greater knowledge of scientific principles and problem solving skills, and is responsible for oversight of quality assurance, method evaluation, and laboratory management.

Both bachelor and associate degree programs include courses in general and organic chemistry, general biology, microbiology, and anatomy and physiology. Specialized training includes courses in the specific laboratory disciplines. Baccalaureate programs also include courses in statistics, biochemistry, and immunology. Many four-year programs also offer courses in management, business, and computer technology.

There are several certifications available for laboratory personnel. The two most prominent organizations that certify lab personnel in the United States are the American Society of Clinical Pathologists board of Registry and the National Certification Agency for

KEY TERMS

Blood banking tests—Typing, antibody screening, and cross matching that are used to identify and prepare blood components that are compatible for transfusion.

Chemistry tests—Those tests for the measurement of electrolytes, glucose, lipids, proteins, hormones, enzymes, trace metals, drugs, and toxins.

Cytogenetic procedures—Techniques for chromosome counting and identification of abnormal chromosomes and disease genes.

Cytology procedures—Staining and examination of tissue samples in order to identify cancerous changes within cells.

Hematology tests—Tests to count and classify blood cells, diagnose blood diseases including coagulation disorders.

Histology procedures—Cutting, staining, and mounting of specimens for microscopic examination by pathologists.

Immunology tests—Tests which are used to determine a person's ability to resist infections, diagnose autoimmune diseases, allergies, and infectious diseases, and determine tissue compatibility for organ transplantation.

Medical laboratory technician—A clinical laboratory worker who may perform all levels of testing including quality control monitoring, specimen processing, and other laboratory operations.

Medical technologist—A clinical laboratory worker who performs all levels of testing, evaluates laboratory methods, verifies results, detects and resolves analytical problems, performs quality assurance, and consults with physicians and allied health professionals regarding laboratory services.

Microbiology tests—Those tests for the isolation and identification of pathogenic bacteria, yeast, fungi, parasites, and viruses and antibiotic sensitivity testing.

Medical Laboratory Personnel. Technicians with general certification by the American Society of Clinical Pathologists Board of Registry are denoted by the letters MLT (ASCP) and technologists with general certification by MT (ASCP). Technicians with general certification by the National Certification Agency for Medical

Laboratory Personnel are denoted by the letters CLT (NCA) and technologists with general certification by CLS (NCA).

Advanced education and training

Technicians can become technologists through additional education and experience, which may be covered, partially or fully, by a tuition reimbursement program offered by their current employer. Specialist certification is also available in blood banking, chemistry, cytotechnology, hematology, hemapheresis, immunology, and microbiology. For those desiring supervisor and management responsibilities the U.S. Department of Labor's *Occupational Outlook Handbook* suggests that a "graduate education in medical technology, one of the biological sciences, chemistry, management, or education usually speeds advancement." CLIA '88 mandates that a laboratory director hold an M.D. or Ph.D. with board certification or prior laboratory experience. Laboratory managers usually hold a bachelor's degree or higher.

Future outlook

According to the *2000 Wage and Vacancy Survey of Medical Laboratories* conducted by the American Society of Clinical Pathologists, "the year 2000 marked the highest vacancy rates reported per position over the 12-year comparison period." With 87% of the responding laboratories reporting vacancies in medical technologist and manager positions, it is easy to see why the U.S. Department of Labor expects employment opportunities for laboratory scientists to grow through the year 2008.

These shortages are most profound in the Northeast and East North Central regions of the United States, though no region seems unaffected. While over 65% of all laboratories with a vacancy were having trouble filling at least one shift for a staff medical technologist; cytotechnologists, histological technicians, histotechnologists and phlebotomists vacancies pose the greatest concern. The breadth of the problem is clear as over 70% of laboratories are using some combination of salary, benefits, sign-on bonuses, and tuition reimbursement to attract personnel to their facility.

For those laboratory scientists seeking something new, there are also numerous opportunities outside the laboratory in corporations and other businesses. As previously mentioned, manufacturers of home diagnostic testing kits and laboratory equipment and supplies seek experienced technologists to work in product development, marketing, and sales. In addition, the highly computerized laboratory of today is preparing many labora-

tory scientists for positions in information technology for the laboratory, the hospital, or any other business. Positions involving quality assurance or performance improvement, remote site testing, safety compliance or **infection control**, accrediting organizations, employee education, and laboratory consulting represent other avenues of opportunity for laboratory scientists. Better still, an article in the July 1999 issue of *Clinical Laboratory News* entitled “Where Will You Be Working in 2010?” predicts that “One of the major changes in how laboratorians are employed is that many will be self-employed, performing services for multiple companies and organizations. Furthermore, these changes will allow many laboratorians to work from home.”

Regardless of the career path chosen, the key to remaining employable is to continuously strive to gain new skills and to develop a network of contacts from a variety of sources, including co-workers, associations, and vendors.

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Medical lasers

Definition

A laser is a device that transforms one type of energy, usually electrical, into optical energy. The light waves in the beam produced by a laser are nearly parallel (collimated), nearly monochromatic, and coherent. The light beam is produced by exciting atoms and causing them to radiate their energy in phase. The word *laser* is an acronym that stands for Lightwave Amplification by Stimulated Emission of Radiation.

Purpose

Lasers have proven useful in all medical specialties to vaporize or coagulate tissue. Surgeons use lasers to perform controlled linear vaporization in order to cut tissue. Lasers can be used for surgery on all parts of the body, but are used most extensively in eye surgery and cosmetic skin procedures. An additional function of lasers is the sensing of physiological parameters.

Description

Lasers affect human tissue by transferring radiant energy to the target cells. The radiant energy turns into heat when the cells absorb it. As the target cells are heated, all their **proteins** are destroyed and their internal pressure rises rapidly. The cells then explode, giving off smoke-like steam called a laser plume. The major effects of most lasers on tissue are coagulation of **blood** and protein, and vaporization. Vaporization is the removal of tissue through its conversion from a solid to a gas.

Laser types

In general, there are two types of medical laser systems, contact and non-contact. Contact systems work by sending laser light through a fiber or sapphire crystal tip. The tip absorbs the radiant energy and becomes hot. Direct contact between the tissue and the heated tip causes conduction of the heat energy from the tip to the tissue, resulting in the vaporization of the target cells. In contrast, non-contact laser systems do not directly touch the tissue. Instead, the laser light transfers radiant energy to the tissue. Heat results when the cell absorbs the radiant energy and the molecules in the tissue begin to move. In both types of system, the laser light itself is not hot. Heat is created only after the laser's radiant energy is absorbed, either by the tip or by the tissue.

Laser components

All lasers, regardless of size, style, or application, have four main components: the active medium, the excitation mechanism, the feedback mechanism (high reflectance mirror), and the output coupler (partially transmissive mirror). Active media may be solid, liquid, gas, or electronic. Lasers are named for the medium that is used to produce the light. Some solid medium lasers commonly used in medical applications are erbium:yttrium aluminum garnet (Er:YAG); holium:yttrium aluminum garnet (Ho:YAG); neodymium:yttrium aluminum garnet (Nd:YAG); and alexandrite, ruby, and potassium titanyl phosphate (KTP). Carbon dioxide (CO₂), argon, copper vapor, and excimer lasers are examples of medical lasers with gas media. Dye lasers have liquid media and diode lasers have electronic media.

When energy is applied to the active medium of a laser, its electrons are raised to an unstable level of energy, from which they return spontaneously to a lower but relatively long-lived metastable (chemically unstable but not liable to spontaneous transformation) condition. These electrons will not return to their ground energy level. It is therefore possible to pump large amounts of energy into the active medium, to the point that most of its atoms are in a metastable state. The lasing action begins with an electron that returns to its ground state, producing a photon. If the photon has exactly the right wavelength, it will stimulate a metastable atom to emit another photon of the same wavelength. This process is called stimulated emission. If enough stimulated photons travel parallel to the long axis of the laser tube they will continue to stimulate the emissions of photons of the same wavelength. These photons combine coherently until they reach the mirrored ends of the laser tube. When the light beam strikes the reflecting mirror, it is reversed and continues to stimulate the emission of more photons. The beam increases in intensity until it reaches the partially reflecting mirror. A portion of the light is released while the rest is reflected back through the active medium to continue stimulating photon emission.

Medical lasers have three types of excitation mechanisms. In most gas lasers, high-voltage direct current electricity is used. With some CO₂ lasers, radiofrequency electricity excites the gas. This type of excitation is needed to produce an ultrapulsed output, which is the delivery of very fast, extremely powerful bursts of light. Media that do not conduct electricity, such as solid and liquid media, are excited with light produced by flashlamps or other lasers.

Specific medical applications

Certain lasers tend to be used for particular procedures to take advantage of the quality of the light and amount of absorption by different types of tissue. The CO₂ laser is quite versatile, able to perform both cutting and bulk vaporization. It is often used to perform gynecological procedures involving **colposcopy** as well as ear-nose-and throat (ENT) procedures using microlaryngoscopy, such as the treatment of snoring. The CO₂ laser is also useful for cosmetic skin resurfacing and in neurosurgery.

The Nd:YAG laser is a contact laser. It is used in abdominal, gynecological, or urological surgeries performed through laparoscopes, endoscopes, or hysteroscopes. The Er:YAG laser is used for bone cutting, hard tissue drilling in dentistry, and skin resurfacing. The Ho:YAG laser is useful for such orthopedic procedures as joint arthroscopies, as well as for urologic **lithotripsy** and ophthalmologic procedures.

Cosmetic laser hair removal is a very popular procedure that can be performed by diode, alexandrite, and ruby lasers. Ruby lasers can be used to remove tattoos. Argon and excimer lasers are used primarily to reshape the cornea in laser eye surgeries, although **heart** surgeons also use excimer lasers to perform angioplasties. Copper vapor or dye lasers are used to treat port-wine birthmarks. Tunable dye lasers and argon lasers are often used to repair such cosmetic vascular problems as varicose or spider veins.

Pulmonary and esophageal tumors are treated by a laser technique called photodynamic therapy (PDT). This technique has potential applications for treating many other types of tumors. In PDT, a photoreactive drug called dihematoporphyrin is administered systemically. The drug collects in tumor cells at a significantly higher concentration than in normal cells. Laser light from red dye lasers is then applied to the tumor site. The drug preferentially absorbs the light, causing the tumor cells to be vaporized and leaving the normal cells intact.

Operation

When a laser is used in surgery, there are three central control parameters—power in watts (set by the laser nurse); time of exposure (dependent on the speed of movement of the beam or tip); and spot size (an increase or decrease in the area contacted by the laser light, controlled by the surgeon in the field). In general, cutting is done with the smallest possible spot; that is, the beam is kept in tight focus. A change in power level changes the speed of incision. If the surgeon is vaporizing or debulking tissue, the key consideration is power density. Thus,

the spot size can be increased but the power is increased proportionately. Rather than continuous use of a lower level of power that can cause thermal damage to surrounding tissue, the surgeon may use a higher level of power on a pulsed setting. Superpulsing and ultrapulsing are the two levels of pulsing available.

Setting tests

Laser settings can be tested on a wet tongue depressor blade before they are used to vaporize tissue. Ideally, a 0.1-second test shot will leave a scoop-shaped depression in the wood shaped like a golf ball cut in half, with no point. A point indicates that the power density is too high. Rather than vaporizing the tissue cleanly, the laser will carve ridges and furrows in the tissue that might cause bleeding. If the depression is too shallow, the laser will be in use too long and cause charring.

The spatial quality of a laser beam can also be tested on a piece of thermal paper.

Safety issues and precautions

The use of lasers raises important safety issues. Categorized as Class IV devices by the Bureau of Radiological Health (BRH), all medical laser systems are fire hazards. They are also chemical hazards because of the compressed gases required to operate them and the fumes produced from lasing of the active medium. In addition, the laser dyes or solvents may be toxic. Lasers can produce skin or eye **burns**, and can cause retinal damage from direct or reflected beams. Lastly, lasers are explosion hazards; lasing of the active medium may cause flying fragments that can injure nearby personnel. Accordingly, a significant number of safety precautions are recommended. The American National Standards Institute (ANSI) standard Z136.3 addresses the safe use of lasers in health care settings and is an excellent resource for laser safety concerns. The ANSI directive establishes both engineering and administrative/procedural controls for four classes of lasers.

The following are among the recommended precautions:

- warning signs posted outside procedure room entrances
- all windows protected from transmission of laser light (not required for CO₂ lasers because it does not transmit through glass)
- protective eyewear rated for the wavelength being used for all personnel within the nominal hazard zone (which may be the entire procedure room)
- protection of the patient's eyes

KEY TERMS

Active medium—The solid, liquid, gas, or electronic substance used to produce the laser light. It contains atoms whose electrons can be excited to a metastable level of energy.

Excitation—The use of energy to move electrons present in the laser medium to a higher orbit around the atom nucleus.

Feedback—The use of mirrors in a laser tube to reflectively increase the intensity of the produced light.

Metastable—Chemically unstable but not liable to spontaneous transformation. Most of the atoms in the active medium of a laser must be raised to a metastable state before the lasing action can begin.

Output coupler—A mirror in the laser tube that part of the light beam can flow through because it is both reflective and transmissive.

Photodynamic therapy—The use of a photosensitive drug to selectively target tumor cells during laser treatment.

Pulsed laser—A laser that delivers energy in single or multiple pulses less than or equal to 0.25 second.

- lasers operated only by those who have received formal training in laser theory, control techniques, and operation
- the presence of a trained laser nurse or laser safety operator during the procedure
- the proper use of a laser smoke evacuator, equipped with a 0.3-micron filter if viral contamination is a concern
- judicious use of dulled (anodized) **surgical instruments** to reduce beam reflection
- careful packing of tissue surrounding beam area to avoid accidental exposure
- availability of water within the procedure room and a nearby fire extinguisher

Despite the numerous safety concerns associated with lasers, the light is not an ionizing radiation risk. Precautions such as those used with x-ray equipment are not necessary.

Maintenance

The maintenance of lasers requires specially trained laser technicians, often members of the hospital **biomedical engineering** department or an outsource company. Power calibrations are required every six months. Routine maintenance includes changing the laser's filters and deionizer water, replacing flashlamps, checking alignments, power outputs and fail-safe shields, and cleaning optics.

It is important to store lasers away from high-traffic areas to avoid miscalibration and damage to their internal mechanisms.

Health care team roles

Physicians who have received special training in the use of lasers are the only personnel who actually use the laser and control the foot pedal. Laser nurses aid in setting the controls of the device and are often responsible for filling out the laser log documenting the procedure. Laser technicians are responsible for the maintenance of the equipment and, if they are specially trained, laser repair.

The ANSI guidelines recommend the appointment of a laser safety officer (LSO) for the hospital. This person is responsible for ensuring that the safety procedures are followed for every laser procedure performed in the facility. Trained laser nurses or technicians may act under the LSO's authority. In many hospitals, the LSO is a senior laser nurse, a senior laser technician, or even a physician. This person has the authority to turn off the laser if he or she determines that its use would be hazardous to the patient or other personnel.

Training

Although there are no national accreditation standards for laser use, most hospitals have set up a laser committee that reviews applications from physicians who wish to perform laser procedures within the facility. In order to obtain operating privileges, many hospitals require training of at least eight hours with the particular type of laser that is to be used.

Some hospitals run their own training programs, while others rely on outside medical education companies. In either case, the training programs will cover the principles of laser use and safety; have a clinical practicum taught by specialists in the area of the physician's practice, and hands-on sessions with the laser. Many hospitals require practice with both inanimate and animal specimens.

Training for laser nurses is also run internally by each individual hospital. Course work includes basic

information about laser function, operation, and safety as well as specific training with the lasers used in the different procedures. Because laser nurses are often the LSO's eyes and hands in the operating room, it is essential for them to understand and implement the procedures required for safe laser use.

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The Laser Institute of America. 12424 Research Parkway, Orlando, FL 32826.

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Medical malpractice see **Malpractice**

Medical nutrition therapy

Definition

Medical **nutrition** therapy (MNT) refers to the assessment of the nutritional status of patients with an illness, diet-related condition, or injury, in order to benefit the patient's own health and reduce health-care costs. MNT includes setting goals for the patient's treatment and developing a specialized nutrition prescription that includes **patient education** and self-management training. MNT, which is also called therapeutic nutrition, has become an increasingly important component of integrated health-care systems.

Purpose

The purpose of MNT is to identify patients at risk for major nutrition-related health problems and recommend dietary adjustments leading to better health outcomes and improved quality of life. Eight of the 10 leading causes of death in the American population—including coronary **heart** disease, stroke, **diabetes mellitus**, and some can-

cers—are related to food and alcohol consumption patterns. Other important patient populations who benefit from MNT include the obese, the elderly, and infants of low birth weight. **Obesity** increases the risk of **gout**, **osteoarthritis**, sleep apnea, and **hypertension** as well as stroke and cardiovascular disease; while many of the elderly suffer from malnutrition. Low birth rate is the greatest single health risk in newborns.

MNT is also used to treat such disorders as anorexia and bulimia nervosa, **cystic fibrosis**, irritable bowel syndrome, hyperlipidemia, difficulty with lactose digestion, gastric ulcers, sprue (a **malabsorption syndrome**), and (in children) failure to thrive. Adequate nutrition is essential to reduce morbidity and mortality from these and other acute or chronic conditions. MNT helps to contain health-care costs while benefiting patients directly by offering alternatives to more expensive drug treatments and minimizing the need for surgery or lengthy hospital stays.

Description

Medical nutritional therapy is used in a variety of treatment settings, including **home care** and outpatient care as well as acute or long-term care facilities. In most of these settings, medical nutrition therapy includes a comprehensive review of the patient's medical history and a **dietary assessment** with laboratory values and anthropometric measurements.

Intake assessment

A key part of MNT includes an assessment of the patient's current and past diet history. A dietary assessment is often conducted to determine the macronutrient (energy or caloric, protein, and fat) content and the micronutrient (vitamin and mineral) content of the patient's food intake. Some of the most common dietary assessment tools include food records, dietary recalls, food frequency questionnaires, diet histories, and several other methods of data collection, including biochemical indices. A scientific assessment of nutritional status may be compiled from the information collected from clinical evaluations, biochemical tests, and dietary information. The clinical evaluation includes measurements of the patient's height, weight, and percentage of body fat (determined by skinfolds or hydrostatic weighing). In addition, a clinical evaluation may also include observation for signs of nutrient deficiencies in the mouth, skin, eyes, and nails. The information collected from a clinical evaluation is added to the results of the dietary assessment and biochemical tests to provide a comprehensive picture of the patient's current nutritional status and relative risk factors for diet-related illnesses. MNT can then

be designed to treat the patient's specific illness or diet-related condition.

In addition to the patient's overall medical history and specific evaluation of any diet-related illnesses or conditions, an initial evaluation may include an assessment of his or her:

- psychosocial data, including food-related attitudes and behaviors
- sociological data, including cultural practices, housing, cooking facilities, financial resources, and support of family and friends.
- general understanding of nutrition, including the relationship of diet to his or her disease or condition.
- learning style, together with his or her readiness to modify or change behavior.
- current **exercise** and activity level

Dietary modification

Dietary modification may include implementation of specialized diets for chronic conditions and diseases. Specialized diets in medical nutrition therapy may include:

- supplemental nutrition for patients who cannot obtain adequate nutrients through food intake alone
- enteral nutrition delivered via tube feeding into the gastrointestinal tract for those unable to eat normally or digest food
- parenteral nutrition delivered via intravenous infusion (IV) for those who cannot absorb nutrients

Patient education

Patient education is a critical dimension of medical nutrition therapy, in that patient compliance is essential to the success of any preventive or therapeutic nutritional program. Patient education in MNT may include task, guideline, and meal planning exercises. These exercises help to educate patients regarding proper food choices in the treatment or control of their specific illness or condition. Tasks are usually simple and objective responsibilities agreed upon by the dietitian, nutritionist, or doctor and the patient. An example of a task might include the patient's reviewing an itemized grocery receipt with the dietitian to determine if the foods that were purchased were appropriate to the nutrition plan.

A guideline approach provides the patient with nutrition information related to their specific illness, to be applied to their current eating habits. The patient can learn to plan and prepare appropriate meals with the

KEY TERMS

Dietary assessment—An estimation of food and nutrients eaten over a particular time point. Some of the most common dietary assessment methods are food records, dietary recalls, food frequency questionnaires, and diet histories.

Dietary counseling—Nutritional advice provided to an individual patient by a registered dietitian, nutritionist, or doctor for encouraging modification of eating habits.

Dietitian—A health professional with expertise in the field of nutrition and dietetics. Most have a bachelor's degree, followed by a period of clinical training.

Enteral nutrition—Feedings administered through a nose tube (or surgically placed tubes) for patients with eating difficulties.

Parenteral nutrition—Feeding administered most often by an infusion into a vein. It can be used if the gut is not functioning properly or due to other reasons that prevent normal or enteral feeding.

Therapeutic nutrition—Another term for medical nutrition therapy.

dietitian's help, and eventually become able to manage their nutritional regimen on their own.

Preventive care at all points along the spectrum of illness—primary (preventing disease), secondary (early diagnosis), and tertiary (preventing or slowing deterioration)—requires active patient participation as well as guidance from the dietitian and physician or nurse. Education, motivation, and counseling contribute to effective patient participation.

Preparation

There are many nonmedical issues that must be factored into planning appropriate **dietary counseling** and MNT. Due attention must be given to the patient's usual food choices, food likes and dislikes, cultural values, and the patient's ability to implement the dietary changes. In particular, the attitudes of other family members often influence the patient's compliance. Family members who are embarrassed by a patient's eating disorder, for example, may make her or his eating patterns and weight fluctuations the focus of most of the family's interactions. This focus will tend to reinforce the eating disorder rather than the medical nutrition therapy.

Aftercare

Nutrition therapy will be effective only if the patient is willing to implement the suggested recommendations. If a patient does not follow the recommended dietary guidance, then they will not receive a health benefit from MNT.

Patients who require continued MNT (parenteral or enteral nutrition) after leaving a hospital should receive frequent follow-up and monitoring by a registered dietitian.

Results

The large-scale results of MNT have been impressive enough in terms of cost-effectiveness to capture the attention of many large companies. A number of registered dietitians are now conducting on-site nutrition classes in corporate workplaces, participating in health and wellness fairs, and working with corporation food services to design more healthful menus, in addition to offering MNT to the firm's employees.

On the individual level, the effectiveness of MNT depends on the commitment of all members of the health-care team—but especially on the patient who has the nutrition-related illness. Prioritized goals are critical when developing the nutrition treatment plan, together with ongoing assessment by the patient and health care team members. Physicians must understand the patient's dietary plan and reinforce the nutrition therapy when interacting with the patient.

The American Dietetic Association maintains as its official position that MNT is an essential and cost-effective part of comprehensive health care services. Medical nutrition therapy is also effective in treating disease and preventing disease complications.

Health care team roles

In general, only registered dietitians (R.D.) have sufficient training and knowledge to accurately assess the nutritional adequacy of a patient's diet. Nutrition support teams, however, include registered dietitians as team members, often as team leaders. Because food and nutrition services span both medical and social contexts, medical nutrition therapy should be an interdisciplinary task in patient care. Physicians should learn the indications for special diets in order to facilitate referrals to dietitians and to reinforce patient compliance. Dietitians are needed to monitor patient populations receiving enteral, parenteral, and specialized oral therapies in conjunction with other health care team members (physicians, nurses/aids, home care workers, etc).

Some insurance plans cover fees for nutritional counseling by physicians and nurse practitioners as well as by registered dietitians directly supervised by physicians or employed by a participating institution. This inclusiveness reflects the growing significance of MNT in health care as well as the importance of coordinating the work of different health professionals in the area of nutrition.

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- Food and Nutrition Information Center Agricultural Research Service, USDA. National Agricultural Library, Room 304, 10301 Baltimore Avenue, Beltsville, MD 20705-2351. (301) 504-5719. Fax: (301) 504-6409. <<http://www.nal.usda.gov/fnic>>. fnic@nal.usda.gov.

OTHER

- Food and Nutrition Professionals Network. <<http://nutrition.cos.com>>.

Crystal Heather Kaczkowski, MSc.

Medical physics

Definition

Medical physics is the use of physics principles in the practice of medicine. It is most often used to describe physics applications related to the use of radiation in medicine—for example, the physics of diagnostic radiology, radiation oncology, and nuclear medicine. More broadly defined, medical physics may include the physics of other electromagnetic waveforms used in medical procedures such as **electrocardiography** (the study of electrical impulses in the **heart**) and **laser surgery**.

Description

Medical physics refers to the application of physics in medical diagnosis and treatment. The bulk of medical physics is encompassed by four subfields: diagnostic radiological physics, therapeutic radiological physics, medical nuclear physics, and medical health physics.

Diagnostic radiological physics

Diagnostic radiological physics is the branch of physics associated with diagnostic procedures that use x-rays, gamma rays, ultrasound, radio frequency radiation, and magnetic sources (**magnetic resonance imaging**). In this subfield, physicists advise on the protocols and technology used for the creation of images that are generated by these diagnostic methods. Responsibilities of the medical physicist include establishing, monitoring, and evaluating procedures related to equipment use; reporting to regulatory agencies on compliance matters; evaluating and monitoring equipment; and acting as consultant on matters related to instrumentation, equipment, and use of these radiological imaging systems.

Therapeutic radiological physics

Therapeutic radiological physics concerns itself with the physics of therapeutic procedures that use x rays, gamma rays, neutrons, charged particles, and radionuclides from sealed sources (radioactive material that is sealed permanently in a container). These therapeutic

procedures are often used in the treatment of **cancer** and include external beam therapy (where ionizing radiation is directed at the cancer site) and brachytherapy (where containers with radioactive material are placed near or in the tumor). Duties of the therapeutic radiological physicist include providing consultation on matters related to appropriate radiation dose and risks to patients; managing procedures and equipment related to dose and delivery of therapeutic radiation; reporting to regulatory agencies on compliance matters; and designing, evaluating, and monitoring radiation safety program related to therapeutic radiological procedures.

Medical nuclear physics

Also known as nuclear medicine physics, medical nuclear physics is the study of physics related to medical procedures requiring the use of radionuclides (except those radionuclides from sealed sources). These procedures may be diagnostic or therapeutic, and include such procedures as single photon emission computed tomography (SPECT), **positron emission tomography (PET)**, and radioimmunotherapy (radioisotopes attached to molecules that can be targeted to cancer cells). The medical nuclear physicist acts as consultant on matters related to appropriate radionuclide dose and risks; manages procedures and equipment related to dose and delivery of radionuclide imaging equipment; reports to regulatory agencies on compliance matters; and designs, evaluates, and monitors radiation safety program related to the nuclear medicine facility.

Medical health physics

The medical health physicist specializes in issues related to radiation safety in medical procedures. There is some overlap between medical health physics and the three other subfields since the use of radiation for medical purposes always requires some safety safeguards. The medical health physicist takes part in designing and specifying the radiation shielding required to protect patients, health care workers, and the general public; conducts risk assessment of procedures and protective equipment used in radiological and nuclear medicine; acts as consultant on issues related to radiation safety in a medical context; and evaluates and monitors compliance with regulatory radiation guidelines.

Work settings

Medical physicists and medical physics technologists work in clinical settings. Most medical physicists and technologists are employed by hospitals because the equipment used for the radiation-based medical procedures is located in these advanced medical facilities.

At teaching hospitals, medical physicists may, in addition to their role as physicists, be academic faculty at affiliated medical schools and/or clinical residency programs. At larger teaching hospitals, medical physicists may be organized into a medical physics department that provides services to other clinical departments. At non-teaching hospitals, medical physicists are members of individual clinical departments and are part of the hospital staff.

Education and training

The minimum education requirements for a medical physicist are an undergraduate degree—in physics, engineering, mathematics, or a related field—and a master's degree in medical physics. Graduate training should be done in a medical physics program that is accredited by the Commission on Accreditation of Medical Physics Educational Programs, Inc. Graduate work covers the physics principles and technologies associated with the relevant medical procedures and allow for specialization in a medical physics subfield. After the master's degree program, a medical physicist must attend a clinical residency program that lasts one to two years. Medical physicists with master's degrees who have completed residency and have obtained appropriate certification typically provide consultation services in hospitals.

The requirements for a technologist working in medical physics areas are a certificate, associate's degree, or a bachelor's degree in the appropriate subfield (e.g., nuclear medicine, radiography, radiation therapy) from an accredited program.

The requirements for a technologist working in medical physics areas are a certificate, associate's degree, or a bachelor's degree in the appropriate subfield (e.g., nuclear medicine, radiography, radiation therapy) from an accredited program.

Advanced education and training

After formal education, certification in a subfield of medical physics is required for medical physicists but is voluntary for technologists. Certification for United States medical physicists is obtained through one of three organizations: the American Board of Medical Physics, the American Board of Radiology, and the American Board of Science in Nuclear Medicine. Certification to become a qualified medical physicist through the American Board of Medical Physics consists of completing three steps. Part one of the process requires having obtained a graduate degree in physics, medical physics, or other relevant field, and having passed a written exam in general medical physics. The second part requires

passing the first part and having finished a clinical residency program, as well as having passed a written exam in a medical physics subfield. The third part requires having passed the first and second parts, having practiced independently as a medical physicist for a specified number of years, and having passed an oral exam in a medical physics subfield.

If a medical physicist wishes to pursue an academic career of teaching and research, a master's degree is generally not sufficient; he or she will need to have completed a PhD program in medical physics to be seriously considered for academic positions. Other requirements for an academic career include a post-doctoral fellowship of one to two years, certification as described above, and licensure if required by the state.

For technologists working in the areas related to medical physics, certification is voluntary and can be obtained through the American Registry of Radiologic Technologists or, if the specialty is nuclear medicine, the **Nuclear Medicine Technology** Certification Board. Certification may be obtained solely through finishing a specified medical technology program, or through a combination of formal education, clinical experience, and additional Board coursework. Some states also require licensure of their medical technologists.

Future outlook

The demand for medical physicists is expected to grow at a rate of 7% per year, which is about the average rate of job growth. The specialty of radiation therapy is expected to be the source of most new jobs, but developments in nuclear medicine and diagnostic techniques may provide a boost to labor demand in these fields. The average salary of a medical physicist (master's and PhD degree holders combined) in 2000–2001 is estimated to be \$57,060.

The demand for nuclear medicine technologists and radiologic technologists is expected to also grow at the same rate as the average rate for all jobs. There is a shift towards the merging of nuclear medicine and radiology departments, so that demand will be greatest for those technologists who have both nuclear medicine and radiologic skills. In 1998, the average salary of a nuclear medicine technologist was \$40,000; the average salary of a radiologic technician was \$33,000.

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American College of Medical Physics. 11250 Roger Bacon Drive, Suite 8, Reston, VA 20190-5202. (703) 481-5001. <<http://www.acmp.org>>.

American Registry of Radiologic Technologists. 1255 Northland Drive, St. Paul, MN 55120-1155. (651) 687-0048. <<http://www.arrt.org>>.

Genevieve Pham-Kanter

Medical records

Definition

Medical records are physical collections of patient-related materials that include written notes and materials, graphs, test results, x rays, and other data.

Purpose

Medical records have different purposes for the health care practitioner and the patient. The practitioner maintains records to document individual contacts with the patient, to monitor the individual patient's health status, to comply with legal requirements, and to monitor the practitioner's own professional behaviors.

The patient uses his or her medical record to provide information to various health care providers and to maintain a knowledge of his or her own health care.

Description

Medical records are created and maintained by health care professionals to supply medical practitioners with a sequential history of a patient's medical care and conditions affecting it. An individual's medical record is the collection of information that pertains solely to that person. It contains the information health care practitioners need to evaluate and treat the patient's health care needs. The record provides the patient's history of health care, past illnesses, test results, and other specific data.

Individual medical records are confidential, except in cases where disclosure of its contents are required by law. Information contained in a patient's medical record cannot be released without the patient's written consent.

KEY TERMS

Apprenticeship—Training a person who is new to the particular work being done, can also be on-the-job training.

Confidential—In medicine, implies a mutual trust between the patient and health care practitioner.

Medical history—Information about the patient's past medical services, procedures, illnesses, and needs.

Practitioner—Someone who engages in the science of medicine.

Social history—Information about the patient's past social needs and services utilized.

- apprenticeship or on-the-job training

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ORGANIZATIONS

U.S. House of Representatives Committee on Commerce. Washington, DC (202) 225-5735. <<http://commerce.house.gov>>.

Peggy Elaine Browning

Operation

Medical records are created by health care professionals and are an aid in the care of their patients. Specific information regarding a patient is contained in the records. Contents of medical records include health care professionals' notes about the patient, medical and social histories, physicians' assessments, x ray reports, the results of tests, and other materials specific to the treatment of the patient. Materials may be provided to other health care professionals or hospitals only with the patient's written consent.

Maintenance

Medical records are maintained by physicians, physician assistants, nurses, and medical records clerks. Only authorized personnel can make entries in the record.

Health care team roles

Health care professionals are required to keep accurate records. Information is recorded every time the patient is seen by a health care practitioner. Findings of each practitioner who treats the patient records are recorded in the appropriate section of the record.

Training

Health care practitioners receive training in keeping accurate medical records in several different ways, including:

- training during medical or nursing school
- classes at a vocational or business school

Medical terminology

Definition

Medical terminology is a system of words that are used to describe specific medical aspects and diseases. It is based on standard root words, prefixes, and suffixes.

Description

Medical terminology has evolved in great measure from the Latin and Greek languages. During the Renaissance period, the science of anatomy was begun. Many early anatomists were faculty members in Italian schools of medicine. These early anatomists assigned Latin names to structures that they discovered. This tradition has continued. For this reason, Latin accounts for the majority of root words in the English language.

Some names for conditions were retained from the teachings of Galen (A.D. 130–200), a Greek physician who wrote texts on medicine in the later part of his life. These remained influential for almost 1,500 years. Many of the disease and condition names first used by Galen have been retained. This accounts for the fact that the second most common source of medical root words is the Greek language.

Other older roots have their origins in Arabic. This is due to the fact that Arabic scholars were important teachers of medicine through the middle ages. Some modern roots are taken from the English language. This reflects the pre-eminence of the English language in medicine and biomedical sciences for the past half century.

The Latin language adds suffixes to nouns to denote different syntax constructions. Since suffixes were commonly used by Italian scientists, their use in medical settings were also retained. Some prefixes are adaptations of Latin words. In medical descriptions and terminology, they were attached to root words rather than being separate from the word that they were modifying. Prefixes are often used to indicate locations on the body or directions relative to planes or structures in the body.

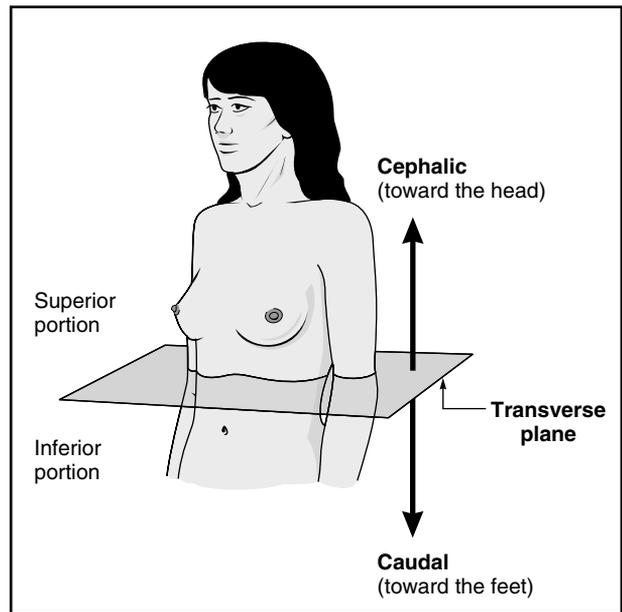
Some words in modern medical terminology have been borrowed from biology. Many of these are names of genus and species of pathogens. The use of Latin for these names dates to Carl Linnaeus (1707–1778) who founded the modern system of taxonomy.

Finally, from approximately 1650 through to 1850—while the system of medical terminology currently in use was being developed—Latin was the language of educated persons. This is another reason for the inclusion of so many linguistic elements (prefixes, roots, and suffixes) from the Latin language.

An example will illustrate how the system works. Consider that task of describing the movement of a finger and its associated structures. Two sets of muscles are involved. Extensors move a structure away from the body while flexors bring the same structure back towards the body. The fingers are called digits. A problem arises with realization that there are three bones in the fingers. Structures that are nearer to the center of the body are referred to as being proximal, while structures that are farther away are distal. A muscle that moves the smallest bone in a finger towards the palm is called a flexor digiti minimus. Thus, an accurate description of a person curling the small finger is action by the flexor digiti minimus on the distal phalanx of the fourth finger. Uncurling the same finger requires action by the extensor digiti minimus on the distal phalanx. While this system may seem cumbersome, it is precise and unambiguous.

Consider another example: an adenocarcinoma of the left superior lobe of the lung. The root (carcin-) indicates tissue that is cancerous. The suffix (-oma) indicates a tumor or abnormal growth. The prefix (adeno-) pertains to a gland. Thus, there is an abnormal or cancerous growth that has its origins in a glandular cell. The remainder of the description indicates the location of the growth. The designation (left) is in reference to the person who has the growth or is being examined, not the person who is performing the examination. Superior indicates the upper of the two lobes of the left lung.

Medical terminology is also employed when describing diseases or procedures. As an example, review acute **pancreatitis** in the posterior portion of the organ. The root (pancrea-) indicates the organ of involvement,



The transverse plane, also known as the horizontal plane, divides the body into superior (upper) and inferior (lower) portions. This division can be at the waist or any other level across the body. (Delmar Publishers, Inc. Reproduced by permission.)

the **pancreas**. The suffix (-itis) indicates an inflammation. Acute denotes a rapid onset, as contrasted to chronic which is of long duration. Posterior refers to the portion of the pancreas that is to the rear of the body. This portion of the organ is also called the head of the pancreas. This illustrates another important aspect of medical terminology, that there is frequently more than one way to accurately describe a location or structure.

An example of a procedure is a choledocholithotomy. This is a surgical operation to remove (-otomy) a stone (-litho-) that originated in the gall bladder (chole-) but is currently located in the common bile duct (-docho-). An hysterosalpingogram is an x-ray image (-gram) of the uterus (hystero-) and Fallopian tubes (-salpingo-).

The rules for combining prefixes, roots, and suffixes are generally based on Latin. In the Latin language, nouns have five different cases and can be singular or plural. Different endings indicate the form and meaning of the word. To make things more confusing for individuals who have not studied Latin, there may also be different forms of a word. The nominative singular form of the word for Fallopian tube is salpinx. The combining root is salpingo-. There are examples of combining forms in English. The plural of index is indices, the plural of apex is apices. As in Latin, English has different forms. Indexes is an acceptable plural form. The rules for words

KEY TERMS

- Ab**—Prefix meaning away from.
Ad—Prefix meaning to or toward.
Caudal—Toward the tail or rump.
Cranial—Toward the head.
Distal—Toward the periphery of the body.
-itis—Suffix meaning inflammation of.
Myo—Root word meaning muscle.
Ophthalmo—A root meaning eye.
-osis—Suffix meaning an increase when referring to a pathogenic condition.
Proximal—Toward the center of the body.

that come from Greek are quite similar although the endings may vary.

Viewpoints

One of the keys to medical terminology is learning a list of common prefixes, root words, and suffixes. Once that task is accomplished, constructing and understanding previously unseen words becomes possible. The system does not eliminate a medical dictionary but it does facilitate learning and communication.

In many respects, medical terms form a language that must be memorized and mastered. A second key to acquiring proficiency in medical terminology is practice with applications. This task is not fundamentally different than developing skill in a sport or learning to play a musical instrument.

Early anatomists and modern surgeons both share a need for precision in description. The system of medical terminology currently in use provides such details. Taken together, the system of prefixes and suffixes provides great precision and specificity.

Professional implications

A working knowledge of medical terminology is an absolute necessity for success in any of the medical sciences. It is highly useful for individuals who interact with medical professionals. Although knowledge of classical Latin or Greek is no longer the prerequisite for medical training as it was 50 years ago, knowledge of Latin eases the burden of learning much modern medical terminology.

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- American Academy of Family Physicians. 11400 Tomahawk Creek Parkway, Leawood, KS 66211-2672. (913) 906-6000. <<http://www.aafp.org>>.

American Medical Informatics Association. 4915 St. Elmo Avenue, Suite 401, Bethesda, MD 20814. (301) 657-1291. <<http://www.amia.org>>.

College of American Pathologists. 325 Waukegan Road, Northfield, IL 60093. (800) 323-4040. <<http://www.cap.org>>.

OTHER

British Medical Informatics Society. <<http://www.bmis.org>>.

English Centre. <<http://ec.hku.hk/mt>>.

International Medical Informatics Association.

<<http://www.imia.org>>.

University of Minnesota.

<http://www.gen.umn.edu/faculty_staff/jensen/1135/med_term_activites/default.html>.

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Medicare

Definition

Medicare is a national health insurance program created and administered by the federal government in the United States to address the medical needs of older American citizens. Medicare is available to U.S. citizens 65 years of age and older and some people with disabilities under age 65.

Description

Medicare is the largest health insurance program in the United States. The program was created as part of the Social Security Act in 1965 and was put into effect in 1966. At the end of 1966, Medicare served approximately 3.9 million individuals; today it serves about 39 million people.

In 1973, the Medicare program was expanded to include people who have permanent kidney failure and need dialysis or transplants and people under the age of 65 who have specific types of disabilities. Medicare was originally administered by the Social Security Administration, but in 1977, the program was transferred to the Health Care Financing Administration (HCFA), which is a part of the United States Department of Health and Human Services (DHHS). HCFA also administers **Medicaid** and the State Children's Health Insurance Program.

Medicare is an entitlement program similar to Social Security and is not based on financial need. Medicare benefits are available to all American citizens over the

age of 65 because they or their spouses have paid Social Security taxes through their working years. Since Medicare is a federal program, the rules for eligibility remain constant throughout the nation and coverage remains constant regardless of where the person receives treatment in the United States.

Medicare benefits are divided into two different types referred to as Part A or B. Medicare Part A is hospital insurance and it provides basic coverage for hospital stays and post-hospital nursing facilities, home health care, and hospice care for terminally ill patients. Most people automatically receive Part A when they turn 65 and do not have to pay a premium because they or their spouse paid Medicare taxes while they were working.

Medicare Part B is medical insurance. It covers most fees associated with basic doctor visits and laboratory testing. It also pays for some outpatient medical services such as medical equipment, supplies, and home health care and **physical therapy**. However, these services and supplies are only covered by Part B when medically necessary and prescribed by a doctor. Enrollment in Part B is optional and the Medicare recipient pays a premium of approximately \$50 per month for these added benefits. Not every person who receives Medicare Part A enrolls in Part B.

Although Medicare provides fairly broad coverage of medical treatment, neither Part A or B pays for the cost of prescription drugs or other medications.

Medicare is funded solely by the federal government. States do not make matching contributions to the Medicare fund. Social Security contributions, monthly premiums paid by program participants, and general government revenues generate the money used to support the Medicare program. Insurance coverage provided by Medicare is similar to that provided by private health insurance. Medicare usually pays 50–80% of the medical bill, while the recipient pays the remaining balance for services provided.

Viewpoints

As the population of the United States ages, concerns about health care and the financing of quality health care for all members of the elderly population grow. One concern is that health insurance provided by the Medicare program will become obsolete or will be cut from the federal budget in an attempt to save money. Another concern is that money provided by the Social Security Administration for Medicare will be depleted before the aging population of the United States can actually benefit from the taxes they are now paying.

KEY TERMS

DHHS—Department of Health and Human Service. The federal agency that distributes funds for Medicare.

HCFA—Health Care Financing Administration. The federal agency that provides guidelines for the Medicare program.

Medicare Part A—Hospital insurance provided by Medicare, provided free to persons aged 65 and older.

Medicare Part B—Medical insurance provided by Medicare that requires recipients pay a monthly premium. Part B pays for some medical services Part A does not.

Professional implications

During the Clinton administration, several initiatives were started that saved funds for Medicare. The DHHS also supports several initiatives to save and improve the program. However, continuance of the federal health insurance program is still a problem U.S. citizens expect legislation to resolve.

Some of the successful initiatives include:

- **Fighting fraud and abuse:** A great amount of attention has focused on Medicare abuse, fraud, and waste. As a result, over-payments were stopped, fraud was decreased, and abuse was investigated. This saved the Medicare program \$500 million in just one year.
- **Preserving the Medicare benefit:** Due to aggressive action by the HCFA and the Balanced Budget Act, it is estimated that funds have been appropriated to keep Medicare viable through 2026.
- **Prescription drug benefit proposal:** Health care reformers suggest that prescription drugs be made available through the Medicare program due to the high cost of prescription medication.
- **Supporting Preventive Medicine and the Healthy Aging Project:** Medicare programs are supporting preventive medicine and diagnostic treatments in anticipation that preventive measures will improve the health of older Americans and thereby reduce health care costs.

Medicare benefits and health care financing are major issues in the United States. Legislators and federal agencies continue to work on initiatives that will keep health care programs in place and working for the good of American citizens.

Resources

ORGANIZATIONS

Health Care Financing Administration. United States Department of Health and Human Services. 200 Independence Avenue SW, Washington, DC 20201. <<http://www.hcfa.gov>>.

United States Department of Health and Human Services. 200 Independence Avenue SW, Washington, DC 20201. <<http://www.hhs.gov>>.

Peggy Elaine Browning

Medication administration *see*
Administering medication

Medication preparation from a vial

Definition

Medical preparation from a vial is the method of preparing a drug contained in a vial into a usable form that is safe and effective for human delivery.

Purpose

- To facilitate safe and effective delivery of medications.
- To transform the medication from solid form to fluid form where appropriate.
- To prepare and transport the medication to equipment more suitable for final delivery.

Precautions

There are several precautions that health care providers need to keep in mind when preparing medications. These precautions protect both the practitioner and the patient. Risks most common to the health care provider include needlestick injuries from the equipment used to prepare the medication and the risk of splashing harmful drugs onto the skin, eyes and other mucous membranes, by which the body may uptake all or part of the drug. These are generally caused by incorrect methods of medication preparation. Failure to maintain sterility and contamination of the medication are the largest possible risks for the patient during this procedure. Strict adherence to guidelines set out by the health institution as well as those guidelines recommended for preparing particular medications provided by the manufacturers are vital to ensure safe preparation of any medication.

Description

Nearly all medications used for injections are distributed by manufacturers in sterile containers called vials. Some medications in these vials are in liquid form, whereas others are in solid form. Those in solid form usually break down readily in liquid form, losing their effectiveness. The solid (often powder) medication is then prepared by the health care provider shortly before use. Liquid medications are usually stable at room temperature and retain their quality. Many do not require further preparation or dilution to use, depending of course, on the route of administration chosen. It is considered safe practice to first read the manufacturer's documentation before preparing any drug for the first time or in cases where there is difference of opinion between health care providers in how the medication should be prepared from the vial. Workplace policy for delivery of particular drugs should also consult, as these can vary from institution to institution.

Preparation

Preparation of solid/powder medication from a vial:

- Check the medication order to ensure the right drug, the right dosage, the right medication chart for your patient, the correct time, the correct date, and the correct route of administration.
- Ensure familiarity with the correct dilution or mixing fluid to be used for the drug, for example, sterile water or normal saline.
- Gather the items to be used to prepare the medication from the vial. Usually for basic drug delivery, this requires a syringe, needle, dilution fluid, an alcohol swab, and the medication vial.
- Remove the protective cover from the vial and rub the penetrable surface with an alcohol swab. (This procedure is not standard at all institutions.)
- Wash the hands and don protective clothing (gloves, gowns, face mask, etc.) if you are drawing up hazardous drugs such as those used in chemotherapy.
- Maintain an **aseptic technique** throughout the preparation. While gloves are not always necessary, do not touch any parts of the equipment that deliver the medication directly to the patient.
- Draw up the dilution fluid into the syringe.
- Attach a needle to the same syringe (if not attached already) and insert directly into the vial.
- Inject all or a portion of the dilution fluid (depending on the manufacturer's recommendations) into the vial. Do not withdraw the syringe or needle from the vial.



Gloved hands should be used to take medication from a vial into a syringe. (Delmar Publishers, Inc. Reproduced by permission.)

- While holding the vial, **syringe and needle** (still inserted into the vial) in one hand, shake the vial vigorously to allow the dilution fluid and solid form medication to mix. Keep shaking the vial vigorously until all solid elements of the medication have been fully dissolved.
- Withdraw the contents of the vial back into the syringe. Remove all the fluid content of the vial to ensure the patient receives the full dose.
- Remove the needle and syringe from the vial.
- Remove the needle used for preparing your medication and attach a new sterile needle for delivery of the drug.
- Check the drug vial and medication order again for the correct drug and dosage requirements. The prepared medication should then be verified by a second health care provider (if required by the institution) for accuracy.
- Dispose of the used needle and vial safely and according to institution policy. Your prepared medication should now be safe for patient delivery.

Aftercare

It is essential to correctly dispose of items used during medication preparation. Needles should be disposed

of in needles or sharps containers, and vials should be disposed of in the appropriate manner. If hazardous chemicals are spilled, these should be cleaned according to protocol before any other staff member enters the area.

Complications

Needlestick injuries and splashing of medication onto the health care provider are common risks. Complications for the patient may arise if the medication was contaminated through improper preparation on behalf of the health care provider.

Results

Correct methods result in a medication successfully prepared for safe and effective delivery.

Health care team roles

Medication may be prescribed by a physician or advanced practice nurse. Medication may be prepared from the vial by a variety of health care professionals, including doctors, nurses, and emergency medical personnel. Medication preparation usually takes place in a professional health care environment, such as a hospital, clinic, or physician's office.

Resources

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Dean Andrew Bielanowski, R.N.

Meditation

Definition

Meditation is a practice of concentrated focus upon a sound, object, visualization, the breath, movement, or attention itself in order to increase awareness of the present moment, reduce **stress**, promote **relaxation**, and enhance personal and spiritual growth.

Origins

Meditation techniques have been practiced for millennia. Originally, they were intended to develop spiritual understanding, awareness, and direct experience of ultimate reality. The many different religious traditions in the world have given rise to a rich variety of meditative practices. These include the contemplative practices of Christian religious orders, the Buddhist practice of sitting meditation, and the whirling movements of the Sufi dervishes. Although meditation is an important spiritual practice in many religious and spiritual traditions, it can be practiced by anyone regardless of their religious or cultural background to relieve stress and **pain**.

As Western medical practitioners begin to understand the mind's role in health and disease, there has been more interest in the use of meditation in medicine. Meditative practices are increasingly offered in medical clinics and hospitals as a tool for improving health and quality of life. Meditation has been used as the primary therapy for treating certain diseases; as an additional therapy in a comprehensive treatment plan; and as a means of improving the quality of life of people with debilitating, chronic, or terminal illnesses.

Benefits

Meditation benefits people with or without acute medical illness or stress. People who meditate regularly have been shown to feel less **anxiety** and depression. They also report that they experience more enjoyment and appreciation of life and that their relationships with others are improved. Meditation produces a state of deep relaxation and a sense of balance or equanimity. According to Michael J. Baime, "Meditation cultivates an emotional stability that allows the meditator to experience intense emotions fully while simultaneously maintaining perspective on them." Out of this experience of emotional stability, one may gain greater insight and understanding about one's thoughts, feelings, and actions. This insight in turn offers the possibility to feel more confident and in control of life. Meditation facilitates a greater sense of calmness, empathy, and acceptance of self and others.

Meditation can be used with other forms of medical treatment and is an important complementary therapy for both the treatment and prevention of many stress-related conditions. Regular meditation can reduce the number of symptoms experienced by patients with a wide range of illnesses and disorders. Based upon clinical evidence as well as theoretical understanding, meditation is considered to be one of the better therapies for panic disorder, generalized anxiety disorder, substance dependence and

abuse, ulcers, colitis, chronic pain, psoriasis, and dysthymic disorder. It is considered to be a valuable adjunctive therapy for moderate **hypertension** (high **blood pressure**), prevention of cardiac arrest (**heart** attack), prevention of atherosclerosis (hardening of arteries), arthritis (including **fibromyalgia**), **cancer**, insomnia, migraine, and prevention of stroke. Meditation may also be a valuable complementary therapy for **allergies** and **asthma** because of the role stress plays in these conditions. Meditative practices have been reported to improve function or reduce symptoms in patients with some neurological disorders as well. These include people with **Parkinson's disease**, people who experience fatigue with **multiple sclerosis**, and people with epilepsy who are resistant to standard treatment.

Overall, a 1995 report to the National Institutes of Health on alternative medicine concluded that, "More than 30 years of research, as well as the experience of a large and growing number of individuals and health care providers, suggests that meditation and similar forms of relaxation can lead to better health, higher quality of life, and lowered health care costs..."

Description

Sitting meditation is generally done in an upright seated position, either in a chair or cross-legged on a cushion on the floor. The spine is straight yet relaxed. Sometimes the eyes are closed. Other times the eyes are open and gazing softly into the distance or at an object. Depending on the type of meditation, the meditator may be concentrating on the sensation of the movement of the breath, counting the breath, silently repeating a sound, chanting, visualizing an image, focusing awareness on the center of the body, opening to all sensory experiences including thoughts, or performing stylized ritual movements with the hands.

Movement meditation can be spontaneous and free-form or involve highly structured, choreographed, repetitive patterns. Movement meditation is particularly helpful for those people who find it difficult to remain still.

Generally speaking, there are two main types of meditation. These types are concentration meditation and mindfulness meditation. Concentration meditation practices involve focusing attention on a single object. Objects of meditation can include the breath, an inner or external image, a movement pattern (as in tai chi or **yoga**), or a sound, word, or phrase that is repeated silently (mantra). The purpose of concentrative practices is to learn to focus one's attention or develop concentration. When thoughts or emotions arise, the meditator gently directs the mind back to the original object of concentration.

Mindfulness meditation practices involve becoming aware of the entire field of attention. The meditator is instructed to be aware of all thoughts, feelings, perceptions or sensations as they arise in each moment. Mindfulness meditation practices are enhanced by the meditator's ability to focus and quiet the mind. Many meditation practices are a blend of these two forms.

The study and application of meditation to health care has focused on three specific approaches: transcendental meditation (TM); the "relaxation response," a general approach to meditation developed by Dr. Herbert Benson; and mindfulness meditation, specifically the program of mindfulness-based stress reduction (MBSR) developed by Jon Kabat-Zinn.

Transcendental meditation

TM has its origins in the Vedic tradition of India and was introduced to the West by Maharishi Mahesh Yogi. TM has been taught to somewhere between two and four million people. It is one of the most widely practiced forms of meditation in the West. TM has been studied many times; these studies have produced much of the information about the physiology of meditation. In TM, the meditator sits with closed eyes and concentrates on a single syllable or word (mantra) for 20 minutes at a time, twice a day. When thoughts or feelings arise, the attention is brought back to the mantra. According to Charles Alexander, an important TM researcher, "During TM, ordinary waking mental activity is said to settle down, until even the subtlest thought is transcended and a completely unified wholeness of awareness...is experienced. In this silent, self-referential state of pure wakefulness, consciousness is fully awake to itself alone..." TM supporters believe that TM practices are more beneficial than other meditation practices.

The relaxation response

The relaxation response involves a similar form of mental focusing. Dr. Herbert Benson, one of the first Western doctors to conduct research on the effects of meditation, developed this approach after observing the profound health benefits of a state of bodily calm he calls "the relaxation response." In order to elicit this response in the body, he teaches patients to focus upon the repetition of a word, sound, prayer, phrase, or movement activity (including swimming, jogging, yoga, and even knitting) for 10–20 minutes at a time, twice a day. Patients are also taught not to pay attention to distracting thoughts and to return their focus to the original repetition. The choice of the focused repetition is up to the individual. Instead of Sanskrit terms, the meditator can choose what



Row of Zen Buddhist nuns with shaved heads and dark robes.. (Horace Bristol/Corbis. Reproduced by permission.)

is personally meaningful, such as a phrase from a Christian or Jewish prayer.

Mindfulness meditation

Mindfulness meditation comes out of traditional Buddhist meditation practices. Psychologist Jon Kabat-Zinn has been instrumental in bringing this form of meditation into medical settings. In formal mindfulness practice, the meditator sits with eyes closed, focusing the attention on the sensations and movement of the breath for approximately 45–60 minutes at a time, at least once a day. Informal mindfulness practice involves bringing awareness to every activity in daily life. Wandering thoughts or distracting feelings are simply noticed without resisting or reacting to them. The essence of mindfulness meditation is not what one focuses on but rather the quality of awareness the meditator brings to each moment. According to Kabat-Zinn, “It is this investiga-

tive, discerning observation of whatever comes up in the present moment that is the hallmark of mindfulness and differentiates it most from other forms of meditation. The goal of mindfulness is for you to be more aware, more in touch with life and whatever is happening in your own body and mind at the time it is happening—that is, the present moment.” The MBSR program consists of a series of classes involving meditation, movement, and group process. There are over 240 MBSR programs offered in health care settings around the world.

Meditation is not considered a medical procedure or intervention by most insurers. Many patients pay for meditation training themselves. Frequently, religious groups or meditation centers offer meditation instruction free of charge or for a nominal donation. Hospitals may offer MBSR classes at a reduced rate for their patients and a slightly higher rate for the general public.

Precautions

Meditation appears to be safe for most people. There are, however, case reports and studies noting some adverse effects. Thirty-three to 50% of the people participating in long silent meditation retreats (two weeks to three months) reported increased tension, anxiety, confusion, and depression. On the other hand, most of these same people also reported very positive effects from their meditation practice. Kabat-Zinn notes that these studies fail to differentiate between serious psychiatric disturbances and normal emotional mood swings. These studies do suggest, however, that meditation may not be recommended for people with psychotic disorders, severe depression, and other severe **personality disorders** unless they are also receiving psychological or medical treatment.

Side effects

There are no reported side effects from meditation except for positive benefits.

Research and general acceptance

The scientific study of the physiological effects of meditation began in the early 1960s. These studies prove that meditation affects **metabolism**, the **endocrine system**, the **central nervous system**, and the **autonomic nervous system**. In one study, three advanced practitioners of Tibetan Buddhist meditation practices demonstrated the ability to increase “inner heat” as much as 61%. During a different meditative practice they were able to dramatically slow down the rate at which their bodies consumed oxygen. Preliminary research shows that mindfulness meditation is associated with increased levels of melatonin. These findings suggest a potential role for meditation in the treatment and prevention of breast and prostate cancer.

Despite the inherent difficulties in designing research studies, there is a large amount of evidence of the medical benefits of meditation. Meditation is particularly effective as a treatment for chronic pain. Studies have shown meditation reduces symptoms of pain and pain-related drug use. In a four-year follow-up study, the majority of patients in a MBSR program reported “moderate to great improvement” in pain as a result of participation in the program.

Meditation has long been recommended as a treatment for high **blood** pressure; however, there is a debate over the amount of benefit that meditation offers. Although most studies show a reduction in blood pressure with meditation, medication is still more effective at lowering high blood pressure.

KEY TERMS

Dervish—A member of the Sufi order. Their practice of meditation involves whirling ecstatic dance.

Mantra—A sacred word or formula repeated over and over to concentrate the mind.

Transcendental meditation (TM)—A meditation technique based on Hindu practices that involves the repetition of a mantra.

Meditation may also be an effective treatment for **coronary artery disease**. A study of 21 patients practicing TM for eight months showed increases in their amount of **exercise** tolerance, amount of workload, and a delay in the onset of ST-segment depression. Meditation is also an important part of Dean Ornish’s program, which has been proven to reverse coronary artery disease.

Research also suggests that meditation is effective in the treatment of chemical dependency. Gelderloos and others reviewed 24 studies and reported that all of them showed that TM is helpful in programs to stop smoking and also in programs for drug and alcohol abuse.

Studies also imply that meditation is helpful in reducing symptoms of anxiety and in treating anxiety-related disorders. Furthermore, a study in 1998 of 37 psoriasis patients showed that those practicing mindfulness meditation had more rapid clearing of their skin condition, with standard UV light treatment, than the control subjects. Another study found that meditation decreased the symptoms of fibromyalgia; over half of the patients reported significant improvement. Meditation was one of several stress management techniques used in a small study of HIV-positive men. The study showed improvements in the T-cell counts of the men, as well as in several psychological measures of well-being.

Training and certification

There is no program of certification or licensure for instructors who wish to teach meditation as a medical therapy. Meditation teachers within a particular religious tradition usually have extensive experience and expertise with faith questions and religious practices but may not have been trained to work with medical patients. Different programs have varied requirements for someone to teach meditation. In order to be recognized as an instructor of TM, one must receive extensive training. The Center for Mindfulness in Medicine, Health Care

and Society at the University of Massachusetts Medical Center offers training and workshops for health professionals and others interested in teaching mindfulness-based stress reduction. The Center does not, however, certify that someone is qualified to teach meditation. The University of Pennsylvania program for Stress Management suggests that a person have at least ten years of personal experience with the practice of mindfulness meditation before receiving additional instruction to teach meditation. Teachers are also expected to spend at least two weeks each year in intensive meditation retreats.

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ORGANIZATIONS

- The Center for Mindfulness in Medicine, Health Care and Society. Stress Reduction Clinic. University of Massachusetts Memorial Health Care. 55 Lake Avenue North, Worcester, MA 01655. (508) 856-2656. Fax (508) 856-1977. jon.kabat-zinn@banyan@ummed.edu. <<http://www.mbst.com>>.
- Insight Meditation Society. 1230 Pleasant, St. Barre, MA 01005. (978) 355-4378. FAX: (978) 355-6398. <<http://www.dharma.org>>.
- Mind-Body Medical Institute. Beth Israel Deaconess Medical Center. One Deaconess Road, Boston, MA 02215. (617) 632-9525. <<http://www.mindbody.harvard.edu>>.

OTHER

Videos are available from the organizations listed above.

Linda Chrisman

Meiosis see **Cell division**

Melanoma see **Malignant melanoma**

Membranes see **Cell membranes**

Memory

Definition

Memory is the ability to recall information in the form of past events, ideas, and feelings. People have different types of memories, including short-term and long-term memory, and auditory and visual memory.

Description

A brief history

The study of memory can be traced all the way back to Plato and Aristotle. Plato's metaphor for memory likened it to the impression made by a seal on wax and has been sustained throughout the history of Psychology. Aristotle's differentiation between memory and recollection closely parallels what we now refer to as short- and long-term memory. Although many other explanations of memory have been offered throughout history it would be another 1500 years before scientific methods were used in the study of memory.

The first use of the scientific method (i.e., rigorous experimental controls and statistical analyses) in the study of memory is credited to the German psychologist Hermann Ebbinghaus (1850–1909). Prior to the publication of his book *On Memory* in 1885, very little had been written about memory utilizing scientific methods and precise terminology. Ebbinghaus began by memorizing lists of unrelated words and later tested his memory for these words. He soon realized that some words were more familiar than others and were easier to recall. Consequently, he constructed lists of nonsense syllables, consisting of a consonant, a vowel, and a consonant. They are often referred to as CVCs, or trigrams (e.g., BIJ, VUN, PIB). Ebbinghaus wanted to know how much he could remember after various delay intervals, from 20 minutes to 30 days. It quickly became obvious that much of what he learned was quickly forgotten. But he also noticed that the more frequently he rehearsed (i.e., repeated) the list on day 1, the more quickly he could relearn it on day 2. He thus established a basic principle, namely that the time spent on learning affects the subsequent recall of the material. Ebbinghaus's approach has been referred to as a quantity-orientated approach. This perspective treats memory as a storehouse in which items are deposited and are later retrieved. It continues to be used to produce much of the data found in scientific journals today.

Ebbinghaus laid the foundation for the study of memory but he had little to say about the causes of forgetting. Georg Elias Muller (1850–1934) was the pioneer

of what we now call the interference theory of forgetting. The interference theory, simplified, suggests that forgetting is not a consequence of material dying away but rather is due to other memories interfering at the time of retrieval. Two types of interference are retroactive interference and proactive interference. Retroactive interference refers to recently learned material interfering with the ability to remember previously stored information. Proactive interference refers to just the opposite phenomenon, when previously learned material interferes with the remembering of similar newly learned material.

Decay theory refers to the notion that the passage of time will cause memory traces to erode if they are not accessed from time to time. Generally speaking the longer the interval between learning and recall the less information will be recalled. The decay theory more effectively accounts for forgetting in the short term (e.g., remembering a phone number), whereas interference theory better accounts for long term forgetting.

The three-box model of memory

There are several existing models of memory but we will focus our attention on the three-box model because it is effective in organizing and accounting for many of the major research findings, and is the most widely used model you will encounter.

The three-box approach was originally termed the separate storage model by its developers, Atkinson and Shiffrin, in 1971. They proposed three separate but interacting systems that are used to gather, store, maintain, and retrieve information. The three systems are: sensory memory which acquires and holds incoming information for a second or two; short-term memory (STM) which holds information for approximately 30 seconds, unless an effort is made to keep it there longer; and long-term memory (LTM) which can hold information from a few minutes to decades.

Information from the environment enters the sensory memory store and remains there for half a second for visual stimuli and approximately two seconds for auditory stimuli. We also receive information from our sense of **smell** and from our sense of touch. These are referred to respectively as olfactory memory and tactile memory. Research in these latter two areas is relatively limited. The sensory memory store has been studied most extensively in regard to **vision** or iconic memory. A flash of lightening lasts only a fraction of a second but we can see the impression of the countryside for a moment after it occurs. This persisting impression is what is referred to as iconic sensory memory store.

We have all had the experience of performing a task while people are speaking in the background. In such sit-

uations you are not attending to the conversation but are instead focussed on the task at hand. Now suppose you hear your own name come up in the ongoing conversation. You suddenly become aware of it. This is an example of auditory sensory memory. Obviously, some portion of the speech stream is being stored in memory, otherwise you would not be able to recognize your name when it occurs.

One important thing to remember about both visual and auditory sensory memory is that the information is maintained for, at the very most, a few seconds before it is lost forever unless you pay attention to it and place it in your short term memory. Information that has been attended to is transferred from the sensory system to the short term memory (STM) store and remains there for thirty seconds or so unless the information is rehearsed, in which case it may remain for a longer period of time. STM is sometimes referred to as working memory or immediate memory because we have easy access to its contents. We have all experienced dialing the operator to obtain a phone number. Typically, we rehearse (i.e., repeat) the number to commit it to memory, hang up the receiver, and then dial the number. Should we need to use the same number later that day we most will likely have to look it up again. This illustrates the fact that information in STM will disappear unless we make a concerted effort to maintain it. Moreover, the capacity of STM is limited. If phone numbers were any longer than seven digits, dialing errors would increase substantially. Push button phones lowered the frequency of dialing errors because the time required to maintain the phone number in memory was reduced. With the old rotary phones, we used to have to wait until the disk returned to its original position before dialing the next number. With the higher digits (0, 9, 8, etc.) this could take a couple of seconds, thus putting an extra burden on our short term memory.

If information is transferred from STM to the LTM store it's retention may last from minutes to decades and in some cases its storage is permanent. It is here, in LTM, that information is organized and indexed. You know your name, what you did last Saturday night, how to ride a bicycle, and who the president of the United States is. These are all examples of information that resides in LTM. There are three different types of information in LTM: episodic memory; procedural memory; and semantic memory.

Episodic memory refers to the memory of events or activities (e.g., summer vacation or graduation day). What these memories have in common is that they refer to specific experiences. Some episodic memories are readily recalled while others may need prompting. Generally speaking the more significant the experience the more readily it can be recalled. Some insignificant

events may need considerable prompting if they are to be remembered and some may not be remembered at all.

Procedural memory contains stored physical skills and behavioral operations. For example you may have learned how to roller-blade or skateboard. You have learned how to write a letter or an essay. Procedural memories are “how-to” memories. These memories are readily available even after years of disuse. The expression “It’s like riding a bike, you never forget” captures this sense of permanency.

Semantic memory refers to general knowledge (e.g., the capital of France; what a zebra looks like). Semantic memory involves the meaning of words and objects. For example, most people know what an igloo is, but not as a result of having built one or being inside one.

WHAT GETS STORED AND WHAT GETS LOST? If we stop to consider the sheer volume of sensory input with which we are bombarded each day, it would be inconceivable that all of it passes into STM let alone LTM. What determines what gets saved and what gets lost? As mentioned earlier what we attend to in the sensory memory gets transferred to STM store. But how does this occur?

Encoding is the process by which information is added to our memory stores. Encoding changes the information we receive from our senses into a format that our brains can process and store. We do not encode into memory all that we see, hear, smell, touch, or feel. Sensory memory not only acts a holding tank from which items are selected for encoding and storage in STM, but it also acts as a filter, keeping out unimportant bits of information.

Information that is rehearsed in STM is accessible for immediate use, and can also be transferred to LTM. Other than acting as a retaining center for new information, the STM store also holds information for immediate use that has been recovered from the LTM store. It is for this reason that it is often referred to as working memory. When you spell a word the letters themselves and their appropriate arrangements enter the STM system as a result of having been retrieved from LTM.

When we make a deliberate effort to remember material we not only use rehearsal strategies, but other processes as well. Two of these processes are deep processing and mnemonics. Deep processing refers to the degree or “depth” to which we analyze or deal with the information. It can be contrasted with rote memorization, which can occur without our having any real understanding of the material. For example, it is possible (with considerable effort), to memorize passages of Latin without having any knowledge whatsoever of what the sentences mean. With deep processing however, the material to be

remembered is not simply rehearsed but understood, elaborated upon, and thought about. It is its meaning that is encoded, not merely its initial form of expression. For example suppose you are trying to remember that an erythrocyte is a red **blood** cell. If you also appreciate that that the protein hemoglobin produces the red color, and the unique biconcave shape of the erythrocyte increases its surface area and thus facilitates the exchange of O₂ and CO₂ into or out of the cells of our bodies, you are using deep processing. On the other hand if you simply memorize the spelling of erythrocyte and repeat to yourself that it is a red blood cell you are using rehearsal.

To increase the chances of retrieving information from LTM, mnemonics may help. A mnemonic is a trick or device that we can use when encoding information that will help us retrieve it later on. Using our above example of erythrocytes, if you were to use the mnemonic “Red Engines Haul Oil to Boston” you could use that simple sentence to recall a fair amount of information about erythrocytes. In this example, the first letter of each word corresponds to some aspect of the to-be-remembered material (red blood cells, erythrocytes, hemoglobin, oxygen, and body) and the sentence describes what the red blood cells do—carry oxygen to the bodies cells. A good mnemonic is one that is simple, uses concrete nouns, and permits the formation of a clear visual image. If the mnemonic itself is difficult to remember, its usefulness is nullified.

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Timothy E. Moore

Meningioma see **Brain tumor**

Meningitis

Definition

Meningitis is a potentially fatal inflammation of the meninges, the thin, membranous covering of the **brain** and the **spinal cord**. Meningitis is most commonly

caused by **infection (bacteria, viruses, or fungi)**, although it can also be caused by bleeding into the meninges, **cancer**, diseases of the **immune system**, and an inflammatory response to certain types of **chemotherapy** or other chemical agents. The most serious and difficult-to-treat types of meningitis tend to be those caused by bacteria.

Description

Meningitis is a particularly dangerous infection because of the very delicate nature of the brain. Brain cells are among a very small number of cells in the body that, once killed, will not regenerate. Therefore, if enough brain tissue is damaged, serious, life-long handicaps may remain.

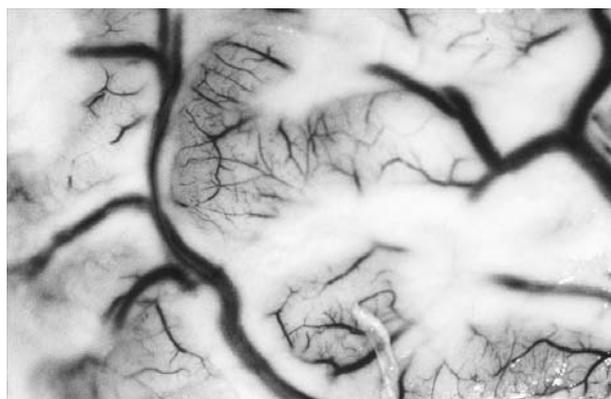
To understand meningitis, it is important to have a basic understanding of the anatomy of the brain. The meninges are three separate membranes layered together that encase the brain and spinal cord:

- The dura is the toughest, outermost layer, and is closely attached to the inside of the **skull**.
- The arachnoid, the middle layer, is important because of its involvement in the normal flow of the cerebrospinal fluid (CSF), a lubricating and nutritive fluid that bathes both the brain and the spinal cord.
- The pia, the innermost layer, helps direct **blood vessels** into the brain.

The space between the arachnoid and the pia contains CSF, which helps insulate the brain from trauma. Many **blood** vessels course through this space.

CSF, produced within specialized chambers deep inside the brain, flows over the surface of the brain and spinal cord. This fluid serves to cushion these relatively delicate structures, as well as to supply important nutrients for brain cells. CSF is reabsorbed by blood vessels located within the meninges. A careful balance between CSF production and reabsorption is important to avoid the accumulation of too much CSF.

Because the brain is enclosed in the hard, bony case of the skull, any disease that produces swelling of the brain will be damaging. The skull cannot expand at all; so, when any swollen brain tissue pushes up against the skull's hard bone, brain tissue may become damaged and ultimately die. Swelling on one side of the brain will not only cause pressure and damage to that side of the brain, but, because it takes up precious space within the tight confines of the skull, the opposite side of the brain will also be pushed against the skull, causing damage to that side also.



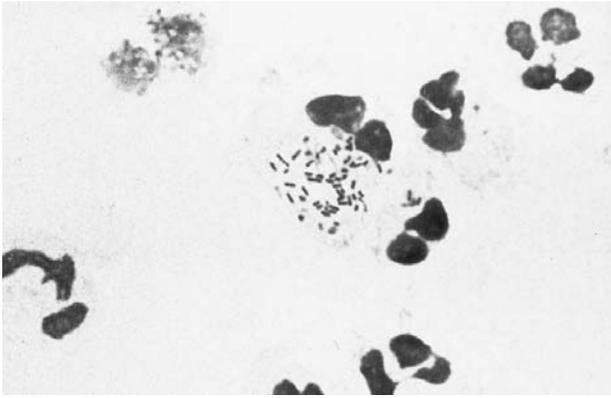
Brain tissue covered with thick white exudate from acute meningitis. (Custom Medical Stock Photo. Reproduced by permission.)

Another way that infections injure the brain involves the way the chemical environment of the brain changes in response to that infection. Brain cells require a very well-regulated environment. Careful balance of oxygen, carbon dioxide, sugar (glucose), sodium, **calcium**, potassium, and other substances must be maintained to avoid damage to brain tissue. An infection upsets this balance. Brain damage can occur when cells are either deprived of important nutrients or exposed to toxic levels of particular substances.

The cells lining the brain's tiny blood vessels (capillaries) are specifically designed to prevent many substances from passing into brain tissue. This is commonly referred to as the blood-brain barrier. The blood-brain barrier prevents various substances that could be harmful to brain tissue (toxins), as well as many agents of infection, from crossing from the blood stream into the brain tissue. While this barrier is obviously an important protective feature for the brain, it also serves to complicate treatment in the case of an infection by making it difficult for medications to pass out of the blood and into the brain tissue where an infection is located.

Causes and symptoms

The most common infectious causes of meningitis vary according to an individual's age, habits, living environment, and health status. While nonbacterial types of meningitis are most common, bacterial meningitis is the more potentially life threatening. Three bacterial agents are responsible for about 80% of all bacterial meningitis cases. These bacteria are *Haemophilus influenzae* type b, *Neisseria meningitidis* (causing meningococcal meningitis), and *Streptococcus pneumoniae* (causing pneumococcal meningitis).



Gram stain of *Haemophilus influenzae* (causes bacterial meningitis) in cerebrospinal fluid (CSF). (Delmar Publishers, Inc. Reproduced by permission.)

In newborns, the most common agents of meningitis are those contracted from the newborn's mother, including Group B streptococci (which is becoming an increasingly common infecting organism in the newborn period), *Escherichia coli*, and *Listeria monocytogenes*. The highest incidence of meningitis occurs in babies younger than a month old, with an increased risk of meningitis continuing through about two years of age.

Older children are more frequently infected by the bacteria *Haemophilus influenzae*, *Neisseria meningitidis*, and *Streptococci pneumoniae*.

Adults are most commonly infected by either *S. pneumoniae* or *N. meningitidis*, with pneumococcal meningitis the most common. Certain conditions predispose an individual to this type of meningitis, including **alcoholism** and chronic upper respiratory tract infections (especially of the middle ear, sinuses, and mastoids).

N. meningitidis is the only organism that can cause epidemics of meningitis. In particular, these appear to occur when a child in a crowded day-care situation, or a military recruit in a crowded training camp, has fallen ill with meningococcal meningitis.

Viral causes of meningitis include the herpes simplex virus, the mumps and measles viruses (against which most children are protected due to mass immunization programs), the virus that causes chicken pox, the rabies virus, and a number of viruses that are acquired through the bites of infected mosquitoes.

A number of medical conditions predispose individuals to meningitis caused by specific organisms. People with **AIDS** (acquired **immunodeficiency** syndrome) are more prone to getting meningitis from fungi, as well as from the agent that causes **tuberculosis**. Persons who have had their spleens removed, or whose spleens are no longer functional (as in the case of individuals with **sick-**

le cell disease) are more susceptible to meningococcal and pneumococcal meningitis.

The majority of meningitis infections are acquired by blood-borne spread. A person may have another type of infection (of the **lungs**, throat, or tissues of the **heart**) caused by an organism that can also cause meningitis. If this initial infection is not properly treated, the organism will continue to multiply, find its way into the blood stream, and be delivered in sufficient quantities to pass the blood brain barrier. Direct spread occurs when an organism spreads to the meninges from infected tissue next to or very near the meninges. This can occur, for example, with a severe, poorly treated ear or sinus infection.

Persons who suffer from skull **fractures** possess abnormal openings to the sinuses, nasal passages, and middle ears. Organisms that usually live in the human **respiratory system** without causing disease can pass through such openings, reach the meninges, and cause infection. Similarly, people who undergo surgical procedures or who have had **foreign bodies** surgically placed within their skulls (such as tubes to drain abnormal amounts of accumulated CSF) have an increased risk of meningitis.

Organisms can also reach the meninges via an uncommon but interesting method called intraneural spread. This involves an organism invading the body at a considerable distance away from the head, spreading along a nerve, and using that nerve as a ladder into the skull where the organism can multiply and cause meningitis. Herpes simplex virus is known to use this type of spread, as is the rabies virus.

The most classic symptoms of meningitis (particularly of bacterial meningitis) include **fever**, headache, vomiting, sensitivity to light (photophobia), irritability, severe fatigue (lethargy), stiff neck, and a reddish purple rash on the skin. Untreated, the disease progresses with seizures, confusion, and eventually **coma**.

A very young infant may not show the classic signs of meningitis. Early in infancy, a baby's immune system is not yet developed enough to mount a fever in response to infection, so fever may be absent. In some infants with meningitis, seizures are the only identifiable symptom. Similarly, debilitated elderly people may not have fever or other identifiable symptoms of meningitis.

Brain damage due to meningitis occurs from a variety of phenomena. The action of infectious agents on the brain tissue is one direct cause of damage. Other types of damage may be due to the mechanical effects of swelling and compression of brain tissue against the skull. Swelling of the meninges may interfere with the normal absorption of CSF by blood vessels, causing accumulation of CSF and damage from the resulting pressure on the

brain. Interference with the brain's carefully regulated chemical environment may cause abnormal and damaging amounts of normally present substances (carbon dioxide, potassium) to accumulate. Inflammation may cause the blood-brain barrier to become less effective at preventing the passage of toxic substances into brain tissue.

Diagnosis

A number of techniques are used when examining a person suspected of having meningitis to verify the diagnosis. Certain manipulations of the head (lowering the head, chin towards chest, for example) are difficult to perform and painful for a person with meningitis.

The most important test used to diagnose meningitis is the lumbar puncture (commonly called a spinal tap). Lumbar puncture (LP) involves the insertion of a thin needle into a space between the vertebrae in the lower back and the withdrawal of a small amount of CSF. The CSF is then examined under a **microscope** to look for bacteria or fungi. Normal CSF contains set percentages of glucose and protein. These percentages will vary with bacterial, viral, or other causes of meningitis. For example, bacterial meningitis causes a greatly decreased percentage of glucose in the CSF because the bacteria are essentially consuming or "eating" that glucose and using it for their own **nutrition** and energy production. Normal CSF should contain no infection-fighting cells (white blood cells), so the presence of white blood cells in CSF is another indication of meningitis. Some of the withdrawn CSF is put into special lab dishes to allow growth of the infecting organism, which can then be identified more easily. Special immunologic and serologic tests may also be used to help identify the infectious agent.

In rare instances a lumbar puncture cannot be performed because of the amount of swelling and pressure within the skull (intracranial pressure). This pressure is measured immediately upon insertion of an LP needle. If it is found to be high, no fluid is withdrawn because doing so could cause herniation of the brain stem. Herniation of the brain stem occurs when the part of the brain connecting to the spinal cord is thrust through the opening at the base of the skull into the spinal canal. Such herniation will cause compression of those structures within the brain stem that control the most vital functions of the body (breathing, heart beat, consciousness). Death or permanent debilitation follows herniation of the brain stem.

Treatment

Antibiotic medications (forms of penicillin and cephalosporins, for example) are the most important ele-

ments of treatment against bacterial meningitis. Because of the effectiveness of the blood-brain barrier in preventing passage of substances into the brain, medications must be delivered directly into an affected person's veins (intravenously, or IV), at very high doses. **Antiviral drugs** (acyclovir) may be helpful in shortening the duration of viral meningitis, and antifungal medications are also available.

Other treatments involve decreasing inflammation (with steroid preparations) and paying careful attention to the balance of fluids, glucose, sodium, potassium, oxygen, and carbon dioxide in a person's system. People who develop seizures will require medications to halt the seizures and prevent their return.

Prognosis

Viral meningitis is the least severe type, and persons usually recover with no long-term effects from the infection. Bacterial infections, however, are much more severe, and rapidly progress. Without very rapid treatment with the appropriate antibiotic, an infection can swiftly lead to coma and death, often in less than 24 hours. While death rates from meningitis vary depending upon the specific infecting organism, the overall death rate is just under 20%.

The most frequent long-term effects of meningitis include deafness and blindness, which may be caused by the compression of specific nerves and brain areas responsible for the senses of **hearing** and sight. Some people develop permanent seizure disorders, requiring life-long treatment with antiseizure medications. Scarring of the meninges may result in obstruction of the normal flow of CSF, causing abnormal accumulation of CSF. This may be a chronic problem for some people, requiring the installation of shunt tubes to drain the accumulation on a regular basis.

Health care team roles

Family physicians, pediatricians, emergency physicians, or internists usually make the initial diagnosis of meningitis. Laboratory technicians identify organisms that cause meningitis. Nurses and other hospital staff provide supportive care, and patient and family education. Occasionally, physical therapists are needed to help the patient recover lost muscle functioning.

Prevention

Prevention of meningitis primarily involves the appropriate treatment of other infections an individual may acquire, particularly those known to seed to the

KEY TERMS

Arachnoid mater—The middle layer of the meninges.

Blood-brain barrier—An arrangement of cells within the blood vessels of the brain that prevents toxic substances, infectious agents, and many medications, from passing from the blood into the brain.

Cerebrospinal fluid (CSF)—Fluid made in chambers within the brain which then flows over the surface of the brain and spinal cord. CSF provides nutrition to cells of the nervous system, as well as providing a cushion for the nervous system structures.

Dura mater—The outermost layer of the meninges.

Lumbar puncture (LP)—A medical test in which a very narrow needle is inserted into a specific space between the vertebrae of the lower back in order to obtain a sample of CSF for examination.

Meninges—The three-layer membranous covering of the brain and spinal cord, composed of the dura, arachnoid, and pia. It provides protection for the brain and spinal cord, as well as housing many blood vessels and participating in the appropriate flow of CSF.

Photophobia—Abnormal sensitivity to light.

Pia mater—The innermost layer of the meninges.

meninges (such as ear and sinus infections). Preventive treatment with **antibiotics** is sometimes recommended for those in close contacts with an individual who is ill with meningococcal or *H. influenzae* type b meningitis. A meningococcal vaccine is sometimes recommended to individuals traveling to very high risk areas. A vaccine for *H. influenzae* type b is now given to babies as part of the standard array of childhood immunizations.

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ORGANIZATIONS

American Academy of Emergency Medicine. 611 East Wells Street, Milwaukee, WI 53202. (800) 884-2236. <<http://www.aaem.org>>.

Meningitis Foundation of America Inc. 7155 Shadeland Station, Suite 190, Indianapolis, Indiana 46256-3922. (800) 668-1129 or (317) 595-6383. <<http://www.musa.org/default.htm>>.

OTHER

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L. Fleming Fallon, Jr., M.D., Dr.P.H.

Menkes' syndrome *see* **Mineral deficiency**

Menopause

Definition

Medically, menopause is the cessation of menstruation and signifies the inability to bear children. It is determined as one year from the last menstrual cycle. Menopause is a natural life-stage transition. Medical events, like surgery or **chemotherapy**, however, can also produce menopause.

Description

Menopause is a natural transition that will affect every woman. By the year 2020, it is estimated that there will be 62 million American women reaching menopause.

Most of these women will spend one-third to one-half of their lives postmenopause.

No changes in life expectancy or general health have affected the age at which menopause occurs. The average age of onset of natural menopause is 51, with a normal range between 48 and 58. There are women who experience it as early as 35 and as late as 60. Eight percent of women stop menstruating before age 40, and 5% continue to have periods until they are near 60. Usually, there is an underlying factor to extremely early or late menopause.

Attempts at defining factors that can predict age of onset have not been successful. It is clear that heredity and smoking seem to be linked to the timing of menopause. A mother's age at menopause may indicate when her daughter will cease menstruation, though this is not a hard- and-fast rule. If a mother entered **puberty** late and her daughter had her first period at an early age, there may be no correlation. The mother may have experienced poor **nutrition** as a child or had an hormonal deficiency or some other medical condition to delay puberty.

Smokers enter menopause as much as 1.5 years earlier than non-smokers. Other determinants can be number of pregnancies, body mass, depression, chemical exposure, and exposure to pelvic radiation as a child. Women who have had children, have larger body mass, and who had higher cognitive scores as children may enter menopause later. Conversely, women who never had children, are depressed, were exposed to toxic chemicals, or had pelvic radiation usually have an earlier menopause.

There are four types of menopause. The most prevalent is natural, spontaneous menopause. Premature (spontaneous), surgical, and induced menopause occur because of a medical condition, a surgical procedure, or other outside cause.

Natural (spontaneous) menopause

Most menopause is natural and occurs as part of the aging cycle for women. Technically, it refers to a state in a woman's menstrual cycle which happens a year from the date of her last menstrual period. Indications that the process is starting may occur in a woman's 40's with the lengthening and irregularity of menstrual cycles. The process can take as long as eight years, or may be over in two. Only 10% of women report that menstruation ceases suddenly, with no cycle irregularity prior.

There are four stages that a woman experiences when she experiences natural menopause.

MENSTRUATION. When a woman enters puberty, each month her body releases one of the more than 400,000 eggs that are stored in her ovaries, and the lining of the womb (uterus) thickens in anticipation of receiving a fertilized egg. If the egg is not fertilized, progesterone levels drop and the uterine lining sheds. This is a normal menstrual cycle.

By the time a woman reaches her late 30s or 40s, her ovaries begin to produce less estrogen and progesterone, releasing eggs less often. The gradual decline of estrogen causes a wide variety of changes in tissues that respond to estrogen—including the vagina, vulva, uterus, bladder, urethra, breasts, bones, **heart, blood vessels, brain, skin, hair, and mucous membranes.**

As the levels of hormones fluctuate, the menstrual cycle begins to change. Some women may have longer periods with heavy flow followed by shorter cycles and hardly any bleeding, beginning as much as two to eight years before menopause. Others will begin to miss periods completely. During this time, a woman also becomes less able to get pregnant (although **contraception** should be continued until the postmenopausal state is established). This is the stage of premenopause which represents the very beginning of the process. Typically, it begins when a woman is in her mid-to-late forties.

PERIMENOPAUSAL TRANSITION. Perimenopause is the stage most women consider as going through menopause. Here a woman's cycles become very erratic. She may experience more hot flashes and other symptoms. Only about 15% of women report severe symptoms. This stage lasts about four years, the two years prior to the last cycle and the two years following it. For 95% of women, the age of onset ranges from 39 to 51 years. The average age for perimenopause is 47.5 years, with completion at 51.

MENOPAUSE. This is the permanent cessation of menstruation following the loss of ovarian activity. It often is not officially noted until a year with no cycles has passed.

POSTMENOPAUSE. This stage represents the last years of a woman's life. She may well spend a third to half of her life in this stage. During the first years after menopause, a woman may still experience some perimenopausal symptoms. Here, a woman will begin to deal with some of the effects of aging. In 2001, a woman at 50 or 51 may truly be at mid-life, according to the calendar, since many women will live to be a hundred.

Premature (spontaneous) menopause

Premature menopause occurs spontaneously, without any outside interventions or stresses, and affects

about 0.3% of women. It is generally due to ovarian failure and occurs before age 40. Because hormonal levels plummet dramatically, these women experience severe vasomotor symptoms that can last as long as 8.5 years. Fertility may end over several months or immediately.

Surgical menopause

What a woman would normally experience between a two to eight-year period during normal menopause, women with surgical or premature menopause experience immediately and at a very young age. Some of these women are as young as 15. Fertility ends immediately.

Bilateral oophorectomy, or the surgical removal of both ovaries, can be the result of several different procedures. A complete hysterectomy, or the removal of the uterus and the ovaries, results in menopause. It is performed to remove cancerous growths in the ovaries, uterus, or cervix, and may be done in some types of colon **cancer** surgery. It can also be done to remove non-malignant fibroid tumors in the uterus or to mitigate the effects of endometriosis (although these procedures do not always require the removal of the ovaries). If surgery leaves one or both ovaries, often menopause is avoided. However, in some cases, menopause occurs regardless of whether the ovaries are left intact.

Induced menopause

Induced menopause occurs when a woman has been exposed to pelvic radiation or chemotherapy. The drugs in chemotherapy used to combat cancer can seriously damage the ovaries. This condition may be temporary, lasting only a few months or years. Permanent menopause is more likely if a combination of drugs are used or the woman is close to perimenopause. Pelvic radiation therapy usually produces permanent menopause. Other types of radiation therapy, away from the ovaries, may not affect ovarian hormones at all, thus avoiding induced menopause.

Causes and symptoms

Causes

The cause of most menopausal symptoms has been attributed in part to low estrogen levels in the body. Increased amounts of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) are also involved. If a woman is overweight, she may experience milder symptoms because the fat stored in her body is converted to estrogen when the hormone levels fall. Also, women who endure premenstrual syndrome (PMS) are more apt to report mood swings. This may be due to differences in hormone levels. New research is beginning to

tie psychological factors to these symptoms as well. For example, women who are depressed and angry, especially if they are unhappy in their relationships, often report more pronounced symptoms.

Ethnicity may also be a factor in the development of symptoms. Since most of the menopausal research has been conducted on white women, cross-ethnic studies in 2000 were conducted to discover any racial or ethnic variables. The frequency and type of symptoms reported varied widely between ethnic groups. Japanese American and Chinese American women reported fewer symptoms than the other women. African-American women experienced more hot flashes and vaginal dryness. Hispanic women had more vaginal dryness, urine leakage, and heart palpitations. Non-Hispanic white women reported more sleep difficulties.

It is unclear whether cultural or biological factors are involved in these differences. As for causal agents, that may be too early to tell. In any case, the health care team should be aware that ethnic differences in symptom manifestation do exist in menopause.

Symptoms

About 20% of women in the United States experience menopause with few symptoms. All others report a variety of complaints throughout perimenopause; some mild, some severe enough to interfere with work or daily activities.

There are a variety of symptoms a woman may experience in perimenopause:

- changes in the menstrual cycle, resulting in long cycles and missed periods
- hot flashes
- night sweats
- insomnia
- mood swings/irritability
- **memory** or concentration problems
- vaginal dryness
- heavy bleeding
- fatigue
- depression
- hair changes
- headaches
- heart palpitations
- sexual disinterest
- urinary changes
- weight gain

Diagnosis

The clearest indication of menopause is the absence of a period for one year. It is also possible to diagnose menopause by testing hormone levels. One important test measures the levels of follicle-stimulating hormone (FSH), which rise steadily as a woman ages.

Treatment of specific symptoms should be handled as they manifest and are reported.

Treatment

Hormone replacement therapy

The standard treatment for menopause has been hormone replacement therapy, primarily with estrogen. Hormone replacement therapy can treat menopausal symptoms by boosting the estrogen levels enough to suppress symptoms while also providing protection against heart disease and **osteoporosis**, which causes the bones to weaken. Experts disagree on whether HRT increases or decreases the risk of developing **breast cancer**.

There are two types of hormone treatments: hormone replacement therapy (HRT) and estrogen replacement therapy (ERT). HRT is the administration of estrogen and progesterone; ERT is the administration of estrogen alone. Only women who have had a hysterectomy (removal of the uterus) can take estrogen alone, since taking this “unopposed” estrogen can cause uterine cancer. The combination of progesterone and estrogen in HRT eliminates the risk of uterine cancer.

Most physicians do not recommend HRT until a woman’s periods have stopped completely for one year. This is because women in early menopause who still have an occasional period are still producing estrogen; HRT would then provide far too much estrogen. One way of determining if HRT may be necessary is to measure FSH levels yearly beginning at age 50. When these levels are at or greater than 20 U/l, a postmenopausal hormone program may be recommended.

Many doctors believe that every woman (except those with certain cancers) should take hormones as they approach menopause because of the protection against heart disease, osteoporosis, and uterine cancer and the relatively low risk of breast cancer. Heart disease and osteoporosis are two of the leading causes of disability and death among post-menopausal women. Research in 2000 and 2001 has been challenging the effectiveness of estrogen in preventing heart disease, as well as **colorectal cancer** and **Alzheimer’s disease**. No substantial study has proven that estrogen is a sound preventative.

Women are poor candidates for hormone replacement therapy if they:

- have ever had breast or endometrial cancer
- have a close relative (mother, sister, grandmother) who died of breast cancer or have two relatives who got breast cancer before age 40
- have had endometrial cancer
- have had **gallbladder** or **liver** disease
- have **blood** clots or phlebitis

Some women with liver or gall bladder disease, or who have clotting problems, may be able to go on HRT if they use a patch to administer the hormones through the skin, bypassing the liver.

Women would make good candidates for HRT if they:

- need to prevent osteoporosis
- have had their ovaries removed
- have significant symptoms

In some women, taking hormones can eliminate hot flashes, vaginal dryness, urinary incontinence (depending on the cause), insomnia, moodiness, memory problems, heavy irregular periods, and concentration problems. But side effects of treatment include bloating, breakthrough bleeding, headaches, vaginal discharge, fluid retention, swollen breasts, and nausea. There can also be an increased risk of gall bladder disease and blood clots. Up to 20% of women who try hormone replacement stop within nine months because of these side effects. However, some side effects can be lessened or prevented by changing the HRT regimen.

The decision should be made by a woman and her doctor after taking into consideration her medical history and situation. Women who choose to take hormones should have an annual mammogram, breast exam, and pelvic exam and should report any unusual vaginal bleeding or spotting (a sign of possible uterine cancer).

Designer estrogen

A new type of hormone therapy offers some of the same protection against degenerative diseases and bone loss as estrogen, but without the increased risk of breast cancer. This new class of drugs, known as designer estrogens. Under development for nearly a decade, new drugs like Evista are being approved to prevent and treat osteoporosis in 2001. Unfortunately, these drugs have not been effective in combating hot flashes.

Male hormones

The ovaries also produce a small amount of male hormones, which decreases slightly as a woman enters menopause. The vast majority of women never need testosterone replacement, but it can be important if a woman has declining interest in sex. Testosterone can improve the libido, and decrease **anxiety** and depression; adding testosterone especially helps women who have had hysterectomies. Testosterone also eases breast tenderness and helps prevent bone loss.

However, testosterone does have side effects. Some women experience mild acne and some facial hair growth, but because only small amounts of testosterone are prescribed, most women do not appear to have extreme masculine changes.

Birth control pills

Women who are still having periods but who have annoying menopausal symptoms may take low-dose birth control pills to ease the problems; this treatment has been approved by the FDA for perimenopausal symptoms in women under age 55. HRT is the preferred treatment for menopause, however, because it uses lower doses of estrogen.

Alternative treatment

Some women also report success in using natural remedies to treat unpleasant symptoms of menopause. Not all women need estrogen, and some women cannot take it. Many doctors do not want to give hormones to women who are still having their periods, however erratically. Indeed, only a third of menopausal women in the United States try HRT and of those who do, eventually half of them drop the therapy. Some are worried about breast cancer, some cannot tolerate the side effects, some do not want to medicate what they consider to be a natural occurrence.

HERBS. Herbs have been used to relieve menopausal symptoms for centuries. In general, most herbs are considered safe, and there is no substantial evidence that herbal products are a major source of toxic reactions. But because herbal products are not regulated in the United States, contamination or accidental **overdose** is possible. Herbs should be bought from a recognized company or through a qualified herbal practitioner.

Women who choose to take herbs for menopausal symptoms should learn as much as possible about herbal products and work with a qualified practitioner (an herbalist, a specialist in Chinese medicine, or a naturopathic physician). Pregnant women should avoid herbs because of unknown effects on a developing fetus.

The following list of herbs include those that herbalists most often prescribe to treat menstrual complaints:

- Black cohosh (*Cimicifuga racemosa*): hot flashes and other menstrual complaints.
- Black currant: breast tenderness.
- Chaste tree/chasteberry (*Vitex agnus-castus*): hot flashes, excessive menstrual bleeding, fibroids, and moodiness.
- Evening primrose oil (*Oenothera biennis*): mood swings, irritability, and breast tenderness.
- Fennel (*Foeniculum vulgare*): hot flashes, digestive gas, and bloating.
- Flaxseed (linseed): excessive menstrual bleeding, breast tenderness, and other symptoms, including dry skin and vaginal dryness.
- Gingko (*Gingko biloba*): memory problems.
- Ginseng (*Panax ginseng*): hot flashes, fatigue and vaginal thinning.
- Hawthorne (*Crataegus laevigata*): memory problems, fuzzy thinking.
- Lady's mantle: excessive menstrual bleeding.
- Mexican wild yam (*Dioscorea villosa*) root: vaginal dryness, hot flashes and general menopause symptoms.
- Motherwort (*Leonurus cardiaca*): night sweats, hot flashes.
- Oat (*Avena sativa*) straw: mood swings, anxiety.
- Red clover (*Trifolium pratense*): hot flashes.
- Sage (*Salvia officinalis*): mood swings, headaches, night sweats.
- Valerian (*Valeriana officinalis*): insomnia.

NATURAL ESTROGENS (PHYTOESTROGENS). Research in the efficacy of phytoestrogens, particularly soy products, have been mixed. Some trials suggest that the estrogen compounds in soy products can indeed relieve the severity of hot flashes and lower cholesterol. Others do not.

It is true that people in Asian countries who eat foods high in plant estrogens (especially soy products) have lower rates of breast cancer and report fewer “symptoms” of menopause. While up to 80% of menopausal women in the United States complain of hot flashes, night sweats, and vaginal dryness, only 15% of Japanese women have similar complaints. It is unclear whether this statistic is due to eating phytoestrogens alone or is a factor of genetics or culture.

The study of phytoestrogens is so new that there are not very many recommendations on how much a woman

can consume. Herbal practitioners recommend a dose based on a woman's history, body size, lifestyle, diet, and reported symptoms. In one study at Bowman-Gray Medical School in North Carolina, women were able to ease their symptoms by eating a large amount of fruits, vegetables, and whole grains, together with 4 oz (113g) of tofu four times a week.

What concerns some critics of other alternative remedies is that many women think that “natural” or “plant-based” means “harmless.” In large doses, phytoestrogens can promote the abnormal growth of cells in the uterine lining. Unopposed estrogen of any type can lead to endometrial cancer, which is why women on conventional estrogen-replacement therapy usually take progesterone (progestin) along with their estrogen. However, a plant-based progesterone product can sometimes be effective alone, without estrogen, in assisting the menopausal woman in rebalancing her hormonal action throughout this transition time.

YOGA. Some women find that **yoga** (the ancient meditation/exercise developed in India 5,000 years ago) can ease menopausal symptoms. Yoga focuses on helping women unite the mind, body, and spirit to create balance. Studies have found that yoga can reduce **stress**, improve mood, boost a sluggish **metabolism**, and slow the heart rate. Specific yoga positions deal with particular problems, such as hot flashes, mood swings, vaginal and urinary problems, and other pains.

EXERCISE. **Exercise** helps ease hot flashes by lowering the amount of circulating FSH and LH and by raising endorphin levels (which drop when having a hot flash). Even exercising 20 minutes three times a week can significantly reduce hot flashes.

ACUPUNCTURE. This ancient Asian art involves placing very thin needles into different parts of the body to stimulate the system and unblock energy. It is usually painless and has been used for many menopausal symptoms, including insomnia, hot flashes, and irregular periods. Practitioners believe that acupuncture can facilitate the opening of blocked energy channels, allowing the life force energy (chi) to flow freely. Blocked energy, they report, increases the symptoms of menopause.

ACUPRESSURE AND MASSAGE. Therapeutic massage involving **acupressure** can bring relief from a wide range of menopause symptoms by placing finger pressure at the same meridian points on the body that are used in acupuncture. There are more than 80 different types of massage, including foot reflexology, **Shiatsu** massage, or Swedish massage, but they are all based on the idea that boosting the circulation of blood and lymph benefits health, and relaxing the body and mind.

KEY TERMS

Amenorrhea—The cessation of menstrual cycles.

Bilateral oophorectomy—The surgical removal of both ovaries.

Endometrium—The lining of the uterus, which is shed with each menstrual period.

Estrogen—Female hormone produced by the ovaries and released by the follicles as they mature. Responsible for female sexual characteristics, estrogen stimulates and triggers a response from at least 300 tissues, and may help some types of breast cancer to grow. After menopause, the production of the hormone gradually stops.

Estrogen replacement therapy (ERT)—A treatment for menopause in which estrogen is given in pill, patch, or cream form.

Follicle-stimulating hormone (FSH)—The pituitary hormone that stimulates the ovary to mature egg capsules (follicles). It is linked with rising estrogen production throughout the cycle. An elevated FSH (above 40) indicates menopause.

Hormone—A chemical messenger secreted by a gland that is released into the blood, and that travels to distant cells where it exerts an effect.

Hormone replacement therapy (HRT)—The use of estrogen and progesterone to replace hormones that the ovary no longer supplies.

Hot flash—A wave of heat that is one of the most common perimenopausal symptoms, triggered

by the hypothalamus' response to estrogen withdrawal.

Hysterectomy—Surgical removal of the uterus.

Ovary—One of the two almond-shaped glands in the female reproductive system responsible for producing eggs and the hormones estrogen and progesterone.

Ovulation—The monthly release of an egg from the ovary.

Pituitary gland—The “master gland” at the base of the brain that secretes a number of hormones responsible for growth, reproduction, and other activities. Pituitary hormones stimulate the ovaries to release estrogen and progesterone.

Progesterone—The hormone that is produced by the ovary after ovulation to prepare the uterine lining for a fertilized egg.

Testosterone—Male hormone produced by the testes and (in small amounts) in the ovaries. Testosterone is responsible for some masculine secondary sex characteristics such as growth of body hair and deepening voice.

Uterus—The female reproductive organ that contains and nourishes a fetus from implantation until birth. Also known as the womb.

Vagina—The tube-like passage from the vulva (a woman's external genital structures) to the cervix (the portion of the uterus that projects into the vagina).

BIOFEEDBACK. Some women have been able to control hot flashes through biofeedback, a painless technique that helps a person train her mind to control her body. A biofeedback machine provides information about body processes (such as heart rate) as the woman relaxes her body. Using this technique, it is possible to control the body's temperature, heart rate, and breathing.

Prognosis

Menopause is a natural condition of aging. Some women have no problems at all with menopause, while others notice significant unpleasant symptoms. A wide array of treatments, from natural products to hormone replacement, mean that no woman needs to suffer through this time of her life.

Health care team roles

Physicians, nurses, physician assistants, and alternative/complimentary health care practitioners assume important roles in a woman's successful transition into postmenopause. Since new research in menopause treatment is occurring every year, it will be the health care team's obligation to provide the woman with accurate options that are specific to her individual case. Referrals for counseling and other psychological services may be necessary if depression or anxiety about aging is a problem. Since the symptoms of perimenopause are not life-threatening, the health care team may be more willing to suggest alternative methods like herbal remedies, yoga, and acupressure, as well as lifestyle changes like exercise and a healthy diet. The goal of the health care team

should be to normalize this transition as much as possible and not stigmatize it as a medical condition.

Prevention

Menopause is a natural part of the aging process and not a disease that needs to be prevented. A variety of treatments are available to treat uncomfortable perimenopausal symptoms. Hormone replacement therapy is often used to combat serious symptoms and prevent a number of degenerative diseases such as heart disease and osteoporosis.

Resources

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ORGANIZATIONS

American Menopause Foundation, Inc., Empire State Bldg., 350 Fifth Ave., Ste. 2822, New York, NY 10118. (212) 714-2398.

Federation of Feminist Women's Health Centers. 633 East 11th Ave., Eugene, OR 97401. (503) 344-0966.

Hysterectomy Educational Resources and Services Foundation (HERS). 422 Bryn Mawr Ave., Bala Cynwyd, PA 19004. (215) 667-7757.

National Women's Health Network. 1325 G St. NW, Washington, DC 20005. (202) 347-1140.

North American Menopause Society. PO Box 94527, Cleveland, OH 44101. (440) 442-7550, (800) 774-5342. <<http://www.menopause.org/>>.

Resources for Midlife and Older Women. 226 E. 70 St., Ste. 1C, New York, NY 10021. (212) 439-1913.

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Meno Times. <<http://www.aimnet.com/~hyperion/menotimes.index.html>>.

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Janie F. Franz

Mercury hygiene

Definition

Proper handling and use of mercury in the oral health care setting is referred to as mercury hygiene. Designated as a hazardous substance by the National Occupational Health and Safety Commission, mercury is considered a health risk in the workplace and must be handled according to specific guidelines.

Precautions

Permissible exposure limits in the United States are 0.1 and 0.05 mg/cubic meters. Dental offices, which use liquid mercury on a regular basis in amalgam restorations, are required to follow appropriate measures to manage and reduce the risk of mercury spills and vapor release.

Description

Pure mercury in the dental workplace is found in predosed amalgam capsules that include separate compartments for alloy powder and mercury. Amalgam has been used to fill teeth for thousands of years and has been available in its present formulation since the late nineteenth century. Amalgam contains 50% metallic mercury, 35% silver, 9% tin, 6% **copper**, and a trace of **zinc**. United States dentists place more than 100 million amalgam fillings each year. Dental mercury, supplied in the form of an odorless, silvery liquid with a metallic luster, is considered harmful at concentrations greater than 3%, and toxic at concentrations greater than 25%.

KEY TERMS

Amalgam—As applied to dentistry, a filling material composed of mercury, silver, tin, copper, and zinc.

Erethism—Morbid excitability, characterized by abnormal shyness, depression, despondency, and irritability.

Mercurialism—Chronic poisoning from mercury.

Preparation

Dental employers are required to conduct a risk assessment for mercury hygiene that includes the following documentation:

- date of the assessment
- the product name for mercury-containing substances
- a statement that the material safety data sheet (MSDS) and other relevant information have been reviewed
- a statement on the significance of the degree of risk
- a list of control measures in place
- a decision on the need for health surveillance

Amalgam that is mixed but unused during restoration care is normally collected and sold for reprocessing. Minor particles, plus amalgam dust formed during the removal of old restorations, is removed by rinsing or by high speed suction. Significantly lower amounts of mercury are found in dental operatory waste water when amalgam separators are used. Use of a rubber dam and high-speed evacuation are also appropriate control measures.

The American Dental Association reports that amalgamators, the mixing machines used to produce amalgam, may become contaminated with mercury and emit minute amounts of mercury vapor. Old amalgamators may need to be classified as hazardous waste for disposal.

Disposable monitoring discs are available that measure any hazard from mercury vapor in dental offices. Discs are assessed by an appropriate agency, and the office is given a report and advice on mercury hygiene.

Aftercare

First aid

Following mercury exposure, **first aid** procedures are as follows:

- Eye contact: Flush under upper and lower lids for 15 minutes, and seek medical attention.

- Skin contact: Wash contaminated clothing thoroughly with soap and water. Seek medical attention.
- Inhalation: Move victim to fresh air, give artificial respiration if necessary. Seek medical attention.
- Ingestion: Give a conscious victim water and induce vomiting. Seek medical attention. For a person who is unconscious or convulsing, do not give anything by mouth or induce vomiting.

Spill management

Since spilled mercury gives off a toxic, odorless vapor, spills must be cleaned up immediately if predosed capsules break. Persons handling cleanup should wear gloves and collect mercury with a suction pump and aspirator bottle. A regular vacuum cleaner is not appropriate since a vacuum cleaner can spread mercury vapor. No mercury should enter drains. Fine droplets may be covered with **calcium** polysulphide, powdered sulfur, or a 20% solution of sodium thiosulphate. Droplets are to be put in a closed container.

Complications

Inhalation of mercury vapor is toxic, and there is danger of cumulative effects of exposure. Possible complications include difficulty breathing, cough, **fever**, nausea, vomiting, headache, excessive salivation and metallic **taste**, cardiac abnormalities, pulmonary irritation and pneumonitis, **edema**, fibrosis, kidney and **brain** damage, and death.

Effects of accidental ingestion are burning of the mouth and throat, thirst, nausea, and vomiting. Mercury is not usually absorbed well enough through ingestion to cause acute effects.

Eye contact with mercury in liquid form may cause irritation and redness. Skin contact may result in allergic reactions and irritation. Enough mercury can be absorbed through the skin for toxicity.

The chronic health effects of mercury exposure are termed mercurialism. Mercurialism includes fine tremors and erethism, a syndrome of psychological effects including abnormal shyness, depression, despondency, irritability, or excitability. With severe mercury exposure, hallucinations, loss of **memory**, and mental deterioration may occur. Other possible chronic health effects are kidney damage, **stomatitis**, increased tooth mobility, blue pigmentation of the gum tissue, **diarrhea**, and weight loss. Individuals with pre-existing conditions affecting the **respiratory system, kidneys**, and nervous system may find their conditions aggravated by mercury exposure.

Results

Proper mercury hygiene results in a safe working environment for dental personnel. With control measures in place, dental amalgam does not appear to represent an environmental problem. Organized dentistry claims that mercury combined into amalgam forms a biologically inactive substance. Its widespread and long-term use have not brought to light any adverse side effects in dental patients.

Health care team roles

An employer is required to identify staff members who may be exposed to mercury, such as dentists and chair-side assistants, then conduct and document appropriate training. Issues to be addressed include any factors that may affect the level of exposure, such as working hours and preventive measures used in the practice. Safe work practices in handling mercury overlap with dental workplace safety in general. They include:

- avoiding contact and inhalation of vapor during handling of mercury
- wearing gloves and protective eyewear
- storing capsules in a cool area in labeled containers and protected from breakage
- never disassembling capsules
- salvaging amalgam waste and residue for recycling
- separating clinical clothing from street wear

Dental employers must re-evaluate mercury risk when work practices are modified with new or improved control measures, when new information becomes available, or every five years.

Resources

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Consumers for Dental Choice. National Institute for Science, Law and Public Policy, 1424 16th St., NW Suite 105, Washington, DC 20036. <<http://www.amalgam.org>>.

United States Environmental Protection Agency. Office of Emergency and Remedial Response, 1200 Pennsylvania Ave. NW, Washington, DC 20460. <<http://www.epa.gov/superfund/tools/merc/index.htm>>.

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Mercy killing see **Euthanasia**

Metabolism

Definition

Metabolism refers to the highly integrated network of chemical reactions by which living cells grow and sustain themselves.

Description

The metabolism's network of chemical reactions are composed of two major types of pathways: anabolism and catabolism. Anabolism uses energy stored in the form of adenosine triphosphate (ATP) to build larger molecules from smaller molecules. Catabolic reactions degrade larger molecules in order to produce ATP and raw materials for anabolic reactions.

Function

Together, the body's anabolic and catabolic networks have three major functions:

- to extract energy from nutrients
- to synthesize the building blocks that make up the large molecules of life: **proteins, fats, carbohydrates**, nucleic acids, and combinations of these substances
- to synthesize and degrade molecules required for special functions in the cell

These reactions are controlled by *enzymes*, protein catalysts that increase the speed of chemical reactions in

the cell without themselves being changed. Each enzyme catalyzes a specific chemical reaction by acting on a specific substrate, or raw material. Each reaction is just one in a sequence of catalytic steps in a metabolic pathway(s). These sequences may be composed of up to 20 enzymes, each one creating a product that becomes the substrate or raw material for the subsequent enzyme. Often, an additional molecule called a *coenzyme*, is required for the enzyme to function. For example, some coenzymes accept an electron that is released from the substrate during the enzymatic reaction. Most of the water-soluble **vitamins** of the B complex serve as coenzymes; **riboflavin** (vitamin B₂) for example, is a precursor of the coenzyme flavine adenine dinucleotide, while pantothenate is a component of coenzyme A, an important intermediate metabolite.

The series of products created by the sequential enzymatic steps of anabolism or catabolism are called metabolic intermediates, or metabolites. Each step represents a small change in the molecule, usually the removal, transfer, or addition of a specific atom, molecule or group of atoms that serves as a functional group, such as the amino groups (-NH₂) of proteins.

Typically, these metabolic pathways are linear. That is, they begin with a specific substrate and end with a specific product. Some pathways, such as the Krebs cycle, are cyclic. Often, metabolic pathways also have branches that feed into or out of them. The specific sequences of intermediates in the pathways of cell metabolism are called intermediary metabolism.

There are thousands of chemical reactions in the body and many of these pathways are identical in most forms of life.

According to the first law of thermodynamics, in any physical or chemical change, the total amount of energy in the universe remains constant, that is, energy cannot be created or destroyed. Thus, when the energy stored in nutrient molecules is released and captured in the form of ATP, some energy is lost as heat but the total amount of energy is unchanged.

The second law of thermodynamics states that physical and chemical changes proceed in such a direction that useful energy undergoes irreversible degradation into a randomized form—entropy. The dissipation of energy during metabolism represents an increase in the randomness, or disorder, of the organism's environment. Because this disorder is irreversible, it provides the driving force and direction to all metabolic enzymatic reactions.

Even in the simplest cells, such as **bacteria**, there are at least a thousand such reactions. Regardless of the

number, all cellular reactions can be classified as one of two types of metabolism: anabolism and catabolism. These reactions, while opposite in nature, are linked through the common bond of energy. Anabolism, or biosynthesis, is the synthetic phase of metabolism during which small building block molecules, or precursors, are built into large molecular components of cells, such as carbohydrates and proteins.

Catabolic reactions are used to capture and save energy from nutrients, as well as to degrade larger molecules into smaller, molecular raw materials for reuse by the cell. The energy is stored in the form of energy-rich ATP, which powers the reactions of anabolism. The useful energy of ATP is stored in the form of a high-energy bond between the second and third phosphate groups of ATP. The cell makes ATP by adding a phosphate group to the molecule adenosine diphosphate (ADP). Therefore, ATP is the major chemical link between the energy-yielding reactions of catabolism, and the energy-requiring reactions of anabolism.

In some cases, energy is also conserved as energy-rich hydrogen atoms in the coenzyme nicotinamide adenine dinucleotide phosphate (NADPH) in the reduced form of NADPH. The NADPH can then be used as a source of high-energy hydrogen atoms during certain biosynthetic reactions of anabolism.

In addition to the obvious difference in the direction of their metabolic goals, anabolism and catabolism differ in other significant ways. For example, the various degradative pathways of catabolism are convergent. That is, many hundreds of different proteins, polysaccharides and **lipids** are broken down into relatively few catabolic end products. The hundreds of anabolic pathways, however, are divergent. That is, the cell uses relatively few biosynthetic precursor molecules to synthesize a vast number of different proteins, polysaccharides and lipids.

The opposing pathways of anabolism and catabolism may also use different reaction intermediates or different enzymatic reactions in some of the steps. For example, there are 11 enzymatic steps in the breakdown of glucose into pyruvic acid in the **liver**. But the liver uses only nine of those same steps in the synthesis of glucose, replacing the other two steps with a different set of enzyme-catalyzed reactions. This occurs because the pathway to degradation of glucose releases energy, while the anabolic process of glucose synthesis requires energy. The two different reactions of anabolism are required to overcome the energy barrier that would otherwise prevent the synthesis of glucose.

Another reason for having slightly different pathways is that the corresponding anabolic and catabolic routes must be independently regulated. Otherwise, if the two phases of metabolism shared the exact pathway (only in reverse) a slowdown in the anabolic pathway would slow catabolism, and vice versa.

In addition to regulating the direction of metabolic pathways, cells, especially those in multicellular organisms, also exert control at three different levels: allosteric enzymes, hormones, and enzyme concentration.

Allosteric enzymes in metabolic pathways change their activity in response to molecules that either stimulate or inhibit their catalytic activity. While the end product of an enzyme cascade is used up, the cascade continues to synthesize that product. The result is a steady-state condition in which the product is used up as it is produced and there is no significant accumulation of product. However, when the product accumulates above the steady-state level for any reason, in excess of the cell's needs, the end product acts as an inhibitor of the first enzyme of the sequence. This process is called allosteric inhibition, and is a type of feedback inhibition.

A classic example of allosteric inhibition is the case of the enzymatic conversion of the amino acids: L-threonine into L-isoleucine by bacteria. The first of five enzymes, threonine dehydratase is inhibited by the end product, isoleucine. This inhibition is very specific, and is accomplished only by isoleucine, which binds to a site on the enzyme molecule called the regulatory, or allosteric, site. This site is different from the active site of the enzyme, which is the site of the catalytic action of the enzyme on the substrate, or molecule being acted on by the enzyme.

Some allosteric enzymes may be stimulated by modulator molecules. These molecules are not the end product of a series of reactions, but rather may be the substrate molecule itself. These enzymes have two or more substrate binding sites, which serve a dual function as both catalytic sites and regulatory sites. Such allosteric enzymes respond to excessive concentrations of substrates that must be removed. Also, some enzymes have two or more modulators with opposite effects and possess their own specific allosteric site. When occupied, one site may speed up the catalytic reaction, while the other may slow it down. ADP and AMP (adenosine monophosphate) stimulate certain metabolic pathway enzymes, for example, while ATP inhibits the same allosteric enzymes.

The activity of allosteric enzymes in one pathway may also be modulated by intermediate or final products from other pathways. Such cross-reaction is an important

way in which the rates of different enzyme systems can be coordinated with each other.

Hormonal control of metabolism is regulated by chemical messengers secreted into the **blood** by different endocrine glands. These messengers, called hormones, travel to other tissues or organs, where they may stimulate or inhibit specific metabolic pathways.

A classic example of hormonal control of metabolism is the hormone adrenaline, which is secreted by the medulla of the adrenal gland and carried by the blood to the liver. In the liver, adrenaline stimulates the breakdown of glycogen to glucose, increasing the blood sugar level. In the **skeletal muscles**, adrenaline stimulates the breakdown of glycogen to lactate ATP.

Adrenaline exerts its effect by binding to a receptor site on the cell surfaces of liver and muscle cells. From there, adrenaline initiates a series of signals that ultimately causes an inactive form of the enzyme glycogen phosphorylase to become active. This enzyme is the first in a sequence that leads to the breakdown of glycogen to glucose and other products.

Finally, the concentration of the enzymes themselves exert a profound influence on the rate of metabolic activity. For example, the ability of the liver to turn enzymes on and off—a process called enzyme induction—assures that adequate amounts of needed enzymes are available, while inhibiting the cell from wasting its energy and other resources on making enzymes that are not needed.

For example, in the presence of a high-carbohydrate, low-protein diet, the liver enzymes that degrade amino acids are present in low concentrations. In the presence of a high-protein diet, however, the liver produces increased amounts of enzymes needed for degrading these molecules.

The basis of both anabolic and catabolic pathways is the reactions of reduction and oxidation. Oxidation refers to the combination of an atom or molecule with oxygen, or the loss from it of hydrogen or of one or more electrons. Reduction, the opposite of oxidation, is the gain of one or more electrons by an atom or molecule. The nature of these reactions requires them to occur together; i.e., oxidation always occurs in conjunction with reduction. The term “redox” refers to this coupling of reduction and oxidation.

Redox reactions form the basis of metabolism and are the basis of oxidative phosphorylation, the process by which electrons from organic substances such as glucose are transferred from organic compounds such as glucose to electron carriers (usually coenzymes), and then are passed through a series of different electron carriers to molecules of oxygen molecules. The transfer of electrons

in oxidative phosphorylation occurs along the electron transport chain. During this process, called aerobic respiration, energy is released, some of which is used to make ATP from ADP. The major electron carriers are the coenzymes nicotinamide adenine dinucleotide (NADH) or flavin adenine dinucleotide (FADH₂). Oxidative phosphorylation is the major source of ATP in aerobic organisms, from bacteria to humans.

Some anaerobic bacteria, however, also carry out respiration, but use other inorganic molecules, such as nitrate (NO₃⁻) or sulfate (SO₄²⁻) ions as the final electron acceptors. In this form of respiration, called anaerobic respiration, nitrate is reduced to nitrite ion (NO₂⁻), **nitrous oxide** (N₂O) or nitrogen gas (N₂), and sulfate is reduced to form hydrogen sulfide (H₂S).

Much of the metabolic activity of cells consists largely of central metabolic pathways that transform large amounts of proteins, fats and carbohydrates. Foremost among these pathways are glycolysis, which can occur in either aerobic or anaerobic conditions, and the Krebs cycle, which is coupled to the electron transport chain, which accepts electrons removed from reduced coenzymes of glycolysis and the Krebs cycle. The final electron acceptor of the chain is usually oxygen, but some bacteria use specific, oxidized ions as the final acceptor in anaerobic conditions.

As vital as these reactions are, there are other metabolic pathways in which the flow of substrates and products is much smaller, yet the products quite important. These pathways constitute secondary metabolism, which produces specialized molecules needed by the cell or by tissues or organs in small quantities. Such molecules may be coenzymes, hormones, nucleotides, toxins, or **antibiotics**.

The process of extracting energy by the central metabolic pathways that break down fats, polysaccharides and proteins, and conserving it as ATP, occurs in three stages in aerobic organisms. In anaerobic organisms, only one stage is present. In each case, the first step is glycolysis.

Metabolic pathways

Glycolysis is a ubiquitous central pathway of glucose metabolism among living things, from bacteria to plants and humans. The glycolytic series of reactions converts glucose into the molecule pyruvate, with the production of ATP. This pathway is controlled by both the concentration of substrates entering glycolysis as well as by feedback inhibition of the pathway's allosteric enzymes.

Glucose, a hexose (6-carbon) sugar, enters the pathway through phosphorylation of the number six carbon by the enzyme hexokinase. In this reaction, ATP relinquishes one of its phosphates, becoming ADP, while glucose is converted to glucose-6-phosphate. When the need for further oxidation of glucose-6-phosphate by the cell decreases, the concentration of this metabolite increases, as serves as a feedback inhibitor of the allosteric enzyme hexokinase. In the liver, however, glucose-6-phosphate is converted to glycogen, a storage form of glucose. Thus a buildup of glucose-6-phosphate is normal for liver, and feedback inhibition would interfere with this vital pathway. To produce glucose-6-phosphate, the liver must use the enzyme glucokinase, which is not inhibited by an increase in the concentration of glucose-6-phosphate.

In the liver and muscle cells, another enzyme, glycogen phosphorylase, breaks down glycogen into glucose molecules, which then enter glycolysis.

Two other allosteric enzyme regulatory reactions also help to regulate glycolysis: the conversion of fructose 6-phosphate to fructose 1,6-diphosphate by phosphofructokinase and the conversion of phosphoenolpyruvate to pyruvate by pyruvate kinase.

The first stage of glycolysis prepares the glucose molecule for the second stage, during which energy is conserved in the form of ATP. As part of the preparatory state, however, two ATP molecules are consumed.

At the fourth step of glycolysis, the doubly phosphorylated molecule (fructose 1,6-diphosphate) is cleaved into two 3-carbon molecules, dihydroxyacetone phosphate and glyceraldehyde 3-phosphate. These 3-carbon molecules are readily converted from one to another, however it is only glyceraldehyde 3-phosphate that undergoes five further changes during the energy conserving stage. In the first step of this second stage, a molecule of the coenzyme NAD⁺ is reduced to NADH. During oxidative phosphorylation, the NADH will be oxidized, giving up its electrons to the electron transport system.

At steps seven and 10 of glycolysis, ADP is phosphorylated to ATP, using phosphate groups added to the original 6-carbon molecule in the preparatory stage. Since this phosphorylation of ADP occurs by enzymatic removal of a phosphate group from each of two substrates of glycolysis, this process is called substrate level phosphorylation of ADP. It differs markedly from the phosphorylation of ADP that occurs in the more complex oxidative phosphorylation processes in the electron transport chain. Since two three-carbon molecules derived from the original six-carbon hexose undergo this process, two molecules of ATP are formed from glucose

during this stage, for a net overall gain of two ATP (two ATP having been used in the preparatory stage).

Aerobic organisms use glycolysis as the first stage in the complete degradation of glucose to carbon dioxide and water. During this process, the pyruvate formed by glycolysis is oxidized to acetyl-Coenzyme A (acetyl-CoA), with the loss of its carboxyl group as carbon dioxide.

The fate of pyruvate formed by glycolysis differs among species, and within the same species depending on the level of oxygen available for further oxidation of the products of glycolysis.

Under aerobic conditions, or in the case of bacteria using a non-oxygen final electron acceptor, acetyl-CoA, enters the Krebs cycle by combining with citric acid. The Krebs cycle continues the oxidation process, extracting electrons as it proceeds. The electrons are carried by coenzymes (NADH and FADH) to the electron transport chain, where the final reactions of oxidation produce ATP.

During these reactions, the acetyl group is oxidized completely to carbon dioxide and water by the citric acid cycle. This final oxidative degradation requires oxygen as the final electron acceptor in the electron transport chain.

Organisms that lack the enzyme systems necessary for oxidative phosphorylation also use glycolysis to produce pyruvate and a small amount of ATP. But pyruvate is then converted into lactate, ethanol or other organic alcohols or acids. This process is called fermentation, and does not produce more ATP. The NADH produced during the energy-conserving stage of fermentation is used during the synthesis of other molecules. Thus, glycolysis is the major central pathway of glucose catabolism in virtually all organisms.

While the main function of glycolysis is to produce ATP, there are minor catabolic pathways that produce specialized products for cells. One, the pentose phosphate pathway, produces NADPH and the sugar ribose 5-phosphate. NADPH is used to reduce substrates in the synthesis of fatty acids, and ribose 5-phosphate is used in the synthesis of nucleic acids.

Another secondary pathway for glucose in animal tissues produces D-glucuronate, which is important in detoxifying and excreting foreign organic compounds and in synthesizing **vitamin C**.

Most of the energy conservation achieved by the oxidative phosphorylation of glucose occurs during the Krebs cycle. Pyruvate is first converted to acetyl-CoA, in an enzymatic step that converts one of its carbons into carbon dioxide, and NAD⁺ is reduced to NADH. Acetyl-CoA enters the 8-step Krebs cycle by combining with the

4-carbon oxaloacetic acid to form the 6-carbon citric acid. During the next seven steps, three molecules of NAD⁺ and one molecule of FAD⁺ are reduced, one ATP is formed by substrate level phosphorylation, and two carbons are oxidized to CO₂.

The reduced coenzymes produced during conversion of pyruvic acid to acetyl-CoA and the Krebs cycle are oxidized along the electron transport chain. As the electrons released by the coenzymes pass through the stepwise chain of redox reactions, there is a stepwise release of energy that is ultimately used to phosphorylate molecules of ADP to ATP. The energy is converted into a gradient of protons established across the membrane of the bacterial cell or of the organelle of the eucaryotic cells. The energy of the proton flow back into the cell or organelle is used by the enzyme ATP synthetase to phosphorylate ADP molecules.

FADH₂ releases its electrons at a lower level along the chain than does NADH. The electrons of the former coenzyme thus pass along fewer electron acceptors than NADH, and this difference is reflected in the number of ATP molecules produced by the sequential transfer of each coenzyme's electrons along the chain. The oxidation of each NADH produces three ATP, while the oxidation of FADH₂ produces two.

The total number of ATP produced by glycolysis and metabolism is 38, which includes a net of two from glycolysis (substrate level phosphorylation), 30 from the oxidation of 10 NADH molecules, four from oxidation of two FADH₂ molecules, and two from substrate level phosphorylation in the Krebs cycle.

In addition to their role in the catabolism of glucose, glycolysis and the Krebs cycle also participate in the breakdown of proteins and fats. Proteins are initially degraded into constituent amino acids, which may be converted to pyruvic acid or acetyl-CoA before being passed into the Krebs cycle; or they may enter the Krebs cycle directly after being converted into one of the metabolites of this metabolic pathway.

Lipids are first hydrolyzed into glycerol and fatty acids, glycerol being converted to the glyceraldehyde 3-phosphate metabolite of glycolysis, while fatty acids are degraded to acetyl-CoA, which then enters the Krebs cycle.

Although metabolic pathways in both single-celled and multicellular organisms have much in common, especially in the case of certain central metabolic pathways, they may occur in different locations.

In the simplest organisms, the prokaryotes, metabolic pathways are not contained in compartments separated by internal membranes. Rather, glycolysis takes place in

KEY TERMS

Coenzyme—A coenzyme is required for the enzyme to function.

Enzymes—Enzymes are protein catalysts that increase the speed of chemical reactions in the cell without themselves being changed.

Glycolysis—The major central pathway of glucose catabolism in virtually all organisms. The main function of glycolysis is to produce ATP.

Hormones—Hormones are messengers that travel to tissues or organs, where they may stimulate or inhibit specific metabolic pathways.

Oxidation—Oxidation refers to the combination of an atom or molecule with oxygen, or the loss from it of hydrogen or of one or more electrons.

Phenylketonuria (PKU)—A rare hereditary condition in which phenylalanine (an amino acid) is not properly metabolized. PKU may cause severe mental retardation.

Reduction—Reduction, the opposite of oxidation, is the gain of one or more electrons by an atom or molecule. The nature of these reactions requires them to occur together; i.e., oxidation always occurs in conjunction with reduction. The term “redox” refers to this coupling of reduction and oxidation.

the cytosol, while the electron transport chain and lipid synthesis occurs in the cell membrane. Proteins are made on ribosomes in the cytosol.

In eucaryotic cells, glycolysis, gluconeogenesis and fatty acid synthesis takes place in the cytosol, while the Krebs cycle is isolated within mitochondria; glycogen is made in glycogen granules, lipid is synthesized in the endoplasmic reticulum and lysosomes carry on a variety of hydrolytic activities. As in procaryotic cells, ribosomes in the cytosol are the site of protein synthesis.

Role in human health

All reactions of metabolism are part of the overall goal of the organism to maintain its internal order; whether the organism is a single celled protozoan or a human. Organisms maintain this order by removing energy from nutrients or sunlight and returning to their environment an equal amount of energy in a less useful form, mostly heat. This heat becomes dissipated throughout the rest of the organism’s environment.

The metabolic pathways discussed oxidize organic matter to produce ATP in order to supply the body with the energy and nutrients it needs for maintenance of body functions, growth, tissue repair, and other processes.

Common diseases and disorders

There are a number of disorders affecting the metabolism. Inborn errors of metabolism (or human hereditary biochemical disorders) have genetic origins; these errors interfere with the synthesis including proteins, carbohydrates, fats enzymes, and many other substances in the body. If the abnormality with synthesis is severe, clinical and chemical consequences may result. Abnormalities in the breakdown, storage, or production of proteins, fats and carbohydrates or in the energy cycles of cells are typically the manifestation of this disorder. Disease and death may result from the absence or excess of normal or abnormal metabolites. Some examples of these inborn errors of metabolism are: galactosemia, phenylketonuria, lactose intolerance, and maple syrup urine disease. Many of these inborn errors of metabolism are untreatable. Some inborn errors of metabolism require dietary and/or nutrient modification depending on the specific metabolic error. Registered dietitians and physicians can assist the patient with the diet modifications needed for each disease.

A disorder with the **thyroid gland** may have an effect on metabolism. Thyroid hormones have an impact on growth, use of energy, and heat production as well as affecting the use of vitamins, proteins, carbohydrates, fats, electrolytes, and water. They can also alter the effect of other hormones and drugs. Hypothyroidism may result if there is a temporary or permanent reduction in thyroid hormone secretion. Treatment for this condition is most often successful and allows patients to live normally.

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Crystal Heather Kaczowski, MSc.

Methylcobalamin *see* **Vitamin B₁₂**

Microalbumin test *see* **Urinalysis**

Microscope

Definition

A microscope is an optical instrument consisting of a lens or combination of lenses for enlarging images of objects. It is typically used in a laboratory to view objects that are not visible to the naked eye.

Purpose

In health care, a microscope is used in a laboratory to determine the amount or number of analytes (measured substances) present in a specimen, such as **blood**, urine, or stool. Laboratory tests may be ordered for various reasons:

- to detect disease or to quantify the risk of future disease
- to establish or exclude a diagnosis
- to assess the severity of a disease
- to direct the selection of interventions
- to monitor the progress of a disorder
- to monitor the effectiveness of a treatment

Description

In health care, the most commonly used microscope to evaluate laboratory specimens is the compound microscope, a kind of light microscope (also known as an optical microscope). The compound microscope contains several lenses that magnify the image of a specimen. The lens located directly over the object is called the objective lens, and the lens closest to the eye is called the eyepiece. The total magnification is a product of the magnification of these two lenses—if the objective lens

magnifies 100-fold, and the eyepiece magnifies 10-fold, then the final magnification will be 1,000-fold. But enlarging the image of a specimen is not the only consideration for selection of a microscope. A key property of a microscope is its power of resolution—its ability to distinguish between two objects, such as two cells, positioned closely together. The resolving power of a microscope is denoted by the numerical aperture value (NA). The larger the number, the greater the resolution of the lens.

In addition to the eyepiece and objective there are several other components of a compound microscope that require adjustment by the user. The condenser is a lens that is located below the stage. Its purpose is to focus the light on the specimen. The iris diaphragm is located beneath the condenser. It can be closed to reduce the amount of peripheral light passing through the specimen. This is useful when viewing unstained cells because a narrow diaphragm adds contrast; however, if closed too much the brightness and resolution are reduced significantly. For most applications the iris diaphragm can be positioned correctly by closing it all the way, and then opening it until the black diaphragm is just beyond the field of view. The type of illumination used by most microscopes is called Koehler illumination. To use Koehler illumination the filament of the microscope lamp should be focused on the iris diaphragm by moving the condenser lens. This will evenly distribute the light through the specimen.

In addition to the light microscope, there are several other types that are used for specific purposes. A brief description of those used in a clinical laboratory follows:

- **Darkfield microscope.** A darkfield microscope uses a special condenser that directs the light away from the objective unless it passes through the cell or object from the side. The background appears dark and the object light. The darkfield scope is used when examining unstained cells or objects. The most frequent clinical application is the examination of fluid from a genital chancre for the characteristic corkscrew shaped organism that causes **syphilis**, *Treponema pallidum*.
- **The fluorescence microscope.** Fluorescence is the emission of long wavelength light (visible light of a specific color) by compounds when excited by short wavelength (higher energy) light. Fluorescence microscopes are used to examine cells or objects stained with fluorescent dyes. They use an ultraviolet light source (mercury vapor lamp) to transmit short wavelength light through the specimen. The light passes through a darkfield condenser that blocks all light from the objective except rays that pass through the object. A barrier filter above the objective removes any residual ultravi-



A lab technologist uses a microscope to examine blood films. (Photograph by Carolyn A. McKeone. Science Source/Photo Researchers. Reproduced by permission.)

olet light and transmits the wavelength emitted by the fluorochrome. This technique is used to identify antibodies attached to cell components. Because the background is dark and fluorescence dyes are more sensitive than other stains, it permits the detection of extremely low concentrations of antibody.

- An inverted microscope is one in which the light source is above the stage and the objectives are beneath the specimen rather than above it. This type of microscope is ideal for examining cells in tissue culture and for manipulating cells as is done in artificial reproductive procedures. The cell culture can be placed on the stage and the technologist can manipulate the cells because access to them is unobstructed.
- Phase contrast microscope. This type of microscope uses a condenser with a diaphragm inside that contains an annulus (ring cutout) in the center. The objective is constructed so that it diffracts the light transmitted through the annulus. When this light passes through the specimen, dense objects such as nuclei enhance this effect. Light from dense objects seem to reach the eye a fraction of a second later and the objects appears darker. Phase contrast makes it easier to distinguish different types of unstained cells and is preferred for **urinalysis**.
- Interference-contrast microscope. One disadvantage of phase contrast is that light is refracted from the edge of objects giving cells a halo. Interference-contrast microscopy uses polarizing filters and prisms to achieve the same effect as the annulus without the halo effect.
- Polarizing microscope. Some objects, such as certain crystals or minerals are able to change the direction (rotate) of light. This property is called birefringence and the object is said to be anisotropic. The polarizing microscope uses a polarizing filter beneath the stage. This transmits all the light from the lamp through the specimen in the same plane. A second polarizing filter called the analyzer is placed before the eyepiece so that it is out of phase with the substage polarizing filter. The analyzer blocks all of the light causing a dark background unless the object on the slide is anisotropic. Birefringent objects rotate the light so that it passes through the analyzer lens and the object appears light (white) against a dark background. This technique is

used to identify uric acid needles in joint fluid from a patient with **gout**, since uric crystals are birefringent.

- The transmission electron microscope uses electromagnetic lenses, not optical lenses, that focus a high-velocity electron beam instead of visible light. A transmission electron microscope directs a beam of electrons through a specimen. Only a small piece of a cell can be observed in any one section. Generally, an electron microscope cannot be used to study live cells because they are too vulnerable to the required conditions and preparatory techniques. However, magnification can be achieved on the order of one thousand fold higher than a compound microscope.

Many medical tests require the use of a compound microscope for evaluation. These include:

- Biopsy. Tissue examined for **cancer** or other abnormalities.
- Blood cells. Identification of abnormal red and white blood cells, immature cells, and the different types of white cells.
- Bone marrow aspiration. Examination of marrow from hipbone or breastbone under a microscope for abnormalities of blood cell precursors and bone marrow tissue.
- Chorionic villus sampling. Examination of chromosomes of fetal cells under the microscope to determine if an abnormal number are present or if there is structural damage.
- Papanicolaou (Pap) test. Microscopic examination of cells scraped from the cervix to detect cancer.
- Microbiological exam. Microscopic examination of specimens (some normally sterile) for the presence of **bacteria**, parasites, yeast, and **fungi**. Most often this involves use of the **Gram stain** or acid-fast stain.
- Cytological exam of body fluids. Examination of urine, cerebrospinal fluid, pleural, pericardial, and synovial fluid for blood cells, malignant cells, crystals, bacteria, and other cells.
- Seminal fluid exam. The determination of sperm concentration, viability, and morphology (appearance).

Operation

After a specimen is prepared and placed on the microscope, the microscope is adjusted to change the magnification and focus the image. Precise mechanical adjustments are necessary to manipulate the objective and eyepiece, the substage condenser, iris diaphragm, and the object.

KEY TERMS

Condenser—A lens or system of lenses to collect light rays and converge them to a focus.

Electron microscope—A device which beams electrons instead of light beams at and through an object. A powerful magnet is used to bend the electron beam (instead of a glass lens). This type of microscope provides the greatest resolution of extremely small details, such as individual atoms in an object or substance.

Eyepiece—The lens system nearest the eye which magnifies the primary image produced by the objective so as to form a secondary, virtual image 10 in (25 cm) away from the eyepoint.

Light microscope—A device that works by passing visible light through a condenser and an objective lens.

Objective—The lens system near the object which forms the primary inverted image.

Magnification—The apparent increase in size under the microscope.

Resolution—Degree of detail, ranging from low to high, determining the ability to distinguish between two objects positioned closely together.

Maintenance

The microscope should be kept covered when not in use. It should be cleaned, lubricated, and adjusted by a microscope technician at least once a year to conserve the life of the instrument. Lenses should be cleaned after each use taking care to remove any oil from the lens surface. When cleaning the lenses, use only lens paper to avoid scratching the lenses.

Health care team roles

Collection of a specimen for laboratory evaluation is typically done by a nurse or other health care practitioner. For example, venipuncture (puncture of a vein for the withdrawal of blood) may be performed by various members of the health care team. Although labs employ phlebotomists (individuals who perform venipuncture) to collect blood specimens, nurses must know how to perform this procedure because they routinely perform it in the home, in long-term care settings, and in hospital critical care units.

The nurse may inform the client about the reasons for the test, what to expect during the test, and any asso-

ciated side effects or risks. The nurse should notify the practitioner of any client or family concerns not alleviated by discussions.

Assessment of the client for symptoms such as post-puncture bleeding or occlusion is the responsibility of a nurse or other allied health professional.

Training

Microscopes are usually used by pathologists, laboratory technologists, and technicians who evaluate specimens. Proper use of a microscope is part of training for nurses and other allied health care professionals.

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American Society of Clinical Pathologists. 2100 West Harrison Street, Chicago, IL 60612. (312) 738-1336. <<http://www.ascp.org>>.

Jennifer F. Wilson

Migraine headache

Definition

Migraine is a type of headache marked by severe head **pain** lasting several hours or more.

Description

A migraine is an intense, often debilitating type of headache. Migraines affect as many as 24 million people in the United States, and are responsible for approximately \$17 billion in lost work, poor job performance, and direct medical costs. Approximately 18% of women and 6% of men experience at least one migraine attack per year. More than three million women and one million men have one or more severe headaches every month. Migraines often begin in adolescence, and are uncommon after age 60.

Two types of migraine are recognized. Eighty percent of migraine sufferers experience migraine without aura, formerly called common migraine. In migraine

with aura, formerly called classic migraine, pain is preceded or accompanied by visual or other sensory disturbances, including hallucinations, partial obstruction of the visual field, numbness or tingling, or a feeling of heaviness. Symptoms are often more prominent on one side of the body, and may begin as early as 72 hours before the onset of pain.

Causes and symptoms

Causes

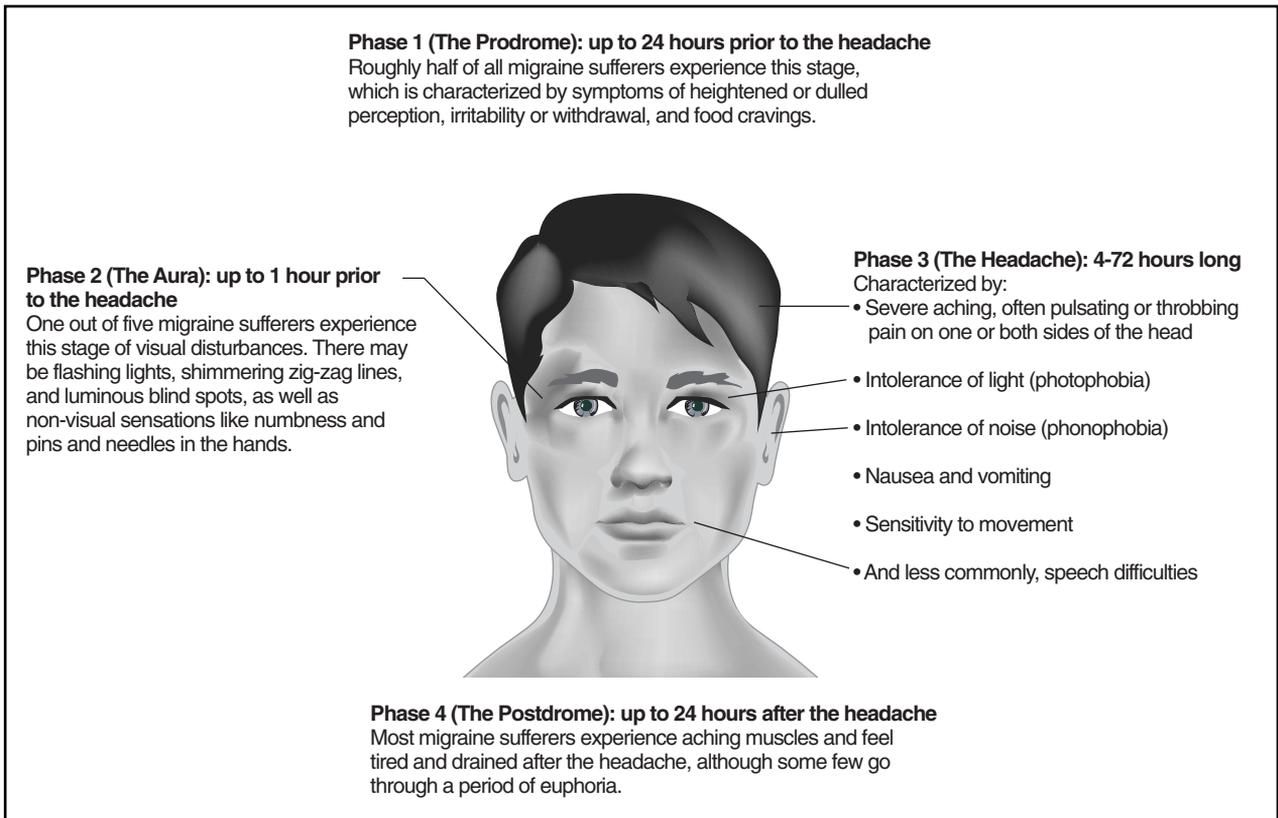
The physiological basis of migraine has proved difficult to uncover. Genetics appear to play a part for many, but not all, people with migraine. There are many potential triggers for a migraine attack, and discovering one's own set of triggers is often the key to prevention.

PHYSIOLOGY. The most widely accepted hypothesis suggests that a migraine attack is precipitated when pain-sensing nerve cells in the **brain** (called nociceptors) release chemicals called neuropeptides. Another brain chemical, a neurotransmitter called substance P, increases the pain sensitivity of nearby nociceptors. Neuropeptides act on the smooth muscle that surrounds cranial **blood vessels**. This smooth muscle regulates **blood** flow in the brain by relaxing or contracting, which dilates (enlarges) or constricts (narrows) the enclosed blood vessels.

At the onset of a migraine headache, neuropeptides are thought to cause muscle **relaxation**, which allows vessel dilation and increased blood flow. Other neuropeptides increase the leakiness of cranial vessels, allowing fluid leak, and promote inflammation and tissue swelling. The pain of migraine is thought to result from this combination of increased pain sensitivity, tissue and vessel swelling, and inflammation. The aura seen during a migraine may be related to constriction in the blood vessels that dilate in the headache phase.

GENETICS. Susceptibility to migraine may be inherited. A child of a migraine sufferer has as much as a 50% chance of developing migraine. If both parents are affected, the probability rises to 70%. However, the gene or genes responsible have not been identified, and many cases of migraine have no obvious familial basis. It is likely that whatever genes are involved set the stage for migraine, and that full development requires environmental influences as well.

TRIGGERS. A wide variety of foods, drugs, environmental cues, and personal events are known to trigger migraines. It is not known how most triggers set off the events of migraine, nor why individual migraine sufferers are affected by particular triggers but not others.



The phases of a typical migraine headache. (Illustration by Hans & Cassidy.)

Common food triggers include:

- aged cheese
- alcohol, especially red wine
- **caffeine** and caffeine withdrawal
- chocolate
- intensely sweet foods
- dairy products
- fermented or pickled foods
- citrus fruits
- nuts
- aspartame
- processed foods, especially those containing nitrites, sulfites, or monosodium glutamate (MSG)

Environmental and event-related triggers include:

- **stress** or time pressure
- menstrual periods, menopause
- sleep changes or disturbances, oversleeping
- prolonged overexertion or uncomfortable posture
- hunger or fasting

- odors, smoke, or perfume
- strong glare or flashing lights

Drugs that may trigger migraine include:

- oral contraceptives
- estrogen replacement therapy
- nitrates, often found in cured meats such as bacon and ham
- theophylline, an **asthma** drug
- reserpine, a tranquilizer
- nifedipine, a **calcium** channel blocker
- indomethacin, an NSAID
- cimetidine, a histamine H₂ antagonist
- decongestant overuse
- analgesic overuse
- benzodiazepine (a type of tranquilizer) withdrawal

Symptoms

Migraine without aura may be preceded by elevations in mood or energy level for up to 24 hours before

the attack. Other premigraine symptoms may include fatigue, depression, and excessive yawning.

Aura most often begins with shimmering, jagged arcs of white or colored light progressing through the visual field over the course of 10–20 minutes. This may be preceded or replaced by dark areas or other visual disturbances. Numbness and tingling is common, especially of the face and hands. These sensations may spread, and may be accompanied by a sensation of weakness or heaviness in the affected limb.

The pain of migraine is often present only on one side of the head, although it may involve both, or switch sides during attacks. The pain is usually throbbing, and may range from mild to incapacitating. It is often accompanied by nausea or vomiting, painful sensitivity to light (photophobia) and sound (phonophobia), and intolerance of food or odors. Blurred **vision** is common.

Migraine pain tends to intensify over the first 30 minutes to several hours, and may last from several hours to a day or longer. Afterward, the affected person is usually weary, and sensitive to sudden head movements.

Diagnosis

Migraine is diagnosed by a careful medical history. Lab tests and imaging studies such as computed tomography (CT) or **magnetic resonance imaging** (MRI) scans have not been useful for identifying migraine. However, for some patients, those tests may be needed to rule out a **brain tumor** or other structural causes of migraine headache.

Treatment

Once a migraine begins, the person will usually seek out a dark, quiet room to lessen painful stimuli. Several drugs may be used to reduce the pain and severity of the attack, and many people with migraines learn to prevent attacks altogether by recognizing and avoiding their triggers.

Nonsteroidal anti-inflammatory drugs (NSAIDs) are helpful for early and mild headache. NSAIDs include acetaminophen, ibuprofen, naproxen, and others. A recent study concluded that a combination of acetaminophen, aspirin, and caffeine could effectively relieve symptoms for many migraine patients. One such over-the-counter preparation is Excedrin Migraine.

More severe or unresponsive attacks may be treated with drugs that act on serotonin receptors in the smooth muscle surrounding cranial blood vessels. Serotonin, also known as 5-hydroxytryptamine, constricts these vessels, relieving migraine pain. Drugs that mimic serotonin and

bind to these receptors have the same effect. The oldest of them is ergotamine, a derivative of a common grain fungus. Ergotamine and dihydroergotamine are used for both acute relief and preventive treatment. Derivatives with fewer side effects have come onto the market in the past decade, including sumatriptan (Imitrex). Some of these drugs are available as nasal sprays, intramuscular injections, or rectal suppositories for patients in whom vomiting precludes oral administration. Other drugs used for acute attacks include meperidine (Demerol) and metoclopramide (Reglan).

Continued use of some antimigraine drugs can lead to “rebound headache,” marked by frequent or chronic headaches, especially in the early morning hours. This can be avoided by using antimigraine drugs under a health care provider’s supervision, with the minimum dose necessary to treat symptoms. Patients with frequent migraines may need preventive therapy.

Alternative treatments are aimed at prevention. Since migraines are often linked with food **allergies** or intolerances, identifying and eliminating the offending food or foods can decrease the frequency of migraines and/or alleviate these headaches altogether. Herbal therapy with feverfew (*Chrysanthemum parthenium*) may lessen the frequency of attacks. Learning to increase the flow of blood to the extremities through biofeedback training may allow a patient to prevent some of the vascular changes once a migraine begins. Relaxation using focused breathing techniques can also be useful. During a migraine, keep the lights low; put the feet in a tub of hot water and place a cold cloth on the occipital region (the back of the head). This draws the blood to the feet and decreases the pressure in the head.

Prognosis

Most people with migraines can bring their attacks under control by recognizing and avoiding their triggers, and by using the appropriate drugs when migraines occur. There are, unfortunately, some people with severe migraines that do not respond to either preventive or drug therapy. Migraines usually wane in intensity after age 60.

Health care team roles

The advanced practice nurse (APN) can play a pivotal role in helping patients control migraine symptoms. One of the most important screening questions for a patient with a headache is “Do you think that this is the worst headache you have ever had?” If the answer is yes, a more thorough diagnostic work up is justified in order to rule out any tumor or brain bleed. Imaging studies, like

CT and/or MRI scanning, which are performed by a radiologist technician, should be considered.

The APN must recognize that many people with migraines are underdiagnosed and unhappy with the practitioner's treatment plan. Knowing this will help the APN focus on both quick pain relief methods and complementary therapies.

The **registered nurse (RN)** and **licensed practical nurse (LPN)** can also contribute to a patient's successful migraine management by reinforcing the concept of rapid medication administration at the initial onset of migraine symptoms.

Patient education

The importance of teaching patients about their migraine medications and any potential side effects cannot be overstated. Explaining the expected time frame for relief before administering the next medication is helpful. Nurses can also advise patients about nonpharmacological interventions that may also be beneficial for migraine sufferers. Finally, the RN or LPN can demonstrate breathing relaxation techniques for patient to reinforce their proper use and understanding.

Prevention

The frequency of migraine may be lessened by avoiding triggers. It is useful to keep a headache journal, recording the particulars and noting possible triggers for each attack. Specific measures which may help include:

- eating at regular times, and not skipping meals
- reducing the use of caffeine and pain relievers
- restricting physical exertion, especially on hot days
- keeping regular sleep hours, but not oversleeping
- managing time to avoid stress at work and home

Some drugs can be used for migraine prevention, including specific members of these drug classes:

- beta blockers
- tricyclic antidepressants
- calcium channel blockers
- anticonvulsants
- fluoxetine (Prozac)
- monoamine oxidase inhibitors (MAOIs)
- serotonin antagonists

For most patients, preventive drug therapy is not an appropriate option, since it requires continued use of powerful drugs. However, for women whose migraines coincide with their menstrual periods, limited preventive

KEY TERMS

Migraine—A type of headache marked by severe head pain lasting several hours or more.

Neuropeptide—A peptide (chemical derived from protein) that affects nerves and their functions. Endorphins and enkephalins are neuropeptides.

Neurotransmitter—Chemical produced by nerve cells that sends an impulse across a synapse to a muscle, organ, or another nerve cell. Norepinephrine and acetylcholine are types of neurotransmitters.

Nociceptors—Nerve cells in the brain that are responsible for the sensation of pain.

Photophobia—Sensitivity to light.

Phonophobia—Sensitivity to sound.

treatment may be effective. Since these drugs are appropriate for patients with other medical conditions, the decision to prescribe them for migraine may be influenced by expected benefit elsewhere.

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Lori Beck

Milk of magnesia see **Antacids**

Mineral deficiency

Definition

Mineral deficiency describes a condition in which the concentration of any one of the **minerals** essential to human health is abnormally low in the body. In some cases, an abnormally low mineral concentration is defined as that which leads to an impairment in a function dependent on the mineral. In other cases, an abnormally low mineral concentration signifies a lower level than that found in a specific healthy population.

Mineral nutrients are the inorganic elements or inorganic molecules required for life. As far as human **nutrition** is concerned, the inorganic nutrients include water, sodium, potassium, chloride, **calcium**, phosphate, sulfate, magnesium, **iron**, **copper**, **zinc**, manganese, iodine, selenium, and molybdenum. Some of the inorganic nutrients, such as water, do not occur as single atoms, but occur as molecules. Other inorganic nutrients that are molecules include phosphate, sulfate, and selenite. Phosphate contains an atom of **phosphorus**. Sulfate contains an atom of sulfur. Humans do not need to eat sulfate, since the body can acquire all the sulfate it needs from protein. Selenium occurs in foods as selenite and selenate.

The mineral content of the body can be measured by testing samples of **blood** plasma, red blood cells, or urine. In the case of calcium and phosphate deficiency, the diagnosis may also involve taking x rays of the skeleton. In the case of iodine deficiency, the diagnosis may include examining the patient's neck with the eyes and hands. In the case of iron deficiency, the diagnosis may include the performance of a stair-stepping test by the patient. Since all the minerals serve strikingly different functions in the body, the tests for the corresponding deficiency are markedly different from each other.

Description

Laboratory studies with animals have revealed that severe deficiencies in any one of the inorganic nutrients can result in very specific symptoms, and finally in death, due to the failure of functions associated with that nutrient. In humans, deficiency in one nutrient may occur less often than deficiency in several nutrients. A patient suffering from malnutrition is deficient in a variety of nutrients. In the United States, malnutrition is most often found among severe alcoholics. In part, this is because the alcohol consumption may supply half of the energy requirement, resulting in a mineral and vitamin intake of half the expected level. Deficiencies in one nutrient do occur, for example, in human populations living in

iodine-poor regions of the world, and in iron deficient persons who lose excess iron by bleeding.

Inorganic nutrients have a great variety of functions in the body. Water, sodium, and potassium deficiencies are most closely associated with abnormal nerve action and cardiac arrhythmias. Deficiencies in these nutrients tend to result not from a lack of content in the diet, but from excessive fluid and electrolyte losses due to severe **diarrhea** and other causes. Iodine deficiency is a global **public health** problem. It occurs in parts of the world with iodine-deficient soils, and results in goiter, which involves a relatively harmless swelling of the neck, and cretinism, a severe birth defect. The only use of iodine in the body is for making thyroid hormone. However, since thyroid hormone has a variety of roles in development of the embryo, iodine deficiency during **pregnancy** results in a number of birth defects.

Calcium from the diet is absorbed in the gastrointestinal tract while the excess is excreted in the urine. A minimum of 500–1000 mg of calcium is required daily in order to maintain a normal calcium concentration. Normally, the body transfers calcium to the blood from the bones to maintain calcium homeostasis. If calcium intake falls short of requirement, too much calcium will be mobilized from the bones, weakening the bones and contributing to **osteoporosis**.

Dietary phosphate deficiency is rare because phosphate is plentiful in plant and animal foods, but also because phosphate is efficiently absorbed from the diet into the body.

Iron deficiency causes anemia (lack of red blood cells), which results in tiredness and shortness of breath.

Dietary deficiencies in the remaining inorganic nutrients tend to be rare. Magnesium deficiency is uncommon, but when it occurs it tends to occur in chronic alcoholics, in persons taking diuretic drugs, and in those suffering from severe and prolonged diarrhea. Magnesium deficiency tends to occur with the same conditions that provoke deficiencies in sodium and potassium. Zinc deficiency is found primarily in impoverished populations in the Middle East, who rely on unleavened whole wheat bread as a major food source. Copper deficiency is rare but dramatic, and health-threatening changes in copper **metabolism** occur in two genetic diseases, Wilson's disease and Menkes' disease.

Selenium deficiency may occur in regions of the world where the soils are poor in selenium. Low-selenium soils can produce foods that are also low in selenium. **Premature infants** may also be at risk for selenium deficiency.

Causes and symptoms

Sodium deficiency

Sodium deficiency (hyponatremia) and water imbalances (**dehydration**) are the most serious and widespread deficiencies in the world. These electrolyte deficiencies tend to arise from excessive losses from the body, as during prolonged and severe diarrhea or vomiting. Diarrheal diseases are a major world health problem, and are responsible for about a quarter of the 10 million infant deaths that occur each year. Nearly all of these deaths occur in impoverished parts of Africa and Asia, where they result from contamination of the water supply by animal and human feces.

The main concern in treating diarrheal diseases is dehydration, that is, the losses of sodium and water which deplete the fluids of the circulatory system (the **heart**, veins, arteries, and capillaries). Severe losses of the fluids of the circulatory system result in **shock**. Shock nearly always occurs when dehydration is severe enough to produce a 10% reduction in body weight. Shock, which is defined as inadequate supply of blood to the various tissues of the body, results in a lack of oxygen to all the cells of the body. Although diarrheal fluids contain a number of electrolytes, the main concern in avoiding shock is the replacement of sodium and water.

Sodium deficiency also frequently results during treatment with drugs called diuretics. Diuretics cause a loss of sodium from the body. These drugs are used to treat high **blood pressure (hypertension)**, where the resulting decline in blood pressure reduces the risk for cardiovascular disease. However, diuretics can lead to sodium deficiency, resulting in low plasma sodium levels. Hyponatremia occurs in approximately 1% of all hospital admissions and is especially problematic in the elderly.

Potassium deficiency

Potassium plays a major part in cell metabolism and in nerve and muscle cell function. Most of the body's potassium is located in the cells. Too high or low concentrations of blood potassium can have serious effects such as an abnormal heart rhythm or cardiac arrest. Like other electrolytes, potassium balance is regulated through gastrointestinal tract absorption of food, while excretion is controlled by the kidney.

A low potassium blood level is referred to as hypokalemia. Hypokalemia is common in the elderly. Common causes include decreased intake of potassium during acute illness, nausea and vomiting, and treatment with diuretics. Since several foods contain potassium, hypokalemia is not typically due to a low intake. It is

usually due to malfunction of the **kidneys** or abnormal loss through the gastrointestinal tract. People with heart disease have to be especially cautious regarding hypokalemia (particularly when taking digoxin), because they are prone to developing abnormal rhythms. A side effect of some diuretics is excessive loss of potassium, therefore, hypokalemia may result.

High sources of potassium are:

- bananas
- melons
- tomatoes
- oranges
- potatoes and sweet potatoes
- green leafy vegetables such as spinach, turnip greens, collard greens, kale, etc.
- most peas and beans
- potassium supplements
- salt substitutes (potassium chloride)

Calcium and phosphate deficiency

Calcium and phosphate are closely related nutrients. About 99% of the calcium and 85% of the phosphate in the body occur in the skeleton, where they exist as crystals of solid calcium phosphate. Conditions such as growth, pregnancy, and **lactation** are associated with increased phosphate requirements.

The body's calcium reserves are predominantly stored in bones although the blood and cells also contain calcium. Calcium is necessary for proper functioning in many areas of the body including nerve conduction, **muscle contraction**, and enzyme functions. Like other electrolytes, calcium levels are controlled both in blood and cells. A low calcium blood level is referred to as hypocalcemia. Hypocalcemia can result from a number of problems. The most common reason is an inability to mobilize calcium from the bones or a chronic loss of calcium in the urine.

Other causes of hypocalcemia include:

- low blood albumin concentration
- hypoparathyroidism
- **vitamin D** deficiency
- renal failure
- magnesium depletion
- acute pancreatitis
- hypoproteinemia (low blood protein)
- septic shock

- hyperphosphatemia (high blood phosphate levels)
- drugs such as those used to treat hypercalcemia or anti-convulsants
- excessive secretion of calcitonin

An abnormally low blood calcium concentration may not produce any symptoms. However, over time, the lack of calcium in the blood can affect **brain** function, causing neurologic symptoms such as **memory** loss, depression, confusion, delirium, and hallucinations. Once calcium levels return to normal, these symptoms are reversible. Very severe cases of hypocalcemia can lead to seizures, tetany, and muscle spasms in the throat, affecting breathing.

Calcium deficiency due to vitamin D deficiency can be found among certain populations. Vitamin D is required for the efficient absorption of calcium from the diet, and hence vitamin D deficiency in growing infants and children can result in calcium deficiency. The body can produce Vitamin D with sun exposure. Vitamin D deficiency can be found among young infants, the elderly, and others who may be shielded from sunshine for prolonged periods of time. Vitamin D deficiency impairs the absorption of calcium from the diet, and in this way can provoke calcium deficiency even when the diet contains adequate calcium.

Both calcium and phosphate occur in a great variety of foods, but many men, and women in particular, consume less than the required amount of calcium daily. Men over 65 years, postmenopausal women, and women who are lactating tend to be in negative calcium balance, and thus calcium is drawn from the bones to maintain calcium homeostasis. Milk, eggs, and green, leafy vegetables are rich in calcium and phosphate. Whole cow milk, for example, contains about 1.2 g calcium and 0.95 g phosphorus per 2.2 lbs (1 kg) of food. Broccoli contains 1.0 g calcium and 0.67 g phosphorus per 2.2 lbs (1 kg) of food. Meat, poultry, and fish are also high in phosphorus (phosphate).

Iodine deficiency

Iodine deficiency tends to occur in regions of the world where the soil is poor in iodine. Where soil used in agriculture is low in iodine, the foods grown in the soil will also be iodine poor. An iodine intake of 0.10–0.15 mg/day is considered to be nutritionally adequate, while iodine deficiency occurs at below 0.05 mg/day. Goiter, an enlargement of the **thyroid gland** (located in the neck), results from iodine deficiency. Goiter continues to be a problem in eastern Europe, parts of India and South America, and in Southeast Asia. Goiter has been eradicated in the United States because of the fortification of

foods with iodine. Iodine deficiency during pregnancy results in cretinism in the newborn. Cretinism involves mental retardation, a large tongue, and sometimes deafness, muteness, and lameness.

Iron deficiency

Iron deficiency occurs due to periods of dietary deficiency, rapid growth, and excessive loss of the body's iron. Human milk and cow milk both contain low levels of iron. Infants are at risk for iron deficiency because their rapid rate of growth needs a corresponding increased supply of dietary iron, for use in making blood and muscles. Human milk is a better source of iron than cow milk, since about half of the iron in human breast milk is absorbed by the infant's digestive tract. In contrast, only 10% of the iron in cow milk is absorbed by the infant. Surveys of lower-income families in the United States have revealed that about 6% of the infants are anemic indicating a deficiency of iron in their diets. Blood loss that occurs with menstruation in women, as well as with a variety of causes of intestinal bleeding, is a major cause of iron deficiency. The symptoms of iron deficiency are generally limited to anemia, and the resulting tiredness, weakness, and a reduced ability to perform physical work.

Magnesium deficiency

Magnesium influences the function of many enzymes. Dietary intake is essential to maintain normal levels. The body's magnesium stores are predominately found in bone with little appearing in the blood. Excess is excreted in the urine or stool.

Magnesium deficiency results in hypomagnesemia, which is defined as serum magnesium levels below 0.8 mmol/L. Normal blood serum magnesium levels are 1.2–2.0 mmol/L. Some of the symptoms of hypomagnesemia, which include twitching and convulsions, actually result from hypocalcemia. Other symptoms of hypomagnesemia, such as cardiac arrhythmias, result from low potassium levels. Metabolic and nutritional disorders are usually the culprit of hypomagnesemia, most often when intake of magnesium is decreased during starvation or intestinal malabsorption compounded with greater kidney excretion. Magnesium levels below 0.5 mmol/L provoke a decline in serum calcium levels. Hypomagnesemia can also result in low serum potassium.

Zinc deficiency

Zinc deficiency has been found among peasant populations in rural areas of the Middle East. Unleavened whole wheat bread can account for 75% of the energy intake in these areas. This diet, which does not contain

meat, does contain zinc, but it also contains phytic acid at a level of about 3 g/day. The phytic acid, which naturally occurs in wheat, inhibits zinc absorption. The yeast used to leaven bread produces enzymes that inactivate the phytic acid. Unleavened bread does not contain yeast, and therefore, contains intact phytic acid. The symptoms of zinc deficiency include lack of sexual maturation, lack of pubic hair, and small stature. The amount of phytic acid in a typical American diet cannot provoke zinc deficiency.

Zinc deficiency is relatively uncommon in healthy adults in the United States, but often occurs in adults with **alcoholism** or intestinal malabsorption problems. Zinc levels also may be problematic in the elderly, pregnant women, diabetics, **AIDS** patients, and those with chronic infections and/or trauma. Low plasma zinc has been found in patients with alcoholic cirrhosis, **Crohn's disease**, and celiac disease. Experimental studies with humans have shown that the signs of zinc deficiency are detectable after two to five weeks of consumption of the zinc-free diet. The signs include a rash and diarrhea. The rash occurs on the face, groin, hands, and feet. These symptoms can easily be reversed by administering zinc. Absorption of zinc is largely dependent on the presence or absence of other foods that affect zinc absorption. Meats, **liver**, eggs, and seafoods are good choices of zinc because these foods do not contain many other components which interfere with zinc absorption. An emerging concern is that increased calcium intake can interfere with zinc absorption or retention. Hence, there is some interest in the question of whether persons taking calcium to prevent osteoporosis should also take zinc supplements.

Copper deficiency

Copper deficiency is relatively uncommon but severe alterations in copper metabolism occur in two genetic diseases, Wilson's disease and Menkes' disease. Both of these diseases are rare. Menkes' disease occurs in about one in 50,000 to 100,000 births while Wilson's disease occurs in approximately one in 200,000 births in the United States. Both diseases involve mutations in copper transport **proteins**, that is, in special channels that allow the passage of copper ions through **cell membranes**. Menkes' disease is a genetic disease involving mental retardation and death before the age of three years. The disease also results in steely or kinky hair. The hair is tangled, grayish, and easily broken. Menkes' disease involves a decrease in copper levels in the serum, liver, and brain, and increases in copper in the cells of the intestines and kidney.

The richest sources of copper are shellfish, nuts, seeds, cocoa powder, liver, organ meats, legumes, and the germ and bran portions of grains.

Selenium deficiency

Selenium deficiency may occur in premature infants, since this population naturally tends to have low levels of plasma selenium. Full term infants have plasma selenium levels of about 0.001–0.002 mmol/L, while premature infants may have levels about one third this amount. Whether these lower levels result in adverse consequences is not clear. Total parental nutrition often leads to selenium deficiency if it is not administered in the fluids. Selenium deficiency occurs in regions of the world containing low-selenium soils. These regions include Keshan Province in China, New Zealand, and Finland. In Keshan Province, a disease (Keshan disease) occurs which results in deterioration of regions of the heart and the development of fibers in these regions. Keshan disease, which may be fatal, is thought to result from a combination of selenium deficiency and a virus.

The richest sources of selenium are organ meats and seafood. In addition, muscle meats, cereals and grains, dairy products, and fruits and vegetables provide good sources of selenium.

Other ultratrace mineral deficiencies

Manganese deficiency is very rare. Experimental studies with humans fed a manganese deficient diet have revealed that the deficiency produces a scaly, red rash on the skin of the upper torso. The importance of manganese in human nutrition still needs to be established. It is thought that the possibility in becoming manganese deficient is increased in alcohol abusers. Molybdenum deficiency has probably never occurred, but indirect evidence suggests that if molybdenum deficiency could occur, it would result in mental retardation and death

There is some evidence that other inorganic nutrients, such as chromium and boron, play a part in human health, but their role is not well established. Chromium has a function related to insulin and thus influences carbohydrate, lipid, and protein metabolism. Boron is believed to affect macromineral metabolism in humans. Fluoride has been proven to increase the strength of bones and teeth, but there is little or no reason to believe that is needed for human life.

Diagnosis

The diagnosis of deficiencies in water, sodium, potassium, iron, calcium, and phosphate involve chemical testing of the blood plasma, urine, and red blood cells.

KEY TERMS

Dehydration—A deficit of body water that results when the output of water exceeds intake.

Diuretic—An agent or drug that eliminates excessive water in the body by increasing the flow of urine.

Electrolyte—A substance such as an acid, bases, or salt. An electrolyte's water solution will conduct an electric current and ionizes. Calcium, potassium, magnesium, and sodium are electrolytes.

Homeostatis—An organism's regulation of body processes to maintain internal equilibrium in temperature and fluid content.

Recommended Dietary Allowance—The Recommended Dietary Allowances (RDAs) are quantities of nutrients that are required each day to maintain human health. RDAs are established by the Food and Nutrition Board of the National Academy of Sciences and may be revised every few years. A separate RDA value exists for each nutrient. In 2001, the RDA will be replaced by the Dietary Reference Intakes (DRI) and will apply to Americans and Canadians.

Hypocalcemia is usually first discovered during routine blood tests because often there are no symptoms evident.

Iodine deficiency can be diagnosed by measuring the concentration of iodine in the urine. A urinary level greater than 0.05 mg iodine per gram creatinine means adequate iodine status. Levels under 0.025 mg iodine/g creatinine indicate a serious risk.

There is no reliable test for zinc deficiency. When humans eat diets containing normal levels of zinc (16 mg/day), the level of urinary zinc is about 0.45 mg/day, while humans consuming low-zinc diets (0.3 mg/day) may have urinary levels of about 0.150 mg/day. Plasma zinc levels tend to be maintained during a dietary deficiency in zinc. Plasma and urinary zinc levels can be influenced by a variety of factors, and for this reason cannot provide a clear picture of zinc status.

Selenium deficiency may be diagnosed by measuring the selenium in plasma (70 ng/mL) or red blood cells (90 ng/mL), where the normal values are indicated. There is also some interest in measuring the activity of an enzyme in blood platelets, in order to assess selenium status. This enzyme is glutathione peroxidase. Platelets

are small cells of the bloodstream which are used mainly to allow the clotting of blood after an injury.

Treatment

The treatment of deficiencies in sodium, potassium, calcium, phosphate, and iron often involves intravenous injections of the deficient mineral. Potassium, however, usually can be replaced relatively easily by eating foods rich in potassium or by taking potassium salts (potassium chloride) orally.

Iodine deficiency can be easily prevented and treated by fortifying foods with iodine. Table salt is fortified with 100 mg potassium iodide per kg sodium chloride. Goiter was once common in the United States in areas from Washington State to the Great Lakes region, but this problem has been eliminated by iodized salt. Public health programs in impoverished countries have administered injections of synthetic oils containing iodine. Goiter is reversible, but cretinism is not.

Magnesium deficiency can be treated with a magnesium rich diet. If magnesium deficiency is due to a prolonged period of depletion, treatment may include injections of magnesium sulfate (2.0 mL of 50% $MgSO_4$). Where magnesium deficiency is severe enough to provoke convulsions, magnesium needs to be administered by injections or infusions. For infusion, 500 mL of a 1% solution (1 gram/100 mL) of magnesium sulfate is gradually introduced into a vein over the course of about five hours. When hypomagnesemia occurs along with hypocalcemia, the magnesium must be replaced before successful treatment of the calcium disorder.

Zinc deficiency and copper deficiency are quite uncommon, but when they are detected or suspected, they can be treated by consuming zinc or copper, on a daily basis, at levels defined by the RDA.

Selenium deficiency in adults can be treated by eating 100 mg selenium per day for a week, where the selenium is supplied as selenomethionine. The incidence of Keshan disease in China has been reduced by supplementing children with 1.0 mg sodium selenite per week.

Prognosis

In iodine deficiency, the prognosis for treating goiter is excellent, however cretinism cannot be reversed. The effects of iron deficiency are not life-threatening and can be easily treated. The prognosis for treating magnesium deficiency is excellent. The symptoms may be relieved promptly or, at most, within two days of starting treatment. In cases of zinc deficiency in Iran and other parts of the Middle East, supplementation of affected young adults with zinc has been found to provoke the growth of

pubic hair and enlargement of genitalia to a normal size within a few months.

Health care team roles

Mineral deficiencies are normally diagnosed and treated by physicians. Dietiticians may be employed in efforts of **patient education**. For example, the dietitian may counsel a patient about a healthy diet to prevent further deficiencies, or be involved in community programs to educate the public at large.

Prevention

In the healthy population, all mineral deficiencies can be prevented by the consumption of inorganic nutrients at levels defined by the Recommended Dietary Allowances (RDA) or Dietary Reference Intakes (DRI). Where a balanced diet is not available, government programs for treating individuals, or for fortifying the food supply, may be used. Government sponsored programs for the prevention of iron deficiency and iodine deficiency are widespread throughout the world. Selenium treatment programs have been used in parts of the world where selenium deficiency exists. Attention to potassium status, and to the prevention of potassium deficiency, is an issue mainly in patients taking diuretic drugs. In many cases of mineral deficiency, the deficiency occurs because of disease, and individual medical attention, rather than preventative measures, is used. Calcium supplements are widely used with the hope of preventing osteoporosis. The prevention of deficiencies in magnesium, copper, manganese, or molybdenum are not major health issues in the United States. Ensuring an adequate intake of these minerals, by eating a balanced diet or by taking mineral supplements, is the best way to prevent deficiencies.

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- Food and Nutrition Information Center Agricultural Research Service, USDA. National Agricultural Library, Room 304, 10301 Baltimore Avenue, Beltsville, MD 20705-2351. (301) 504-5719. Fax (301) 504-6409. <<http://www.nal.usda.gov/fnic/>>. fnic@nal.usda.gov.

OTHER

- Food and Nutrition Professionals Network. <<http://nutrition.cos.com/>>.

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Minerals

Definition

Minerals are naturally occurring inorganic substances that are obtained from food and perform a range of important functions in the body. Minerals are categorized as major minerals, or macronutrients, which are present in the body in amounts greater than five grams; and trace minerals, which are present in amounts below five grams. Trace minerals are sometimes called micronutrients.

Description

Major minerals

The major minerals consist of **calcium, phosphorus, potassium, sulfur, sodium, chloride, and magnesium**. Sodium, potassium, and chloride are sometimes grouped together as electrolytes. An electrolyte is a substance that breaks down into ions when it is dissolved in a suitable medium and thus becomes a conductor of electricity. Each of the major minerals aids in maintaining the body's

fluid, electrolyte, and **acid-base balance** as well as having specific functions.

CALCIUM. Calcium is the most abundant mineral in the human body; 99% of it is stored in the bones and teeth. Calcium maintains bone structure and helps regulate **blood** calcium levels. This mineral is also necessary for the transport of electrical ions across **cell membranes**. Inadequate calcium intake during childhood and adulthood can result in **osteoporosis**, in which there is loss of bone substance. Many Americans do not get enough calcium in their diets. Good dietary sources of calcium include milk, broccoli, mustard greens, kale, cheese, and sardines. The recommended dietary allowance (RDA) of calcium for adults is about 800 mg.

PHOSPHORUS. Phosphorus is also an abundant mineral. Most of the phosphorus—about 80%—that occurs in the body is combined with calcium in the bones and teeth. Phosphorus plays a role in the energy **metabolism** of cells; helps maintain the body's acid-base balance; and is needed for tissue growth and renewal. Animal products that are high in protein, such as milk, cottage cheese, and steak, are excellent sources of phosphorus. Deficiencies of phosphorus are rare except in patients taking **antacids** for long periods of time. The RDA of phosphorus for adults is 800 mg.

MAGNESIUM. About 50% of the body's magnesium is in the bones, with the remainder in the cells of the muscles and soft tissues. Magnesium functions in the operation of enzymes and aids in the metabolism of calcium, potassium, and **vitamin D**. Magnesium deficiency can result from a low intake of the mineral, from **diarrhea**, and from **alcoholism**. Magnesium deficiency can cause hallucinations and has been associated with **heart** problems. Good dietary sources of magnesium include spinach, oysters, baked potatoes, and sunflower seeds.

Magnesium is used in a number of over-the-counter preparations as an antacid and laxative. The most common uses of magnesium in clinical medicine include treatment of tachycardia (excessively rapid heartbeat), and depletion of electrolytes (chloride, potassium, and sodium). It is also used to manage premature labor. The RDA of magnesium is 350 mg for men, 280 mg for women.

SODIUM. Sodium is a mineral that plays an important role in the proper functioning of nerves and muscles. It is also an important component of intracellular fluid. Sodium deficiency does not occur with a normal diet, but may result from illness or injury. Too much sodium in the diet may raise **blood pressure** and cause **hypertension**. Salt is the main source of sodium in the diet, but table salt is not the most significant source of sodium. Most sodium in the average American's diet comes from processed

and fast foods. The RDA of sodium is between 100 and 3300 mg.

POTASSIUM. Potassium helps maintain fluid and **electrolyte balance** in the body. Potassium is found in a variety of foods; however, potassium deficiency can result from illness, injury, or treatment with diuretics. The best sources of dietary potassium are fresh fruits and vegetables, especially bananas, potatoes, and raisins. The RDA of potassium is between 1875 and 5625 mg.

CHLORIDE. Chloride helps maintain **fluid balance** in the body. It is an essential component of the hydrochloric acid in the gastric fluid required for digestion. Chloride deficiency can result from repeated vomiting, diuretic therapy, or kidney disease. The RDA of chloride is between 1700 and 5100 mg.

SULFUR. Sulfur occurs in the body in such other compounds as **thiamine** and **proteins**. It helps to maintain the structure of skin, hair, and nails, and functions in oxidation/reduction reactions. Sulfur deficiency is a relatively unusual condition, because the body's need for sulfur is satisfied by the amino acids contained in foods high in protein.

Trace minerals

The trace minerals, or micronutrients, include **iron**, iodine, **zinc**, fluoride, selenium, chromium, and **copper**. Even though these elements are present in very small amounts in the human body, they serve many important functions.

IRON. Iron is a component of hemoglobin in red blood cells and myoglobin in muscle cells. It helps these compounds to hold and carry oxygen throughout the blood and the muscles. Iron also aids in enzyme activity and cell synthesis. Lack of iron in the diet can cause iron-deficiency anemia, which is the most common nutrient deficiency in the world. Symptoms include tiredness, weakness, and a tendency to feel cold. Animal foods such as meat, poultry, and fish are excellent sources of iron. **Vitamin C** also helps promote the absorption of iron. The RDA of iron is 10 mg for men, 18 mg for women.

IODINE. Iodine is a mineral that is needed for the hormone thyroxine, which plays a part in energy metabolism. Iodine deficiency causes an enlargement of the **thyroid gland** in the neck, which is known as a goiter. A deficiency in pregnant women can also result in mental and physical retardation known as cretinism. Iodine can be found in seafood, foods grown on land, and bakery products. The RDA of iodine is 150 micrograms.

ZINC. Zinc is needed in only very small amounts, but it functions in nearly every organ of the body. It plays a role in the **immune system**, sperm production, **taste**

perception, and wound healing. Inadequate intakes of zinc can result in poor growth and appetite as well as poor taste acuity. Too much zinc can impair the absorption of iron and copper in the body. Sources of zinc include meat, shellfish, poultry, legumes, and whole grains. The RDA of zinc is 15 mg.

SELENIUM. Selenium is a relatively rare nonmetallic trace element; there is less than 1 milligram of selenium in the average human body. The selenium is concentrated in the **liver, kidneys, and pancreas**; and in males, in the testes and seminal vesicles. It also activates thyroid hormone, which regulates the body's metabolism. Selenium can be found in a variety of foods; good sources of it include brewer's yeast, wheat germ, wheat bran, kelp (seaweed), shellfish, brazil nuts, barley, and oats. Selenium is most widely recognized as a substance that speeds up the metabolism of fatty acids and works together with **Vitamin E** (tocopherol) as an antioxidant. Antioxidants are organic substances that are able to counteract the damage done by oxidation to human tissue. The RDA of selenium is between 0.05 and 0.2 micrograms.

FLUORIDE. Fluoride has not been proven to be an essential mineral, but it does play a role in forming bones and teeth. Fluoride is most readily available from fluoridated drinking water. Too much of this element can cause a discoloration of the teeth known as **fluorosis**, but adequate fluoride consumption throughout life will help protect against **dental caries**. The RDA of fluoride is between 1.5 and 4.0 mg.

CHROMIUM. Chromium is closely associated with the hormone insulin, which regulates blood glucose levels. Chromium is usually depleted during food processing, which increases the chance for a deficiency if fast foods are eaten very often. Good sources of chromium include liver, whole grains, cheese, and nuts. The RDA of chromium is between 0.05 and 0.2 mg.

COPPER. Copper helps to form hemoglobin and collagen in the body as well as enzymes. Copper deficiency can impair growth and development, but is rarely encountered. Copper toxicity is also rare, but can occur from too much supplementation. Copper can be found in cherries, legumes, whole grains, seafood, nuts, and organ meats. The RDA of copper is 2–3 mg.

OTHER MICRONUTRIENTS. There are other trace minerals found in the body including boron, molybdenum, cobalt, and nickel. These minerals are all important to the body's health, but they are readily available in a normal diet. Deficiencies of these micronutrients are extremely rare.

KEY TERMS

Acid-base balance—The balance between the acidity and alkalinity of body fluids.

Antioxidant—A substance that works to counteract the damage done by oxidation to human tissue. Dietary antioxidants include the trace mineral selenium.

Electrolyte—An element or compound that dissociates in water and acts as a conductor of electricity.

Hemoglobin—A protein found in red blood cells that carries oxygen from the lungs to the tissues of the body.

Inorganic—Pertaining to chemical compounds that are not hydrocarbons or their derivatives.

Myoglobin—A form of hemoglobin found in muscle tissue.

Trace element—An element that is required in only minute quantities for the maintenance of good health. Trace elements are also called micronutrients.

Complications

Vitamin and mineral supplementation has become a very common practice in the general population, due in part to aggressive advertising and marketing of dietary supplements. While vitamin and mineral supplements are beneficial to those whose diets are lacking in certain nutrients, extremely high doses of some minerals can have toxic effects. For example, too much iron can cause tissue damage and **infection**. High levels of magnesium can cause depressed deep tendon **reflexes**, fatigue, and sleepiness. High levels of selenium have been associated with tooth decay.

On the other hand, care should be taken to meet the body's needs for higher levels of mineral intake during **pregnancy** and periods of high physical or emotional **stress** (surgery, trauma, etc.).

Health care team roles

Professional dietitians and other **nutrition** experts are primarily responsible for recommending mineral supplementation when it is necessary and for educating consumers on the dangers of excess supplementation. They also play a role in educating the public on the benefits of

eating a well-balanced diet in order to receive adequate amounts of the various minerals.

Dentists and dental hygienists should instruct patients about the importance of dietary calcium and fluoridated water to healthy teeth.

Physicians, registered nurses, and pharmacists should instruct patients about the possible side effects of certain medications— particularly diuretics, antihypertensives, and some types of laxatives— that may cause electrolyte imbalance. Emergency room personnel should be knowledgeable about mineral deficiencies and mineral toxicities in the differential diagnosis of such symptoms as cardiac arrhythmias, seizures, disorientation, muscle twitching, and muscle weakness.

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Miscarriage

Definition

A miscarriage is the loss of an embryo or fetus before the twentieth week of **pregnancy**. A pregnancy loss after the twentieth week is called a stillbirth.

Description

According to the December 1999 news release from the U.S. government's National Center for Health Statistics, about 16% of recognized pregnancies end in miscarriage (i.e., prior to 20 weeks' gestation) or stillbirth (after 20 weeks' gestation). The medical term used for a miscarriage is spontaneous abortion, or early pregnancy loss. Most miscarriages occur during the first trimester of pregnancy. However, the statistics are unclear for the total number of recognized and unrecognized miscarriages in the United States. This is because a number of recognized miscarriages go undetected. When the pregnancy loss occurs early, the woman may not have missed her period yet. In this instance, she would not be aware of the pregnancy loss. Medical attention would not have been sought, and no statistic would have been generated.

Causes and symptoms

Causes of miscarriage may be genetic, anatomic, endocrinologic, infectious, immunologic, or exposure to a toxin. About 50–60% of first-trimester miscarriages occur as a result of a chromosomal abnormality, which renders the fetus non-viable. A definitive cause for the loss of a pregnancy cannot always be determined, as the products of conception (POC) are often passed by the woman at home or at work; they have not been collected for pathologic examination. The chromosomal abnormality is usually of spontaneous origin, a mutation that is not repeated in a subsequent pregnancy that continues to term.

A woman with a malformed uterus (e.g., bicornate) or cervix is also at increased risk for miscarriage. Women whose mothers took the medication diethylstilbestrol (DES) while they were *in utero* are especially likely to have suffered reproductive tract anomalies. The presence of fibroids can compete with the fetus for space and **blood** supply, and may result in miscarriage.

In about 17% of cases, a miscarriage is hormonal in nature, such as with insufficient secretion of progesterone, which results in a luteal phase insufficiency. Polycystic ovarian syndrome (PCOS), thyroid dysfunction, and poorly controlled **diabetes mellitus** are other hormonal causes of miscarriage.

Bacterial vaginosis, which may be present in as many as 31% of pregnant women, has been shown to increase the risk of miscarriage two fold, although it does not appear to affect a woman's ability to conceive. Individuals with a compromised **immune system**, causing them to be more susceptible to infectious organisms, are at increased risk of miscarriage. Toxoplasmosis can

also cause miscarriages. The age of the egg at the time of fertilization may also be a factor. The older the egg, relative to ovulation, may be at greater risk of pregnancy loss.

Toxins and other workplace hazards that may increase the risk of miscarriage include:

- smoking, where the risk increases with each 10 cigarettes smoked daily
- caffeine, as in coffee, when four or more cups are consumed daily
- alcohol
- exposure to arsenic, lead, formaldehyde, benzene, and ethylene oxide
- multiple pregnancy, as in the case of carrying twins
- treatment with **anticancer drugs**, such as methotrexate
- exposure to ionizing radiation

The most common sign that a pregnancy is in danger is vaginal bleeding. The amount can vary from very light to heavy. The color of the blood varies as well, from brown to bright red. However, bleeding in early pregnancy is relatively common, and does not necessarily indicate impending miscarriage. One in four or five pregnant women experience bleeding in early pregnancy. Many women have some bleeding at the time of implantation, which occurs seven to 10 days after conception. Because of the possibility of pregnancy loss, any bleeding during pregnancy should be immediately reported to a woman's health care provider. The blood may be clotted, containing visible pieces of tissue. Bleeding may also be a sign of ectopic pregnancy, where the egg implants in a location other than the uterus, 95% of the time in a fallopian tube. Growth of the fertilized egg can lead to rupture of the tube, and can be life-threatening to the mother if untreated.

Cramping is another sign of a possible miscarriage. Cramping occurs as the uterus tries to expel the POC. The woman may also experience **pain**, dull and unrelenting, or sharp and intermittent, in the lower abdomen or back. When pain and bleeding persist, miscarriage is most likely to occur.

Diagnosis

If a woman experiences any sign of potential miscarriage, she should be examined by her health care provider. The physician, nurse midwife or nurse practitioner will usually perform a pelvic examination to check whether the cervix is closed or open. The cervix should remain closed throughout the pregnancy, opening only at the time of labor and delivery. If the cervix is open, the

miscarriage has either already taken place or is inevitable. The size, firmness, and tenderness of the uterus will be checked by the practitioner. Blood tests may be ordered to determine if the level of beta-hCG, which should have been rising as the pregnancy continued, has begun to decline. If bleeding has been heavy, blood work may be ordered to check the woman's hemoglobin (oxygen-carrying red blood cells; how much hemoglobin is in the blood) and **hematocrit** (volume of packed blood cells) levels. An ultrasound may also be conducted to see if miscarriage has already occurred, if the fetus is alive or dead, and to check for intrauterine versus extrauterine implantation. An ultrasound can also detect the presence of any uterine abnormalities.

The further into the gestation period, the more likely it is that the fetus and placenta may be expelled separately. If some of the POC has been retained, the miscarriage is referred to as an incomplete abortion. An incomplete abortion presents the risk of **infection**, which, left untreated and unpassed, can lead to a potential life-threatening sepsis. A missed abortion is defined by the death of the fetus that has remained *in utero* for several weeks. Most missed abortions terminate spontaneously.

Treatment

Most miscarriages require no treatment. However, if infection has set in (i.e., indicated by **fever** and/or chills), or the POC have been retained, a D & C (i.e., prior to 16 weeks) or a D & E (i.e., after 16 weeks) may be required to remove any remaining tissue or blood clots from inside the uterus. An IV solution containing oxytocin may be used to induce uterine contractions to assist in complete expulsion of the POC, although this is not done in some practices. In early gestation (prior to six weeks), oral mifepristone (antiprogesterone RU 486) may be used to effect abortion. Two clinical studies, one in 1992 and another in 1993, demonstrated that the drug was effective as an abortifacient. In the earlier investigation, RU 486 administration to pregnant women was followed by a prostaglandin analogue; the success rate was 95%. In 1993, when a single 600-mg dose of RU 486 was given to women prior to six weeks' gestation, an 85% abortion rate was achieved.

Antibiotics will be prescribed in the event of infection, and may be ordered prophylactically. The woman is usually told to avoid the use of tampons and to abstain from sexual intercourse until the cervix has had a chance to close and heal. Rh-negative women will be given an injection of RhoGAM by the nurse. The purpose of this is to prevent Rh incompatibility between the mother and her baby in a future pregnancy.

KEY TERMS

Abortifacient—An agent that induces abortion.

Diethylstilbestrol (DES)—A synthetic estrogen drug used to treat several hormonal conditions. DES was used from 1938 until 1971, when it was found to cause reproductive tract defects in the children of women who took the drug while pregnant.

Dilation and curettage (D & C)—An obstetrical or gynecologic procedure in which the cervix is dilated and the contents of the uterus scraped and suctioned out. During pregnancy it is the term used until 16 weeks gestation.

Dilatation and evacuation (D & E)—An obstetrical procedure performed after 16 weeks gestation in which the cervix is dilated and the contents evacuated.

Embryo—The unborn child in the first eight weeks after conception. After the eighth week, the unborn child is called a fetus.

Mifepristone—A drug used to induce abortion. Also called RU-486.

Prostaglandin analogue—Any of a group of naturally occurring, chemically related hydroxy fatty acids that stimulate contractility of the uterine and other smooth muscle. These compounds have structures similar to those of others, but they differ in terms of a particular component.

Prognosis

Most miscarriages are uncomplicated and do not affect the woman's future ability to carry to term. About 90% of women who had one miscarriage have a successful pregnancy in the future. About 75% of women experiencing two miscarriages will carry to term in the future. Even women who have three consecutive miscarriages have a 50% chance of a successful fourth pregnancy. However, women who have had three or more miscarriages (repeated pregnancy loss [RPL]) may pursue further medical evaluation—earlier, if the woman is 35 or older. Following a miscarriage a woman should wait at least until she has had her next period before attempting to become pregnant again.

While the woman is able to recover physically from a miscarriage from within a few days to a couple of months, an emotional recovery may take much longer. Grieving the loss of the pregnancy may take some time

for the woman, her partner, other family members, and even close friends. Some women may develop major depression, acute **stress disorder**, or even **post-traumatic stress disorder (PTSD)**. Feelings of loss, of self-blame, of anger at a body that has “failed” them are all common.

Health care team roles

A nurse may be the first contact for the woman experiencing a miscarriage, either by telephone, at the clinic or doctor's office, or in the emergency department. The nurse's ability to create a calm environment, and to be supportive of the woman's grieving can enable the woman to move forward after the experience. The nurse should be able to supply the woman with information about miscarriage and community resources, such as support groups.

The ultrasound technologist may perform the ultrasound on the woman undergoing a miscarriage. Usually the technologist will give the report of the findings to the woman's practitioner, not to the woman directly. However, **anxiety** and fear can affect how information is heard and processed. The technologist's use of a soft, soothing voice can help calm the woman, better enabling her to hear the outcome of the ultrasound from her practitioner.

Prevention

Because the majority of miscarriages are spontaneous chromosomal abnormalities, little prevention is available. However, regular screening for sexually transmitted diseases (STDs) and bacterial vaginosis can decrease the risks to a future pregnancy. If the miscarriage was due to a luteal phase deficiency, supplemental progesterone may be prescribed for future pregnancies.

If the nurse has telephone contact with the woman during the miscarriage, the nurse should request that the woman collect any tissue that is expelled—and collected, perhaps, on a sanitary pad. The nurse should ask the patient to bring it along with her to her next examination, so that it may be analyzed. While this may place an emotional burden on the woman, it can allow for the possible determination of the cause of the miscarriage. This information can help the woman and her practitioner prepare for a subsequent pregnancy. In addition, studies have shown that determining the cause can often assist the woman in overcoming her feelings of self-blame.

Resources

BOOKS

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- Hinton, Clara H. *Silent Grief; Miscarriage—Finding Your Way Through the Darkness*. Green Forest, AK: New Leaf Press, 1998.
- Kohn, Ingrid, and Perry-Lynn Moffitt. *A Silent Sorrow. Pregnancy Loss: Guidance and Support for You and Your Family*. New York: Routledge, 2000.
- Pasquariello, Patrick S. *Children's Hospital of Philadelphia: Book of Pregnancy and Child Care*. New York: John Wiley & Sons, 1999.
- Scott, James R., Philip J. Di Saia, Charles B. Hammond, and William N. Spellacy, eds. *Danforth's Obstetrics and Gynecology*. Philadelphia: Lippincott Williams & Wilkins, 1999.

PERIODICALS

"The Effects of Workplace Hazards on Female Reproductive Health." <<http://www.cdc.gov/niosh>>.

ORGANIZATIONS

- Hygeia. <<http://www.hygeia.org>>.
- March of Dimes Birth Defects Foundation. 1275 Mamaroneck Avenue, White Plains, NY 10605. (888) 663-4637. <<http://www.modimes.org>>.
- Resolve: The National Infertility Association. 1310 Broadway, Somerville, MA 02144. (617) 623-0744. resolveinc@aol.com. <<http://www.resolve.org>>.

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Mitosis see **Cell division**

Mongolism see **Down syndrome**

Mouth cancer see **Oral cancer**

Mouthwash see **Oral hygiene aids**

Movement disorders

Definition

Movement disorders are a group of neurological diseases and syndromes that involve the motor and movement systems' ability to produce and control movement.

Description

Though it seems simple and effortless, normal movement actually requires an astonishingly complex

system of control. Disruption of any portion of this system can cause a person to produce movements that are too weak, too forceful, too uncoordinated, or too poorly controlled for the task at hand. Unwanted movements may occur at rest. Intentional movement may become impossible. These conditions are examples of movement disorders.

Abnormal movements themselves are symptoms of underlying disorders. In some cases, the abnormal movements are the only symptoms. The more common diseases causing motor disorders include:

- **spinal cord injury (SCI)**
- stroke
- **multiple sclerosis (MS)**
- **muscular dystrophy (MD)**
- huntington's chorea (HC)
- **cerebral palsy (CP)**
- dystonias
- tremor
- myasthenia gravis (MG)
- parkinsonism (PD)
- Tourette syndrome

Other causes of motor disorders are Wilson's disease (WD), inherited ataxias (Friedreich's ataxia, Machado-Joseph disease, and spinocerebellar ataxias), and encephalopathies.

Causes and symptoms

Causes

Movement is produced and coordinated by several interacting **brain** centers, including the motor cortex, the cerebellum, and a group of structures in the inner portions of the brain called the basal ganglia. Sensory information provides critical input on the current position and velocity of body parts, and spinal nerve cells (**neurons**) help prevent opposing muscle groups from contracting simultaneously.

To understand how movement disorders occur, it is helpful to consider a normal volunteer movements, such as reaching to touch a nearby object with the right index finger. To accomplish the desired movement, the arm must be lifted and extended. The hand must be held out to align with the forearm, and the forefinger must be extended while the other fingers remain flexed.

THE MOTOR CORTEX. Voluntary motor commands begin in the motor cortex located on the outer, wrinkled surface of the brain. Movement of the right arm is begun

by the left motor cortex, which generates a large volley of signals to the involved muscles. These electrical signals pass along upper motor neurons, through the mid-brain, to the **spinal cord** (SC). Within the SC, these signals connect to lower motor neurons, which convey the signals from the SC to the surface of the muscles involved. Neural activation of the muscles causes contraction, and the force of contraction pulling on the skeleton causes movement of the arm, hand, and fingers.

Damage to, or death of any of the neurons along this path, can cause weakness or **paralysis** of the affected muscles.

THE CEREBELLUM. Once the movement of the arm is initiated, sensory information is needed to guide the finger to its precise destination. In addition to sight, the most important source of information comes from the “position sense,” provided by the many sensory receptors located within the limbs (proprioception). Proprioception allows a person to touch his or her nose with a finger even with the eyes closed. The balance organs in the ears provide important information about posture. Both postural and proprioceptive information are processed by a structure at the rear of the brain, called the cerebellum. The cerebellum sends out electrical signals to modify movements as they progress, “sculpting” the barrage of voluntary commands into a tightly controlled, constantly evolving pattern. Cerebellar disorders cause inability to control the force, fine positioning, and speed of movements (ataxia). Disorders of the cerebellum may also impair the ability to judge distance, so that a person under- or overreaches the target (dysmetria). Tremor during voluntary movements can also result from cerebellar damage.

THE BASAL GANGLIA. Both the cerebellum and the motor cortex send information to a set of structures deep within the brain that helps control involuntary components of movement (basal ganglia). The basal ganglia send output messages to the motor cortex, helping to initiate movements, regulate repetitive or patterned movements, and control muscle tone.

Circuits within the basal ganglia are complex. Within this structure, some groups of cells begin the action of other basal ganglia components, and some groups of cells block the action. These complicated feedback circuits are not entirely understood. Disruptions of these circuits are known to cause several distinct movement disorders. A portion of the basal ganglia, called the *substantia nigra*, sends electrical signals that block output from another structure, the subthalamic nucleus. The subthalamic nucleus sends signals to the globus pallidus, which in turn blocks the thalamic nuclei. Finally, the thalamic nuclei send signals to the motor cortex. The *sub-*

stantia nigra, then begins movement, and the globus pallidus blocks it.

This complicated circuit can be disrupted at several points. Loss of *substantia nigra*, cells increases blocking of the thalamic nuclei and prevents them from sending signals to the motor cortex. Degeneration of these nerve cells, as in PD, results in lower production of dopamine and fewer connections with other nerve cells and muscles, leading to a loss of movement (motor activity).

In contrast, cell loss in early HD decreases the blocking of signals from the thalamic nuclei, causing more cortex stimulation and stronger, but uncontrolled, movements.

Disruptions in other portions of the basal ganglia are thought to cause tics, tremors, dystonia, and a variety of other movement disorders, although the exact mechanisms are not well understood.

Some movement disorders, including HD, are caused by inherited genetic defects and inherited ataxias. Some diseases that cause sustained **muscle contraction** limited to a particular muscle group (focal dystonia) are inherited, but others are caused by trauma. The cause of most cases of PD is unknown, although genes have been identified for some familial forms.

ANTAGONISTIC MUSCLE PAIRS. This picture of movement, however, is too simple. One important refinement to it comes from considering the role of opposing, or antagonistic, muscle pairs. Contraction of the bicep muscle, located on the top of the upper arm, pulls on the forearm to flex the elbow and bend the arm. Contraction of the triceps, located on the opposite side, extends the elbow and straightens the arm. Within the spine, these muscles are normally wired so that willed (voluntary) contraction of one is automatically accompanied by blocking of the other. In other words, the command to contract the biceps provokes another command within the spine to prevent contraction of the triceps. In this way, these antagonist muscles are kept from resisting one another. Spinal cord or brain injury, can damage this control system and cause involuntary simultaneous contraction and spasticity, an increase in resistance to movement during motion.

While the peripheral mechanism, antagonistic muscle pairs, is certainly important, it is not the only one of concern with regard to movement disorders. Central pattern generators (CPGs) in the spinal cord are especially relevant because of their role in sensory processing. Filtration and processing of sensory input is accomplished locally, where the response of spinal pattern generator circuitry fits into continual movement, as necessary. Thus, although the brain receives much of the sensory input, the responses to spinal inputs are first the

responsibility of the local spinal circuitry. Multi-segmental **reflexes** and anticipatory postural adjustments are as critical in the etiology of these syndromes.

Common conditions causing motor disorders

SPINAL CORD INJURY (SCI). Spinal cord injury (SCI) is very complex and can be very serious. An injury can affect the body in a multitude of ways depending on where the spinal cord (SC) is damaged. It is the largest nerve in the body and is composed of nerve fibers. These nerve fibers that manage the body's communication systems are responsible for its motor, sensory, and autonomic functions. They act as messenger between the brain and the rest of the body. The vertebral column—protective bone segments—surrounds the SC, perhaps because of its important in the nervous system. Approximately 18 inches (39 cm) long, the SC runs from the base of the brain, down the middle of the back, to the waist. Nerve fibers in the upper SC are upper motor neurons (UMNs). Spinal nerves branching off the SC that run up and down the neck and back are lower motor neurons (LMNs), and branch off between each vertebrae and go out to all parts of the body. The lower spinal nerve fibers continue down through the spinal canal to the sacrum (tailbone) at the end of the SC.

Divided into four sections at the top of the spinal column is the cervical spine. It is composed of eight cervical nerves and seven cervical vertebrae. Further down is the thoracic spine, which includes the chest and twelve thoracic vertebrae. The lumbar spine is below that, and comprises five lumbar vertebrae. The bottom section is the sacral area, and there the bones fuse together into one bone.

When the SC is damaged by either a traumatic injury or from a disease, all nerves above the injury level still function normally. Those from the point of injury and below, however, are damaged, and messages between the brain and parts of the body that could once be sent are no longer are no longer possible. The patient must undergo **physical examination** by the doctor to earn the exact location of injury to the spinal cord. Frequently, the physician will use a “pin-prick” test,” which evaluates the patient's level of feeling (sensory level). X rays are also frequently used to image the affected vertebrae. The patient's input is critical; he or she will be asked what parts of the body can be moved, and all major muscle groups will be tested (motor level) for strength. All of these tests are important, as they reveal what nerves and muscles are functioning. Each SCI is unique, and is defined by its type and level. Its level will be judged by the lowest level on the SC after which there is absence of feeling and/or movement (motor level).

Loss of feeling and/or movement in the head, neck, shoulder, arms, and/or upper chest is termed “tetraplegia,” and is injury at level C1 to T1. The cervical spine is the highest part of the spinal cord and is designated by the letter “C.” The thoracic spine is next to the highest, and is designated by the letter “T.” T2 to S5 is paraplegia. The higher on the **vertebral column**, the closer the SCI is to the brain. Therefore, someone with a T-8 (thoracic spine; eight of 12 thoracic vertebrae) level injury would have more feeling and movement than someone with a C-5 (cervical spine; five of seven cervical vertebrae) level of injury.

STROKE. During a stroke, brain tissue is destroyed. This is caused by some malfunction of the brain's **blood vessels**. There are two major classifications of stroke: hemorrhagic and ischemic. The most common type of stroke is ischemic, caused by the same kind of vascular disease as **heart** attack. By “ischemic” it is meant that the **blood** flow to an area is insufficient; there is not enough oxygen to support the cells. The brain cells will cease to function if blood circulation is not restored quickly enough after a stroke. Cell death by lack of oxygen is termed “infarction.” To be more specific, physicians often refer to this type of infarction as “cerebral.” As of 2001, stroke is the third leading cause of disability and the fifth leading cause of death in the United States. Annually, 500,000 people suffer strokes; 150,000 die of them.

A hemorrhagic stroke happens with the rupture of a blood vessel. Bleeding occurs inside the **skull**. Usually, the cause is **hypertension**, or high blood pressure—but it can also be caused by trauma. An aneurysm (a sac formed by localized dilatation of the wall of an artery, a vein or the heart) may also cause a hemorrhagic stroke. Whatever the origin of the stroke, bleeding can rip through the tender connections within the brain, and ultimately compress brain cells until they die.

The extent of damage due to stroke depends on the severity of the stroke and where in the brain the blood supply was suspended. Each area of the brain is served by specific blood vessels; if a blood vessel in the area that controls muscle movements became blocked, those muscles will be weak, or paralyzed. The loss of function is greatest immediately after a stroke, but some usually some function is regained. Some brain cells do die, while some injured cells may recover. Bleeding on the brain, such as from a **head injury** or brain aneurysm, can also cause brain cell death from lack of oxygen. Symptoms may resemble those of a stroke. The best prevention for a stroke is for the patient to discuss risk factors with a physician.

MULTIPLE SCLEROSIS (MS). Multiple sclerosis (MS) is a demyelinating disease that is related to the inflammatory process. One feature of MS is multiple, separate, and harmful neurologic episodes caused by **central nervous system (CNS)** lesions. The result is multiple, clearly defined areas (plaque) of myelin (the protective sheath around nerves) in the brain's white matter SC known as perivenous distribution (i.e., not in the peripheral nervous system).

MS occurs early in the inflammatory phase, and disrupts the messages that are being transmitted within the body. The disease is called MS because the scar tissue (sclerosis) forms at various locations. Some of the diseased areas of the myelin may cause no obvious symptoms, while other areas may interfere with functions or sensations controlled by the brain or SC. For this reason, the symptoms and the severity of the disability varies greatly among persons with MS.

The cause of MS remains unknown, but many think that it may be an autoimmune disease. Normally, the **immune system** works by recognizing foreign invaders and producing its own cells to counteract or defend against attacks. In MS, the immune system is disrupted as the body incorrectly identifies itself as an invader and begins to attack its own cells. The body no longer recognizes myelin as its own and declares war on this nerve tissue. Further, linkage studies have noted significant genetic factors. A common first symptom is visual impairment, due to optic neuritis (inflammation of the optic nerve).

MUSCULAR DYSTROPHY (MD). The name "muscular dystrophy" (MD) encompasses a number of progressive hereditary diseases that makes muscles weaken and degenerate. Not a contagious disease, there are a multitude of variations. Each type has its own pattern of heredity, onset age, and speed with which muscle is lost. Alterations in specific genes causes different types of disease. There was no prevention or cure for MD as of 2001. However, because of research being done at this time, there is reason for hope for a cure.

HUNTINGTON'S CHOREA (HC). A genetically inherited disease, Huntington's chorea (HC) has neurological and psychotic characteristics. The forties or fifties are the usual ages of onset, but early and late onset are also possible. Either neurological or psychotic changes can mark the beginning of the disease. Symptoms of neurological changes may vary, but can begin with chorea—a series of movements that resemble dancing, with jerkiness and one part of the body moving to another. One might display clumsiness, jumpiness, and become fidgety. There may be movement in the face, particularly around the jaw, and walking may become difficult. It may be diffi-

cult to maintain posture. Paranoia, personality changes, and confusion may present, as well. It is also possible for **dementia** to occur.

Diagnosis of HC is dependent upon clinical symptomatology and MRI (magnetic brain imaging), as well as discovering family history of the disease. An MRI that reveals atrophy (shrinkage) of part of the basal ganglia, which is involved in movement and known as the caudate nucleus, is characteristic of HC.

CEREBRAL PALSY. In cerebral palsy (CP), abnormal development of or damage to motor areas in the brain disrupts the brain's ability to control movement and posture. The term CP is a term used to describe a group of chronic disorders impairing control of movement that appear in the first few years of life and generally do not worsen over time. Symptoms differ from person to person, and may change over time. Individuals with the disease may have difficulty with fine motor tasks (e.g., writing), and balance or walking. They may have involuntary movements. Cerebral palsy, which may be congenital (present at birth) or acquired after birth, results from brain injury that does not worsen over time. Possible causes of CP include developmental abnormalities of the brain, brain injury caused by low oxygen levels (asphyxia) or poor circulation, **infection**, and trauma to the fetus or newborn. Doctors encourage pregnant women to follow a program of regular **prenatal care** beginning early in **pregnancy** to help prevent CP.

DYSTONIAS. Dystonias are sustained muscle contractions that often cause twisting or repetitive movements and abnormal postures. Dystonias may be limited to one area (focal) or may affect the entire body (general). Focal dystonias may affect the neck (cervical dystonia or torticollis), the face (one-sided, or hemifacial spasm), contraction of the eyelid (blepharospasm), contraction of the mouth and jaw (oromandibular dystonia), simultaneous spasm of the chin and eyelid (Meige syndrome), the vocal cords (laryngeal dystonia), or the arms and legs (writer's and occupational cramps). Dystonia may be painful and incapacitating.

TREMORS. Uncontrollable (involuntary) shaking of body parts are known as tremors. Tremors may occur only when muscles are relaxed, during actions, or when holding active postures.

MYASTHENIA GRAVIS (MG). Myasthenia gravis (MG), a chronic autoimmune disease, is characterized by fluctuating degrees of weakness of the skeletal, or voluntary muscles. Muscle weakness of increasing severity is the key symptom of this disorder; it worsens with activity, and improves after periods of rest. It does not always include muscles that control facial expression, such as muscles of the eyes, talking, chewing, and swallowing,

but can affect the muscles involved with breathing, the neck, and limb movements. A defect in the transmission of nerve impulses to muscles is responsible for MG. The symptoms of MG range in type and degree. It is not directly genetic, and it is not infectious. It can be controlled through medications that improve neuromuscular transmission, thereby improving muscle strength, or through medications that suppress the manufacture by the body of abnormal antibodies. Because of unpleasant, major side effects, these drugs must be used with caution and monitored carefully. Myasthenia gravis is caused by an autoimmune response attack on acetylcholine (neurotransmitter) receptors at muscular junctions.

PARKINSON'S DISEASE (PD). The possibility of developing **Parkinson's disease**, or parkinsonism, increases with age, with age of onset usually not less than 40 years of age. Approximately 500,000 people in the United States suffer from the disease, which affects both sexes equally. The cause of its most common form, PD (as well as related disorders) is not known—though genetic risk has been identified as a probable factor by the National Institutes of Health. Interestingly, the disorder is observed at the same rate in almost part of the globe, and is as common today as it was in late 1800s.

The two terms, Parkinson's disease (PD) and parkinsonism, are used interchangeably, as they both describe patients with the same symptoms. The four primary symptoms of PD are tremor or trembling, rigidity or stiffness of the limbs and trunk, bradykinesia (slowness of movement), and impaired balance and coordination.

There are a number of causes of parkinsonism, including degenerative neurologic disease, metabolic conditions, toxins, drugs, viral encephalitis (von Economo's disease), and related disorders result from the loss of dopamine, a chemical messenger responsible for transmitting signals within the brain. When certain nerve cells (neurons) that produce dopamine die or become impaired, dopamine is depleted. The result is nerve cells that fire out of control. Individuals with PD are then unable to direct or control their movements in a normal manner. The disease, which is usually not inherited, is both chronic and progressive, with subtle early symptoms and gradual progression.

Management of a movement disorder begins with determining its cause. Physical and **occupational therapy** may help to compensate for lost control and strength. Pharmacologic therapy can help to compensate for some imbalances of the basal ganglionic circuit. For instance, levodopa (L-dopa), or related compounds, can substitute for the loss of dopamine-producing cells in PD. Conversely, blocking normal dopamine action may be used to treat some hyperkinetic disorders, including tics.

Oral medications can also help to reduce overall muscle tone. Local injections of botulinum toxin (BOTOX) can selectively weaken overactive muscles in dystonia and spasticity. Destruction of peripheral nerves through injection of phenol can reduce spasticity. It should be noted, however, that all of these treatments have some side effects.

Other movement disorders

Tic disorders are very quick, involuntary, rapid, non-rhythmic, and short-lived movements or sounds; tics can sometimes be controlled briefly. Tics are usually repeated movements. They commonly involve the motor systems and often involve the facial muscles, such as the eyelids or eyebrows. The most well-known tic disorder is Tourette syndrome. Tourette syndrome (TS) is an abnormal condition that causes uncontrollable facial grimaces and tics, and arm and shoulder movements. Tourette syndrome is best known, perhaps, for uncontrollable vocal tics that include grunts, shouts, and use of obscene language (coprolalia). It is also known as Gilles de la Tourette syndrome. Tics are more common among males than females. As with Tourette syndrome, tics may be associated with head injury, stroke, **carbon monoxide poisoning**, and mental retardation.

Myoclonus is a sudden, shock-like muscle contraction. Myoclonic jerks may occur singly or repetitively. Unlike tics, myoclonus cannot be controlled even briefly.

Postural instability is the loss of ability to maintain upright posture, caused by slow or absent righting reflexes (those that help to maintain balance).

Spasticity is a condition in which certain muscles are continuously contracted, causing stiffness or tightness of the muscles.

Flaccid paralysis is the loss of muscle tone of the paralyzed part and an accompanying absence of reflexes.

Diagnosis

A complete and thorough clinical examination should be performed. Diagnosis of movement disorders requires a careful medical history and a thorough physical and neurological examination. A thorough orthopedic exam may be important because patients with increased muscle tone may develop curvature of the spine (**scoliosis**), hip dislocation, and tendon shortening. During the neurologic exam, the doctor will observe the individual's posture, tone, symmetry, and reflexes.

Certain symptoms may indicate a movement disorder disease. Doctors will pay special attention to the rate of development of children with CP, particularly with

KEY TERMS

Botulinum toxin (botox)—Any of a group of potent bacterial toxins or poisons produced by different strains of the bacterium *Clostridium botulinum*. The toxins cause muscle paralysis, and thus force the relaxation of a muscle in spasm.

Cerebral palsy (CJP)—A movement disorder caused by a permanent brain defect or an injury present at birth, or shortly after. It is frequently associated with premature birth. Cerebral palsy is not progressive.

Computed tomography (CT)—An imaging technique in which cross-sectional x rays of the body are compiled to create a three-dimensional image of the body's internal structures.

Encephalopathy—An abnormality in the structure or function of tissues of the brain.

Fetal tissue transplantation (FTT)—A method of treating PD and other neurological diseases by grafting brain cells from human fetuses onto the basal ganglia. Human adults cannot grow new brain cells, but developing fetuses can. Grafting fetal tissue stimulates the growth of new brain cells in affected adult brains.

Huntington's chorea (HC) disease (HD)—A rare, genetically inherited condition with both neurological and psychiatric manifestations that begins with either type of change. The chorea is progressive, and presents as jerky muscle movements and mental deterioration that ends in dementia. The symptoms of HC usually appear in patients in their 40s or 50s; however, early- or late-onset is possible. Huntington's chorea may also cause clumsiness, jumpiness, and fidgetiness, and facial movements—particularly around the jaw—may occur. It may become difficult to walk, and can affect posture. Paranoia, confusion, or personality changes may noted. A significant dementia develops as the disease progresses. There is no cure or effective treatment for the condition.

Levodopa (L-dopa)—A substance used in the treatment of PD. Levodopa can cross the blood-brain barrier that protects the brain. Once in the brain, it is converted to dopamine, and thus can replace the dopamine lost in PD.

Magnetic resonance imaging (MRI)—An imaging

technique that uses a large circular magnet and radio waves to generate signals from atoms in the body. These signals are used to construct images of internal structures.

Paraplegia—Paralysis of the lower half of the body involving both legs and usually due to disease or injury to the spinal cord.

Parkinson's disease (PD)—A slowly progressive disease that destroys nerve cells in the basal ganglia and thus causes loss of dopamine, a chemical that aids in transmission of nerve signals (neurotransmitter). Parkinsonism is characterized by shaking in resting muscles, a stooping posture, slurred speech, muscular stiffness, and weakness.

Positron emission tomography (PET)—A diagnostic technique in which computer-assisted x rays are used to track a radioactive substance inside a patient's body. Biochemical activity of the brain can be studied using PET.

Progressive supranuclear palsy—A rare disease that shows some of the same features of PD, but differs in several ways. They usually do not develop tremors, but they have rigidity, bradykinesia (slow movements), and falls. The disorder gradually destroys nerve cells in the parts of the brain that control eye movements, breathing, and muscle coordination. The loss of nerve cells causes palsy (paralysis) that slowly gets worse as the disease progresses. The palsy affects the ability to move the eyes vertically (up and down) at first. Their eye movements then become even more restrictive (ophthalmoplegia). The ability to relax the muscles is lost, as is control over balance.

Tourette syndrome (TS)—An abnormal condition that causes uncontrollable facial grimaces and tics, and arm and shoulder movements. Tourette syndrome is best known, perhaps, for uncontrollable vocal tics that include grunts, shouts, and use of obscene language (coprolalia). Also known as Gilles de la Tourette syndrome.

Wilson's disease (WD)—An inborn defect of copper metabolism in which free copper may be deposited in a variety of areas of the body. Deposits in the brain can cause tremor and other symptoms of PD.

regard to head size and head growth, since abnormalities in these areas may point to a brain problem. Eye problems, such as blurred or double **vision**, red-green color distortion, or blindness in one eye, may occur. When combined with muscle weakness in extremities and paresthesias (transitory abnormal sensory feeling such as numbness or prickling), MS may be suspected.

Diagnostic tests should be conducted. These include brain imaging studies, such as computed tomography (CT) scan, **positron emission tomography (PET)**, or **magnetic resonance imaging (MRI)** scans. Routine blood and urine analyses are performed. A lumbar puncture (spinal tap) may be necessary. Video recording of the abnormal movement is often used to analyze movement patterns and to track progress of the disorder and its management. **Genetic testing** is available for some forms of movement disorders. If MS is suspected, physicians may study the patient's cerebrospinal fluid and the antibody, immunoglobulin G.

Treatment

Ongoing clinical studies indicate that estrogen may have beneficial effects on controlling movement disorders, such as PD, chorea, dystonia, tics, and myoclonus.

Deep brain stimulation, which inactivates the thalamus or globus pallidus through electrical shocks, may be useful to ease tremor of the arm in individuals with ET and tremor due to MS. In PD, the procedure may improve arm speed and dexterity, reduce tremor, and block the involuntary movements (dyskinesia) associated with the medications used to treat the disease.

Surgical destruction, or inactivation of basal ganglionic circuits, has proven effective for PD, and as of 2001 is being tested for other movement disorders. Transplantation of fetal cells into the basal ganglia has produced mixed results in PD.

Health care team roles

Nursing and allied health professionals play a key role in educating individuals with movement disorders about their conditions and appropriate treatment options. Physical, speech, and occupational therapy are often essential to the rehabilitation of individuals with movement disorders. Psychological counseling may be helpful to the individual and to family members and close friends.

The patient who has had a stroke may be treated by doctors, therapists, and nurses who work to keep the patient's muscles strong, prevent muscular contractions, avoid the bedsores that can result from being in one position for too long, and teach the patient to walk and talk

again. With SCI, expert nursing care is important to prevent complications from weakness and paralysis, including bedsores. Physical and occupational therapy help to preserve muscle function and teach techniques to help the patient function despite lost functionality.

Prognosis

The prognosis for a patient with a movement disorder depends on the nature of the disorder. The age of onset has major implications in prognosis.

Prevention

Prevention depends on the specific disorder. With some diseases, certain preventive strategies can be particularly helpful. In the case of MS and stroke, for example, smoking cessation would drastically reduce the number of cases. Longtime smokers may face a much higher risk of both MS and stroke, according to researchers at Harvard University. In the case of MS, women who smoked at least one pack per day for at least 25 years had a greater chance of developing the disorder than nonsmokers.

A number of permanent cases of parkinsonism that presented in the early 1980s were caused by a contaminant found in some illicit street drugs. For the most part, cases of the disease induced by legal, prescribed drugs were only temporary: when the drug was stopped, the symptoms stopped, too. Permanent parkinsonism had only been the result of the contaminant found in the street drug.

In 1996, clinicians at the University of Hawaii found that patients with high blood levels of uric acid, a natural antioxidant, have a lower chance of developing Parkinsonism and **gout** (acute inflammatory arthritis) than people with lower levels. The study concluded that people with high levels of the antioxidant, uric acid, may be more resistant to developing parkinsonism. This was also shown in a pilot study in 1991, when investigator Stanley Fahn of Columbia University found that parkinsonism patients who were administered large doses of oral **vitamin C** and synthetic **vitamin E** supplements (3000 mg and 3200 iu daily, respectively) delayed the progression of the disease. He concluded that it was likely that it was the vitamin C alone, or in combination with vitamin E that actively worked.

- Parkinsonism (PD). Deprenyl (selegiline), administered early in the onset of the disorder, can slow progression of the disease. Antioxidants such as vitamin E and selenium may be of some benefit, as well.
- Spinal cord injury (SCI). Attention to following safety precautions may help to reduce the risk of SCI. The

most frequent causes of SCI are motor vehicle crashes, **falls**, violence, and sports and recreation, especially diving. Proper protective equipment should be used if an injury is possible, and appropriate safety measures should be practiced. Depth of water should be checked and obstructions should be noted before diving. When in an automobile, seat belts should always be used.

- Stroke. Major risk factors include high **blood pressure**, high cholesterol level, smoking, and diabetes. Drugs, such as aspirin (half of an adult tablet or one children’s tablet daily), can be taken to reduce the tendency of blood platelets (responsible for the clotting of blood) to form dangerous blood clots, a major cause of stroke. When stronger drugs are needed, a doctor may prescribe anticoagulants, such as heparin or warfarin (Coumadin). Research in the year 2001 suggests that paralysis and other symptoms may be prevented or reversed if certain drugs that break up clots are given within three hours of the onset of a stroke.

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ORGANIZATIONS

American Association of Neuroscience Nurses, 4700 W. Lake Avenue, Glenview, IL 60025. (888) 557-2266. <<http://www.aann.org>>.

American Spinal Injury Association. 345 E. Superior Street, Chicago, IL 60611. (312)238-1242. <<http://www.asia-spinalinjury.org>>.

Muscular Dystrophy Association, 3300 East Sunrise Drive, Tucson, AZ 85718-3208, (520) 529-2000 or (800) 572-1717. <<http://www.mdaua.org>>.

Myasthenia Gravis Foundation of America, Inc., 5841 Cedar Lake Road, Suite 204, Minneapolis, MN 55416, (952) 545-9438 or (800)541-5454. <<http://www.myasthenia.org>>.

National Institute of Neurological Disorders and Stroke. P.O. Box 5801, Bethesda, MD 20824, (800) 352-9424. <<http://www.ninds.nih.gov>>.

National Spinal Cord Injury Association, The Zalco Building, 8701 Georgia Avenue, Suite 500, 8701 Georgia Avenue, Silver Springs, MD 20910, (800) 962-9629 or (301) 588-6959. <<http://www.spinalcord.org>>.

National Spinal Cord Injury Statistical Center, UAB-Spain Rehabilitation Center, Rm 544, 619 19th Street South, SRC 544, Birmingham, AL 35249-7330, (205) 934-5359.

Paralyzed Veterans of America. 801 18th Street NW, Washington, DC 20006, (800) 424-8288 or infor@pva.org, <<http://www.pva.org>>.

The Movement Disorder Society. 611 East Wells Street, Milwaukee, WI 53202, (414) 276-2145. <<http://www.movementdisorders.org>>.

WE MOVE. 204 West 84th Street, New York, NY 10024. (800) 437- MOV2 or (212) 875-8389. <<http://www.wemove.org>>.

OTHER

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Randi B. Jenkins

Movement therapy

Definition

Movement therapy refers to a broad range of Eastern and Western movement approaches used to promote physical, mental, emotional, and spiritual well-being.

Origins

Movement is fundamental to human life. In fact movement is life. Contemporary physics tells us that the universe and everything in it is in constant motion. We can move our body and at the most basic level our body is movement. According to the somatic educator Thomas Hanna, “The living body is a moving body—indeed, it is a constantly moving body.” The poet and philosopher Alan Watts eloquently states a similar view, “A living body is not a fixed thing but a flowing event, like a flame

or a whirlpool.” Centuries earlier, the great Western philosopher Socrates understood what modern physics has proven, “The universe is motion and nothing else.”

Since the beginning of time, indigenous societies around the world have used movement and dance for individual and community healing. Movement and song were used for personal healing, to create community, to ensure successful crops, and to promote fertility. Movement is still an essential part of many healing traditions and practices throughout the world.

Western movement therapies generally developed out of the realm of dance. Many of these movement approaches were created by former dancers or choreographers who were searching for a way to prevent injury, attempting to recover from an injury, or who were curious about the effects of new ways of moving. Some movement therapies arose out of the fields of **physical therapy**, psychology, and bodywork. Other movement therapies were developed as way to treat an incurable disease or condition.

Eastern movement therapies, such as **yoga**, **qigong**, and **t'ai chi** began as a spiritual or self-defense practices and evolved into healing therapies. In China, for example, Taoist monks learned to use specific breathing and movement patterns in order to promote mental clarity, physical strength, and support their practice of **meditation**. These practices, later known as qigong and t'ai chi, eventually became recognized as ways to increase health and prolong life.

Benefits

The physical benefits of movement therapy include greater ease and range of movement, increased balance, strength and flexibility, improved muscle tone and coordination, joint resiliency, cardiovascular conditioning, enhanced athletic performance, stimulation of circulation, prevention of injuries, greater longevity, **pain** relief, and relief of rheumatic, neurological, spinal, **stress**, and respiratory disorders. Movement therapy can also be used as a meditation practice to quiet the mind, foster self-knowledge, and increase awareness. In addition, movement therapy is beneficial in alleviating emotional distress that is expressed through the body. These conditions include eating disorders, excessive clinging, and **anxiety** attacks. Since movements are related to thoughts and feelings, movement therapy can also bring about changes in attitude and emotions. People report an increase in self-esteem and self-image. Communication skills can be enhanced and tolerance of others increased. The physical openness facilitated by movement therapy leads to greater emotional openness and creativity.

Description

There are countless approaches to movement therapy. Some approaches emphasize awareness and attention to inner sensations. Other approaches use movement as a form of **psychotherapy**, expressing and working through deep emotional issues. Some approaches emphasize alignment with gravity and specific movement sequences, while other approaches encourage spontaneous movement. Some approaches are primarily concerned with increasing the ease and efficiency of bodily movement. Other approaches address the reality of the body “as movement” instead of the body as only something that runs or walks through space.

The term movement therapy is often associated with **dance therapy**. Some dance therapists work privately with people who are interested in personal growth. Others work in mental health settings with autistic, **brain** injured and learning disabled children, the elderly, and disabled adults.

Laban movement analysis (LMA), formerly known as Effort-Shape, is a comprehensive system for discriminating, describing, analyzing, and categorizing movements. LMA can be applied to dance, athletic coaching, fitness, acting, psychotherapy, and a variety of other professions. Certified movement analysts can “observe recurring patterns, note movement preferences, assess physical blocks and dysfunctional movement patterns, and suggest new movement patterns.” As a student of Rudolf Laban, Irmgard Bartenieff developed his form of movement analysis into a system of body training or reeducation called Bartenieff fundamentals (BF). The basic premise of this work is that once the student experiences a physical foundation, emotional and intellectual expression becomes richer. BF uses specific exercises that are practiced on the floor, sitting, or standing to engage the deeper muscles of the body and enable a greater range of movement.

Authentic movement (AM) is based upon Mary Starks Whitehouse’s understanding of dance, movement, and depth psychology. There is no movement instruction in AM, simply a mover and a witness. The mover waits and listens for an impulse to move and then follows or “moves with” the spontaneous movements that arise. These movements may or may not be visible to the witness. The movements may be in response to an emotion, a dream, a thought, pain, joy, or whatever is being experienced in the moment. The witness serves as a compassionate, non judgmental mirror and brings a “special quality of attention or presence.” At the end of the session the mover and witness speak about their experiences together. AM is a powerful approach for self development and awareness and provides access to preverbal

memories, creative ideas, and unconscious movement patterns that limit growth.

Gabrielle Roth (5 Rhythms movement) and Anna Halprin have both developed dynamic movement practices that emphasize personal growth, awareness, expression, and community. Although fundamentally different forms, each of these movement/dance approaches recognize and encourage our inherent desire for movement.

Several forms of movement therapy grew out of specific bodywork modalities. Rolfing movement integration (RMI) and Rolfing rhythms are movement forms which reinforce and help to integrate the structural body changes brought about by the hands-on work of Rolfing (structural integration). RMI uses a combination of touch and verbal directions to help develop greater awareness of one's vertical alignment and habitual movement patterns. RMI teacher Mary Bond says, "The premise of Rolfing Movement Integration... is that you can restore your structure to balance by changing the movement habits that perpetuate imbalance." Rolfing rhythms are a series of lively exercises designed to encourage awareness of the Rolfing principles of ease, length, balance, and harmony with gravity.

The movement education component of Aston-Patterning bodywork is called neurokinetics. This movement therapy teaches ways of moving with greater ease throughout everyday activities. These movement patterns can also be used to release tension in the body. Aston fitness is an **exercise** program which includes warm-up techniques, exercises to increase muscle tone and stability, stretching, and cardiovascular fitness.

Rosen method movement (an adjunct to Rosen method bodywork) consists of simple fun movement exercises done to music in a group setting. Through gentle swinging, bouncing, and stretching, every joint in the body experiences a full range of movement. The movements help to increase balance and rhythm and create more space for effortless breathing.

The movement form of Trager psychophysical integration bodywork, Mentastics, consists of fun, easy swinging, shaking, and stretching movements. These movements, developed by Dr. Milton Trager, create an experience of lightness and freedom in the body, allowing for greater ease in movement. Trager also worked successfully with polio patients.

Awareness through movement, the movement therapy form of the Feldenkrais method, consists of specific structured movement experiences taught as a group lesson. These lessons reeducate the brain without tiring the muscles. Most lessons are done lying down on the floor or sitting. Moshe Feldenkrais designed the lessons to

"improve ability... turn the impossible into the possible, the difficult into the easy, and the easy into the pleasant."

Ideokinesis is another movement approach emphasizing neuromuscular reeducation. Lulu Sweigart based her work on the pioneering approach of her teacher Mabel Elsworth Todd. Ideokinesis uses imagery to train the nervous system to stimulate the right muscles for the intended movement. If one continues to give the nervous system a clear mental picture of the movement intended, it will automatically select the best way to perform the movement. For example, to enhance balance in standing, Sweigart taught people to visualize "lines of movement" traveling through their bodies. Sweigart did not train teachers in ideokinesis but some individuals use ideokinetic imagery in the process of teaching movement.

The Mensendieck system of functional movement techniques is both corrective and preventative. Bess Mensendieck, a medical doctor, developed a series of exercises to reshape, rebuild, and revitalize the body. A student of this approach learns to use the conscious will to relax muscles and release tension. There are more than 200 exercises that emphasize correct and graceful body movement through everyday activities. Unlike other movement therapy approaches this work is done undressed or in a bikini bottom, in front of mirrors. This allows the student to observe and feel where a movement originates. Success has been reported with many conditions including **Parkinson's disease**, muscle and joint injuries, and repetitive strain injuries.

The Alexander technique is another functional approach to movement therapy. In this approach a teacher gently uses hands and verbal directions to subtly guide the student through movements such as sitting, standing up, bending and walking. The Alexander technique emphasizes balance in the neck-head relationship. A teacher lightly steers the students head into the proper balance on the tip of the spine while the student is moving in ordinary ways. The student learns to respond to movement demands with the whole body, in a light integrated way. This approach to movement is particularly popular with actors and other performers.

Pilates or physical mind method is also popular with actors, dancers, athletes, and a broad range of other people. Pilates consists of over 500 exercises done on the floor or primarily with customized exercise equipment. The exercises combine sensory awareness and physical training. Students learn to move from a stable, central core. The exercises promote strength, flexibility, and balance. Pilates training is increasingly available in sports medicine clinics, fitness centers, dance schools, spas, and physical therapy offices.

Many approaches to movement therapy emphasize awareness of internal sensations. Charlotte Selver, a student of somatic pioneer Elsa Gindler, calls her style of teaching sensory awareness (SA). This approach has influenced the thinking of many innovators, including Fritz Perls, who developed gestalt therapy. Rather than suggesting a series of structured movements, visualizations, or body positions, in SA the teacher outlines experiments in which one can become aware of the sensations involved in any movement. A teacher might ask the student to feel the movement of her breathing while running, sitting, picking up a book, etc. This close attunement to inner sensory experience encourages an experience of body-mind unity in which breathing becomes less restricted and posture, coordination, flexibility, and balance are improved. There may also be the experience of increased energy and aliveness.

Gerda Alexander Eutony (GAE) is another movement therapy approach that is based upon internal awareness. Through GAE one becomes a master of self-sensing and knowing which includes becoming sensitive to the external environment, as well. For example, while lying on the floor sensing the breath, skin or form of the body, one also senses the connection with the ground. GAE is taught in group classes or private lessons which also include hands-on therapy. In 1987, after two years of observation in clinics throughout the world, GAE became the first mind-body discipline accepted by the World Health Organization (WHO) as an alternative health-care technique.

Kinetic awareness developed by dancer-choreographer Elaine Summers, emphasizes emotional and physical inquiry. Privately or in a group, a teacher sets up situations for the student to explore the possible causes of pain and movement restrictions within the body. Rubber balls of various sizes are used as props to focus attention inward, support the body in a stretched position and massage a specific area of the body. The work helps one to deal with chronic pain, move easily again after injuries and increase energy, flexibility, coordination, and comfort.

Body-mind centering (BMC) was developed by Bonnie Bainbridge Cohen and is a comprehensive educational and therapeutic approach to movement. BMC practitioners use movement, touch, guided imagery, developmental repatterning, dialogue, music, large balls, and other props in an individual session to meet the needs of each person. BMC encourages people to develop a sensate awareness and experience of the ligaments, nerves, muscles, skin, fluids, organs, glands, fat, and fascia that make up one's body. It has been effective in preventing and rehabilitating from chronic injuries and in

improving neuromuscular response in children with **cerebral palsy** and other neurological disorders.

Continuum movement has also been shown to be effective in treating neurological disorders including spinal chord injury. Developed by Emilie Conrad and Susan Harper, continuum movement is an inquiry into the creative flux of our body and all of life. Sound, breath, subtle and dynamic movements are explored that stimulate the brain and increase resonance with the fluid world of movement. The emphasis is upon unpredictable, spontaneous or spiral movements rather than a linear movement pattern. According to Conrad, "Awareness changes how we physically move. As we become more fluid and resilient so do the mental, emotional, and spiritual movements of our lives."

Eastern movement therapies such as yoga, t'ai chi, and qigong are also effective in healing and preventing a wide range of physical disorders, encouraging emotional stability, and enhancing spiritual awareness. There are a number of different approaches to yoga. Some emphasize the development of physical strength, flexibility, and alignment. Other forms of yoga emphasize inner awareness, opening, and meditation.

Precautions

People with acute injuries and chronic physical and mental conditions need to be careful when choosing a form of movement therapy. It is best to consult with a knowledgeable physician, physical therapist, or mental health therapist.

Research and general acceptance

Although research has documented the effects of dance therapy, qigong, t'ai chi, yoga, Alexander technique, awareness through movement (Feldenkrais), and Rolwing movement, other forms of movement therapy have not been as thoroughly researched.

Training and certification

Training and certification varies widely with each form of movement therapy. Many approaches require several years of extensive training and experience with the particular movement form.

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Linda Chrisman

MR *see* **Magnetic resonance imaging**

MRA *see* **Magnetic resonance imaging**

MRI *see* **Magnetic resonance imaging**

MRI unit *see* **Magnetic resonance imaging unit**

MRS *see* **Magnetic resonance imaging**

MS *see* **Multiple sclerosis**

Mucoviscidosis *see* **Cystic fibrosis**

MUGA scan *see* **Multiple-gated acquisition (MUGA) scan**

Multiple-gated acquisition (MUGA) scan

Definition

The **multiple-gated acquisition (MUGA) scan**, also called a cardiac **blood** pool study, is a non-invasive nuclear medicine test that displays the distribution of a radioactive tracer in the **heart**. The images of the heart are obtained at intervals throughout the **cardiac cycle** and are used to calculate ejection fraction and evaluate regional myocardial wall motion.

Purpose

A MUGA scan may be done at rest and with **stress**. The resting study is primarily performed to obtain the ejection fraction of the right and left ventricles, to evaluate the left ventricular regional wall motion, to assess the effects of cardiotoxic drugs (i.e., **chemotherapy**), and to differentiate the cause of shortness of breath (pulmonary

vs. cardiac). Ejection fraction and wall motion are also important measurements made during a stress study, but the stress study is performed primarily to detect **coronary artery disease** and to evaluate angina.

Precautions

The use of a radioactive material is required to perform this study, so pregnant women should not have this test unless absolutely necessary. Women who are breast feeding are asked to stop for a specified period of time, typically 24 hours. Patients who have had other recent nuclear medicine studies may need to wait until residual radioactivity in the body has cleared before having this test.

Description

The MUGA scan is a series of images that demonstrate the flow of blood through the heart, enabling clinicians to obtain information about heart muscle activity. Before images are taken, a radionuclide is injected into the bloodstream, a process that requires two injections in most institutions. The first contains a chemical that adheres to red blood cells, and the second contains a radioactive tracer (Tc99m) that attaches to that chemical. Alternatively, the two chemicals can be mixed together first and then injected, but the material then tends to accumulate in bone and may obscure the heart.

A gamma camera takes the pictures, which is driven by a computer program that times the pictures, processes the information, and performs the mathematical calculations to provide ejection fraction and demonstrate wall motion. Images are obtained at various intervals during the cardiac cycle. Electrodes are placed on the patient so that a time frame can be established, for example, the time period between each "R" wave. The time frame is divided into several intervals, or "multiple gates." The result is a series of pictures showing the left and right ventricles at end-diastole and end-systole, and a number of stages in between.

A MUGA scan is performed in a hospital nuclear medicine department or in an out-patient facility and takes approximately 30 minutes to one hour. The patient lies down on a bed alongside the gamma camera and receives the radionuclide injections, then multiple images are taken. If a stress study is indicated, the rest study is performed first. For stress, the patient usually lies on a special bed fitted with a bicycle apparatus. While an image is being recorded, the patient is asked to cycle for about two minutes, then the resistance of the wheels are increased. After another two minutes of **exercise**, another image is obtained and the resistance is increased again.

Blood pressure and ECG are also monitored. After the stress portion is finished, one more resting, or recovery, study is obtained.

Preparation

Standard preparation an ECG for is required. In addition, special handling of nuclear materials may be required for the injections.

Aftercare

The patient can resume normal activities immediately after the test.

Results

A normal MUGA scan should not demonstrate areas of akinesis (lack of movement), or hypokinesis (decreased movement) of the walls. Abnormal motion, especially in the left ventricle, is suggestive of an infarct or other myocardial defect. The ejection fraction is a measure of heart function and should be within the normal limits established by the testing facility.

Health care team roles

A MUGA scan is performed by a nuclear medicine technologist, who is trained to handle radioactive materials, give injections, operate the equipment, take blood pressures, and process the data. The data is interpreted by a radiologist, nuclear medicine specialist, or cardiologist. The stress portion of the test may be monitored by a doctor. Patients receive results from their personal physician or the doctor who ordered the test.

Resources

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KEY TERMS

Ejection fraction—The fraction of blood in the ventricle that is ejected during each beat. One of the main advantages of the MUGA scan is its ability to measure ejection fraction, one of the most important measures of the heart's performance.

Electrocardiogram—A test in which electrodes are placed on the body to record the heart's electrical activities.

Ischemia—A decreased supply of oxygenated blood to a body part or organ, often marked by pain and organ dysfunction, as in ischemic heart disease.

Non-invasive—A procedure that does not penetrate the body.

ORGANIZATIONS

American Heart Association. National Center. 7272 Greenville Avenue, Dallas, TX 75231-4596. (214) 373-6300. <<http://www.medsearch.com/pf/profiles/amerh/>>.

Texas Heart Institute Heart Information Service. P.O. Box 20345, Houston, TX 77225-0345. (800) 292-2221. <<http://www.tmc.edu/thi/his.html>>.

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Multiple pregnancy

Definition

A multiple **pregnancy** is a pregnancy in which more than one fetus develops in the uterus at the same time. Multiple pregnancies occur in 1–2% of pregnancies. The rate of twinning (the bearing of twins) is believed to be underestimated, as twin pregnancies with a singleton (an offspring born singly) birth are usually not recorded as twins.

Description

A multiple pregnancy may be the result of the natural process of twinning, or it may be the result of the woman having taken fertility drugs. Because of the increase in artificial reproductive technology (ART), the incidence of multiple pregnancies has increased. An April 1999 National Vital Statistics report from the Centers for Disease Control and Prevention (CDC) states that since

1980 the number of twins has risen by 52% and the number of triplets and high order multiples (more than three) has increased by 404%. An older maternal age and the use of fertility techniques are seen as the two major factors in these increases. While singletons have a 10% risk of being born preterm, multiple births have a 57% chance of being born prematurely. Premature birth places a neonate at higher risk for morbidity and mortality.

There are two categories of twins: monozygotic and dizygotic. Monozygotic twins are twins that have developed from a single fertilized ovum that split during embryonic development. These twins have the same genetic makeup and are always the same sex. They may be surrounded by one chorion (the outer embryonic membrane of the developing fetus), or may each have their own chorion. They may be surrounded by one amniotic sac (innermost of the membranes surrounding the embryo) or may each have their own amniotic sac. They may share a placenta or may each have their own placenta. These different possibilities depend on the time of the embryonic development at which the division took place. About two to 5% of monozygotic twins will share one amniotic sac. This rare occurrence puts the twins at risk for umbilical cord entanglement, cessation of **blood** flow, and death.

Double survival of monoamniotic twins is rare. Monozygotic twins may be referred to as identical. Dizygotic twins have developed from two fertilized ova. Their genetic makeup is different, and they are no more similar as any two siblings in a family. They may be the same or different sex. Each have their own chorion, amniotic sac, and placenta. While each twin has its own placenta, the placental implantations may be close enough that they fuse into one. Dizygotic twins may be referred to as fraternal. Multiple pregnancies of three or more fetuses may be the result of a single fertilized egg that splits, of multiple egg fertilizations, or a combination of the two processes.

Twins may not grow at the same rate. When there is 25% or more disparity between them, this is referred to as discordance, which occurs in about 10% of twin pregnancies. An extreme case of discordance occurs in the condition called twin-to-twin transfusion, also known as twin oligohydramnios polyhydramnios sequence. In this situation, one twin becomes the donor twin (receives too little blood from vessels in the fetuses' shared placenta that connect their blood circulations) and the other twin is the recipient (receives too much blood). The donor twin becomes small, pale, hypotensive, and anemic, with very little amniotic fluid. The recipient twin is large, polycythemic, hypertensive, with an excess of amniotic fluid. Both are at risk for **heart failure** and death.

At the time of delivery twins may be in any of the following combinations: vertex-vertex, breech-vertex, vertex-breech, breech-breech, vertex-transverse, or breech-transverse.

Causes and symptoms

In a woman's menstrual cycle, one egg, or ovum, is released every month. If more than one egg is released, it is possible for each egg to be fertilized separately by different spermatozoans. Fertility drugs encourage the release of more than one egg during the monthly menstrual cycle. In the case of monozygotic twins, only one egg was released and fertilized; but after fertilization it split, and separate fetuses developed. If the split is not complete, conjoined twins develop. Conjoined twins share certain body parts and organs. They may be referred to as Siamese twins. The chance of multiple pregnancy increases with an increase in parity and in maternal age up to about 35 years old, and then the incidence begins to decline. Genetics and racial background also play a role.

Diagnosis

A multiple pregnancy is suspected if the woman's uterus is growing too quickly for the gestational age, with excessive maternal weight gain, elevated levels of alpha-fetoprotein (a fetal protein that increases in the mother's blood during pregnancy) levels, unexplained severe maternal anemia, or with the auscultation (listening to sound to aid in diagnosis and treatment) of more than one fetal heartbeat. If undiagnosed at the time of quickening, the mother may feel movement in different parts of the uterus at the same time. Ultrasound can confirm or deny the presence of a multiple pregnancy. Once the multiple pregnancy is confirmed, ultrasonography may be used to check fetal growth over time, and the presence of any anomalies. There is a condition referred to as vanishing twin that occurs in up to 50% of twin pregnancies diagnosed very early by ultrasound. While twin sacs were seen on early sonography, a singleton is born. In these cases, there may have been early pregnancy vaginal bleeding and a lower human chorionic gonadotropin (hCG; a type of hormone) level than would be expected. The placenta often shows a whitish area and the remnant of a gestational sac. The mother and surviving twin (born singly) are both healthy.

Treatment

The diagnosis of a multiple pregnancy will result in it being treated as a **high-risk pregnancy** because of associated maternal and fetal risks. In a triplet pregnancy



An ultrasound image of identical twin male fetuses. The distortion is due to “twin B” being closer to the monitor. (Courtesy of Melissa Doig.)

the mother may be offered the choice of selective reduction to twins. However, the literature is unclear as to the overall value of reduction from three to two fetuses. In high order multiples, to decrease the risk of very early preterm birth and potential loss of fetal viability, selective reduction may take place. In selective reduction high order multiples are reduced to triplets or twins. The procedure is usually completed prior to the end of the third month of gestation and involves a chemical injection into one or more developing embryos. A fetus that shows chromosomal damage is usually targeted first. While this process increases the chances of the viability of the remaining fetuses, it carries a significant emotional burden for the mother and partner. It also raises ethical issues concerning the “right-to-life” of a fetus. Efforts are being made in the field of ART to prevent the development of high order multiples in order to avoid this particular situation.

Prognosis

Prognosis for a multiple pregnancy depends on many factors. The higher the number of fetuses, the greater the risks. A twin pregnancy carries significantly more risks than a singleton pregnancy. The risks for triplets are similar to that of twins. The risks increase significantly with multiples of four or higher. Twins have a ten-fold risk of perinatal mortality over singletons.

While many multiple pregnancies have an excellent outcome, it is still considered a high-risk pregnancy. The average gestation for a singleton is 38 to 42 weeks. For twins gestation averages 37 weeks; for triplets, 33 weeks; and for quadruplets, 31 weeks. The mother carrying a multiple pregnancy has an increased risk of:

- premature birth
- pregnancy-related **hypertension** and preeclampsia

KEY TERMS

Breech—The buttocks or hind end of the body.

Chorion—The outer embryonic membrane of the developing fetus that gives rise to the placenta. Inside the chorion is the amniotic sac or sacs, inside of which are the fetuses.

Morbidity—Morbidity refers to an illness or disease condition. In statistics it refers to the rate at which a disease occurs.

Mortality—Mortality means death. In statistics it refers to the rate at which death occurs in a population for a particular disease condition.

Parity—The number of pregnancies with a fetus reaching viable gestation.

Singleton—A singleton is a fetus that develops alone in the uterus.

Transverse—At right angles to the anterior-posterior body axis.

Vertex—The top of the head or highest point of the skull.

- hydramnios (excess amniotic fluid)
- placenta previa (placenta covering the mouth of the womb-cervix)
- folic acid and **iron** deficiency
- gestational diabetes
- urinary tract infection
- placental abruption after the vaginal delivery of the first twin (separation of the placenta from the uterus before the baby is born)
- uterine atony (failure of the uterus to contract after birth) and postpartal hemorrhage due to exaggerated stretching of the uterus
- fatigue and backache
- cesarian delivery

The risks to fetuses in a multiple pregnancy are greater than that for a singleton and include:

- premature birth (**Preterm labor** for twins is seven to ten times more likely than for singletons and is a significant factor in perinatal morbidity and mortality.)
- intrauterine growth restriction
- congenital anomalies

- cerebral palsy with increased risk often due to preterm delivery
- discordance; more common with triplets than with twins
- dead fetus syndrome
- combined pregnancy, in which one twin develops in the uterus while the other is ectopic (other than in the uterus, such as the fallopian tube or peritoneal cavity)
- delayed delivery of second twin
- placental abruption

Health care team roles

While a mother carrying a singleton may have one ultrasound done during the pregnancy, the mother of a multiple pregnancy is much more likely to have several ultrasounds done. The experience, skill, and ability of the ultrasound technician to provide a calm environment can be a great help to the mother and her partner. The nurse working in a high-risk obstetric practice can provide a great deal of teaching both to inform the mother about what to expect and to decrease **anxiety** through knowledge.

Prevention

Twinning is a naturally occurring phenomenon and cannot be completely prevented. It occurs more often in older mothers. Multiple births due to ART are a concern because a multiple pregnancy represents a complication of pregnancy. Efforts within the ART community are being made to minimize the incidence of high order multiples. Efforts to prevent or minimize maternal and fetal complications will result in closer monitoring. More frequent ultrasounds, biophysical profile, and/or nonstress tests may be ordered. Cervical length and change may be monitored as an indicator of preterm delivery. If both twins are vertex and vaginal delivery is attempted, both fetal **heart** rates will be monitored. Caesarian deliveries of twins are more common than for singletons. This is especially true in high order multiples. The overall cesarian delivery rate tends to be about 75%.

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The National Organization of Mothers of Twins Clubs, Inc. (NOMOTC). Executive Office, P.O. BOX 438, Thompson Station, TN 37179-0438. (615) 595-0936. (877) 540-2200. <<http://www.nomotc.org/>>.

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Multiple sclerosis

Definition

Multiple sclerosis (MS) is a chronic autoimmune disorder affecting movement, sensation, and bodily functions. It is caused by destruction of the myelin sheath (insulation) covering nerve fibers (**neurons**) in the **central nervous system (brain and spinal cord)**.

Description

MS is a nerve disorder caused by destruction of the insulating layer surrounding neurons in the brain and spinal cord. This insulation, called myelin, helps electrical signals pass quickly and smoothly between the brain and the rest of the body. When the myelin is destroyed neuronal messages are sent more slowly and less efficiently. Patches of scar tissue, called plaque, form over the affected areas, further disrupting neuronal communication. The symptoms of MS occur when the brain and spinal cord nerves no longer communicate properly with other parts of the body. MS causes a wide variety of symptoms and can affect **vision**, balance, strength, sensation, coordination, and bodily functions.

Multiple sclerosis affects more than a quarter of a million people in the United States. Most people have their first symptoms between the ages of 20 and 40 years; symptoms rarely begin before 15 years or after 60 years of age. Women are almost twice as likely as men to get MS, especially in their early years. People of northern European heritage are more likely to be affected than people of other racial backgrounds, and MS rates are higher in the United States, Canada, and Northern Europe than in other parts of the world. MS is very rare among Asians, North and South American natives, and Eskimos. Between 10% and 20% of people with MS have a benign type, meaning their symptoms progress very little over the course of their lives.

Causes and symptoms

Causes

Multiple sclerosis is an autoimmune disease, meaning its cause is due to an attack by the body's own **immune system**. For unknown reasons immune cells attack and destroy the myelin sheath that insulates neurons in the brain and spinal cord. This myelin sheath, created by other brain cells called glia, speeds transmission and prevents electrical activity in one cell from short-circuiting to another cell. Disruption of communication between the brain and other parts of the body prevents normal passage of sensations and control messages, leading to the symptoms of MS. The demyelinated areas appear as plaques, small round areas of gray neurons without the white myelin covering. The progression of symptoms is correlated with development of new plaques in the portion of the brain or spinal cord controlling the affected areas. Because there appears to be no pattern in the appearance of new plaques, the progression of MS is unpredictable.

Despite considerable research the trigger for this autoimmune destruction is still unknown. At various times evidence has pointed to genes, environmental factors, **viruses**, or a combination of these factors.

The risk of developing MS is higher if another family member is affected, suggesting the influence of genetic factors. In addition, the higher prevalence of MS among people of northern European ancestry suggests some genetic susceptibility.

The role of an environmental factor is suggested by studies of the effect of migration on the risk of developing MS. Age plays an important role in determining this change in risk. Young people in low-risk groups who move into countries with higher MS rates display the risk rates of their new surroundings, while older migrants retain the risk of their original home country. One interpretation of these studies is that an environmental factor, either protective or harmful, is acquired in early life. The risk of disease later in life reflects the effects of the early environment.

These same data can be used to support the involvement of a slow-acting virus, one that is acquired early on but begins its destructive effects much later. Slow viruses are known to cause other diseases, including **Creutzfeldt-Jakob disease** and bovine spongiform encephalopathy ("mad cow" disease). In addition, viruses have been implicated in other autoimmune diseases. Many claims have been made for the role of viruses, slow or otherwise, as the trigger for MS; however, as of 2001, no strong candidate has emerged.

How a virus could trigger the autoimmune reaction is also unclear. There are two main models of virally induced autoimmunity. The first suggests the immune system is actually attacking a virus (one too well hidden for detection in the laboratory), and the myelin damage is an unintentional consequence of fighting the **infection**. The second model suggests the immune system mistakes myelin for a viral protein encountered during a prior infection. Primed for the attack, the immune system destroys myelin because it resembles the previously recognized viral invader.

Either of these models allows a role for genetic factors, since certain genes can increase the likelihood of autoimmunity. Environmental factors, as well, might change the sensitivity of the immune system or interact with myelin to provide the trigger for the secondary **immune response**. Possible environmental triggers that have been invoked in MS include viral infection, trauma, electrical injury, and chemical exposure—although controlled studies have not supported a causative role.

Symptoms

The symptoms of multiple sclerosis may occur in one of three patterns:

- The most common pattern is the “relapsing-remitting” pattern, in which there are clearly defined symptomatic attacks lasting 24 hours or more, followed by complete or almost complete improvement. The period between attacks may be a year or more at the beginning of the disease, but may shrink to several months as the disease progresses. This pattern is especially common among younger people who develop MS.
- In the “primary progressive” pattern, the disease progresses without remission, or with occasional plateaus or slight improvements. This pattern is more common among older people.
- In the “secondary progressive” pattern, the person with MS begins with relapses and remissions, followed by more steady progression of symptoms.

Because plaques may form in any part of the central nervous system, the symptoms of MS vary widely from person-to-person and from stage-to-stage of the disease. Initial symptoms often include:

- muscle weakness causing difficulty walking
- loss of coordination or balance
- numbness, “pins and needles,” or other abnormal sensations
- visual disturbances, including blurred or double vision

Later symptoms may include:

- fatigue
- muscle spasticity and stiffness
- tremors
- paralysis
- **pain**
- vertigo
- speech or swallowing difficulty
- loss of bowel and bladder control
- sexual dysfunction
- changes in cognitive ability

Weakness in one or both legs is common, and may be the first symptom noticed by a person with MS. Muscle spasticity, or excessive tightness, is also common and may be more disabling than weakness.

Double vision (diplopia) or eye tremor (nystagmus) may result from involvement of the nerve pathways controlling movement of the eye muscles. Visual disturbances result from involvement of the optic nerves (optic neuritis) and may include development of blind spots in one or both eyes, changes in color vision, or blindness. Optic neuritis usually involves only one eye at a time and is often associated with movement of the effected eye.

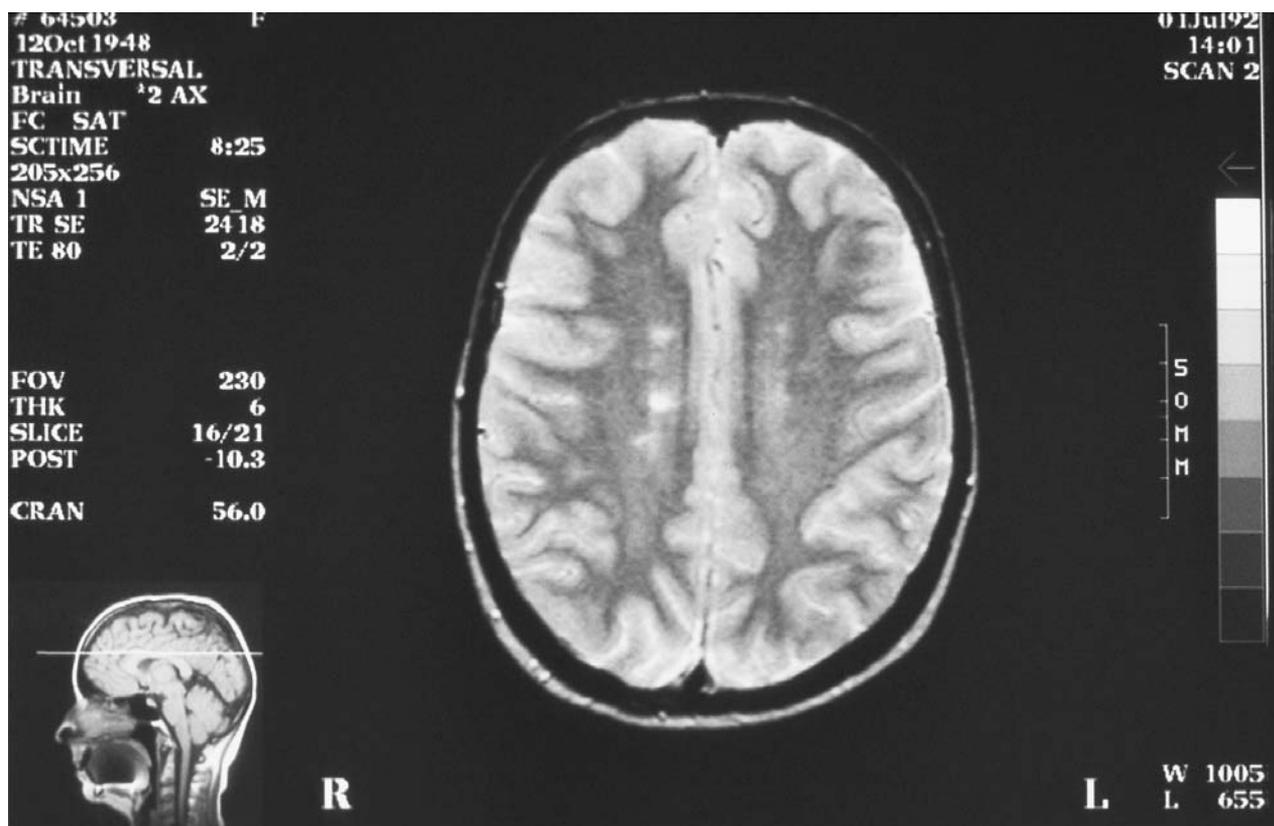
More than half of all people affected by MS have pain during the course of their disease. Many experience chronic pain, including pain from spasticity. Acute pain occurs in about 10% of cases. This pain may be a sharp, stabbing pain especially in the face, neck, or down the back. Facial numbness and weakness are also common.

Cognitive changes, including **memory** disturbances, depression, and personality changes, are found in people affected by MS, though it is not entirely clear whether these changes are due primarily to the disease or to the psychological reaction to it. Depression may be severe enough to require treatment in up to 25% of those with MS. A smaller number of people experience disease-related euphoria, or abnormally elevated mood, usually after a long disease duration and in combination with other psychological changes.

Symptoms of MS may be worsened by heat or increased body temperature including **fever**; intense physical activity; or exposure to sun, hot baths, or showers.

Diagnosis

There is no single test that confirms the diagnosis of multiple sclerosis and there are a number of other diseases with similar symptoms. While one person’s diagnosis may be immediately suggested by symptoms and history, another’s may not be confirmed without multiple



This image, made using magnetic resonance imaging (MRI), shows lesions on the left lobe of the brain of a multiple sclerosis patient. (Comp-Unique/Custom Medical Stock Photo. Reproduced by permission.)

tests and prolonged observation. The distribution of symptoms is important, as MS affects multiple areas of the body over time. The pattern of symptoms is also critical, especially evidence of the relapsing-remitting pattern. Thus, a detailed medical history is one of the most important parts of the diagnostic process. A thorough search to exclude other causes of a person's symptoms is especially important if the following features are present: 1) family history of neurologic disease, 2) symptoms and findings attributable to a single anatomic location, 3) persistent back pain, 4) age of onset over 60 or under 15 years of age, or 5) progressively worsening disease.

In addition to a medical history and a standard neurological exam, several lab tests are used to help confirm or rule out a diagnosis of MS:

- **Magnetic resonance imaging (MRI)** can reveal plaques on the brain and spinal cord. Gadolinium enhancement can distinguish between old and new plaques, allowing a correlation of new plaques with new symptoms. Plaques may be seen in several other diseases as well, including encephalomyelitis, neurosarcoidosis, and cerebral lupus. Plaques seen on an MRI may, however, be difficult to distinguish from

damage caused by small strokes, areas of decreased **blood** flow, or changes seen with trauma or normal aging.

- A lumbar puncture, or spinal tap, is done to measure levels of immune **proteins**, which are usually elevated in the cerebrospinal fluid of a person with MS. This test may not be necessary if other diagnostic tests are positive.
- Evoked potential tests, electrical tests of conduction speed in the neurons, can reveal reduced speeds consistent with the damage caused by plaques. These tests may be done with small electrical charges applied to the skin (somatosensory evoked potential), with light patterns flashed on the eyes (visual evoked potential), or with sounds presented to the ears (auditory evoked potential).

A clinician making the diagnosis, usually a neurologist, may classify the disease in one of three ways:

- “Definite MS” means that the symptoms and test results all point toward MS as the cause.
- “Probable MS” and “Possible MS” reflect less certainty and may require more time for observing the pro-

gression of the disease and the distribution of symptoms.

Treatment

As of 2001 three drugs shown to affect the course of the disease have been approved for the treatment of MS. None of these drugs is a cure, but they can slow disease progression in many cases.

Avonex and Betaseron are forms of the immune system protein beta interferon, while Copaxone is glatiramer acetate (formerly called copolymer-1). All three have been shown to reduce the rate of relapse in the relapsing-remitting form of MS. Different measurements from tests of each drug have demonstrated other benefits as well. Avonex may slow the progress of physical impairment, Betaseron may reduce the severity of symptoms, and Copaxone may decrease disability. All three drugs are administered by injection. Copaxone is given daily, Betaseron every other day, and Avonex weekly. Betaseron, however, is known to lead to the development of neutralizing antibodies, which reduce the effectiveness of treatment.

Immunosuppressant drugs have been used for many years to treat acute exacerbations (relapses). These drugs include **corticosteroids** such as prednisone and methylprednisolone, the hormone adrenocorticotropic hormone (ACTH), and azathioprine. Recent studies indicate that several days of intravenous methylprednisolone may be more effective than other immunosuppressant treatments for acute symptoms. This treatment may require hospitalization.

MS causes a large variety of symptoms, and the treatments for these are equally diverse. Most symptoms can be treated and complications avoided with good care and attention from medical professionals. Good health and **nutrition** remain important preventive measures. **Vaccination** against **influenza** can prevent respiratory complications and, contrary to earlier concerns, is not associated with worsening of symptoms. Preventing complications such as **pneumonia**, bed sores, injuries from **falls**, or urinary infection requires attention to the primary problems that may cause them. Shortened life spans with MS are almost always due to complications rather than primary symptoms themselves.

Physical therapy helps a person with MS to strengthen and retrain affected muscles; to maintain range of motion to prevent muscle stiffening; to learn to use assistive devices such as canes and walkers; and to learn safer and more energy-efficient ways of moving, sitting, and transferring. **Exercise** and stretching programs are usually designed by a physical therapist and

taught to patients and their caregivers for use at home. Exercise is an important part of maintaining function for a person with MS. Swimming is often recommended, not only because it is a low-impact workout, but also because it allows strenuous activity without overheating.

Occupational therapy helps a person with MS adapt to the local environment and adapt the environment. An occupational therapist may suggest alternate strategies and assistive devices for activities of daily living, such as dressing, feeding, and washing, and may evaluate both home and work environments for safety and efficiency improvements.

Training in bowel and bladder care may be needed to prevent or compensate for incontinence. If the urge to urinate becomes great before the bladder is full, some drugs may be helpful, including propantheline bromide (Probanthine), oxybutynin chloride (Ditropan), or imipramine (Tofranil). Baclofen (Lioresal) may relax the sphincter muscle, allowing full emptying. Intermittent catheterization is effective in controlling bladder dysfunction. In this technique, a catheter is used to periodically empty the bladder.

Spasticity can be treated with oral medications, including baclofen and diazepam (Valium), or by injection with botulinum toxin (Botox). Spasticity relief may also bring relief from chronic pain. Other more acute types of pain may respond to carbamazepine (Tegretol) or diphenylhydantoin (Dilantin). Low back pain is common from increased use of the back muscles to compensate for weakened legs. Physical therapy and over-the-counter pain relievers may be helpful.

Fatigue may be partially avoidable with changes in the daily routine to allow more frequent rests. Amantadine (Symmetrel) and pemoline (Cylert) may improve alertness and lessen fatigue. Visual disturbances often respond to corticosteroids. Other symptoms that may be treated with drugs include seizures, vertigo, and tremor.

Myloral, an oral preparation of bovine myelin, has recently been tested in clinical trials for its effectiveness in reducing the frequency and severity of relapses. Preliminary data indicate no difference between it and placebo.

Alternative treatment

Bee venom has been suggested as a treatment for MS, but no studies or objective reports support this claim.

In British studies **marijuana** has been shown to have variable effects on the symptoms of MS. Improvements have been documented for tremor, pain, and spasticity,

and worsening for posture and balance. Side effects have included weakness, dizziness, **relaxation**, and lack of coordination, as well as euphoria. As a result marijuana is not recommended as an alternative treatment. As of 2001 the use of marijuana for medical purposes was still illegal in most states of the United States.

Some studies support the value of high doses of **vitamins**, **minerals**, and other dietary supplements for controlling disease progression or improving symptoms. Alpha-linoleic and linoleic acids, as well as selenium and **vitamin E**, have shown effectiveness in the treatment of MS. Selenium and vitamin E act as antioxidants. In addition, the Swank diet (low in saturated **fats**), maintained over a long period of time, may retard the disease process.

Removal of mercury fillings has been touted as a possible cure, but is of no proven benefit.

Prognosis

It is difficult to predict how multiple sclerosis will progress in any one person. Most people with MS will be able to continue to walk and function at their work for many years after their initial diagnosis. The factors associated with the mildest course of MS are being female, having the relapsing-remitting form, having the first symptoms at a younger age, having longer periods of remission between relapses, and initial symptoms of decreased sensation or vision rather than of weakness or lack of coordination.

Approximately 5% of people with MS have the severe progressive form that leads to death from complications within five years. At the other extreme, 10-20% have a benign form, with very slow or no progression of their symptoms. The most recent studies show that about seven out of 10 people with MS are still alive 25 years after their diagnosis, compared to about nine out of 10 people of similar age without the disease. On average, MS shortens the lives of affected women by about six years and men by about 11 years. Suicide is a significant cause of death in MS, especially in younger persons.

The degree of disability a person experiences five years after onset is, on average, about three-quarters of the expected disability at 10-15 years. A benign course for the first five years usually indicates the disease will not cause marked disability.

Health care team roles

Physicians provide initial diagnoses. Neurologists may support diagnoses and monitor disease progression. Physical and occupational therapists provide exercise and environmental support for relief from muscle strains

KEY TERMS

Evoked potentials—Tests that measure the brain's electrical response to stimulation of sensory organs (eyes or ears) or peripheral nerves (skin).

Myelin—A layer of fatty cells that surrounds many nerve fibers in the brain and spinal cord. The myelin sheath acts as insulation that channels electrical impulses.

Nystagmus—Uncontrollable movements of the eye.

Plaque—Patches of scar tissue that form where a layer of myelin covering the nerve fibers is destroyed by the multiple sclerosis disease process.

Primary progressive—A pattern of symptoms of multiple sclerosis in which the disease progresses without remission, or with occasional plateaus or slight improvements.

Relapsing-remitting—A pattern of symptoms of multiple sclerosis in which symptomatic attacks last 24 hours or more, followed by complete or almost complete improvement.

Secondary progressive—A pattern of symptoms of multiple sclerosis in which there are relapses and remissions, followed by more steady progression of symptoms.

and weakness. Radiologists are important in documenting disease progression. Psychiatrists, psychologists, and other therapists may be helpful in treating depression that may accompany MS. Nurses provide bedside care, education for the patient and caregiver, preparation for home management of the disease, and home safety assessment.

Prevention

There is no known way to prevent MS. Until its cause is discovered, this situation is unlikely to change. Good nutrition; adequate rest; avoidance of **stress**, heat, and extreme physical exertion; and good bladder hygiene may improve quality of life and reduce symptoms for those who are affected by the disease.

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ORGANIZATIONS

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<<http://www.aan.com>>.
- Multiple Sclerosis Foundation. 6350 North Andrews Ave., Fort Lauderdale, FL 33309-2130, (800) 441-7055.
<<http://www.msfacts.org>>.
- National Multiple Sclerosis Society. 733 Third Avenue, New York, NY 10017, (800) 344-4867.
<<http://www.nmss.org>>.

OTHER

- Computer Literate Advocates for Multiple Sclerosis.
<<http://www.clams.org>>.
- International Multiple Sclerosis Support Foundation.
<<http://www.msnews.org>>.
- MS World. <<http://www.msworld.org>>.
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L. Fleming Fallon, Jr., M.D., Dr.P.H.

Muscle contraction

Definition

Muscle contraction is the response a muscle has to any kind of stimuli where the result is shortening in length and development of force.

Description

There are three general types of muscle in our bodies. They are skeletal (striated), cardiac, and smooth (visceral) muscle. When **skeletal muscles** contract, they help the body move and breathe. Skeletal muscles are

attached to bones and function in a fashion similar to a lever. Skeletal muscle responds to stimuli that are both voluntary and involuntary.

Although similar to skeletal muscle, cardiac muscle is unique to the **heart**. Cardiac cells are smaller and contain more mitochondria than skeletal muscle. The mitochondria produce high-energy molecules in the form of ATP to supply cardiac muscles with the fuel they need to continuously contract, pumping **blood** through the circulatory system. The heart is an involuntary muscle and does not need any input from the nervous system to initiate and maintain a contraction.

Myofibrils within the muscle fibers (muscle cells) of skeletal and cardiac muscle have thick and thin filaments that overlap to create patterns called I-bands, H-zones, A-bands, Z-discs, and M-line. Thin filaments contain two strands of protein called actin that is wound into a helical structure with a strand of two other **proteins** called troponin and tropomyosin. Thick filaments contain many small filaments of protein called myosin filaments, which consist of a head and a tail. These patterns give skeletal and cardiac muscle a “striated” appearance. During skeletal and cardiac muscle contraction, the I-band shortens, while the other bands and zones remain the same length.

Smooth muscle lines the walls of the body’s viscera (organs), particularly the **blood vessels** and **digestive system**. It lacks striations found in skeletal muscle. When smooth muscles contract, they control the passage of substances through the tubular structures of the blood vessels and intestines. Smooth muscle is controlled involuntarily.

Function

The nature of the contraction

Muscle contractions generally involve the shortening of a muscle while exerting a force and performing work. However, there are many different types of contractions, and some do not strictly follow that definition. Isometric contraction occurs when the muscle does not shorten, but it does exert force (e.g. pushing or pulling an immovable object). Isotonic contractions take place when the muscle length shortens and the force remains the same (e.g. lifting a weight at the gym). In an auxotonic contraction the force gradually increases while the muscle length is shortening (e.g. pulling on a rubber band). Conversely, a meiotonic contraction occurs when the force decreases as the muscle length shortens (e.g. depressing a key on a computer keyboard). Most muscle contractions involve a combination of two or more of the above contractions and are called mixed contractions.

For example, when lifting a large bucket filled with water, there is first an isometric contraction, followed by isotonic shortening.

While skeletal muscle is resting, there is still a force exerted due to the tension created from the muscle’s connection to the bone on each end of the muscle. This force is called the resting force and is similar to the force of a rubber band that is stretched. Tests performed in the laboratory demonstrate that muscles have an optimal length where contraction produces a maximum active force. Maximum force usually occurs at the natural length of the muscle and is termed optimal length (L_0).

Since cardiac muscle is not connected to bones like skeletal muscle, it functions over a greater range of lengths. Additionally, its maximum force ability is observed at a lower L_0 , giving it a “reserve” length. This allows cardiac muscle to contract more forcefully when necessary. The muscle is re-lengthened when the chamber of the heart fills with blood.

Smooth muscle does not make the typical isotonic contractions seen in skeletal and cardiac muscle. Most smooth muscle contractions of the digestive tract occur as a substance passes through the hollow tube that smooth muscle comprises; therefore, smooth muscle shortens against a decreasing load. On the other hand, smooth muscle in blood vessels maintains a partially isometric contraction where the force is held constant for an extended period of time, resulting in a particular **blood pressure**.

The nature of the biochemistry of the contraction

Muscle contraction involves the sliding of thick filaments of myosin past thin filaments of actin. The interaction of myosin and actin begins when a high-energy molecule of ATP located in the head of the myosin filament is hydrolyzed into an inorganic phosphate (P_i) molecule and ADP. The myosin head subsequently attaches to an actin filament forming a crossbridge. The ADP and P_i are then released, and the myosin head undergoes a conformational change that causes the actin filament to move relative to the myosin filament. Then, ATP once again binds to the myosin head and causes myosin to dissociate from the actin filament. These steps are repeated very rapidly, causing the myosin head to “walk” along the actin filament, resulting in a muscle contraction. Only when ATP is present can the myosin head detach from the actin filament to continue the process. If ATP is not present, then the muscle will become stiff and unable to relax as is seen in rigor mortis.

KEY TERMS

ADP (adenosine diphosphate)—A molecule that accepts phosphate groups in biochemical reactions.

ATP (adenosine triphosphate)—A high energy molecule that releases a phosphate group, providing energy to power reactions.

Voluntary movement—Movement as a result of conscious effort.

Work—Describes the amount of force used to move an object a certain distance.

The nature of control of the contraction

Muscle cells contain a highly excitable membrane called the sarcoplasmic reticulum, which can be excited to release **calcium** ions and produce an action potential. Most stimulation occurs through motor **neurons** that originate in the somatic portion of the **central nervous system** and innervate the muscles at the myoneural junction. When the motor neuron nears the muscle it branches to innervate several different muscle fibers. Many different nerves innervate muscles responsible for fine and precise motor movements, each nerve innervating only a couple muscle fibers. Conversely, only a few nerves innervate muscles responsible for large, imprecise movements, each nerve branching many times to innervate many muscle fibers.

The nerve side of the myoneural junction makes up the presynaptic portion. Muscle is located on the other side of the junction, forming the postsynaptic portion. As an action potential travels down the nerve and reaches the axon terminal, extracellular calcium ions enter the terminal. Neurotransmitter vesicles in the axon terminal migrate to the axon membrane, fusing with it to release acetylcholine into the synaptic cleft. Molecules of acetylcholine diffuse across the cleft and bind to receptors on the postsynaptic membrane of the muscle. Then, ion channels in the postsynaptic membrane open, allowing potassium and sodium ions to enter. This creates an electrical potential (end-plate potential) and depolarization of the postsynaptic membrane, which then travels down the entire muscle membrane, resulting in a muscle action potential. As an action potential travels down the muscle fiber, a membrane system located within the muscle called the sarcoplasmic reticulum releases calcium ions, which are stored within the membrane system. The calcium ions diffuse into an area of actin and myosin filaments where they bind to troponin molecules associated

with the actin filaments. Then the actin filaments are enabled to interact with the myosin filaments and the result is a muscle contraction.

In order to halt a contraction after the initial action potential is fired, acetylcholine diffuses away from the receptor in the postsynaptic cleft, and an enzyme called cholinesterase hydrolyzes acetylcholine into choline and acetate. Choline is taken back into the presynaptic cleft and recycled into more acetylcholine in the neurotransmitter vesicles.

Role in human health

The coordination between the nervous system and muscles permits many actions such as walking, talking, eating, digesting food, breathing, and giving birth. Muscle contractions have several roles. When a muscle functions as a motor it consumes fuel and does work (e.g. walking, lifting, etc.). This produces heat, which helps to warm the body (e.g. shivering). Muscles also function as regulators. They control the passage of substances through the digestive system, and control the beating of the heart muscle and the diameter of blood vessels, resulting in specific blood pressures.

If the body develops any one of a number of problems that affect muscle contraction, both the motor and regulatory properties of muscles can be injured. Anything from walking, breathing, talking, or digesting food can be damaged, depending on the problem encountered.

Common diseases and disorders

Muscle contraction can be affected on a multitude of levels. Neurological problems, autoimmune diseases, infectious diseases and **spinal cord** injuries can all contribute to impaired muscle contraction.

Muscle cramping is a common disorder. Cramping occurs when the muscle contracts involuntarily at a rate of about 300 contractions per second, a much higher rate than the maximum voluntary contraction. It is not known why cramping occurs. Researchers think that it may be a result of electrolyte imbalance in the extracellular fluid surrounding the muscle fiber and nerves. Drinking a sports beverage or eating a banana can replace electrolytes. This is especially important after strenuous **exercise**.

About 12,000 Americans suffer from myasthenia gravis. Myasthenia gravis is an autoimmune disease in which the body's **immune system** has a reaction to acetylcholine receptors, reducing the number of receptors on the postsynaptic membrane. As a result, not enough acetylcholine binds to receptors, and not enough sodium and potassium ion channels open. Therefore, end-plate

potentials may not be high enough to create an action potential, resulting in muscle weakness. Myasthenia gravis can be treated with administration of cholinesterase inhibitors, which allow acetylcholine to remain in the cleft for a longer period of time. Thus, the receptors present can be stimulated over and over to permit sufficient ion flow to create an end-plate potential.

Microorganisms can cause some muscle disorders. Tetanus, also called “lock jaw,” is a neurological disorder caused by tetanospasmin, a powerful toxin produced by the **bacteria** *Clostridium tetani*. The toxin blocks inhibitory neurotransmitters that normally stop the release of acetylcholine. A build-up of acetylcholine occurs in the space between the pre- and postsynaptic cleft, resulting in a summation of muscle contractions. Summation of muscle contractions produces muscle rigidity. Tetanus is treated with **antibiotics** and antitoxins.

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Sally C. McFarlane-Parrott

Muscle relaxants

Definition

Skeletal muscle relaxants are drugs that relax striated muscles (those that control the skeleton). They are a separate class of drugs from the muscle relaxant drugs used during intubations and surgery to reduce the need for anesthesia and facilitate intubation.

Purpose

Skeletal muscle relaxants may be used for relief of spasticity in neuromuscular diseases, such as **multiple sclerosis**, as well as for **spinal cord injury** and stroke. They may also be used for **pain** relief in minor strain injuries and control of the muscle symptoms of tetanus. Dantrolene (Dantrium) has been used to prevent or treat malignant hyperthermia in surgery.

Description

Although the muscle relaxants may be divided into only two groups, centrally acting and peripherally acting, the centrally acting group, which appears to act on the **central nervous system**, contains 10 drugs which are chemically different, while only dantrolene has a direct action at the level of the nerve-muscle connection.

Baclofen (Lioresal) may be administered orally or intrathecally for control of spasticity due to neuromuscular disease.

Carisoprodol (Soma), chlorphenesin (Maolate), chlorzoxazone (Paraflex), cyclobenzaprine (Flexeril), diazepam (Valium), metaxalone (Skelaxin), methocarbamol (Robaxin), and orphenadrine (Norflex) are used primarily as an adjunct for rest in management of acute muscle spasms associated with sprains. Muscle relaxation may also be an adjunct to **physical therapy** in rehabilitation following stroke, **spinal cord** injury, or other musculoskeletal conditions.

Diazepam and methocarbamol are also used by injection for relief of tetanus.

Recommended dosage

Dose varies with the drug, route of administration, and purpose. There may be individual variations in absorption that require doses higher than those usually recommended, particularly with methocarbamol. Consult specific references for further information.

Precautions

All drugs in this class may cause sedation. Baclofen, when administered intrathecally, may cause severe central nervous system (CNS) depression with cardiovascular collapse and **respiratory failure**.

Diazepam may be addictive. It is a controlled substance under federal law.

Dantrolene has a potential for hepatotoxicity. The incidence of symptomatic hepatitis is dose related, but may occur even with a short period of doses at or above. Even short periods of doses at or above 800 mg per day

KEY TERMS

Central nervous system—The brain and spinal cord.

Intrathecal—Introduced into or occurring in the space under the arachnoid membrane which covers the brain and spinal cord.

Pregnancy category—A system of classifying drugs according to their established risks for use during pregnancy. Category A: Controlled human studies have demonstrated no fetal risk. Category B: Animal studies indicate no fetal risk, but no human studies, or adverse effects in animals, but not in well-controlled human studies. Category C: No adequate human or animal studies, or adverse fetal effects in animal studies, but no available human data. Category D: Evidence of fetal risk, but benefits outweigh risks. Category X: Evidence of fetal risk. Risks outweigh any benefits.

Sedative—Medicine used to treat nervousness or restlessness.

Spasm—Sudden, involuntary tensing of a muscle or a group of muscles.

Tranquilizer (minor)—A drug that has a calming effect and is used to treat anxiety and emotional tension.

greatly increases the risk of serious **liver** injury. Overt hepatitis has been most frequently observed between the third and twelfth months of therapy. Risk of hepatic injury appears to be greater in women, in patients over 35 years of age and in patients taking other medications in addition to dantrolene.

Tizanidine may cause low **blood pressure**, but this may be controlled by starting with a low dose and increasing it gradually. The drug may rarely cause liver damage.

Methocarbamol and chlorzoxazone may cause harmless color changes in urine—orange or reddish-purple with chlorzoxazone and purple, brown, or green with methocarbamol. The urine will return to its normal color when the patient stops taking the medicine.

Most drugs in this class are well tolerated.

Not all drugs in this group have been evaluated for safety in **pregnancy** and breast feeding.

Baclofen is pregnancy category C. It has caused fetal abnormalities in rats at doses 13 times above the human dose. Baclofen passes into breast milk, and breast feeding while taking baclofen is not recommended.

Diazepam is category D. All benzodiazepines cross the placenta. Although the drugs appear to be safe for use during the first trimester of pregnancy, use later in pregnancy may be associated with cleft lip and palate. Diazepam should not be taken while breast feeding. Infants who were breast fed while their mothers took diazepam were excessively sleepy and lethargic.

Dantrolene is category C. In animal studies it has reduced the rate of survival of the newborn when given in doses seven times the normal human dose. Mothers should not breast feed while receiving dantrolene.

Interactions

Skeletal muscle relaxants have many potential **drug interactions**. Individual references should be consulted.

Because these drugs cause sedation, they should be used with caution with other drugs that may also cause drowsiness.

The activity of diazepam may be increased by drugs that inhibit its **metabolism** in the liver. These include: cimetidine, oral contraceptives, disulfiram, fluoxetine, isoniazid, ketoconazole, metoprolol, propoxyphene, propranolol, and valproic acid.

Dantrolene may have an interaction with estrogens. Although no interaction has been demonstrated, the rate of liver damage in women over the age of 35 who were taking estrogens is higher than in other groups.

Samuel D. Uretsky, PharmD

Muscle strain see **Sprains and strains**

Muscle testing

Definition

Muscle testing is the evaluation of contractile units, including muscles and tendons, and their ability to generate forces.

Purpose

Muscle testing is indicated in any individual with suspected or actual impaired muscle performance, including strength, power, or endurance. Impairments in muscle function may result from cardiovascular, pulmonary, musculoskeletal or neuromuscular disease or disorders. Identification of specific muscles or muscle groups with impaired function provides information for

appropriate intervention, which may include strengthening exercises, functional drills, bracing, or compensatory muscle use.

Precautions

It is important to determine the patient's ability to withstand the force to be applied. The patient should have good cardiovascular function, be instructed against using the Valsalva maneuver, and be positioned appropriately. Care should be taken with any body part that is under movement restriction due to fracture, post-surgical, or other tissue healing.

Description

Forms of muscle testing include manual strength testing, functional tests, and dynamometry.

Manual muscle testing

Manual muscle strength testing is a widely used form of muscle testing in the clinic. In this form of testing, the individual is asked to hold a limb or other body part at the end of its available range or at another point in its range of motion while the clinician provides manual resistance. General procedures include the following:

- The patient should be placed in a position that provides overall support to the body so that he or she can concentrate his or her effort on the part being tested.
- The part to be tested initially is placed in an antigravity position. If muscles are too weak to function against gravity, they are then tested in the horizontal plane.
- The proximal part of the area being tested should be stabilized to reduce the opportunity for compensatory action by muscles other than those being tested.
- Resistance needs to be applied directly opposite the "line of pull" of the muscles being tested.
- Gradual, not sudden, application of pressure should take place, using a long lever arm in most cases.
- Both sides should be assessed to provide a comparison, especially when one side is affected by pathology and the other is not.

Grading of muscle tests is used to determine a patient's **physical therapy** diagnosis and in assessing progress over time. Objective observation includes determining the patient's ability to hold a test position, move through a full range of motion, or to overcome gravity. Care must be taken in grading, however, due to the inevitable subjectivity of muscle testing. Subjective factors include the clinician's impression of how much resistance to apply and how much is tolerated. Consistent

testing procedures, including accurate joint placement and prohibition of compensatory movements, allow for increased reliability in using manual muscle testing as an evaluation tool. In studies comparing manual testing and dynamometry, results show positive correlation; however, manual muscle testing is less sensitive than dynamometry.

Traditional grading has been described using either the terms "zero," "trace," "poor," "fair," "good," and "normal," or using a numerical scale from 0 through 5. When determining a grade, first determine whether or not the patient can move the body part through its full range against gravity and hold the body part in the test position. This ability results in a grade of fair, or 3, and is the most objective observation made during testing due to the consistency of gravity. A poor grade, or 2, is given when a patient is able to move the body part through its complete range of motion in the horizontal plane, that is, with the effect of gravity eliminated. A trace grade, or 1, is given when there is no visible movement through a part's range, but a slight contraction can be palpated. When there is no evidence of even a slight contraction, a grade of zero is given.

Grades above fair are assessed with the body part in the specified test position. A grade of good, or 4, denotes the ability of the patient to hold the body part in the test position against moderate pressure. A normal grade, or 5, denotes that the patient holds the body part against strong pressure by the clinician.

Pluses and minuses can be added to the above grades to further describe muscle ability, but some discourage their use because it introduces even more subjectivity to grading. In some cases, however, the use of a plus or minus grade provides important information. For example, a patient with a fair grade (3) for a muscle group may not be able to use an orthosis effectively, but if that patient achieves a fair plus (3+), he or she can withstand minimal resistance against gravity and therefore may be able to tolerate the additional weight of an orthosis. Descriptors for plus and minus grades are included in the summary of grades below:

- Normal (5): withstands strong pressure in test position.
- Good plus (4+): withstands moderate to strong pressure.
- Good (4): withstands moderate pressure.
- Good minus (4-): withstands slight to moderate pressure.
- Fair plus (3+): withstands slight pressure.
- Fair (3): holds test position against gravity but tolerates no additional pressure.



This therapist is testing the muscles of the patient's hand by pressing on the thumb. (Photograph by John Watney. Science Source/Photo Researchers. Reproduced by permission.)

- Fair minus (3-): sags from test position or only moves through partial range of motion against gravity (>50% of motion).
- Poor plus (2+): moves through 50% of motion or less in antigravity position, or holds against resistance in gravity-eliminated position (horizontal plane).
- Poor (2): moves through complete range in horizontal plane.
- Poor minus (2-): moves through partial range in horizontal plane.
- Trace (1): slight contraction, but no visible movement of body part detected.
- Zero (0): complete lack of muscle contraction.

It is important to note that manual muscle grades are an ordinal level of measurement, meaning that the categories do not represent equal magnitudes. In other words, the strength required to move from zero to trace is different from the amount of strength required to move from good to normal. Therefore, manual muscle grades are not useful for arithmetical computations.

Manual muscle testing is a relatively quick and inexpensive method of evaluating strength; however, results often do not denote a person's ability to perform functional activities. In addition, a normal muscle grade does not necessarily indicate a patient's ability to return to his or her normal level of activity, especially if it includes sports participation. This ability is better tested with functional tests.

Functional muscle testing

Functional muscle testing allows for the assessment of muscles to perform components of, or entire, tasks related to daily activities. Functional tests look at the ability of muscle groups to decelerate, stabilize or accelerate movement in all three planes of motion in a measurable way. Specific tests can be chosen to look at movements at specific joints or those that are dominant in a certain plane of motion. For example, a single-leg squat provides valuable information about the quadriceps' performance. An anterior jump test provides the same type of information on a more challenging level for the patient.

Categories of functional muscle testing include the following: balance, excursion, lunge, step-up, step-down, jump and hop tests. In performing tests, patient safety is key. Clinical judgment should be used to determine when functional testing is appropriate; for example, a person with a weight-bearing restriction should not perform a balance test on that lower extremity. Testing should be done in a progressive manner; for example, a balance test should be performed before an excursion test, a straight plane lunge test before a rotational lunge test. Tests can be used to document progress by measuring distance of reach, time, degrees of excursion, etc., as appropriate to the specific test.

Dynamometry

Isokinetic dynamometry uses a device that measures the force used in contraction of a muscle group. The device is able to apply maximal resistance at all points in the body part's range of motion at a specified speed. Isokinetic testing can be used to objectively assess strength, power and endurance. Strength is assessed using slow velocity testing to look at peak torques produced. Power testing uses fast velocity settings to look at the amount of work performed during a particular amount of time. **Endurance testing** looks at the patient's ability to maintain force output during numerous repetitions at high velocities.

Advantages of isokinetic testing include the ability to maximally load the muscle throughout its range of motion; stabilization of proximal body parts to prevent substitute motions; measurement of concentric and eccentric loading; and objectivity. As in manual muscle testing, however, isokinetic testing does not necessarily provide an accurate picture of how a muscle will function during actual activities of daily living or sports. In addition, unlike manual muscle testing, it requires expensive equipment and space.

Hand-held and grip dynamometers are smaller, less expensive alternatives for measuring muscle strength in an objective manner. Information regarding force produced during a contraction such as knee extension or hand grip is displayed in units (often pounds) on a display or dial. Use of these instruments, however, is limited to the body parts they were designed to measure; i.e., a grip dynamometer is useful only for measuring grip strength.

Results

Results are recorded as described above, by the use of grades or force units. Regardless of the type of muscle testing used, the results can be used to help determine

Manual muscle testing—levels of muscle performance

Level of performance	Definition
Normal	Completes full range of motion against gravity, and holds test position against strong pressure.
Good	Completes full range of motion against gravity, and holds test position against moderate to strong pressure.
Fair	Completes full range of motion against gravity, and holds test position with slight or no added pressure. There may be a gradual release from test position.
Poor	Completes partial range of motion against gravity, and moves through complete range of motion in horizontal plane.
Poor–Trace	Completes partial range of motion in horizontal plane. No visible movement of the part, but examiner may observe or palpate contractile activity in the muscle.
Zero	No contraction detected in the muscle.

SOURCE: Rothstein, J.M., S.H. Roy, and S.L. Wolf. *The Rehabilitation Specialist's Handbook*. 2nd ed. Philadelphia: F.A. Davis Co., 1998.

specific sites of impairment, in addition to providing data for assessing progress.

Health care team roles

Muscle testing is performed by physicians, especially orthopedic doctors and physiatrists, in addition to physical therapists and occupational therapists. Manual muscle testing often is an integral part of a PT or OT evaluation of muscle function. The following knowledge is required for any health care practitioner to perform an accurate test:

- location, origin and insertion of muscle(s) being tested
- direction of muscle fiber orientation
- function of muscle being tested, in addition to functions of its synergists and antagonists
- appropriate positioning for the test
- recognition of substitution or compensation by other muscles
- recognition of the effects of factors such as restricted range of motion and pain
- specific contraindications
- ability to palpate muscle contraction
- ability to modify a test due to inability to attain a certain position
- ability to communicate to the patient regarding purpose, procedures and patient requirements for the test

KEY TERMS

Valsalva maneuver—Forced expiratory effort against a closed airway, usually used during strenuous effort.

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Muscular dystrophy

Definition

Muscular dystrophy is the name for a group of inherited disorders in which strength and muscle bulk gradually decline. Nine types of muscular dystrophies are generally recognized.

Description

The muscular dystrophies include:

- Duchenne muscular dystrophy (DMD). DMD affects young boys, causing progressive muscle weakness, usually beginning in the legs. It is a severe form of muscular dystrophy. DMD occurs in about 1 in 3,500 male births, and affects approximately 8,000 boys and young men in the United States. A milder form occurs in a very small number of female carriers.
- Becker muscular dystrophy (BMD). BMD affects older boys and young men, following a milder course than DMD. BMD occurs in about one in 30,000 male births.
- Emery-Dreifuss muscular dystrophy (EDMD). EDMD can appear as an autosomal dominant or recessive form of dystrophy. Thus, both young boys and girls can be affected. It causes contractures and weakness in the calves, weakness in the shoulders and upper arms, and problems in the way electrical impulses travel through the **heart** to make it beat (heart conduction defects). Fewer than 300 cases of EDMD have been identified.
- Limb-girdle muscular dystrophy (LGMD). LGMD begins in late childhood to early adulthood and affects both men and women, causing weakness in the muscles around the hips and shoulders and also the muscles of the arms and legs. It is the most variable of the muscular dystrophies, and there are several different forms of the condition now recognized. Many people with suspected LGMD have probably been misdiagnosed in the past, and therefore the prevalence of the condition is difficult to estimate. The highest prevalence of LGMD is in a small mountainous Basque province in northern Spain, where the condition affects 69 persons per million.
- Facioscapulohumeral muscular dystrophy (FSH). FSH, also known as Landouzy-Dejerine condition, begins in late childhood to early adulthood and affects both men and women, causing weakness in the muscles of the face, shoulders, and upper arms. The hips and legs may also be affected. FSH occurs in about one out of every 20,000 people, and affects approximately 13,000 people in the United States.
- Myotonic dystrophy. This is also known as Steinert's disease and affects both men and women, causing generalized weakness first seen in the face, feet, and hands. Other systems of the body can also be affected. It is accompanied by the inability to relax the affected muscles (myotonia). Symptoms may begin from birth through adulthood. It is the most common form of muscular dystrophy, affecting more than 30,000 people in the United States.
- Oculopharyngeal muscular dystrophy (OPMD). OPMD affects adults of both genders, causing weakness in the eye muscles and throat. It is most common among French Canadian families in Quebec, and in Spanish-American families in the southwestern United States.
- Distal muscular dystrophy (DD). DD is a group of rare muscle diseases that have in common weakness and wasting of the distal (farthest from the center) muscles of the forearms, hands, lower legs, and feet. In general, the DDs are less severe, progress more slowly, and involve fewer muscles than the other dystrophies. DD

usually begins in middle age or later, causing weakness in the muscles of the feet and hands. It is most common in Sweden, and rare in other parts of the world.

- **Congenital muscular dystrophy (CMD).** CMD is a rare group of muscular dystrophies that have in common the presence of muscle weakness at birth (congenital). Biopsies of muscles from persons affected with CMD are abnormal. CMD results in generalized weakness, and usually progresses slowly. A subtype, called Fukuyama CMD, also involves mental retardation and lissencephaly. It is more common in Japan.

The muscular dystrophies are genetic conditions, meaning they are caused by alterations in genes. Genes, which are linked together on chromosomes, have two functions. They code for the production of **proteins** and they are the material of inheritance. Parents pass along genes to their children, providing them with a complete set of instructions for making their own proteins.

Because both parents contribute genetic material to their offspring, each child carries two copies of almost every gene, one from each parent. For some conditions to occur, both copies must be altered. Such conditions are called autosomal recessive conditions. Some forms of LGMD, OPMD and DD exhibit this pattern of inheritance, as does CMD. Persons with only one altered copy, called carriers, will not have the condition, but may pass the altered gene on to their children. When two carriers have children, the chances of having a child with the condition is one in four for each **pregnancy**.

Other conditions occur when only one altered gene copy is present. Such conditions are called autosomal dominant conditions. Other forms of LGMD exhibit this pattern of inheritance, as do DM, FSH, OPMD, and some forms of DD. When a person affected by the condition has a child with someone not affected, the chances of having an affected child are one in two. Autosomal dominant conditions tend to be variable in their symptoms even among members of the same family.

Because of chromosomal differences between the genders, some genes are not present in two copies. The chromosomes that determine whether a person is male or female are called the X and Y chromosomes. A person with two X chromosomes is female, while a person with one X and one Y is male. While the X chromosome carries many genes, the Y chromosome carries almost none. Therefore, a male has only one copy of each gene on the X chromosome, and if it is altered, he will have the condition that alteration causes. Such conditions are said to be X-linked. X-linked conditions include DMD, BMD, and EDMD. Women are not usually affected by X-linked conditions, since they will likely have one unaltered copy between the two chromosomes. Some female carriers of

DMD have a mild form of the condition, probably because their one unaltered gene copy is shut down in some of their cells.

Women carriers of X-linked conditions have a one in two chance of passing the altered gene on to each child born. Daughters who inherit the altered gene will be carriers. A son born without the altered gene will be free of the condition and cannot pass it on to his children. A son born with the altered gene will have the condition. He will pass the altered gene on to each of his daughters, who will then be carriers, but to none of his sons (because they inherit his Y chromosome).

Not all genetic alterations are inherited. As many as one-third of the cases of DMD are due to new mutations that arise during egg formation in the mother. New mutations are less common in other forms of muscular dystrophy.

Causes and symptoms

All of the muscular dystrophies are marked by muscle weakness as the major symptom. The distribution of symptoms, age of onset, and progression are significantly different. **Pain** is sometimes a symptom of each, usually due to the effects of weakness on joint position.

Duchenne muscular dystrophy

A boy with Duchenne muscular dystrophy usually begins to show symptoms before ever entering school, making walking difficult and causing balance problems. Most boys begin to walk three to six months later than expected and have difficulty running. Later on, a boy with DMD will push his hands against his knees to rise to a standing position, to compensate for leg weakness. About the same time, his calves will begin to enlarge with fibrous tissue rather than with muscle, and feel firm and rubbery; this condition gives DMD one of its alternate names, pseudohypertrophic muscular dystrophy. He will widen his stance to maintain balance, and walk with a waddling gait to advance his weakened legs. Contractures (permanent muscle tightening) usually begin by age five or six, most severely in the calf muscles. This pulls the foot down and back, forcing the boy to walk on tip-toes. This is called equinus and further decreases balance. Frequent **falls** are common beginning at this age. Climbing stairs and rising unaided may become impossible by age nine or ten, and most boys use a wheelchair for mobility by the age of 12. Weakening of the trunk muscles around this age often leads to **scoliosis** (a side-to-side spine curvature) and kyphosis (a front-to-back curvature of the spine).

The most serious weakness of DMD is weakness of the diaphragm, the sheet of muscles at the top of the abdomen that perform the main work of breathing and coughing. Diaphragm weakness leads to reduced energy and stamina, and increased lung **infection** because of the inability to cough effectively. Young men with DMD often live into their twenties and beyond, provided they have mechanical **ventilation assistance** and good respiratory hygiene.

Among males with DMD, the incidence of cardiomyopathy (weakness of the heart muscle), increases steadily in teenage years. Almost all affected men have cardiomyopathy after 18 years of age. It has also been shown that carrier females are at increased risk for cardiomyopathy and should also be screened.

About one-third of males with DMD experience specific learning disabilities, including trouble learning by ear rather than by sight and trouble paying attention to long lists of instructions. Individualized educational programs usually compensate well for these disabilities.

Becker muscular dystrophy

The symptoms of BMD usually appear in late childhood to early adulthood. Though the progression of symptoms may parallel that of DMD, the symptoms are usually milder and the course more variable. The same pattern of leg weakness, unsteadiness, and contractures occur later for a young man with BMD, often allowing independent walking into the twenties or early thirties. Scoliosis may occur, but is usually milder and progresses more slowly. Cardiomyopathy occurs more commonly in BMD. Problems may include irregular heartbeats (arrhythmias) and congestive **heart failure**. Symptoms may include fatigue, shortness of breath, chest pain, and dizziness. Respiratory weakness also occurs, and may lead to the need for mechanical ventilation.

Emery-Dreifuss muscular dystrophy

This type of muscular dystrophy usually begins in early childhood, often with contractures preceding muscle weakness. Weakness initially affects the shoulder and upper arm, along with the calf muscles, leading to foot-drop. Most men with EDMD survive into middle age, although a defect in the heart's rhythm (heart block) may be fatal if not treated with a pacemaker.

Limb-girdle muscular dystrophy

While there are several genes that cause the various types of LGMD, two major clinical forms of LGMD are currently recognized. A severe childhood form is similar in appearance to DMD, but is inherited as an autosomal

recessive trait. Symptoms of adult-onset LGMD usually appear in a person's teens or twenties, and are marked by progressive weakness and wasting of the muscles closest to the trunk. Contractures may occur, and the ability to walk is usually lost about 20 years after onset. Some people with LGMD develop respiratory weakness that requires use of a ventilator. Life-span may be somewhat shortened. Autosomal dominant forms usually occur later in life and progress in a relatively slow manner.

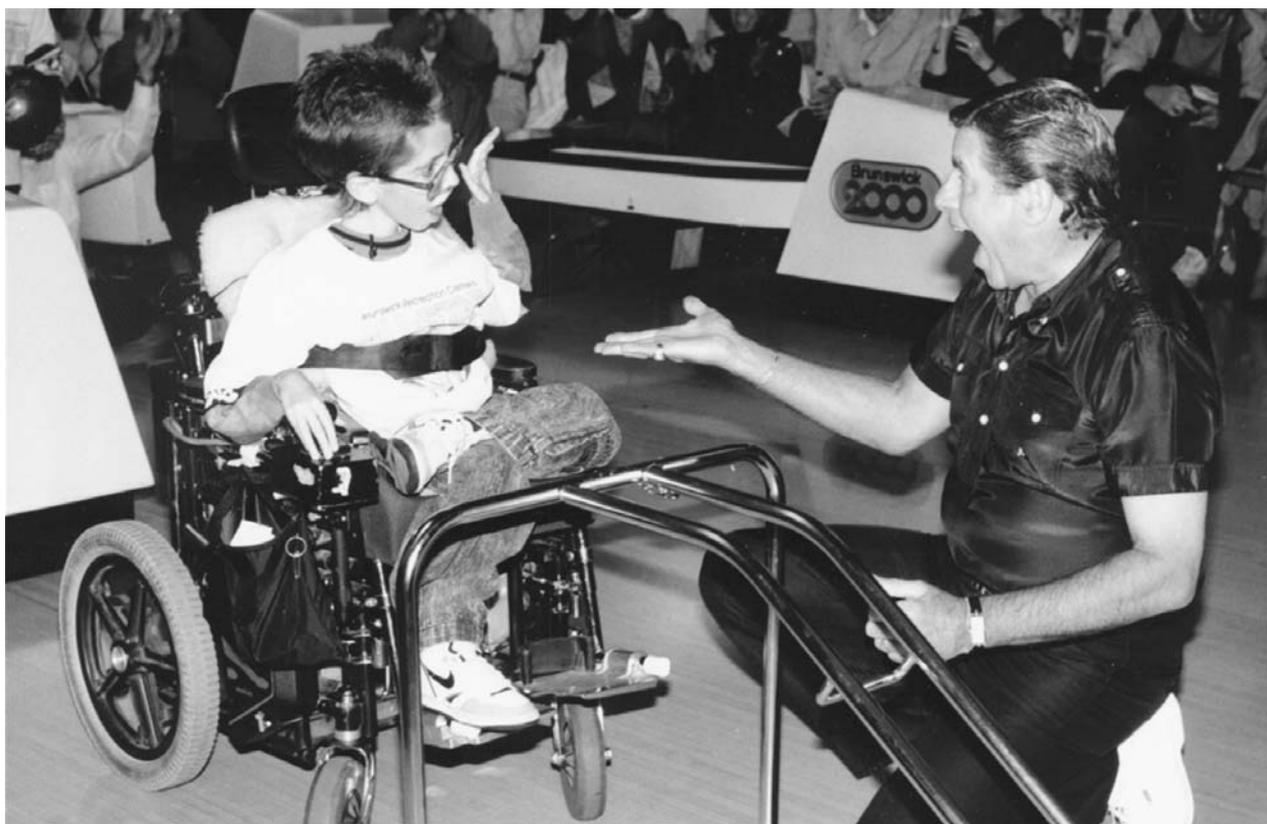
Facioscapulohumeral muscular dystrophy

FSH varies in its severity and age of onset, even among members of the same family. Symptoms most commonly begin in the teens or early twenties, though infant or childhood onset is possible. Symptoms tend to be more severe in those with earlier onset. The condition is named for the regions of the body most severely affected by the condition: muscles of the face (facio-), shoulders (scapulo-), and upper arms (humeral). Hips and legs may be affected as well. More than half of children with FSH may develop partial or complete sensorineural deafness.

The first symptom noticed is often difficulty lifting objects above the shoulders. The weakness may be greater on one side than the other. Shoulder weakness also causes the shoulder blades to jut backward, called scapular winging. Muscles in the upper arm often lose bulk sooner than those of the forearm, giving a "Popeye" appearance to the arms. Facial weakness may lead to loss of facial expression, difficulty closing the eyes completely, and inability to drink through a straw, blow up a balloon, or whistle. Persons with FSH may not be able to wrinkle their foreheads. Contracture of the calf muscles may cause foot-drop, leading to frequent tripping over curbs or rough spots. People with earlier onset often require a wheelchair for mobility, while those with later onset rarely do.

Myotonic dystrophy

Symptoms of myotonic dystrophy include facial weakness and a slack jaw, drooping eyelids (ptosis), and muscle wasting in the forearms and calves. Persons with myotonic dystrophy have difficulty relaxing their grasp, especially if the object is cold. Myotonic dystrophy affects heart muscle, causing arrhythmias and heart block, and the muscles of the **digestive system**, leading to motility disorders and constipation. Other body systems are affected as well. Myotonic dystrophy may cause **cataracts**, retinal degeneration, mental deficiency, frontal balding, skin disorders, testicular atrophy, sleep apnea, and insulin resistance. An increased need or desire for sleep is common, as is diminished motivation. Severe



The “Jerry Lewis MDA Labor Day Telethon” raises money for the Muscular Dystrophy Association. (*Muscular Dystrophy Association. Reproduced by permission.*)

disability affects some people with this type of dystrophy within 20 years of onset, although most do not require a wheelchair even late in life. The condition is extremely variable. Some individuals show profound weakness as newborns (congenital myotonic dystrophy), others show mental retardation in childhood, many show characteristic facial features and muscle wasting in adulthood, while the most mildly affected individuals show only cataracts in middle age with no other symptoms.

Oculopharyngeal muscular dystrophy

OPMD usually begins in a person’s thirties or forties, with weakness in the muscles controlling the eyes and throat. Symptoms include drooping eyelids, difficulty swallowing (**dysphagia**), and weakness progresses to other muscles of the face, neck, and occasionally the upper limbs. Swallowing difficulty may cause aspiration, or the introduction of food or saliva into the airways. **Pneumonia** may follow.

Distal muscular dystrophy

DD usually begins in the twenties or thirties, with weakness in the hands, forearms, and lower legs.

Difficulty with fine movements such as typing or fastening buttons may be the first symptoms. From that point, symptoms slowly progress and the condition usually does not affect life span.

Congenital muscular dystrophy

CMD is marked by severe muscle weakness from birth, with infants displaying “floppiness” (very poor muscle tone). They often have trouble moving their limbs or head against gravity. Mental function is normal but some are never able to walk. They may live into young adulthood or beyond. In contrast, children with Fukuyama CMD are rarely able to walk, and have severe mental retardation. Most children with this type of CMD die in childhood.

Diagnosis

The diagnosis of muscular dystrophy involves a careful medical history and a thorough physical exam to determine the distribution of symptoms and to rule out other causes. Family history may give important clues, since all the muscular dystrophies are genetic conditions, although no family history will be evident in the event of

new mutations. With autosomal recessive inheritance, a family history may also be negative for muscular dystrophy.

Lab tests may include:

- **Blood** level of the muscle enzyme creatine kinase (CK). CK levels rise in the blood due to muscle damage, and may be seen in some conditions even before symptoms appear.
- Muscle biopsy, in which a small piece of muscle tissue is removed for microscopic examination. Changes in the structure of muscle cells and presence of fibrous tissue or other aberrant structures are characteristic of different forms of muscular dystrophy. The muscle tissue can also be stained to detect the presence or absence of particular proteins, including dystrophin.
- Electromyogram (EMG). This electrical test is used to examine the response of the muscles to stimulation. Decreased response is seen in muscular dystrophy. Other characteristic changes are seen in muscular dystrophy.
- Genetic tests. Several of the muscular dystrophies can be positively identified by testing for the presence of the altered gene involved. Accurate genetic tests are available for DMD, BMD, DM, several forms of LGMD, and EDMD. **Genetic testing** for some of these conditions in future pregnancies of an affected individual or parents of an affected individual can be performed before birth through **amniocentesis** or **chorionic villus sampling**. Prenatal testing can only be undertaken after the diagnosis in an affected individual has been genetically confirmed and the couple has been counseled regarding the risks of recurrence.
- Other specific tests as necessary. For EDMD, DMD and BMD, for example, an electrocardiogram may be needed to test heart function, and **hearing** tests are performed for children with FSH.

For most forms of muscular dystrophy, accurate diagnosis is not difficult when performed by someone familiar with the range of conditions. There are exceptions, however. Even with a muscle biopsy, it may be difficult to distinguish between FSH and another muscle condition, polymyositis. Childhood-onset LGMD is often mistaken for the much more common DMD, especially when it occurs in boys. BMD with an early onset appears very similar to DMD, and a genetic test may be needed to accurately distinguish them. The muscular dystrophies may be confused with conditions involving the motor **neurons**, such as spinal muscular atrophy; conditions of the neuromuscular junction, such as myasthenia gravis; and other muscle conditions, as all involve generalized weakness of varying distribution.

Prenatal diagnosis (testing of the baby while in the womb) can be performed for those types of muscular dystrophy where the specific disease-causing gene alteration has been identified in a previously affected family member. Prenatal diagnosis can be accomplished by utilizing DNA extracted from tissue obtained by chorionic villus sampling or amniocentesis.

Treatment

Drugs

There are no cures for any of the muscular dystrophies. Prednisone, a corticosteroid, has been shown to delay the progression of DMD somewhat, for reasons that are still unclear. Some have reported improvement in strength and function in people treated with a single dose. Improvement begins within ten days and plateaus after three months. Long-term benefit has not been demonstrated. Prednisone is also prescribed for BMD, though no controlled studies have tested its benefit. A study is under way in the use of gentamicin, an antibiotic that may slow down the symptoms of DMD in a small number of cases. No other drugs are currently known to have an effect on the course of any other muscular dystrophy.

Treatment of muscular dystrophy is mainly directed at preventing the complications of weakness, including decreased mobility and dexterity, contractures, scoliosis, heart alterations, and respiratory insufficiency.

Physical therapy

Physical therapy, in particular regular stretching, is used to maintain the range of motion of affected muscles and to prevent or delay contractures. Braces are used as well, especially on the ankles and feet to prevent equinus. Full-leg braces may be used in children with DMD to prolong the period of independent walking. Strengthening other muscle groups to compensate for weakness may be possible if the affected muscles are few and isolated, as in the earlier stages of the milder muscular dystrophies. Regular, non-strenuous **exercise** helps maintain general good health. Strenuous exercise is usually not recommended, since it may further damage muscles.

Surgery

When contractures become more pronounced, tenotomy surgery may be performed. In this operation, the tendon of a contracted muscle is cut, and the limb is braced in its normal resting position while the tendon regrows. In FSH, surgical fixation of the scapula can help compensate for shoulder weakness. For a person with OPMD, surgical lifting of the eyelids may help compensate for weakened muscular control. For a person with

DM, sleep apnea may be treated surgically to maintain an open airway. Scoliosis surgery is often needed in boys with DMD, but much less often in other muscular dystrophies. Surgery is recommended at a much lower degree of curvature for DMD than for scoliosis due to other conditions, since the decline in respiratory function in DMD makes surgery at a later time dangerous. In this surgery, the vertebrae are fused together to maintain the spine in an upright position. Steel rods are inserted at the time of operation to keep the spine rigid while the bones grow together.

When any type of surgery is performed in patients with muscular dystrophy, anesthesia must be carefully selected. People with MD are susceptible to a severe reaction, known as malignant hyperthermia, when given halothane anesthetic.

Occupational therapy

An occupational therapist suggests techniques and tools to compensate for the loss of strength and dexterity. Strategies may include modifications in the home, adaptive utensils and dressing aids, compensatory movements and positioning, wheelchair accessories, or communication aids.

Nutrition

Good **nutrition** helps to promote general health in all the muscular dystrophies. No special diet or supplement has been shown to be of particular value in any of the conditions. The weakness in the throat muscles seen especially in OPMD and later DMD may necessitate the use of a gastrostomy tube, inserted directly into the **stomach** to provide nutrition.

Cardiac care

The arrhythmias of EDMD and BMD may be treatable with antiarrhythmic drugs. A pacemaker may be implanted if these do not provide adequate control. Heart transplants are increasingly common for men with BMD. A complete cardiac evaluation is recommended at least once in all carrier females of DMD and EDMD.

Respiratory care

People who develop weakness of the diaphragm or other ventilatory muscles may require a mechanical ventilator to continue breathing deeply enough. Air may be administered through a nasal mask or mouthpiece, or through a tracheostomy tube, which is inserted via a surgical incision through the neck and into the windpipe. Most people with muscular dystrophy do not need a tracheostomy, although some may prefer it to continual use

of a mask or mouthpiece. Supplemental oxygen is not needed. Good hygiene of the **lungs** is critical for health and long-term survival of a person with weakened ventilatory muscles. Assisted cough techniques provide the strength needed to clear the airways of secretions; an assisted cough machine is also available and provides excellent results.

Experimental treatments

Two experimental procedures aiming to cure DMD have attracted a great deal of attention in the past decade. In myoblast transfer, millions of immature muscle cells are injected into an affected muscle. The goal of the treatment is to promote the growth of the injected cells, replacing the defective host cells with healthy new ones. Myoblast transfer is under investigation but remains experimental.

Gene therapy introduces good copies of the altered gene into muscle cells. The goal is to allow the existing muscle cells to use the new gene to produce the protein it cannot make with its abnormal gene. Problems with gene therapy research have included immune rejection of the virus used to introduce the gene, loss of gene function after several weeks, and an inability to get the gene to enough cells to make a functional difference in an affected muscle. Researchers are preparing for the first gene therapy trial for LGMD in the United States. The goal will be to replace the missing sarcoglycan gene(s).

Genetic counseling

Individuals with muscular dystrophy and their families may benefit from **genetic counseling** for information on the condition and recurrence risks for future pregnancies.

Prognosis

The expected lifespan for a male with DMD has increased significantly in the past two decades. Most young men will live into their early or mid-twenties. Respiratory infections become an increasing problem as their breathing becomes weaker, and these infections are usually the cause of death.

The course of the other muscular dystrophies is more variable; expected life spans and degrees of disability are hard to predict, but may be related to age of onset and initial symptoms. Prediction is made more difficult because, as new genes are discovered, it is becoming clear that several of the dystrophies are not uniform disorders, but rather symptom groups caused by different genes.

KEY TERMS

Amniocentesis—A procedure in which a needle is inserted through a pregnant woman's abdomen and into her uterus to withdraw a small sample of the fluid that surrounds the fetus (amniotic fluid) for the purposes of analysis.

Autosomal dominant—Conditions that occur when a person inherits only one abnormal copy of a gene.

Autosomal recessive—Conditions that occur when a person inherits two abnormal copies of a gene, one from each parent.

Becker muscular dystrophy (BMD)—A type of muscular dystrophy that affects older boys and men, and usually follows a milder course than DMD.

Chorionic villus sampling—A medical procedure done during weeks 10-12 of a pregnancy. A needle is inserted into the placenta and a small amount of fetal tissue is withdrawn for analysis.

Contractures—A permanent shortening (as of muscle, tendon, or scar tissue) producing deformity or distortion.

Distal muscular dystrophy (DD)—A form of muscular dystrophy that usually begins in middle age or later, causing weakness in the muscles of the feet and hands.

Duchenne muscular dystrophy (DMD)—The most

severe form of muscular dystrophy, DMD usually affects young boys and causes progressive muscle weakness, usually beginning in the legs.

Dystrophin—A protein that helps muscle tissue repair itself. Both DMD and BMD are caused by abnormalities in the gene that instructs the body how to make this protein.

Facioscapulohumeral muscular dystrophy (FSH)—This form of muscular dystrophy, also known as Landouzy-Dejerine condition, begins in late childhood to early adulthood and affects both men and women, causing weakness in the muscles of the face, shoulders, and upper arms.

Limb-girdle muscular dystrophy (LGMD)—This form of muscular dystrophy begins in late childhood to early adulthood and affects both men and women, causing weakness in the muscles around the hips and shoulders.

Myotonic dystrophy—This type of muscular dystrophy, also known as Steinert's disease, affects both men and women, causing generalized weakness first seen in the face, feet, and hands. It is accompanied by the inability to relax the affected muscles (myotonia).

Oculopharyngeal muscular dystrophy (OPMD)—This type of muscular dystrophy affects adults of both sexes, causing weakness in the eye muscles and throat.

People with dystrophies having significant heart involvement (BMD, EDMD, myotonic dystrophy) may nonetheless have almost normal life spans, provided that cardiac complications are monitored and aggressively treated. The respiratory involvement of BMD and LGMD similarly requires careful and prompt treatment.

Health care team roles

A pediatrician or family physician often make an initial diagnosis of muscular dystrophy. Pathologists and geneticists evaluate materials collected for testing. Physical therapists may provide supportive services. Braces and other assistive devices may be manufactured by orthotists and others with specialty training. Computer engineers have devised equipment for improving communications. Counselors and nurses provide support to people with muscular dystrophy and their families.

Prevention

There is no way to prevent any of the muscular dystrophies in a person who has the genes responsible for these disorders. Accurate genetic tests, including prenatal tests, are available for some of the muscular dystrophies. Results of these tests may be useful for purposes of family planning.

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ORGANIZATIONS

American Academy of Neurology, 1080 Montreal Avenue, St. Paul, Minnesota 55116. (651) 695-1940. Fax: (651) 695-2791. <<http://www.aan.com/>>. info@aan.org.

American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. Fax: (847) 434-8000. <<http://www.aap.org/default.htm>>. kidsdoc@aap.org.

American Academy of Physical Medicine and Rehabilitation, One IBM Plaza, Suite 2500, Chicago, IL 60611-3604. (312) 464-9700. Fax: (312) 464-0227. <<http://www.aapmr.org/consumers/public/amputations.htm>>. info@aapmr.org.

Muscular Dystrophy Association - USA, National Headquarters, 3300 E. Sunrise Drive, Tucson, AZ 85718. (800) 572-1717. <<http://www.mdaua.org/>>. mda@mdausa.org.

OTHER

FacioScapuloHumeral Muscular Dystrophy Society. <<http://www.fshsociety.org/>>.

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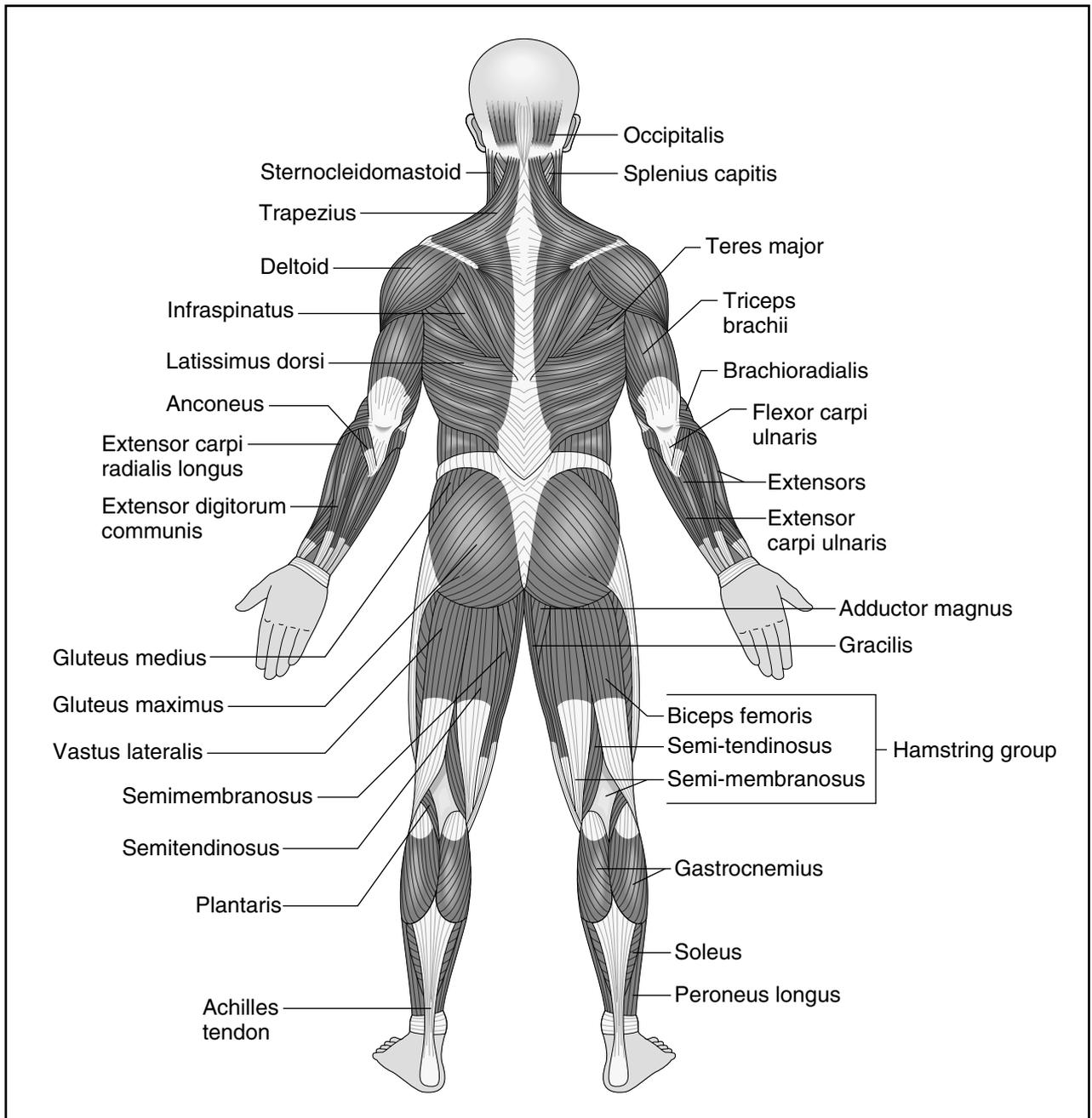
Muscular system

Definition

The muscular system is the body's network of tissues for both voluntary and involuntary movements. Muscle cells are specialized for contraction.

Description

Body movements are generated through the contraction and **relaxation** of specific muscles. Some muscles, like those in the arms and legs, bring about such voluntary movements as raising a hand or flexing the foot. Other muscles are involuntary and function without conscious effort. Voluntary muscles include the **skeletal muscles**, of which there are about 650 in the human body. Skeletal muscles are controlled by the **somatic nervous system**; whereas the **autonomic nervous system** controls the involuntary muscles. Involuntary muscles include muscles that line the internal organs and the **blood vessels**. These smooth muscles are called visceral and vascular smooth muscles, and they perform tasks not generally associated with voluntary activity. Smooth muscles control several automatic physiological responses such as pupil constriction, which occurs when the muscles of the iris contract in bright light. Another example is the dilation of **blood** vessels, which occurs when the smooth muscles surrounding the vessels relax or lengthen. In addition to the categories of skeletal (voluntary) and smooth (involuntary) muscle, there is a third category, namely cardiac muscle, which is neither voluntary nor involuntary. Cardiac muscle is not under con-



Posterior view of the muscular system. (Delmar Publishers, Inc. Reproduced by permission.)

scious control, and it can also function without regulation from the external nervous system.

Smooth muscles derive their name from their appearance under polarized light microscopy. In contrast to cardiac and skeletal muscles, which have striations (appearance of parallel bands or lines), smooth muscle is unstriated. Striations result from the pattern of myofilaments, which are very fine threads of protein. There are

two types of myofilaments, actin and myosin, which line the myofibrils within each muscle cell. When many myofilaments align along the length of a muscle cell, light and dark regions create a striated appearance. This microscopic view of muscle reveals that muscles alter their shape to produce movement. Because muscle cells are usually elongated, they are often called muscle fibers. Compared to other cells in the body, striated mus-

cle cells are distinctive in shape, protein composition, and multinucleated structure.

Skeletal muscles

Skeletal muscles are what most people think of as muscle. Skeletal muscles are the ones that ache when someone goes for their first outdoor run in the spring after not running regularly during the winter. Skeletal muscles are also involved when someone carries heavy grocery bags, practices a difficult musical passage, or combs their hair. **Exercise** may increase the size of muscle fibers, but the number of fibers generally remains constant. Skeletal muscles take up about 40% of the body's mass, or weight. They also consume large amounts of oxygen and nutrients from the blood supply. Multiple levels of skeletal muscle tissue receive their own blood supplies.

GROSS ANATOMY OF STRIATED MUSCLE. At the macroscopic level, skeletal muscles usually originate at one point of attachment to a tendon (a band or cord of tough, fibrous connective tissue) and terminate at another tendon at the other end of an adjoining bone. Tendons are rich in the protein collagen, which is arranged in a wavy pattern so that it can stretch out and provide additional length at the junction between bone and muscle.

Skeletal muscles usually act in pairs, such that the flexing (shortening) of one muscle is balanced by a lengthening (relaxation) of its paired muscle or group of muscles. These antagonistic (opposite) muscles can open and close such joints as the elbow or knee. Muscles that cause a joint to bend or close are called flexor muscles, and those that cause a joint to expand or straighten out are called extensors. Skeletal muscles that support the **skull**, backbone, and rib cage are called axial skeletal muscles; whereas the skeletal muscles of the limbs are called distal. Several skeletal muscles work in a highly coordinated manner in such activities as walking.

Skeletal muscles are organized into extrafusal and intrafusal fibers. Extrafusal fibers are the strong, outer layers of muscle. This type of muscle fiber is the most common. Intrafusal fibers, which make up the central region of the muscle, are weaker than extrafusal fibers. Skeletal muscle fibers are additionally characterized as fast or slow according to their activity patterns. Fast or "white" muscle fibers contract rapidly, have poor blood supply, operate anaerobically (without oxygen), and tire easily. Slow or "red" muscle fibers contract more slowly, have a more adequate blood supply, operate aerobically (with oxygen), and do not fatigue as easily. Slow muscle fibers are used in sustained movements, such as holding a **yoga** posture or standing at attention.

The skeletal muscles are enclosed in a dense sheath of connective tissue called the epimysium. Within the epimysium, muscles are sectioned into columns of muscle fiber bundles called primary bundles or fasciculi. Each fasciculus is covered by a layer of connective tissue called the perimysium. An average skeletal muscle may have 20–40 fasciculi which are further subdivided into several muscle fibers. Each muscle fiber (cell) is covered by connective tissue called endomysium. Both the epimysium and the perimysium contain blood and lymph vessels to supply the muscle with nutrients and oxygen, and to remove waste products. The endomysium has an extensive network of capillaries that supply individual muscle fibers. Individual muscle fibers vary in diameter from 10–60 micrometers and in length from a few millimeters in the smaller muscles to about 12 in (30 cm) in the sartorius muscle of the thigh.

MICROANATOMY OF STRIATED MUSCLE. At the microscopic level, a single striated muscle cell has several hundred nuclei and a striped appearance derived from the pattern of myofilaments. Long, cylindrical muscle fibers are formed from several myoblasts in **fetal development**. Multiple nuclei are important in muscle cells because of the tremendous amount of activity. The two types of myofilaments, actin and myosin, overlap one another in a very precise arrangement. Myosin is a thick protein with two globular head regions. Each myosin filament is surrounded by six actin (thin) filaments. These filaments run along the length of the cell in parallel. Multiple hexagonal arrays of actin and myosin exist in each skeletal muscle cell.

Each actin filament slides along adjacent myosin filaments with the help of other **proteins** and ions present in the cell. Tropomyosin and troponin are two proteins attached to the actin filaments that enable the globular heads on myosin to instantaneously attach to the myosin strands. The attachment and rapid release of this bond induces the sliding motion of these filaments that results in **muscle contraction**. In addition, **calcium** ions and ATP (adenosine triphosphate, the source of cellular energy) are required by the muscle cell to process this reaction. Numerous mitochondria (organelles in a cell that produce enzymes necessary for energy **metabolism**) are present in muscle fibers to supply the extensive ATP required by the cell.

The system of myofilaments within muscle fibers are divided into units called sarcomeres. Each skeletal muscle cell has several myofibrils, long cylindrical columns of myofilaments. Each myofibril is composed of myofilaments that interdigitate to form the striated sarcomere units. The thick myosin filaments of the sarcomere provide the dark, striped appearance in striated muscle, and the thin actin filaments provide the lighter

sarcomere regions between the dark areas. Muscle contraction creates an enlarged center region called the belly of the muscle. The flexing of a muscle—a bicep for example—makes this region anatomically visible.

Cardiac muscle

Cardiac muscle, as is evident from its name, makes up the muscular portion of the **heart**. While almost all cardiac muscle is confined to the heart, some of these cells extend for a short distance into the cardiac vessels before tapering off completely. Heart muscle is also called myocardium. The myocardium has some properties similar to skeletal muscle tissue, but it also has some unique features. Like skeletal muscle, the myocardium is striated; however, the cardiac muscle fibers are smaller and shorter than skeletal muscle fibers. Cardiac muscle fibers average 5–15 micrometers in diameter and 20–30 micrometers in length. In addition, cardiac muscles align lengthwise more than they do in a side-by-side fashion, compared to skeletal muscle fibers. The microscopic structure of cardiac muscle is also distinctive in that these cells are branched in a way that allows them to communicate simultaneously with multiple cardiac muscle fibers.

Smooth muscle

Smooth muscle falls into three general categories: visceral smooth muscle, vascular smooth muscle, and multi-unit smooth muscle. Visceral smooth muscle fibers line such internal organs as the intestines, **stomach**, and uterus. Vascular smooth muscle forms the middle layer of the walls of blood and lymphatic vessels. Arteries generally have a thicker layer of vascular smooth muscle than veins or lymphatic vessels. Multi-unit smooth muscle is found only in the muscles that govern the size of the iris of the eye. Unlike contractions in visceral smooth muscle, contractions in multi-unit smooth muscle fibers do not readily spread to neighboring muscle cells.

Smooth muscle is innervated by both sympathetic and parasympathetic nerves of the autonomic nervous system. Smooth muscle appears unstriated under a polarized light **microscope**, because the myofilaments inside are less organized. Smooth muscle fibers contain actin and myosin myofilaments that are more haphazardly arranged than their counterparts in skeletal muscles. The sympathetic neurotransmitter, ACh, and parasympathetic neurotransmitter, norepinephrine, activate this type of muscle tissue.

Smooth muscle cells are small in diameter, about 5–15 micrometers, but they are long, typically 15–500 micrometers. They are also wider in the center than at

their ends. Gap junctions connect small bundles of cells which are, in turn, arranged in sheets.

Within such hollow organs as the uterus, smooth muscle cells are arranged into two layers. The cells in the outer layer are usually arranged in a longitudinal fashion surrounding the cells in the inner layer, which are arranged in a circular pattern. Many smooth muscles are regulated by hormones in addition to the neurotransmitters of the autonomic nervous system. Moreover, the contraction of some smooth muscles is myogenic or triggered by stretching, as in the uterus and gastrointestinal tract.

Function

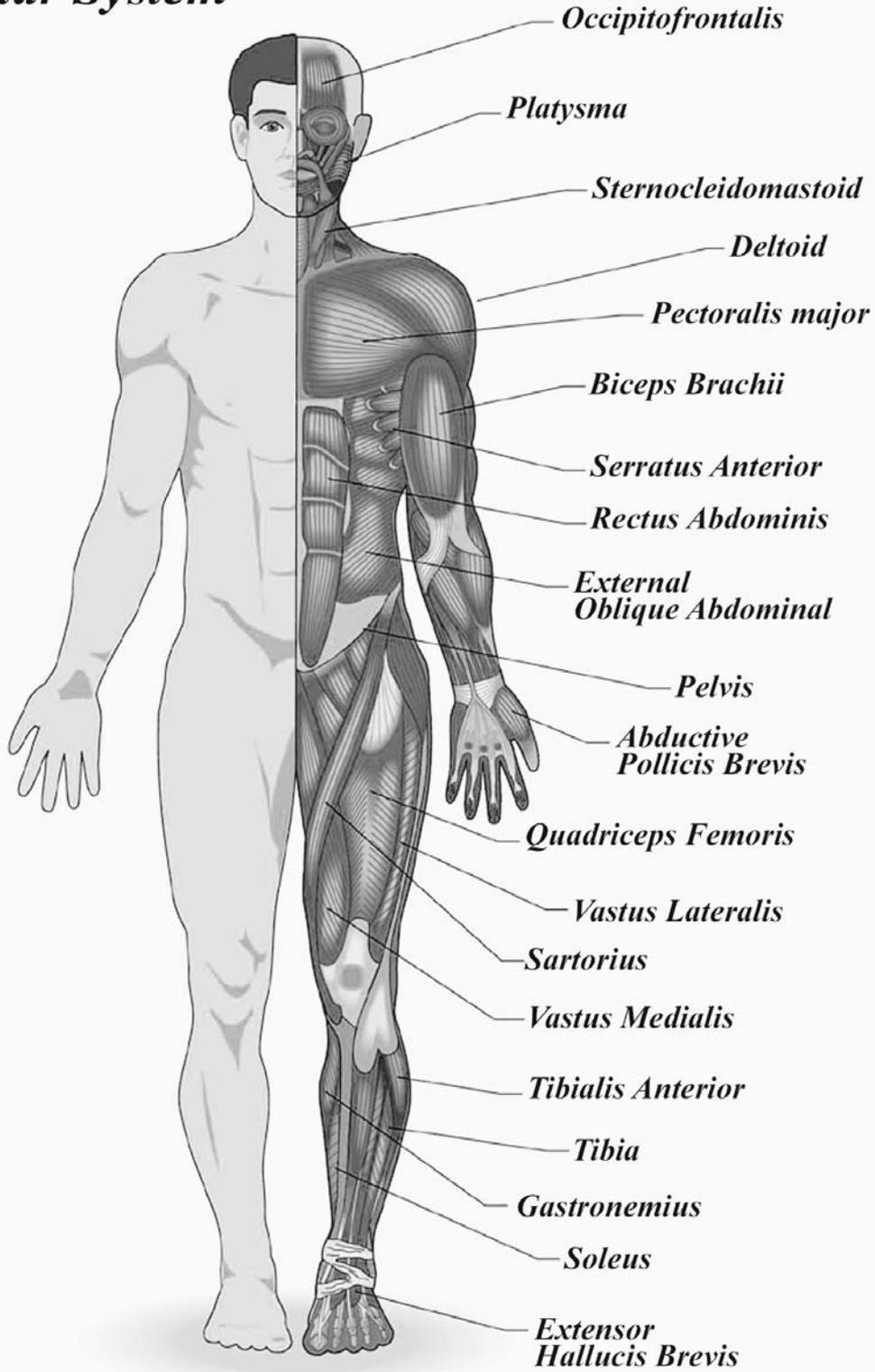
Skeletal muscles

Skeletal muscles function as the link between the somatic nervous system and the **skeletal system**. Skeletal muscles carry out instructions from the **brain** related to voluntary movement or action. For instance, when a person decides to eat a piece of cake, the brain tells the forearm muscle to contract, allowing it to flex and position the hand to lift a forkful of cake to the mouth. But the muscle alone cannot support the weight of the fork; the sturdy bones of the forearm assist the muscles in completing the task of moving the bite of cake. Hence, the skeletal and muscular systems work together as a lever system, with the joints acting as a fulcrum to carry out instructions from the nervous system.

The somatic nervous system controls skeletal muscle movement through motor **neurons**. Alpha motor neurons extend from the **spinal cord** and terminate on individual muscle fibers. The axon, or signal-sending end, of the alpha neuron branches to innervate multiple muscle fibers. The nerve terminal forms a synapse, or junction, with the muscle to create a neuromuscular junction. The neurotransmitter acetylcholine (ACh) is released from the axon terminal into the synapse. From the synapse, the ACh binds to receptors on the muscle surface that trigger events leading to muscle contraction. While alpha motor neurons innervate extrafusal fibers, intrafusal fibers are innervated by gamma motor neurons.

Voluntary skeletal muscle movements are initiated by the motor cortex in the brain. Signals travel down the spinal cord to the alpha motor neuron to result in contraction. Not all movement of skeletal muscles is voluntary, however. Certain **reflexes** occur in response to such dangerous stimuli as extreme heat or the edge of a sharp object. Reflexive skeletal muscular movement is controlled at the level of the spinal cord and does not require higher brain initiation. Reflexive movements are

Muscular System



The muscular system, frontal view. (Kopp Illustration, Inc. Reproduced by permission.)

KEY TERMS

Acetylcholine (ACh)—A short-acting neurotransmitter that functions as a stimulant to the nervous system and as a vasodilator.

Actin—A protein that functions in muscular contraction by combining with myosin.

Adenosine triphosphate (ATP)—A nucleotide that is the primary source of energy in living tissue.

Anaerobic—Pertaining to or caused by the absence of oxygen.

Angina pectoris—A sensation of crushing pain or pressure in the chest, usually near the breastbone, but sometimes radiating to the upper arm or back. Angina pectoris is caused by a deficient supply of blood to the heart.

Axial—Pertaining to the axis of the body, i.e., the head and trunk.

Axon—The appendage of a neuron that transmits impulses away from the cell body.

Cardiac muscle—The striated muscle tissue of the heart. It is sometimes called myocardium.

Distal—Situated away from the point of origin or attachment.

Dystrophy—Any of several disorders characterized by weakening or degeneration of muscle tissue

Epimysium—The sheath of connective tissue around a muscle.

Extensor—A muscle that serves to extend or straighten a part of the body.

Fasciculus (plural, fasciculi)—A small bundle of muscle fibers.

Flexor—A muscle that serves to flex or bend a part of the body.

Multinucleated—Having more than one nucleus in each cell. Muscle cells are multinucleated.

Myasthenia gravis—A disease characterized by the impaired transmission of motor nerve impulses, caused by the autoimmune destruction of acetylcholine receptors.

Myosin—The principal contractile protein in muscle tissue.

Parasympathetic—Pertaining to the part of the autonomic nervous system that generally functions in regulatory opposition to the sympathetic system, as by slowing the heartbeat or contracting the pupil of the eye.

Sarcomere—A segment of myofibril in a striated muscle fiber.

Skeletal muscle—Muscle tissue composed of bundles of striated muscle cells that operate in conjunction with the skeletal system as a lever system.

Smooth muscle—Muscle tissue composed of long, unstriated cells that line internal organs and facilitate such involuntary movements as peristalsis.

Sympathetic—Pertaining to the part of the autonomic nervous system that regulates such involuntary reactions to stress as heartbeat, sweating, and breathing rate.

Synapse—A region in which nerve impulses are transmitted across a gap from an axon terminal to another axon or the end plate of a muscle.

Tendon—A cord or band of dense, tough, fibrous tissue that connects muscles and bones.

processed at this level to minimize the amount of time necessary to implement a response.

In addition to motor neuron activity in the skeletal muscles, a number of sensory nerves carry information to the brain to regulate muscle tension and contraction. Muscles function at peak performance when they are not overstretched or overcontracted. Sensory neurons within the muscle send feedback to the brain with regard to muscle length and state of contraction.

Cardiac muscle

The heart muscle is responsible for more than two billion beats in the course of a human lifetime of average

length. Cardiac muscle cells are surrounded by endomysium like the skeletal muscle cells. The autonomic nerves to the heart, however, do not form any special junctions like those found in skeletal muscle. Instead, the branching structure and extensive interconnectedness of cardiac muscle fibers allows for stimulation of the heart to spread into neighboring myocardial cells. This feature does not require the individual fibers to be stimulated. Although external nervous stimuli can enhance or diminish cardiac muscle contraction, heart muscles can also contract spontaneously. Like skeletal muscle cells, cardiac muscle fibers can increase in size with physical conditioning, but they rarely increase in number.

Smooth muscle

The concentric arrangement of some smooth muscle fibers enables them to control dilation and constriction in the blood vessels, intestines, and other organs. While these cells are not innervated on an individual basis, excitation from one cell can spread to adjacent cells through the nexuses that join neighbor cells. Multi-unit smooth muscles function in a highly localized way in such areas as the iris of the eye. Visceral smooth muscle also facilitates the movement of substances through such tubular areas as blood vessels and the **small intestine**. Smooth muscle differs from skeletal and cardiac muscle in its energy utilization as well. Smooth muscles are not as dependent on oxygen availability as cardiac and skeletal muscles are. Smooth muscle uses glycolysis (the breakdown of **carbohydrates**) to generate much of its metabolic energy.

Common diseases and disorders

Mechanical injury

Disorders of the muscular system can result from genetic, hormonal, infectious, autoimmune, poisonous, or neoplastic causes. But the most common problem associated with this system is injury from misuse. Sprains and tears cause excess blood to seep into skeletal muscle tissue. The residual scar tissue leads to a slightly shorter muscle. Muscular impairment and cramping can result from a diminished blood supply. Cramping can be due to overexertion. An inadequate supply of blood to cardiac muscle causes a sensation of pressure or **pain** in the chest called angina pectoris. Inadequate ionic supplies of calcium, sodium, or potassium can also affect most muscle cells adversely.

Immune system disorders

Muscular system disorders related to the **immune system** include myasthenia gravis and tumors. Myasthenia gravis is characterized by weak and easily fatigued skeletal muscles, one of the symptoms of which is droopy eyelids. Myasthenia gravis is caused by antibodies that a person makes against their own ACh receptors; hence, it is an autoimmune disease. The antibodies disturb normal ACh stimulation to contract skeletal muscles. Failure of the immune system to destroy cancerous cells in muscle can result in muscle tumors. Benign muscle tumors are called myomas, while malignant muscle tumors are called myosarcomas.

Disorders caused by toxins

Muscular disorders may also be caused by toxic substances of various types. A bacterium called *Clostridium tetani* produces a neurotoxin that causes tetanus, which is

a disease characterized by painful repeated muscular contractions. In addition, some types of **gangrene** are caused by clostridial toxins produced under anaerobic conditions deep within a muscle. A poisonous substance called curare, which is derived from tropical plants of the genus *Strychnos* blocks neuromuscular transmission in skeletal muscle, causing **paralysis**. Prolonged periods of ethanol intoxication can also cause muscle damage.

Genetic disorders

The most common type of muscular genetic disorder is muscular dystrophy, of which there are several kinds. Duchenne's **muscular dystrophy** is characterized by increasing muscular weakness and eventual death. Becker's muscular dystrophy is a less severe disorder than Duchenne's, but both can be classified as X-linked recessive genetic disorders. Other types of muscular dystrophy are caused by a mutation that affects a muscle protein called dystrophin. Dystrophin is absent in Duchenne's and altered in Becker's muscular dystrophies. Other genetic disorders, including glycogen storage diseases, myotonic disorders, and familial periodic paralysis, can affect muscle tissues. In glycogen storage diseases, the skeletal muscles accumulate abnormal amounts of glycogen due to a biochemical defect in carbohydrate metabolism. In myotonic disorders, the voluntary muscles are abnormally slow to relax after contraction. Familial periodic paralysis is characterized by episodes of weakness and paralysis combined with loss of deep tendon reflexes.

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National Arthritis and Musculoskeletal and Skin Diseases Information Clearinghouse. 1 AMS Circle, Bethesda, MD 20892. (301) 495-4484.

National Center for Complementary and Alternative Medicine (NCCAM), 31 Center Drive, Room #5B-58, Bethesda, MD 20892-2182. (800) NIH-NCAM. Fax: (301) 495-4957. <<http://nccam.nih.gov>>.

National Institute of Neurological Disorders and Stroke (NINDS). Building 31, Room 8A06, 9000 Rockville Pike, Bethesda, MD 20892. (301) 496-5751. <<http://www.ninds.nih.gov>>.

Crystal Heather Kaczowski, MSc.

Mycobacterial culture *see* **Acid-fast culture**

Myelography

Definition

Myelography is a radiographic and fluoroscopic examination of the spinal canal. A contrast agent is injected through a needle into the space around the **spinal cord** (intrathecal space) to display the spinal cord, spinal canal, and nerve roots on an x ray.

Purpose

The purpose of a myelogram is to evaluate the spinal cord and/or nerve roots for suspected compression. Pressure on these delicate structures causes **pain** or other symptoms. A myelogram is performed when precise detail about the spinal cord is needed to make a definitive diagnosis. In most cases, myelography is used after other studies, such as **magnetic resonance imaging** (MRI) or a computed tomography scan (CT scan), have not yielded enough information to be sure of the disease process. Sometimes myelography followed by CT scan (“CT myelogram”) is an alternative for patients who cannot have an MRI scan, because they have a pacemaker or other implanted metallic device.

A herniated or ruptured intervertebral disc, popularly known as a slipped disc, is one of the most common causes for pressure on the spinal cord or nerve roots. Discs are pads of fiber and cartilage that contain rubbery tissue. They lie between the vertebrae, or individual bones, which make up the spine. Discs act as cushions, accommodating strains, shocks, and position changes. A disc may rupture suddenly, due to injury, or a sudden straining with the spine in an unnatural position. In other cases, the problem may come on gradually as a result of

progressive deterioration of the discs with aging. The lower back is the most common area for this problem, but it sometimes occurs in the neck, and rarely in the upper back. A myelogram can help accurately locate the disc or discs involved.

Myelography may be used when a tumor is suspected. Tumors can originate in the spinal cord, or in tissues surrounding the cord. Cancers that have started in other parts of the body may spread or metastasize in the spine. It is important to precisely locate the mass causing pressure, so effective treatment can be undertaken. Patients with known **cancer** who develop back pain may require a myelogram for evaluation.

Other conditions that may be diagnosed using myelography include arthritic bony growths, known as spurs, narrowing of the spinal canal, called spinal stenosis, or malformations of the spine.

Precautions

Patients who are unable to lie still or cooperate with positioning should not have this examination. Severe congenital spinal abnormalities may make the examination technically difficult to carry out. Patients with a history of severe allergic reaction to contrast material (x-ray dye) should report this to their physician. Pretreatment with medications to minimize the risk of severe reaction may be recommended.

Description

The patient lies on the x-ray table on his or her **stomach**. The radiologist first looks at the spine under fluoroscopy, where the images appear on a monitor. This is done to find the best location to position the needle. The procedure starts out like a spinal tap (or lumbar puncture). The skin is cleaned, then numbed with local anesthetic. A needle is placed into the lower back, between two vertebrae, and then inserted into the intrathecal space. A small amount of cerebrospinal fluid, the clear fluid that surrounds the spinal cord and **brain**, is withdrawn through the needle to confirm accurate needle placement and also may be sent for laboratory studies. Then contrast material (a liquid dye that shows up on x rays) is injected.

The x-ray table is tilted slowly. This allows the contrast material to reach different levels in the spinal canal. The flow is observed under fluoroscopy, then x rays are taken with the table tilted at various angles. The patient’s head may be below his or her legs (Trendelenburg position). A footrest and shoulder supports keep the patient from sliding while the table is being tilted back and forth.

In many instances, a CT scan of the spine will be performed immediately after a myelogram, while the contrast material is still in the spinal canal. This helps outline internal structures most clearly.

A myelogram takes approximately 30–60 minutes. A CT scan adds about another hour to the examination. If the procedure is done as an outpatient exam, some facilities prefer the patient to stay in a recovery area for up to four hours.

Preparation

Patients should be well hydrated at the time of a myelogram. Increasing fluids the day before the study is usually recommended. All food and fluid intake should be stopped approximately four hours before the myelogram.

Certain medications may need to be stopped for one to two days before myelography is performed. These include some antipsychotics, antidepressants, **blood** thinners, and diabetic medications. Patients should consult with their physician and/or the facility where the study is to be done.

Patients who smoke may be asked to stop the day before the test. This helps decrease the chance of nausea or headaches after the myelogram. Immediately before the examination, patients should empty their bowels and bladder.

Aftercare

After the examination is completed, the patient usually rests for several hours, with the head elevated. Extra fluids are encouraged, to help eliminate the contrast material and prevent headaches. A regular diet and routine medications may be resumed. Strenuous physical activity, especially any that involves bending over, may be discouraged for one or two days. The doctor should be notified if a **fever**, excessive nausea and vomiting, severe headache, or stiff neck develops.

Complications

Headache is a common complication of myelography. It may begin several hours to several days after the examination. The cause is thought to be changes in cerebrospinal fluid pressure, not a reaction to the contrast material. The headache may be mild and easily alleviated with rest and increased fluids. Sometimes, nonprescription medicines are recommended. In some instances, the headache may be more severe and require stronger medication or other measures for relief. Many

KEY TERMS

Contrast agent—Also called a contrast medium, this is usually a barium or iodine dye that is injected into the area under investigation. The dye makes the interior body parts more visible on an x-ray film.

factors influence whether the patient develops this problem. These include the type of needle used and the age and sex of the patient. Patients with a history of chronic or recurrent headache are more likely to develop a headache after a myelogram.

The chance of reaction to the contrast material is a very small, but a potentially significant risk with myelography. It is estimated that only 5–10% of patients experience any effect from contrast exposure. The vast majority of reactions are mild, such as sneezing, nausea, or **anxiety**. These usually resolve by themselves. A moderate reaction, like wheezing or **hives**, may be treated with medication, but is not considered life threatening. Severe reactions, such as **heart** or **respiratory failure**, happen very infrequently. These require emergency medical treatment.

Rare complications of myelography include injury to the nerve roots from the needle, or from bleeding into the spaces around the roots. Inflammation of the delicate covering of the spinal cord, called arachnoiditis, or infections, can also occur. Seizures are another very uncommon complication reported after myelography.

Results

A normal myelogram shows a spinal canal of normal width, with no areas of constriction or obstruction.

A myelogram may reveal a **herniated disk**, tumor, bone spurs, or narrowing of the spinal canal (spinal stenosis).

Health care team roles

Myelograms can be performed in a hospital x-ray department or in an outpatient radiology facility. The test is performed by a radiologist with the help of a radiologic technologist. The radiologist will interpret the results of the test and recommend any further treatment. A nurse may assist during the procedure, may prepare the patient before the procedure, or may monitor the patient afterwards.

Historical note on contrast media used for myelography

Until the mid- to late 1970s, myelography was performed using an non-aqueous, oil-based, contrast medium. Use of this medium created a significant problem, since it had to be removed from the intrathecal space after the procedure (since it was non-aqueous, it would not be absorbed). More often than not, the removal process caused significant pain for the patient because, after the physician moved the bolus of contrast material to where the needle was, he/she would attach a syringe and attempt to suck the oily fluid out. The negative pressure in the intrathecal space often pulled on the nerve roots in the vicinity of the needle, causing shooting pains and electrical shock-like sensations that extended down to the patients' legs. In many instances, it was not possible to remove all of the contrast material.

In the 1970s, a non-ionic aqueous (water soluble) contrast agent, suitable for injection into the intrathecal space was developed. Its development and adoption for myelography, eliminated the pain and suffering associated with removal because, like contrast agents injected intravenously, it was absorbed and eventually excreted after the procedure.

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Myocardial infarction

Definition

A myocardial infarction, or **heart** attack, is the death or damage of part of the heart muscle because the supply of **blood** to the heart muscle is severely reduced or stopped.

Description

Myocardial infarction (MI) is the leading cause of death in the United States. More than 1.5 million Americans suffer a myocardial infarction every year, and nearly half a million die, according to the American Heart Association. Most myocardial infarctions are the end result of years of silent, undetected, progressive **coronary artery disease**. A myocardial infarction is often the first detected symptom of coronary artery disease. According to the American Heart Association, 63% of women and 48% of men who died suddenly of coronary artery disease had no previous symptoms. Myocardial infarctions are commonly called heart attacks.

A myocardial infarction occurs when one or more of the coronary arteries that supply blood to the heart are completely blocked and blood to the heart muscle is cut off. The blockage is usually caused by atherosclerosis, the build-up of plaque in artery walls, and/or by a blood clot in a coronary artery. Sometimes, a healthy or atherosclerotic coronary artery has a spasm and the blood flow to part of the heart decreases or stops. The result may be a myocardial infarction.

About half of all myocardial infarction patients wait at least two hours before seeking help. This delay dramatically increases the risk of sudden death or disability. The longer the artery remains blocked during a myocardial infarction, the more damage will be done to the heart. If the blood supply is cut off severely, or for longer than 12 hours, muscle cells suffer irreversible injury and die. The patient can die. That is why it is vitally important to teach patients to recognize the signs of a myocardial infarction and seek immediate medical attention at the nearest hospital with 24-hour emergency cardiac care.

About one fifth of all myocardial infarctions are silent, that is, the patient is unaware that the MI has occurred. Although the patient feels no **pain**, silent myocardial infarctions still damage the heart.

The outcome of a myocardial infarction depends on the location of the blockage, whether the heart rhythm is disturbed, and whether there is collateral circulation to

the territory supplied by the acutely occluded coronary artery. Blockages in the left coronary artery are usually more serious than those affecting the right coronary artery. Blockages that produce arrhythmia (irregular heartbeat) can cause sudden death.

Causes and symptoms

Myocardial infarctions are generally caused by severe coronary artery disease. Most myocardial infarctions are caused by blood clots that form on atherosclerotic plaque. This impedes the coronary artery from supplying oxygen-rich blood to part of the heart. A number of major and contributing risk factors increase the likelihood of developing coronary artery disease. Some of these risk factors can be modified, but others cannot. Persons with more risk factors are more likely to develop coronary artery disease.

Major risk factors

Major risk factors significantly increase the likelihood of developing coronary artery disease. Risk factors that cannot be changed include:

- **Heredity.** People whose parents have coronary artery disease, particularly those who develop it at younger ages, are more likely to be diagnosed with it. African Americans are also at increased risk, due to their higher rate of severe **hypertension** than caucasians.
- **Gender.** Men under the age of 60 years of age are more likely to have myocardial infarctions than women of the same age.
- **Age.** Men over age 45 and women over age 55 are considered at risk. Older adults (those over 65) are more likely to die of a myocardial infarction. Older women are twice as likely to die within a few weeks of a myocardial infarction as men. This increased mortality may be attributable to other co-existing medical problems.

Major risk factors which can be changed are:

- **Smoking.** Smoking greatly increases both the risk of developing coronary artery disease and resulting mortality. Smokers have two to four times the risk of non-smokers of sudden cardiac death and are more than twice as likely to have a myocardial infarction. They are also more likely to die within an hour of a myocardial infarction. Second-hand smoke may also increase risk.
- **High cholesterol.** Cholesterol is produced by the body, and obtained from eating animal products such as meat, eggs, milk, and cheese. Age, gender, heredity, and diet affect cholesterol level. Risk of developing coronary artery disease increases as blood cholesterol levels

increase. When combined with other factors, the risk is even greater. Total cholesterol of 240 mg/dL or more poses a high risk, and 200–239 mg/dL a borderline high risk. In LDL (low-density lipoprotein) cholesterol, high risk starts at 130–159 mg/dL, depending on other risk factors. Low levels of HDL (high-density lipoprotein) increases the risk of coronary disease; high HDL protects against it.

- **Hypertension (high blood pressure).** High blood pressure makes the heart work harder, and over time, weakens it. It increases the risk of myocardial infarction, stroke, kidney failure, and congestive **heart failure**. Blood pressure of 140 over 90 or above is considered high. As the numbers increase, high blood pressure progresses from Stage One (mild) to Stage Four (very severe). When hypertension is combined with **obesity**, smoking, high cholesterol, or diabetes, the risk of myocardial infarction or stroke increases several times.
- **Sedentary lifestyle and lack of physical activity.** Inactivity increases the risk of coronary artery disease. Even modest physical activity is beneficial if done regularly.

Contributing risk factors

Contributing risk factors have been linked to coronary artery disease, but their significance and prevalence are not known yet. Contributing risk factors are:

- **Diabetes mellitus.** The risk of developing coronary artery disease is seriously increased for diabetics. More than 80% of diabetics die of some type of heart or blood vessel disease.
- **Obesity.** Excess weight increases the strain on the heart muscle and increases the risk of developing coronary artery disease, even if no other risk factors are present. Obesity increases both blood pressure and blood cholesterol, and can lead to diabetes.
- **Stress and anger.** Stress and anger can produce physiological changes that contribute to the development of coronary artery disease. Stress, the mental and physical reaction to life's irritations and challenges, increases heart rate and blood pressure, and can injure the lining of the arteries. Evidence shows that anger increases the risk of dying from heart disease and more than doubles the risk of having a myocardial infarction right after an episode of anger.

More than 60% of myocardial infarction patients experience symptoms before the myocardial infarction occurs. These symptoms may occur days or weeks before the myocardial infarction. Sometimes, people do not recognize the symptoms of a myocardial infarction or deny



A myocardial infarction, or heart attack, is caused by blockage in a coronary artery, which prevents blood flow to the heart muscle. (Custom Medical Stock Photo. Reproduced by permission.)

that they are having symptoms. Common symptoms include:

- Uncomfortable pressure, fullness, heaviness, squeezing, or pain in the center of the chest. The sensation lasts more than a few minutes, or may go away and return.
- Pain that spreads to the shoulders, neck, left arm, or jaw.
- Chest discomfort accompanied by lightheadedness, fainting, sweating, nausea, or shortness of breath.

All of these symptoms do not necessarily occur with every myocardial infarction. Sometimes, symptoms disappear and then reappear. Individuals with any of these symptoms should immediately call an emergency rescue service or be driven to the nearest hospital with a 24-hour cardiac care unit, whichever is quicker.

Diagnosis

Experienced emergency care personnel confirm the diagnosis of MI, by taking a thorough history, checking heart rate and blood pressure, performing an electrocardiogram, and drawing a blood sample. The electrocardiogram shows which of the coronary arteries is blocked. The blood test detects the leak of enzymes or other biochemical markers from damaged cells in the heart muscle. In clinical practice, timely treatment is based on the patient history, **physical examination**, and ECG findings.

Treatment

Treatment is initiated in the emergency department with thrombolytic agents, aspirin, oxygen, and beta-blockers. Oxygen is used to ease the heart's workload or to help patients breathe easier. If oxygen is administered within hours of the myocardial infarction, it also may help limit damage to the heart. Subsequent treatment includes close monitoring, nitrates and morphine if needed, electric shock, drug therapy, re-vascularization procedures, coronary **angioplasty**, and coronary artery bypass surgery.

Patients with complications such as arrhythmias, congestive heart failure, and hypertension or hypotension require additional treatment. A defibrillator may be used to restore a normal rhythm. A temporary pacemaker may be inserted to correct a bradyarrhythmia (slow heart rate). ACE inhibitors may be used to treat congestive heart failure.

Drugs to stabilize the patient and limit damage to the heart include thrombolytics, aspirin, anticoagulants, painkillers, and tranquilizers, beta-blockers, ACE inhibitors, nitrates, anti-arrhythmics (rhythm-stabilizing) drugs, and diuretics. Thrombolytics, used to limit damage to the heart, work only if given within six to 12 hours of the onset (when the chest pain began) of the myocardial infarction. Thrombolytic drugs act by dissolving the blood clot that is blocking the acutely occluded coronary artery. They increase the likelihood of survival when given as soon as possible after the myocardial infarction. Thrombolytics given within a few hours after a myocardial infarction are the most effective. Injected intravenously, these include acylated plasminogen streptokinase activator complex (APSAC) or anistreplase (Eminase), recombinant tissue-type plasminogen activator (r-tPA, Retevase, or Activase), and streptokinase (Streptase, Kabikinase). Thrombolytics may only be given if they are not contraindicated by disorders such as active bleeding, trauma or surgery within the preceding two weeks, blood pressure greater than 200/120 mm Hg, and **pregnancy**.

To prevent additional myocardial infarctions, aspirin and heparin, an anticoagulant, often follow the thrombolytic drug. These prevent new blood clots from forming and existing blood clots from growing. Anticoagulant drugs help prevent the blood from clotting. The most common anticoagulants are heparin and warfarin. Heparin is given intravenously while the patient is in the hospital. Aspirin helps to prevent the dissolved blood clots from reforming.

To relieve pain, a nitroglycerin tablet taken under the tongue or given intravenously. If the pain continues, morphine sulfate may be prescribed. Tranquilizers such as

diazepam (Valium) or alprazolam (Ativan) may be prescribed to lessen the **anxiety** and emotional stress associated with myocardial infarction.

To limit the size of the myocardial infarction and prevent another, beta-blockers are often administered intravenously right after the myocardial infarction. These can also help prevent potentially fatal ventricular fibrillation. Beta-blockers include atenolol (Tenormin), metoprolol (Lopressor), nadolol, pindolol (Visken), propranolol (Inderal), and timolol (Blocadren).

Nitrates, a type of vasodilator, may also be given right after a myocardial infarction to help improve the delivery of blood to the heart and ease chest pain and heart failure symptoms. Nitrates include isosorbide mononitrate (Imdur), isosorbide dinitrate (Isordil, Sorbitrate), and nitroglycerin (Nitrostat).

When a myocardial infarction causes an abnormal heartbeat, arrhythmia drugs may be given to restore the heart's normal rhythm. These include amiodarone (Cordarone), atropine, bretylium, disopyramide (Norpace), lidocaine (Xylocaine), procainamide (Procan), propafenone (Rythmol), propranolol (Inderal), quinidine, and sotalol (Betapace). Angiotensin-converting enzyme (ACE) inhibitors reduce the resistance against which the heart beats and are used to manage and prevent heart failure. They are used to treat myocardial infarction patients whose hearts do not pump well or who have symptoms of heart failure. Taken orally, they include Altace, Capoten, Lotensin, Monopril, Prinivil, Vasotec, and Zestril. Angiotensin receptor blockers, such as losartan (Cozaar) may substitute. Diuretics can help get rid of excess fluids that sometimes accumulate when the heart is not pumping effectively. Usually taken orally, they cause the body to dispose of fluids through urination. Common diuretics include: bumetanide (Bumex), chlorthalidone (Hygroton), chlorothiazide (Diuril), furosemide (Lasix), hydrochlorothiazide (Hydrodiuril, Esidrix), spironolactone (Aldactone), and triamterene (Dyrenium).

Percutaneous transluminal coronary angioplasty, a type of catheter-based intervention, and coronary artery bypass surgery are invasive revascularization procedures that open blocked coronary arteries and improve blood flow. They are usually performed only on patients for whom clot-dissolving drugs do not work, or who have poor **exercise** stress tests, poor left ventricular function, or ischemia. Generally, angioplasty is performed before coronary artery bypass surgery.

Percutaneous transluminal coronary angioplasty, usually called coronary angioplasty, is a non-surgical procedure in which a catheter (a tiny plastic tube) tipped with a balloon is threaded from the femoral or brachial

artery (blood vessel in the thigh or arm) into the blocked artery. The balloon is inflated and compresses the plaque to enlarge the blood vessel and open the blocked artery. The balloon is then deflated and the catheter is removed. Coronary angioplasty is performed by a cardiologist in a hospital and generally requires a two-day stay. It is successful about 90% of the time. For one third of patients, the artery restenoses (narrows again) within six months after the procedure. The procedure may be repeated. It is less invasive and less expensive than coronary artery bypass surgery.

In coronary artery bypass surgery, called bypass surgery, a vein taken from the patient's leg, or the internal mammary artery, may be used to reestablish blood flow beyond the coronary artery blockage. The healthy vein or artery then supplies oxygen-rich blood to the heart. Bypass surgery is major surgery appropriate for patients with blockages in two or three major coronary arteries or severely narrowed left main coronary arteries, as well as those who have not responded to other less invasive treatments. It is performed under **general anesthesia** using a heart-lung machine to support the patient while the healthy vein is attached to the coronary artery. About 70% of patients who have bypass surgery experience full relief from angina; about 20% experience partial relief. Long term symptoms recur in only about three or four percent of patients per year. Five years after bypass surgery, survival expectancy is 90%, at 10 years it is about 80%, at 15 years it is about 55%, and at 20 years it is about 40%.

There are three additional catheter-based interventions for unblocking coronary arteries that are currently being performed. During atherectomy, the surgeon shaves off and removes strips of plaque from the blocked artery. Laser angioplasty uses a catheter with a laser tip inserted into the vessel to burn or break down the plaque. Insertion of a metal coil called a stent also may be implanted permanently to keep a blocked artery open.

Prognosis

The sequelae (aftermath) of a myocardial infarction is often severe. Two-thirds of myocardial infarction patients never recover fully. Within one year, 27% of men and 44% of women die. Within six years, 23% of men and 31% of women have another myocardial infarction, 13% of men and 6% of women experience sudden death, and about 20% have heart failure. People who survive a myocardial infarction have a chance of sudden death that is four to six times greater than others and a chance of illness and death that is two to nine times greater. Older women are more likely than men to die within a few weeks of a myocardial infarction.

Health care team roles

Nurses, ECG technicians, laboratory technologists and other allied health professionals have important roles in the diagnosis of acute myocardial infarction as well as institution of timely treatment. Nurses and other practitioners involved in triage or screening in the emergency department must accurately assess patients with chest pain or other indications of myocardial infarction.

ECG technicians and laboratory technologists are responsible for performing the diagnostic tests, ECG and blood chemistries, to confirm the diagnosis of myocardial infarction. In the emergency department and on the hospital floor, nurses and allied health professionals are responsible for closely monitoring patients to prevent complications following myocardial infarction. During the hospitalization, nurses, dieticians, respiratory and physical therapists collaborate to plan a **cardiac rehabilitation** program and provide patient and family education.

Patient education

Nurses, physical therapists, and dieticians work together to educate patients and their families. Patients are taught to recognize and accurately describe symptoms such as pain, pressure, or heaviness in the chest, arm, or jaw. Patients are advised to report any changes in the intensity or quality of their pain to nurses or other health care professionals while in the hospital. When necessary, they are counseled by nursing or pharmacy technicians about the use of sublingual (under the tongue) nitroglycerin to relieve chest pain. They are instructed to seek medical attention immediately should serious symptoms return after they have been discharged.

Along with instruction about medication, follow-up care, and the importance of participating in cardiac rehabilitation, patients are informed about ways to reduce their risk of having another myocardial infarction or other cardiac disorders. This education is tailored to the individual patient's needs. It may include referral to a smoking cessation program; nutritional counseling to reduce dietary fat and sodium and achieve a desirable body weight; and recommendations to increase physical activity. **Patient education** also addresses treatment of any coexisting illnesses such as diabetes, and instruction about ways to more effectively manage stress and anger.

Prevention

Many myocardial infarctions can be prevented through a healthy lifestyle, which can reduce the risk of developing coronary artery disease. For patients who have already had a myocardial infarction, a healthy

lifestyle and carefully following doctor's orders can prevent another myocardial infarction. A heart healthy lifestyle includes a low-fat diet, regular exercise, maintaining a healthy weight, no smoking, moderate drinking, no illegal drugs, controlling hypertension, and managing stress.

A healthy diet includes a variety of foods that are low in fat (especially saturated fat), low in cholesterol, and high in fiber; plenty of fruits and vegetables; and limited sodium. Some foods are low in fat but high in cholesterol, and some are low in cholesterol but high in fat. Saturated fat raises cholesterol, and, in excessive amounts, it increases the amount of the **proteins** in blood that form blood clots. Polyunsaturated and monounsaturated **fats** are relatively good for the heart. Fat should comprise no more than 30% of total daily calories.

Cholesterol, a waxy, lipid-like substance, comes from eating foods such as meat, eggs, and other animal products. It is also produced in the **liver**. Soluble fiber can help lower cholesterol. Patients should be advised to limit cholesterol to about 300 mg per day. Many lipid-lowering drugs reduce LDL-cholesterol by an average of 25–30% when combined with a low-fat, low-cholesterol diet. Fruits and vegetables are rich in fiber, **vitamins**, and **minerals**. They are also low calorie and nearly fat free. **Vitamin C** and beta-carotene, found in many fruits and vegetables, keep LDL-cholesterol from turning into a form that damages coronary arteries. Excess sodium can increase the risk of high blood pressure. Many processed foods contain large amounts of sodium. Patients should be advised to limit daily intake to about 2,400 mg—about the amount in a teaspoon of salt.

The “Food Guide Pyramid” developed by the U.S. Departments of Agriculture and Health and Human Services provides easy to follow guidelines for daily heart-healthy eating: six to 11 servings of bread, cereal, rice, and pasta; three to five servings of vegetables; two to four servings of fruit; two to three servings of milk, yogurt, and cheese; and two to three servings of meat, poultry, fish, dry beans, eggs, and nuts. Fats, oils, and sweets should be used sparingly.

Regular aerobic exercise can lower blood pressure, help control weight, and increase HDL (“highly desirable”) cholesterol. It may keep the **blood vessels** more flexible. Moderate intensity aerobic exercise lasting about 30 minutes four or more times per week is recommended for maximum heart health, according to the Centers for Disease Control and Prevention and the American College of Sports Medicine. Three 10-minute exercise periods are also beneficial. Aerobic exercise—activities such as walking, jogging, and cycling—uses the large muscle groups and forces the body to use oxy-

gen more efficiently. It can also include everyday activities such as active gardening, climbing stairs, or brisk housework.

Maintaining a desirable body weight is vital for heart health. More than half of American adults are overweight as defined by a body mass index (BMI) greater than 25. The percentage of obese adults (BMI greater than 30) is nearly 25%, a 50% increase over the past 20 years. People who are 20% or more over their ideal body weight have an increased risk of developing coronary artery disease. Losing weight can help reduce total and LDL cholesterol, reduce triglycerides, and boost relative levels of HDL cholesterol. It may also reduce blood pressure.

Smoking has many adverse effects on the heart. It increases the heart rate, constricts major arteries, and can create irregular heartbeats. It also raises blood pressure, contributes to the development of plaque, increases the formation of blood clots, and causes blood platelets to cluster and impede blood flow. Quitting can repair heart damage caused by smoking—even heavy smokers can return to heart health. Several studies have shown that ex-smokers face the same risk of heart disease as non-smokers within five to 10 years of quitting.

Patients should be counseled to drink alcohol in moderation. Modest consumption of alcohol may actually protect against coronary artery disease. This is believed to be because alcohol raises HDL cholesterol levels. The American Heart Association defines moderate consumption as one ounce of alcohol per day—roughly one cocktail, one 8-ounce glass of wine, or two 12-ounce glasses of beer. In some people, however, moderate drinking can increase risk factors for heart disease, such as raising blood pressure. Excessive drinking is always bad for heart health. It usually raises blood pressure, and can poison the heart and cause abnormal heart rhythms or even heart failure. Illegal drugs, like cocaine, can seriously harm the heart and should never be used.

High blood pressure, one of the most common and serious risk factors for coronary artery disease, can be effectively controlled through lifestyle changes and medication. Patients with moderate hypertension may be able to control it through lifestyle changes such as reducing sodium and fat, exercising regularly, managing stress, quitting smoking, and drinking alcohol in moderation. When these changes are ineffective, and for those with severe hypertension, there are eight types of drugs that provide effective treatment.

Stress management means controlling mental and physical reactions to life's irritations and challenges. Techniques for controlling stress include taking life more slowly, spending time with family and friends, thinking

KEY TERMS

Angina—Chest pain that occurs when diseased blood vessels restrict the flow of blood to the heart. Angina is often the first symptom of coronary artery disease.

Atherosclerosis—A process in which the walls of the coronary arteries thicken due to the accumulation of plaque in the blood vessels. Atherosclerosis is the cause of coronary artery disease.

Coronary arteries—The two arteries that provide blood to the heart. The coronary arteries surround the heart like a crown, coming out of the aorta, arching down over the top of the heart, and dividing into two branches. These are the arteries where coronary artery disease occurs.

Plaque—A deposit of fatty and other substances that accumulate in the lining of the artery wall.

positively, getting enough sleep, exercising, and practicing **relaxation** techniques.

Daily aspirin therapy has been proven to help prevent blood clots associated with atherosclerosis. It can also prevent myocardial infarctions from recurring, prevent myocardial infarctions from being fatal, and reduce the risk of strokes.

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<<http://www.medsearch.com/pf/profiles/amerh/>>.

National Heart, Lung, and Blood Institute Information Center. P.O. Box 30105, Bethesda, MD 20824-0105.
<<http://www.nhlbi.gov/nhlbi/nhbli.htm>>.

Texas Heart Institute Heart Information Service. P.O. Box 20345, Houston, TX 77225-0345. 1-800-292-2221.
<<http://www.tmc.edu/thi/his.html>>.

Barbara Wexler

Myocardial perfusion scan see **Thallium heart scan**

Myoclonus see **Movement disorders**

Myoglobin test see **Cardiac marker tests**

Myopia

Definition

Myopia is the medical term for nearsightedness. People with myopia see objects more clearly when they are close to the eye, while distant objects appear blurred or fuzzy. Reading and close-up work may be clear, but distance **vision** is less sharply defined.

Description

To understand myopia it is necessary to have a basic knowledge of the main parts of the eye's focusing system: the cornea, the lens, and the retina. The cornea is a tough, transparent, dome-shaped tissue that covers the front of the eye (not to be confused with the white, opaque sclera). The cornea lies in front of the iris (the colored part of the eye). The lens is a transparent, double-convex structure located behind the iris. The retina is a thin membrane that lines the rear of the eyeball. Light-sensitive retinal cells convert incoming light rays into electrical signals that are sent along the optic nerve to the **brain**, which then interprets the images.

In people with normal vision, parallel light rays enter the eye and are bent by the cornea and lens (a process called refraction) to focus precisely on the retina, providing a crisp, clear image. In a myopic eye, the focusing power of the cornea (the major refracting structure of the eye) and the lens is too great with respect to the length of the eyeball. Light rays are bent too much, and they converge in front of the retina. This inaccuracy is called a

refractive error. In other words, an overfocused fuzzy image is sent to the brain.

There are many varieties of myopia. Some common types include:

- physiologic
- pathologic
- acquired

By far the most common form, physiologic myopia, develops in children sometime between the ages of five and 10 and gradually progresses until the eye is fully grown. Physiologic myopia may include refractive myopia (the cornea and lens-bending properties are too strong) and axial myopia (the eyeball is too long). Pathologic myopia is a far less common abnormality. This condition begins as physiologic myopia, but rather than stabilizing, the eye continues to enlarge at an abnormal rate (progressive myopia). This more advanced type of myopia may lead to degenerative changes in the eye (degenerative myopia). Acquired myopia occurs after infancy. This condition may be seen in association with uncontrolled diabetes and certain types of **cataracts**. **Antihypertensive drugs** and other medications can also affect the refractive power of the lens.

Eyecare professionals have debated the role of genetics in the development of myopia for many years. Most believe that a tendency toward myopia may be inherited, but the actual disorder results from a combination of environmental and genetic factors. Environmental factors include close work, work with computer monitors or other instruments that emit some light (electron microscopes, photographic equipment, lasers, etc.), emotional **stress**, and eye strain.

A variety of genetic patterns for inheriting myopia have been suggested, ranging from a recessive pattern with complete penetrance in people who are homozygotic for myopia to an autosomal dominant pattern; an autosomal recessive pattern; and various mixtures of these patterns. One explanation for this lack of agreement is that the genetic profile of high myopia (defined as a refractive error greater than -6 diopters) may differ from that of low myopia. Some researchers think that high myopia is determined to a greater extent by genetic factors than low myopia.

Another explanation for disagreement regarding the role of heredity in myopia is the sensitivity of the human eye to very small changes in its anatomical structure. Since even small deviations from normal structure cause significant refractive errors, it may be difficult to single out any specific genetic or environmental factor as their cause.

Genetic markers and gene mapping

Since 1992, genetic markers that may be associated with genes for myopia have been located on human chromosomes 1, 2, 12, and 18. There is some genetic information on the short arm of chromosome 2 in highly myopic people. Genetic information for low myopia appears to be located on the short arm of chromosome 1, but it is not known whether this information governs the structure of the eye itself or vulnerability to environmental factors.

In 1998, a team of American researchers presented evidence that a gene for familial high myopia with an autosomal dominant transmission pattern could be mapped to human chromosome 18 in eight North American families. The same group also found a second locus for this form of myopia on human chromosome 12 in a large German/Italian family. In 1999, a group of French researchers found no linkage between chromosome 18 among 32 French families with familial high myopia. These findings have been taken to indicate that more than one gene is involved in the transmission of the disorder.

Family studies

It has been known for some years that a family history of myopia is one of the most important risk factors for developing the condition. Only 6–15% of children with myopia come from families in which neither parent is myopic. In families with one myopic parent, 23–40% of the children develop myopia. If both parents are myopic, the rate rises to 33–60% for their children. One American study found that children with two myopic parents are 6.42 times as likely to develop myopia themselves as children with only one or no myopic parents. As of 2001, the precise interplay of genetic and environmental factors in these family patterns, however, is not yet known.

One multigenerational study of Chinese families indicated that persons in the third generation had a higher risk of developing myopia even if their parents were not myopic. The researchers concluded that, at least in China, the genetic factors in myopia have remained constant over the past three generations while the environmental factors have intensified. The increase in the percentage of people with myopia over the last 50 years in the United States has led American researchers to the same conclusion.

Myopia is the most common eye disorder in humans around the world. It affects between 25 and 35% of the adult population in the United States and the developed countries, but is thought to affect as much as 40% of the population in some parts of Asia. Some researchers have

found slightly higher rates of myopia in women than in men.

There is considerable variation in the age distribution of myopia in the United States. The prevalence of myopia rises among children and adolescents in school until it reaches the 25–35% level in the young adult population. It declines slightly in the over-45 age group. Approximately 20% of 65-year-olds have myopia. The figure drops to 14% for Americans over 70.

Other factors that affect the demographic distribution of myopia are income level and education. The prevalence of myopia is higher among people with above-average incomes and educational attainments. Myopia is also more prevalent among people whose work requires a great deal of close focusing, including work with computers.

Causes and symptoms

Myopia is said to be caused by an elongation of the eyeball or a cornea that is steeply curved. This means that the oblong (as opposed to normal spherical) shape of the myopic eye causes the cornea and lens to focus at a point in front of the retina. A more precise explanation is that there is an inadequate correlation between the focusing power of the cornea and lens and the length of the eye.

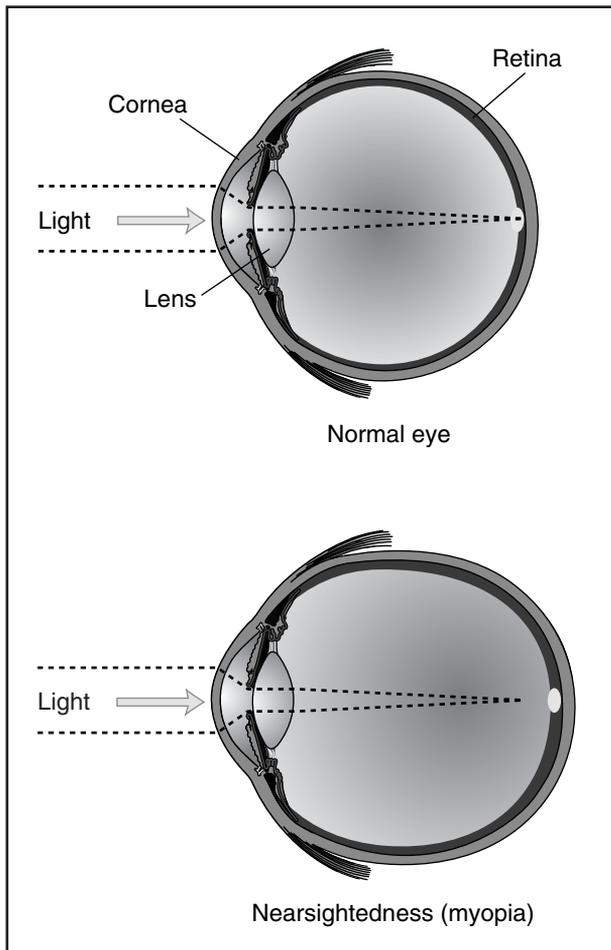
People are generally born with a small amount of **hyperopia** (farsightedness), but as the eye grows this decreases and myopia does not become evident until later. This change is one reason why some researchers think that myopia is an acquired rather than an inherited trait.

The symptoms of myopia are blurred distance vision, eye discomfort, squinting, and eye strain. Headaches may accompany eye strain.

Diagnosis

The diagnosis of myopia is typically made during the first several years of elementary school when a teacher notices a child having difficulty seeing the chalkboard, reading, or concentrating. The teacher or school nurse often recommends an **eye examination** by an ophthalmologist or optometrist. An ophthalmologist is an MD or DO (Doctor of Osteopathy) who is a medical doctor trained in the diagnosis and treatment of eye problems. Ophthalmologists also perform eye surgery. An optometrist (OD) diagnoses, manages, and treats eye and **visual disorders**. In all states, optometrists are licensed to prescribe diagnostic and therapeutic drugs.

A person's distance vision is tested by reading letters or numbers on a chart posted a set distance away (usually 20 ft [6 m]). The doctor asks the person to view images



Myopia, or nearsightedness, is a condition of the eye in which objects are seen more clearly when close to the eye while distant objects appear blurred or fuzzy. (Illustration by Electronic Illustrators Group.)

through a variety of lenses to obtain the best correction. The doctor also examines the inside of the eye and the retina. An instrument called a slit lamp is used to examine the cornea and lens. The eyeglass prescription is written in terms of diopters (D), which measure the degree of refractive error. Mild to moderate myopia usually falls between -1.00D and -6.00D . Normal vision is commonly referred to as 20/20 to describe the eye's focusing ability at a distance of 20 ft (6 m) from an object. For example, 20/50 means that a myopic person must stand 20 ft (6 m) away from an eye chart to see what a normal person can see at 50 ft (15.2 m). The larger the bottom number, the greater the myopia.

Treatment

People with myopia have three main options for treatment: eyeglasses, **contact lenses**, and, for those who meet certain criteria, refractive eye surgery.

Eyeglasses

Eyeglasses are the most common method used to correct myopia. Concave glass or plastic lenses are placed in frames in front of the eyes. The lenses are ground to the thickness and curvature specified in the eyeglass prescription. The lenses cause the light rays to diverge so that they focus further back, directly on the retina, producing clear distance vision.

Contact lenses

Contact lenses are a second option for treatment. Contact lenses are extremely thin, round discs of plastic that are worn on the eye in front of the cornea. Although there may be some initial discomfort, most people quickly grow accustomed to contact lenses. Hard contact lenses, made from a material called PMMA, are virtually obsolete. Rigid gas permeable lenses (RGP) are made of plastic that holds its shape but allows the passage of oxygen into the eye. Some believe that RGP lenses may halt or slow the progression of myopia because they maintain a constant, gentle pressure that flattens the cornea. As of 2001, the National Eye Institute was conducting an ongoing study of RGP lenses called the Contact Lens and Myopia Progression (CLAMP) Study, with results to be released in 2003.

A procedure called orthokeratology acts on this principle of corneal molding. However, when contact lenses are discontinued for a period of time, the cornea will generally go back to its original shape. Rigid gas permeable lenses offer crisp, clear sight. Soft contact lenses are made of flexible plastic and can be up to 80% water. Soft lenses offer increased comfort and have the advantage of extended wear. Some can be worn continuously for up to one week. While oxygen passes freely through soft lenses, bacterial contamination and other problems can occur, requiring replacement of lenses on a regular basis. It is very important to follow the cleaning and disinfecting regimens prescribed because protein and lipid buildup can occur on the lenses, causing discomfort or increasing the risk of **infection**. Contact lenses offer several benefits over glasses, including: better vision, less distortion, clear peripheral vision, and cosmetic appeal. In addition, contacts don't steam up from perspiration or changes in temperature.

Refractive eye surgery

For people who find glasses and contact lenses inconvenient or uncomfortable, and who meet selection criteria regarding age, degree of myopia, general health, etc., refractive eye surgery is a third treatment alternative. As of 2001, four types of corrective surgeries are available:

- **radial keratotomy (RK)**
- photorefractive keratectomy (PRK)
- corneal rings
- laser-assisted in-situ keratomileusis (LASIK), which is still under clinical evaluation by the Food and Drug Administration (FDA)

Refractive eye surgery improves myopic vision by permanently changing the shape of the cornea so that light rays focus properly on the retina. These procedures are performed on an outpatient basis and generally take 10 to 30 minutes.

RADIAL KERATOTOMY. Radial keratotomy (RK), the first of these procedures made available, has a high associated risk of an unfavorable outcome. It was first developed in Japan and the Soviet Union, and introduced into the United States in 1978. The surgeon uses a delicate diamond-tipped blade, a **microscope**, and microscopic instruments to make several spoke-like “radial” incisions in the non-viewing (peripheral) portion of the cornea. As the incisions heal, the slits alter the curve of the cornea, making it more flat, which may improve the focus of images onto the retina. With the advent of laser surgeries, this procedure has become almost obsolete.

PHOTOREFRACTIVE KERATECTOMY. Photorefractive keratectomy (PRK) involves the use of a computer to measure the shape of the cornea. Using these measurements, the surgeon applies a computer-controlled laser to make modifications to the cornea. The PRK procedure flattens the cornea by vaporizing small amounts of tissue from the cornea’s surface. As of early 2001, only two excimer lasers are approved by the FDA for PRK, although other lasers have been used. It is important to make sure the laser being used is FDA approved. Photorefractive keratectomy can be used to treat mild to moderate forms of myopia. The cost is approximately \$2,000 per eye.

LASER-ASSISTED IN-SITU KERATOMILEUSIS. Laser-assisted in-situ keratomileusis (LASIK) is the newest of these procedures. It is recommended for moderate to severe cases of myopia. A variation on the PRK method, LASIK uses lasers and a cutting tool called a microkeratome to cut a circular flap on the cornea. The flap is flipped back to expose the inner layers of the cornea. The cornea is treated with a laser to change its shape and focusing properties, then the flap is replaced.

Risks

All of these surgical procedures carry risks, the most serious being corneal scarring, corneal rupture, infection, cataracts, and loss of vision. In addition, a study published in March 2001 warned that mountain climbers

who have had LASIK surgery should be aware of possible changes in their vision at high altitudes. The lack of oxygen at high altitudes causes temporary changes in the thickness of the cornea.

Since refractive eye surgery doesn’t guarantee 20/20 vision, it is important to have realistic expectations before choosing this treatment. In a 10-year study conducted by the National Eye Institute between 1983 and 1993, over 50% of people with radial keratotomy gained 20/20 vision, and 85% passed a driving test (requiring 20/40 vision) after surgery, without glasses or contact lenses. Even if a person gains near-perfect vision, however, there are potentially irritating side effects, such as postoperative **pain**, poor night vision, variation in visual acuity, light sensitivity and glare, and optical distortion. **Refractive eye surgeries** are considered elective procedures and are rarely covered by insurance plans.

Myopia treatments under research include corneal implants and permanent surgically placed contact lenses.

Alternative treatments

Some eye care professionals recommend treatments to help improve circulation, reduce eye strain, and relax the eye muscles. It is possible that by combining exercises with changes in behavior, the progression of myopia may be slowed or prevented. Alternative treatments include: visual therapy (also referred to as vision training or eye exercises), discontinuing close work, reducing eye strain (taking a rest break during periods of prolonged near vision tasks), and wearing bifocals to decrease the need to accommodate when doing close-up work.

Prognosis

Glasses and contact lenses can (but not always) correct a person’s vision to 20/20. Refractive surgery can make permanent improvements for the right candidates.

While the genetic factors that influence the transmission and severity of myopia cannot be changed, some environmental factors can be modified. They include reducing close work, reading and working in good light, taking frequent breaks when working at a computer or microscope for long periods of time, maintaining good **nutrition**, and practicing visual therapy (when recommended).

Health care team roles

Ophthalmologists and optometrists diagnose myopia. Both may prescribe corrective lenses (glasses or contact lenses). Ophthalmologists perform surgery to correct myopia. Various individuals can fill prescriptions

KEY TERMS

Accommodation—The ability of the lens to change its focus from distant to near objects. It is achieved through the action of the ciliary muscles that change the shape of the lens.

Cornea—The outer, transparent tissue that covers the front of the eye. The cornea is part of the eye's focusing system.

Diopter (D)—A unit of measure for describing refractive power.

Laser-assisted in-situ keratomileusis (LASIK)—A procedure that uses a cutting tool and a laser to modify the cornea and correct moderate to high levels of myopia.

Lens—The transparent, elastic, curved structure behind the iris (colored part of the eye) that helps focus light on the retina.

Ophthalmologist—A medical doctor (MD or DO) who specializes in the diagnosis and medical and surgical treatment of eye diseases and disorders.

Optic nerve—A bundle of nerve fibers that carries visual messages in the form of electrical signals to the brain.

Optometrist—Doctors of optometry are primary health care professionals who examine, diagnose, treat, and manage diseases and disorders of the visual system, the eye, and associated structures, as well as diagnose related systemic conditions. They prescribe glasses, contact lenses, low vision rehabilitation, vision therapy and medications, as well as perform certain surgical procedures.

Orthokeratology—A method of reshaping the cornea using a contact lens. It is not considered a permanent method to reduce myopia.

Peripheral vision—The ability to see objects and movement to the side, outside of the direct line of vision.

Photorefractive keratectomy (PRK)—A procedure that uses an excimer laser to make modifications to the cornea and permanently correct myopia. As of 2001, two lasers have been approved by the FDA for this purpose.

Radial keratotomy (RK)—A surgical procedure involving the use of a diamond-tipped blade to make several spoke-like slits in the peripheral (non-viewing) portion of the cornea to improve the focus of the eye and correct myopia by flattening the cornea.

Refraction—The bending of light rays as they pass from one medium through another. Used to describe the action of the cornea and lens on light rays as they enter they eye. Also used to describe the determination and measurement of the eye's focusing system by an optometrist or ophthalmologist.

Refractive eye surgery—A general term for surgical procedures that can improve or correct refractive errors by permanently changing the shape of the cornea.

Retina—The light-sensitive membrane that lines the back of the eye. The retinal cells process and send visual signals to the brain through the optic nerve.

Visual acuity—The ability to distinguish details and shapes of objects.

for corrective lenses. This is governed by individual state laws.

Prevention

Eye strain can be prevented by using sufficient light for reading and close work, and by wearing corrective lenses as prescribed. Those with corrective lenses should have regular eye examinations to see if their prescription has changed or if any other problems have developed. This is particularly important for people with high (degenerative) myopia who are at a greater risk of devel-

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American Optometric Association. 243 North Lindbergh Blvd., St. Louis, MO 63141. (314) 991-4100. <<http://www.aoanet.org>>.

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Naproxen see **Nonsteroidal anti-inflammatory drugs**

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Nasal cannula/face mask application

Definition

A nasal cannula is a narrow, flexible plastic tubing used to deliver oxygen through the nostrils of patients using nasal breathing. It connects to an oxygen outlet, a tank source or compressor, on one end and has a loop at the other end with dual pronged extended openings at the top of the loop. The prongs are slightly curved to fit readily into the front portion of a patient's nostrils. The tubing of the loop is fitted over the patient's ears and is brought together under the chin by a sliding connector that holds the cannula in place.

A simple oxygen face mask is a plastic device that is contoured to fit over a patient's nose and mouth. It is used to deliver oxygen as the patient breathes through either the nose or the mouth. A simple oxygen mask has open side ports that allow room air to enter the mask and dilute the oxygen, as well as allowing exhaled carbon dioxide to leave the containment space. It also has narrow plastic tubing fixed to the bottom of the mask that is used to connect the mask to an oxygen source. An adjustable elastic band is connected to each side of the mask and slides over the head and above the ears to hold the mask securely in place.

A partial rebreather oxygen mask is similar to a simple face mask, however, the side ports are covered with one-way discs to prevent room air from entering the mask. This mask is called a rebreather because it has a soft plastic reservoir bag connected to the mask that conserves the first third of the patient's exhaled air while the rest escapes through the side ports. This is designed to make use of the carbon dioxide as a respiratory stimulant.

A non-rebreather oxygen mask is similar to a simple face mask but has multiple one-way valves in the side ports. These valves prevent room air from entering the mask but allow exhaled air to leave the mask. It has a

reservoir bag like a partial rebreather mask but the reservoir bag has a one-way valve that prevents exhaled air from entering the reservoir. This allows larger concentrations of oxygen to collect in the reservoir bag for the patient to inhale.

A Venturi oxygen mask is similar to a simple face mask but the tubing that connects to the oxygen source is larger than that of other masks. The connector has interchangeable adaptors that widen or narrow the diameter of the flow through the tubing to allow settings of specific concentrations of oxygen through the mask.

Purpose

The purpose of nasal cannulas and oxygen face masks is to deliver oxygen in as concentrated a form as required for patients who are hypoxic. There are many conditions that cause hypoxemia and require the administration of supplemental oxygen, including respiratory disease, cardiac disease, **shock**, trauma, severe electrolyte imbalance (hypokalemia), low hemoglobin or severe **blood** loss, and seizures. Prompt treatment of these conditions with non-invasive oxygen administration can prevent the need for more invasive procedures such as intubation and mechanical ventilation.

A nasal cannula is used to deliver low concentrations of oxygen. It can deliver from 24% to 40% oxygen at a flow rate of 0.26-1.58 gal (1-6 L) per minute. A simple mask is used to deliver moderate to high concentrations of oxygen. It can deliver from 40% to 60% oxygen at a flow rate of 2.64-3.17 gal (10-12 L) per minute. A partial rebreather mask is used to deliver high concentrations of oxygen. It can deliver 70% to 90% oxygen at a flow of 1.58-3.96 gal (6-15 L) per minute. A non-rebreather mask is used to deliver high flow oxygen. It can deliver 90% to 100% oxygen at a flow of 3.96 gal (15 L) per minute. A variable flow rate mask has interchangeable adaptors that may be set to deliver oxygen at 24%, 28%, 31%, 35%, 40%, or 50%.



Insertion of nasal cannula. (Delmar Publishers, Inc. Reproduced by permission.)

Precautions

Oxygen is flammable. “No Smoking” signs should be posed when a patient is receiving oxygen. Electrical equipment must have special grounding adaptors on plugs to avoid sparks. The patient and family should be warned of the dangers involved in using oxygen at home, such as exercising care when using oxygen near stoves, portable heating units, and ungrounded electrical equipment. Oxygen cylinders must be placed in a cart or base to avoid dropping or bumping the tank. Oxygen tanks or compressors should be turned off when not in use and oxygen valves should be checked routinely to be sure that they are secure. Oxygen levels in reserve tanks should be monitored to ensure continuous therapy.

Patients receiving oxygen should be closely monitored. Arterial **blood gas analysis** or the use of a **pulse oximeter** will ensure that the oxygen concentration being delivered is sufficient to meet the patient’s needs. Monitor the patient’s condition and **vital signs** frequently, according to the policy of the medical setting. The fit of the nasal cannula or mask and all of the oxygen connections should be evaluated, to ensure that no part of the system has been blocked or diverted and the oxygen is being delivered correctly, as ordered.

The use of a face mask can cause a patient to perspire and feel warm, claustrophobic or nauseated. Explain the importance of the oxygen to the patient and encourage him to relax and breathe slowly. A cold cloth on the forehead and moral support can help the patient overcome these anxious feelings. If a patient with an oxygen mask begins to vomit, quickly remove the mask. There is a danger of aspirating vomit into the **lungs** if it collects in the mask over the nose and mouth. Support the patient, assist them in cleaning the mouth after vomiting by rinsing with water or mouthwash, clean off the mask

and the attached tubing, and replace it. The physician should be notified and antiemetics may be ordered.

A nasal cannula is more comfortable for a patient than a mask but can only deliver low concentrations of oxygen. Nasal cannulas should only be used in patients who breathe adequately through their noses. Use of cannulae is not indicated in patients who have severe hypoxia, poor respiratory effort, blocked nasal passages, apnea, or are mouth breathers.

Be cautious about giving oxygen to patients with chronic obstructive pulmonary disease because they may retain carbon dioxide. Oxygen may depress the hypoxic drive in these patients. They should be observed for decreased respirations, an altered mental state or further elevations of their carbon dioxide levels.

Description

Before applying a nasal cannula, the oxygen-flow meter should be turned to the setting in liters per minute that is ordered by the physician. The nurse should use his or her finger tips to ensure that oxygen is flowing through the prongs of the cannula. The nurse should apply a nasal cannula by placing the nasal prongs gently into the patient’s nostrils, draping the tubing over the patient’s ears, and sliding the fit connector up under the chin to hold the tubing securely in place. Two small pieces of clear plastic tape can be used to hold the cannula against the patient’s cheeks to secure the cannula in place if necessary. This is only necessary if the patient is restless, confused, or is a young child who may bat the cannula out of place.

Before applying an oxygen face mask, the nurse should turn on the oxygen flow-meter to the setting in liters per minute that is ordered by the physician. If using a Venturi mask, the adaptor device should be selected and applied to deliver the oxygen concentration that is ordered. Use the finger tips to ensure that oxygen is flowing through the face mask. An oxygen face mask is applied by placing the molded plastic mask onto the patient’s face, over the nose and mouth. The nurse should pull the elastic strap over the patient’s head to the back of the head and adjust the strap on both sides of the mask to secure the mask in a position that seals it against the face. Some masks have a nose-clip that can be gently squeezed to mold the mask over the bridge of the nose. The mask should fit snugly against the face but must not press so tightly as to leave impressions in the skin. If the mask has a reservoir bag and its purpose is to serve as an oxygen reservoir, the nurse should check that oxygen is filling the bag before applying the mask.



A man is given oxygen via a face mask before being transported to the hospital. (Photograph by Adam Hart-Davis. Science Source/Photo Researchers. Reproduced by permission.)

Preparation

The nurse should place the patient in a comfortable position, preferably semi-Fowler's or full Fowler's position (to assist breathing). She or he should take baseline vital signs and note the patient's level of consciousness. A pulse-oximetry reading or draw **blood gases** should be done as ordered for baseline lab values. Oxygen delivery to the patient should be explained, including what equipment is to be used (such as a mask or nasal cannula) and the importance of keeping the apparatus in place. The patient should know of the flammability of oxygen and a "No Smoking" sign should be posted. The nurse should instruct the patient to notify him or her of increasing distress, air hunger, nausea, **anxiety**, dry nasal passages, or "sore throat" (due to drying). The equipment needed should be assembled, including the oxygen-flow meter, humidity bottle if ordered, nasal cannula, or appropriate face mask. The mask or cannula should be connected securely to the oxygen flow-meter. Extension tubing should be used between the mask tubing and the oxygen flow-meter if necessary so that the patient may move about without pulling the mask off or pulling the tubing out of the oxygen source. The nurse should place a pulse-

oximeter machine at hand if ordered, to monitor the patient's response to **oxygen therapy**.

Aftercare

After initiating oxygen therapy, the nurse should stay with the patient for a while to reassure the patient and observe his or her reactions to the therapy. The patient's vital signs should be monitored, along with the level of consciousness, comfort with the oxygen apparatus, and oximetry levels, as ordered by the physician or as directed by policy of the medical setting. Oxygen connections and settings should be checked. The nurse should observe the patient, either for improvements in color, respiratory rate and rhythm, and comfort levels, or for increased or decreased respiratory effort, diaphoresis, alteration in mental status, anxiety and restlessness. Facemasks will interfere with communication and eating. Oxygen will dry out the mucous membranes of the nose and mouth. The nurse should briefly remove the mask periodically to allow the patient to drink or eat, for mouth care, or to communicate clearly. When the mask or cannula is off, the skin on the face and above the ears should be checked for signs of skin irritation. If the skin is irri-

KEY TERMS

Antiemetic—A medication given to decrease nausea and prevent vomiting.

Apnea—The absence or cessation of breathing.

Diaphoresis—Profuse sweating that is often medically induced.

Hypoxemia—Insufficient levels of oxygen in the blood.

Hypoxia—Air hunger or insufficient oxygen to the body tissue.

Endotracheal intubation—The process of inserting a soft plastic cuffed or uncuffed tube through the mouth or nose, past the epiglottis into the bronchus.

Mechanical ventilation—Artificial respiration provided by a machine that delivers pressurized oxygen, either automatically or on demand, to expand the lungs during inhalation, and provides passive resistance during exhalation at a set rate.

Narcosis—A condition of confusion, stupor or unconsciousness caused by a medication, chemicals, lack of oxygen, or a build up of toxins (such as carbon dioxide) in the blood.

Pulse oximeter—A small machine that continuously measures the oxygen saturation of the circulating blood, usually through a finger clamp with an oxygen-sensitive surface that is placed over the nail bed of a finger or toe.

tated above the ears, cotton padding can be placed between the ears and the elastic band or the cannula tubing to protect the skin. If the skin of the face is irritated, the face can be massaged gently and a water-based moisturizer applied. The mask can be loosened slightly to decrease irritation. The use of petroleum ointment to the lips or nose should be avoided because it can obstruct the cannula prong openings. If a humidifier is used with the oxygen apparatus, the humidity bottle should be refilled with distilled water according to the medical setting routine or at least once every eight hours. Blood gas analysis should be done as ordered when a patient is receiving oxygen to determine whether levels of oxygen flow should be decreased or need to be increased. When higher levels of oxygen are no longer needed, a patient using a face mask should be changed to a nasal cannula to improve comfort, the ability to communicate, and the ability to eat and drink more easily during therapy.

Complications

The most serious complication of oxygen therapy is the depression of the hypoxic drive to breathe in patients with chronic lung disease. High levels of oxygen may cause elevated levels of trapped carbon dioxide, which may lead to a decrease in respirations, a state of narcosis, and eventually to respiratory stasis or arrest.

Less serious complications include skin breakdown around the mask or cannula, a dry mouth, nose or lips, **sore throat**, and a decrease in appetite.

Results

Oxygen therapy using a nasal cannula or facemask is usually effective in increasing oxygen levels in the body to a normal or near normal state, providing time for treatment of the underlying disease or impediment causing the hypoxemia. Patients who do not respond to non-invasive oxygen therapy will usually be intubated (endotracheal intubation) and placed on mechanical ventilation with oxygen either as an assist device or as a full-capacity respirator.

Health care team roles

Oxygen is considered a drug and in this context is administered by a licensed nurse or respiratory therapist in the medical setting. Once oxygen therapy has been initiated, non-professional staff may assist in caring for the patient using oxygen therapy, including removing and replacing the mask or cannula for skin care, meals or brief ambulation to the bathroom. Nonprofessional staff must be instructed to remember to turn the oxygen flow back on after removal. They may also be trained to check oxygen apparatus such as, checking tubing connections, replacing the oximeter probe, filling the humidity bottles and cleaning or wiping humidity out of the oxygen mask. This should be performed under the direct supervision of the licensed nurse and the nurse or respiratory therapist will continually assess the patient's respiratory status and oxygen levels. When a patient is going home with oxygen, the licensed nurse or respiratory therapist will educate the patient and the patient's caregivers about the safe use of oxygen in the home. Patients using oxygen in the home should have initial and follow-up visits by a **home care** nurse or respiratory technician to check the patient's status and equipment function in the home. Patients receiving oxygen in the home should be scheduled for regular visits to the physician for follow-up assessment, including pulse oximetry and other therapy.

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Nasal culture see **Nasopharyngeal culture**

Nasal instillation

Definition

A nasal installation is a medicine solution prepared for administration into the nose. Nasal medicine is given in the form of nose drops or nasal sprays.

Purpose

The purpose of a nasal instillation is to deliver medicine directly into the nose and onto the nasal membranes, where it will be absorbed into the body. The most common nasal medicines are decongestant, antihistamine, and steroid nasal sprays used to relieve nasal congestion secondary to colds or **allergies**. Some nasal installations are unrelated to the nose, but are given by this method because of the ease of administration and the quick uptake through the nasal membranes.

Precautions

Nasal membranes are sensitive and can be traumatized by overuse of medication and by forceful insertion of a nasal spray or dropper tip.

Description

To instill nose drops, have the client sit in an upright position with the head and nose tilted slightly back. Hold the dropper near the entry to the nostril and instruct the client to inhale as you drop the appropriate dose into the nostril. Keep the client's head back for two to three minutes to allow the drops to roll to the back of the nostril. Repeat in the other nostril. To instill nasal spray, have the client sit erect with the head and nose upright or tilted slightly forward. Remove the cap from the nasal spray, shake the bottle, and gently place the tip of the spray bottle well into the nostril. Instruct the client to exhale, and then inhale vigorously as you squeeze the bottle to deliver the spray. Repeat in the other nostril.

Preparation

The nurse should wash his or her hands before instilling nasal medicine. Each time the medicine is administered, the medication label should be checked to avoid medication errors. It should be confirmed that it is the right medicine, the correct dose (i.e., strength), the proper time, the right patient, and the appropriate method. The expiration date on the label should be checked to ensure that the medication is not outdated. Prior to administration of the medicine, the bottle or canister should be shaken. The patient should blow his or her nose before nasal instillations. It is not unusual for nasal instillations to stimulate a sneeze. Tissues should be kept at hand so that residue can be wiped away and for the client to use to cover the mouth and nose when sneezing.

Aftercare

After rinsing the dropper or nasal spray tip with warm water, the cap should be replaced. Soiled tissues should be placed in a bag that can be sealed and discarded. When the procedure has been completed, the nurse should wash his or her hands.

Complications

Nasal medicines can irritate the lining of the nasal membranes and cause inflammation or nosebleeds when used to excess. Additionally, patients can develop a functional dependence for certain nasal sprays if used to excess.

Results

Most nasal instillations work promptly because of the quick uptake of medicine through the nasal membranes. If signs of nasal irritation occur or if the desired effect is not achieved after several days, the physician should be consulted.

Health care team roles

Administering any medicine is the responsibility of a licensed nurse (i.e., R.N. or L.P.N) in most health care settings. The patient or a patient's family member or friend can be instructed on how to administer nasal medicine in the home setting.

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Nasal packing

Definition

Nasal packing is gauze, foam, or cotton that has been packed into the nasal chambers. The term nasal packing may refer to individual gauze strips or cotton pledgets that are packed as they are inserted into the nose to form a plug or may refer to a pre-shaped pack of foam, gauze, or cotton that is inserted into the nose as a unit. Nasal packing may be coated with petrolatum, **antibiotics** or

agents that aid in clot formation. Some types of nasal packing have tails made of sutures or ties, which remain outside the nose to assist in repositioning or removing the nasal packing. Pre-formed nasal packs may include small tubes in the center of the pack to allow some air exchange while the packing is in place.

Purpose

Nasal packing is inserted into the nose by a physician to control severe nosebleeds. The purpose of the packing is to apply direct pressure onto the **blood vessels** located in the nasal membranes. Nasal packing may be used after nasal surgery to provide support to the nasal septum, control bleeding and absorb drainage.

Precautions

Nasal packing prevents air exchange through the nose. If both sides of the nose are packed, the client must breathe through his mouth while the packs are in place. Clients with nasal packing should be placed with the head of the bed elevated 30 degrees and observed for respiratory distress. Continued bleeding may not be apparent on the external end of nasal packing. Check the posterior oropharynx area regularly to see if **blood** is trickling into the back of the throat. Nasal packing can slip back or out with movement or sneezing. Check the positioning of the nasal pack routinely both at the external opening of the nose and by examining the oropharynx.

Description

When assisting the physician with nasal packing insertion, tilt the client back into a semi-reclining position to allow visualization into the nose. Monitor the client's respiratory status and **anxiety** during the procedure. Assist them to keep their hands down out of the way during the procedure if necessary. Assist the physician with positioning of the client, the light, suction and the instruments as instructed.

Local packing is a procedure used when only a small part of the nose must be packed. Typically, this occurs when one blood vessel is prone to bleeding, and there is no need to block breathing through the nose. Local packing is used when the pack can remain in place by itself. This situation can be found at the turbinates. Turbinates are folds of tissue on the insides of the nose. The folds are sufficiently firm to support packing. A small piece of gauze or cotton is wedged in between the turbinates where the blood vessel being treated is located. Local packing is left in place for up to 48 hours and then removed. The main advantage to this type of packing is

that it enables the patient to breathe through his or her nose. Local packing is also more comfortable than complete packing, although the patient will still experience a sensation that something is in the nasal cavity.

A postnasal pack is used to treat bleeding in the postnasal area. This is a difficult area to pack. Packs used in this area are pre-formed or made from cotton balls or gauze that have been tied into a tubular shape with heavy gauge suture or umbilical tape. Long lengths of suture or tape are left free. The lengths of suture or tape are used to help position the pack during installation and to remove it. After being tied, the pack is soaked with an antibiotic ointment. Generally, packs are formed larger than needed, so that they completely block the nasal passage. A catheter is passed through the nose and pulled out through the mouth. Strings from one end of the pack are tied to the catheter and the pack is pulled into place by passing through the mouth and up the back of the nasal cavity. The pack is removed in a similar manner. The end of the nose may be taped to keep the packing in place or to prevent the patient from pulling them out. More often a gauze 4x4 is folded and taped across the entrance to the nose to collect excess drainage and remind the client not to interfere with or probe the packing while it is in place.

In patients who are chronic nose pickers, frequent bleeding is common and ulceration of nasal tissue is possible. To promote healing and to prevent nose picking, both sides of the nose are packed with cotton that contains antibiotics. The nose is taped shut with surgical tape to prevent the packing from being removed. The packing is left in the nose for seven to 10 days. If the wound is high up in the nasal cavity, gauze strips treated with petrolatum and antibiotics are used. The strips are placed into the nose one layer at a time, folding one layer on top of the other until the area is completely packed.

Modern pre-formed nasal packs are lubricated with water-soluble lubricant and easily inserted as a unit in a compressed state. They are moistened after insertion by squirting them with saline or nasal medication, which causes them to expand to fill the nose. Newer polymer nasal packs are designed with a non-stick coating and absorbent core to enhance absorption but avoid re-opening the vessels when the pack is removed.

Preparation

When nasal packing is to be inserted in the clinic or emergency room setting, the nurse should wash the hands and put on gloves and a disposable gown. The client should be placed in a sitting position with the nose tilted forward and slightly upward until the physician is ready to insert the packing. The patient should be given 4x4 gauze pads or a washcloth to hold below the nose to catch

the blood with one hand, and he or she should apply pressure to the bridge of the nose with the thumb and forefinger of the other hand, while the nurse prepares the equipment. A drape or towel should be placed around the client's neck and shoulders. The nurse should prepare and instrument tray, which includes nasal speculum, hands free light, flash light, nasal packing material, nasal instruments, tongue blades, suction apparatus, sterile saline, lubricant, and medications as requested by the physician. The nurse should explain the procedure to the client, instructing him or her to keep the hands down during the procedure and breathe through the mouth. The patient may feel discomfort while the nose is being packed such as a feeling of congestion or pressure. If he or she has to sneeze, the patient should warn the staff and to sneeze with the mouth open. Medical personnel should wear gowns, gloves, masks and goggles during the insertion of nasal packing because of the potential for blood spraying if the client sneezes.

Aftercare

The patient should be placed in a semi-reclining position with the head elevated at least 30 degrees and should be allowed to rest. Old blood on the face, neck, and hands should be cleaned away with a warm wet wash cloth, and the soiled linens discarded in a contaminated linen bag. Instruments should be handled according to the contaminated instrument policy of the medical setting. Soiled gowns, gloves, gauze 4x4's, and disposable equipment should be placed in a trash bag that can be sealed and discarded. The nurse should wash the hands again.

The staff should check the nasal drip pad and the oropharynx for bleeding every 15-30 minutes, and notify the physician if the patient drains through four drip pads in an hour or if frank bleeding is observed in the oropharynx. Mouth breathing will cause the patient to have a dry mouth. The patient should be offered ice chips or mouthwash to moisten the mouth. The use of a room humidifier will also help keep the mouth moist. The patient should sneeze with their mouth open to avoid increased pressure in the nose. He or she should not "snuff" drainage in their throat, but spit secretions out into a basin or the sink rather than swallow them. The patient should have tissues on hand for secretions and/or sneezing, and be monitored for respiratory distress, especially for the first hour after packing and during sleep. The patient should know that **analgesics** can be given if they experience a headache after the procedure. The nurse should monitor the patient for nausea or vomiting of old or fresh blood and warn the client to avoid spicy food and smoking while the packing is in place. The patient may

KEY TERMS

Asphyxiation—Smothering. A severe decrease in oxygen concentration in the body, leading to death.

Cautery—Intentional destruction of tissue cells to remove abnormal tissue or form a scar to stop bleeding. Cautery is performed with chemical agents, laser instruments or electrical instruments that burn the tissue.

Oropharynx—An area of the throat visible through the open mouth located between the epiglottis and the soft palate.

Pledget—A small compressed cotton pad that is flat and absorbent.

Turbinate—Ridge-shaped cartilage or soft bony tissue inside the nose.

Ulcer—A sore on the skin or mucous tissue that produces pus and in which tissue is destroyed.

smell a foul odor as the nasal pack ages over the next 48 hours. He or she may also develop bruising or swelling of the eyelids secondary to nasal packing. The patient should not pick at the packing or rub the nose while the packing is in place.

Complications

Because of the complications of using nasal packing, physicians will attempt other methods to control nasal bleeding, such as external pressure, cold packs, cautery or **topical medicine application** before the use of nasal packing. The most common complication of nasal packing is that the removal of the packing dislodges healing tissue and causes the nose to bleed again. Nasal packing can cause a lack of oxygen in those who have difficulty breathing through their mouths such as elderly clients or those with chronic obstructive pulmonary disease (COPD). Nasal packing can lead to a drop in the blood oxygen content and an increase in blood carbon dioxide levels (CO₂). This, in turn, can cause respiratory and cardiac complications, including a racing pulse. Airway obstruction and asphyxiation can occur if the nasal packing slips back into the airway, particularly during sleep. Complications may occur if a pack compresses the Eustachian tube, causing ear problems. Infections can develop in the nose, sinus or middle ear after nasal packing insertion. These infections are not common but can lead to **septic shock**.

Results

Nasal packing is usually an effective method to stop nasal bleeding. In cases of nasal surgery, packing is frequently removed within 24-48 hours following surgery. In the case of nosebleeds, packing may be left in for extended periods of time to promote healing and to prevent the patient from removing scar tissue which might reopen the wound.

Health care team roles

Nasal packing is inserted by a physician. A licensed nurse will routinely assess a client with nasal packing for signs of bleeding, respiratory distress or **infection** while they are in the health care setting. Nasal packing is usually removed by the physician but may be removed by a licensed nurse as ordered by the physician. Clients and care providers can be instructed in the care of a client with nasal packing in the home setting but the client must return to the health care setting for removal of the nasal packing.

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Nasogastric intubation and feeding

Definition

Nasogastric intubation refers to the process of placing a soft plastic nasogastric (NG) tube through a patient's nostril, past the pharynx and down the esophagus into a patient's **stomach**.

Purpose

Nasogastric tubes are inserted to deliver substances directly into the stomach, remove substances from the stomach or as a means of testing stomach function or contents.

The most common purpose for inserting a nasogastric tube is to deliver tube feedings to a patient when they are unable to eat. Patients who may need a NG tube for feedings include: premature babies, patients in a **coma**, patients who have had neck or facial surgery or patients on mechanical ventilation. Other substances that are delivered through a NG tube may include ice water to stop bleeding in the stomach or medications to neutralize swallowed poisons.

Another purpose for inserting a nasogastric tube is to remove substances from the stomach. A NG tube is used to empty the stomach when accidental **poisoning** or drug **overdose** has occurred. A NG tube is used to remove air that accumulates in the stomach during **cardiopulmonary resuscitation (CPR)**. It is used to remove stomach contents after major trauma or surgery to prevent aspiration of the stomach contents. Placing a NG helps prevent nausea and vomiting by removing stomach contents and preventing distention of the stomach when a patient has a bleeding ulcer, bowel obstruction or other gastrointestinal diseases.

A NG tube may be inserted to take samples of stomach contents for laboratory studies and to test for pressure or motor activity of the gastrointestinal tract.

Precautions

Do not use force when inserting a NG tube. If resistance occurs, rotate and retract the tube slightly and try again. Forcing the tube can cause traumatic injury to the tissue of the nose, throat or esophagus.

Always check the tube positioning before giving feedings. If the tube is out of place the patient may aspirate the feeding solution into the **lungs**.

Keep the patient in an upright or semi-upright sitting position when delivering a tube feeding to enhance peristalsis and avoid regurgitation of the feeding.

Check patients who are receiving continuous feedings via a pump or gravity hourly or according to the medical settings policy, to assure that the tube is in position, the formula is flowing at the correct rate and the patient is comfortable with no signs of distention or distress.

Cap or clamp off the NG tube when not in use to prevent backflow of stomach contents or accumulation of air in the stomach.

If a patient has severe sinus conditions, nasal obstruction or has had facial surgery, it may be necessary to place a oral-gastric tube to avoid further nasal trauma.

If the amount of gastric aspirate is large prior to a bolus or intermittent feeding, notify the physician and follow the protocol of the medical setting for re-instilling the gastric aspirate. The feeding size may need to be decreased if the patient is not digesting it.

NG tube placement is meant to be a short-term solution for feeding problems. Patients that require long term tube feeding should have surgical placement of a gastrostomy tube or gastrostomy button. Long-term NG tube usage can cause nasal erosion, sinusitis, esophagitis, gastric ulceration, esophageal-tracheal fistula formation, oral infections and respiratory infections.

Description

To insert a nasogastric tube, have the patient tilt his head slightly back and gently ease the lubricated tubing into the nares. As the tube rounds the bend into the throat, have the patient tilt his head forward into a neutral upright position, hold his breath and swallow. Gently rotate the tubing 180 degrees to redirect the curve of the tube. Ease the tubing down the throat past the closed epiglottis. Gravity and swallowing will help move the tube down the esophagus as you gently continue to advance the tube. The patient can assist by swallowing and can even take sips of water to help move the tubing down into the stomach. Advance the tubing until you reach the marker tape that you applied when measuring the distance to the patient's stomach. Secure the tubing with tape and check the tubing for placement. If the patient gags during the procedure, stop advancing the tube and allow the patient to rest. If the tubing comes out of the mouth, retract the tubing and try again. If the patient is unconscious, advance the tube between respirations to avoid placing the tube into the trachea. If the patient becomes cyanotic, coughs or displays any signs of respiratory distress, remove the tubing, allow the patient to rest and begin again.

Once the NG tube is inserted, there are several methods for checking tube placement. Ask the patient to talk. If the patient cannot make sound, the tube has passed through the vocal cords and into the trachea. Remove the tube and start again. If the patient can talk, use a flashlight to look into the patient's mouth to view the tubing. It should appear straight in the back of the throat with no coiling into the mouth. Next, connect a 30 or 60cc catheter tip syringe to the end of the NG tube and aspirate to see if stomach contents return into the tubing. Stomach aspirate is often clear or yellow appearing but this depends upon what is in the patient's stomach. Stomach aspirate has a pH of 1-4 and an effective way to establish that the tube is in the stomach is to check the pH of the aspirate. Methods for checking tube placement, however, vary according to the medical setting. Follow the medical setting policy for checking tube placement. Another, more traditional method for checking tube placement is to draw 10-20 cc of air into the syringe, place the **stethoscope** over the patient's stomach and quickly inject the bolus of air into the stomach. A whooshing sound should be audible through the stethoscope over the stomach if the tube is in the stomach. If the tube is in the esophagus or trachea, the air sounds will be absent or muffled. The most accurate way to check for tube placement is an x ray of the abdomen. The NG tube is radiographic and will show up clearly on the x ray. A **chest x ray** is rarely done for NG tube placement because of the cost, but if performed for other purposes the radiologist will usually note the positioning of the NG tube on the report.

Preparation

Position the patient in bed with the head of the bed elevated 45-90 degrees and place a towel across the chest up to the patient's neck. Explain the nasal intubation procedure to the patient. Let them know that by holding their breath as the tube is passed through the pharynx, they will close off the airway and that if they swallow when instructed, it will help move the tubing down the esophagus into the stomach. Have the patient blow their nose to clear out the nasal passages and remove dentures if they have them. Question the patient about whether they have had sinus problems, nasal problems such as nosebleeds or nasal surgery in the past. Consult with the physician if the patient has a history of nasal problems. Select a nostril to use for intubation. Assemble the equipment needed, including a nasogastric tube, flash light, emesis basin, tissues, 30cc-60cc catheter tip syringe and irrigation set, a glass of water, water-soluble lubricant, clear plastic tape, a transparent dressing, stethoscope and gloves. Obtain a suction apparatus and connection tubing if the NG tube is to be used for suctioning the stomach.

Prepare a piece of 1-inch tape that is cut horizontally half way through the piece of tape to make two tails. The uncut end will be placed along the patient's nose and the tails wrapped around the tube in opposite directions to secure the tube to the nose after insertion. Develop a hand signal with the patient so that they can ask to stop the procedure to let them rest if they are in distress during the procedure.

NG tubes are available in a variety of types, lengths and sizes. Large-bore tubes (some with a second lumen) are used for suctioning stomach contents. Small-bore tubing is used for feedings. Select the tube appropriate to the patient's size and the purpose for which the tube is being inserted. Wash the hands and put on gloves. Remove the tube from the packaging and uncoil it. Examine the tubing for flaws. Run some water through the tubing to check for leaks. To find the distance to the patient's stomach, use the tube to measure from the tip of the patient's nose back to the ear and then down to the tip of the sternum. Mark this place on the tube using a small piece of tape. Moisten the tip and first few inches of the tubing with water-soluble lubricant and lay it back into the packaging.

Aftercare

After correct positioning of the NG tube has been established, secure the NG tube to the nose with a second piece of plastic tape or use a transparent dressing to hold the tubing to the nose. The intent is to secure the tube so that it will not slip in or out, the method of securing the tube may vary according to the size of the patient, their type of skin and the amount of perspiration on the nose. Securing the other end of the NG tube to the patient's gown with a looped rubber band and safety pin can prevent accidental pulling on the NG tube as the patient moves around. The end of the NG tube should be plugged or clamped when not connected to suction or in use for feedings. Ongoing care of the patient with a NG tube includes encouraging good mouth care and cleansing the nares routinely. Change the tape position daily and examine the tissue around the nose and under the tape for signs of irritation or breakdown. Keep the head of the bed elevated 30 degrees at all times to decrease gastric reflux. Place the head of the bed 30-45 degrees during tube feedings and for 30-60 minutes after intermittent tube feedings if the patient can tolerate this position.

When a NG tube is used to administer tube feedings, they may be given by gravity or by pump. Tube feedings may also be given either intermittently or continuously. The physician will calculate the patient's nutritional needs within a 24-hour period and order the solution, frequency and rate of flow. Tube feedings are supplemented

liquid **nutrition** and may be prepared by the dietary department in a medical setting or provided in prepared cans of formula (such as Ensure) that are manufactured for this purpose. There are a large number of formulas to select from according to the patient's nutritional needs. Be certain that the formula used for tube feeding exactly matches the physician's orders.

Intermittent tube feedings may be given using a large catheter tip syringe or a feeding bag. Check the position of the NG tube according to the policy of the medical center. Aspirate the stomach contents for residual formula from the last feeding. If the residual exceeds 100 cc for an adult, hold the feeding and notify the physician. Re-instill the gastric aspirate according to the policy of the medical center or the physician's order. Review the physician's order and select the appropriate type and amount of feeding. Be sure that the patient remains in an upright position during the feeding. Shake prepared formulas before administering them. Formulas that have been refrigerated should be allowed to warm up to room temperature before administering them. To give the feeding using a syringe, remove the barrel from the syringe. Open the end of the NG tube and connect it to the end of the syringe. Pour the feeding into the wide end of the syringe and hold or secure the syringe to the bed or an IV pole just above the patient's head so that it will flow in slowly by gravity over 15-30 minutes. If more feeding is needed than can be held in the syringe, watch the syringe and refill the syringe until the feeding is complete. When the feeding is complete, rinse the tube with 30 cc of water. Disconnect and recap the end of the NG tube and rinse the syringe according to the medical setting's policy. To give an intermittent feeding using a feeding bag, pour the correct feeding amount into the bag and through the tubing connected to the bag down to the tip of the tubing. Clamp the tubing using the roller clamp apparatus. Hang the bag on an IV pole just above the patient's head. Open the NG tube and connect it to the feeding bag tubing. Open the feeding bag roller clamp apparatus and adjust the flow rate to run the feeding in over the prescribed amount of time (usually 15-30 minutes). When the feeding is complete, purge the line by putting 30 cc of water into the bag and allowing it to flow in wide open. Clamp and disconnect the feeding bag tubing. Recap the NG tube. Rinse and reuse the feeding bag according to the medical center's policy. Feeding bags and syringes are usually replaced every 24 hours to prevent bacterial contamination.

Continuous tube feedings are given using a feeding bag with connected tubing and an automatic food pump to deliver the feeding at a specific rate of flow. Patients receiving continuous tube feedings should be kept in an upright position of 30-45 degrees to prevent reflux of for-

mula. The feeding bag is filled with formula solution for no more than four hours and the pump is set at the flow rate that the physician has ordered. Check the NG tube for correct placement every four hours and aspirate the NG tube to check for formula residual. If the residual is 1.5 times greater than the amount administered each hour, notify the physician. Re-instill the residual by gravity using a syringe and flush the line with 30-60 cc of water. Refill the formula bag for the next four hours. Observe the patient hourly to be sure that the patient is in no distress, the patient's abdomen is not distended, the formula is flowing at the correct rate and that the tubing connections are secure. Refill the bag as necessary or every four hours. The feeding bag and tubing should be changed according to the medical setting's policy, usually every 24 hours to prevent bacterial contamination.

Complications

The complications of nasogastric intubation may include:

- aspiration of the stomach contents leading to asphyxia, **abscess** formation or aspiration pneumonia;
- trauma injury including perforation of the nasal, pharyngeal, esophageal or gastric tissue
- pulmonary hemorrhage, empyema, pneumothorax, pleural effusion or pneumonitis from a malpositioned tube
- nosebleeds
- secondary **infection** in the sinus, throat, esophagus or stomach
- development of a tracheal-esophageal fistula
- erosion and/or necrosis of nasal, pharyngeal, esophageal or gastric tissue

The complications of nasogastric tube feedings may include:

- obstruction of the tube
- perforation of the tube
- tube migration out of correct position
- regurgitation and aspiration of the feeding
- diarrhea
- nausea and vomiting
- abdominal distention, cramping and discomfort from too much feeding or a rate of feeding that is too rapid
- any of the complications listed above in the complications of nasogastric intubation

KEY TERMS

Empyema—A collection of pus in the lung cavity.

Fistula—A passageway or connecting duct that is abnormal and connects body cavities or tissues that should not be connected. Fistulas develop as the result of injury, disease or congenital deformity.

Gastrostomy button—A soft plastic apparatus with a button closure that is surgically inserted and sutured onto the surface of the abdomen. The gastrostomy button is placed in a surgical opening that leads from the stomach to the surface of the abdomen and is used for long term tube feedings in patients who cannot eat to prevent malnutrition.

Gastrostomy tube—A soft plastic tube that is inserted and sutured into a surgical opening that leads from the stomach to the surface of the abdomen. A gastrostomy tube is used for long term tube feedings in patients who cannot eat to prevent malnutrition.

Peristalsis—Muscular contractions of the gastrointestinal tract that move food, fluids and refuse in a wave-like motion through the system.

Reflux—A backward flow of food or fluid from the stomach into the esophagus.

Regurgitation—A vigorous reversed flow of the stomach contents up the esophagus and out of the mouth.

Results

The use of a nasogastric tube for feedings can effectively prevent malnutrition in the patient who is unable to eat. A nasogastric tube is also an effective temporary measure for decompression and removal of stomach contents and free air in a variety of gastrointestinal illnesses, major trauma, or surgery.

Health care team roles

Nasogastric intubation is usually performed by a licensed nurse or physician in the medical setting. Paramedics or other emergency personnel may receive special training to insert NG tubes as appropriate in the field. Patients' families may be trained to insert or change nasogastric tubes in the home setting if a patient is discharged

with a NG tube in place. It is unusual, however, to continue NG tube feedings in the home setting. Most patients who require long-term tube feedings will have a gastrostomy tube or gastrostomy button placed for feedings.

Tube feedings are usually administered by a licensed nurse in the medical setting. Non-licensed personnel may receive special training to start, stop or check tube feedings under the direction of a licensed nurse in some medical settings. Patients and patients' families may be taught by a licensed nurse to administer tube feedings in the home. Patients receiving tube feedings in the home should be monitored by visiting nurses or undergo frequent medical check-ups to assess the their responses to the feedings and the their ongoing nutritional needs.

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Nasopharyngeal culture

Definition

A nasopharyngeal culture is a microbiology test used to identify pathogenic organisms present in the nasal cavity that may be the cause of an upper respiratory tract illness or may be transmitted by carriers to persons susceptible to **infection**.

Purpose

Some of the organisms responsible for upper respiratory infections are carried primarily in the nasopharynx. Nasopharyngeal cultures are performed to isolate these organisms. These include **viruses** such as **influenza**, parainfluenza, and respiratory syncytial virus, which are the most common causes of respiratory infection in young children, and pathogenic **bacteria** such as *Bordetella pertusis* and *Corynebacterium diphtheriae*, which are infrequent causes of infections in the United States. In addition, nasopharyngeal cultures are used to identify carriers of *Staphylococcus aureus*, *Streptococcus pneumoniae*, and *Neisseria meningitidis*. These organisms usually do not cause disease in the nasopharynx or throat. However, asymptomatic carriers may transmit these organisms via nasal secretions to others that will develop serious infections. *Staphylococcus aureus* and *Streptococcus pneumoniae* can cause **pneumonia** and septicemia and *N. meningitidis* can cause outbreaks of **meningitis**.

Bacteria that cause pharyngeal infection (**sovere throat**) such as *Haemophilus influenzae*, *Streptococcus pyrogenes* (group A streptococcus), *Candida albicans*, and *Mycoplasma pneumoniae* may also be isolated from the nasopharynx. The procedure can also be used as a substitute for a **throat culture** in infants, the elderly patient, the debilitated patient, or in cases where a throat culture is difficult to obtain.

Precautions

For best results, the specimen should be obtained prior to initiating any therapy. The health care worker obtaining the specimen should wear gloves to prevent spreading infectious organisms.

Description

Collection and transport

A sample is obtained from the nasopharynx by means of a swab, aspirate, or wash. Swabbing is most commonly used for collection. A **calcium** alginate

(wool) or polyester swab on a flexible wire is most commonly used. The nose is cleared of mucus and the swab is inserted into the nasal cavity and moved forward along the septum until it reaches the rear of the pharynx. The swab is rotated several times and then removed. For viral culture, the swab should be transported in a small amount of veal infusion or sucrose-phosphate broth. For bacterial culture, the swab should be placed in Stuart's or Amie's transport medium. If pertussis is suspected, the swab should be placed directly onto Regan-Lowe media before transporting to the lab. Aspirates are collected by placing a thin flexible catheter or plastic tube onto the end of a 10 mL syringe and applying suction. Washings are collected by irrigating the nasal cavity with 7-10 mL of sterile phosphate buffered saline using a suction bulb and then aspirating the fluid.

VIRUSES. Nasopharyngeal swabs are most often used to collect samples from neonates or young children who have an upper respiratory infection. Most respiratory infections in young children are caused by viruses. Cultures are not routinely ordered for influenza, parainfluenza, or respiratory syncytial virus. Influenza and parainfluenza are cultured in primary monkey kidney cells or chick egg embryos. RSV is most often cultured in HEp2 cells (malignant human epithelioma cells). Since viral cultures can take up to seven to 12 days, tests for viral antigens using fluorescent or enzyme immunoassay are performed frequently.

BACTERIA. Bacterial culture and **Gram stain** are performed routinely for nasopharyngeal specimens. Gram stain is helpful in suggesting the presence of *Candida albicans* (gram-positive budding yeast), *Corynebacterium diphtheriae* (small gram-positive rods arranged like Chinese letters), and *Neisseria meningitidis* (small gram-negative diplococci).

The Gram stain is performed by:

- Transferring a small portion of the specimen to the center of a glass slide, which is then heat-fixed and cooled before staining.
- Placing a few drops of crystal violet on the slide and allowing it to set for 30-60 seconds.
- Rinsing off the crystal violet, gently, with water.
- Applying a few drops of Gram's iodine on the slide and allowing it to set for 60 seconds.
- Rinsing off the iodine, gently, with water.
- Decolorizing by rinsing with 95% ethanol, drop by drop, until the alcohol rinses clear.
- Placing a few drops of safranin on the slide and allowing it to set for 30 seconds.
- Rinsing off the safranin, gently, with water.

KEY TERMS

Antibiotic—A drug given to stop the growth of bacteria. Antibiotics are ineffective against viruses.

Bacilli—Rod-shaped bacterium.

Cocci—Spherical shape bacterium.

Nasopharynx—The back wall of the nasal cavity where it meets the throat.

- Blotting excess water with bibulous paper.
- Allowing the slide to air dry.
- Observing the slide under oil immersion.

Gram-positive cells retain the crystal violet and appear dark purple, while gram-negative cells do not retain the crystal violet. They are stained with the safranin and appear red.

Specimens should be plated on sheep blood agar, which supports the growth of most of the pathogenic bacteria encountered in nasopharyngeal specimens except *Chlamydia*, *Haemophilus*, and *Mycoplasma*; chocolate (heated blood) agar for *Haemophilus*; and a selective medium for gram-positive cocci such as colistin-nalidixic acid (CNA). If *Corynebacterium diphtheriae* is suspected, the specimen should be plated on Loeffler or Tinsdale agar, which permit faster growth than blood agar. If *Bordetella pertussis* is suspected the specimen should be plated on Regan-Lowe (charcoal-horse blood agar) or Bordet-Gengou agar. Cultures should be incubated at 35°C in air at high humidity. Plates should be examined for growth each day and suspect colonies Gram stained and subcultured (that is, transferred to an appropriate medium). If *C. diphtheriae* or *B. pertussis* is suspected, plates should be held for six to seven days. Otherwise, plates showing no growth of suspected pathogens may be discarded after 48 hours. Preliminary identification of the organism can be made from catalase, coagulase, urease, nitrate reduction, sucrose fermentation, and characteristic colonial morphology.

Antibiotic susceptibility testing is performed by the Kirby-Bauer or broth microdilution method for *Haemophilus*, *Neisseria*, *Streptococcus pneumoniae*, or *Staphylococcus aureus*. **Antibiotics** usually included are ampicillin, chloramphenicol, cephalosporins, meropenem, oxacillin, vancomycin, and trimethoprim-sulfamethoxazole. Antibiotic susceptibility is not performed for *C. diphtheriae*, *B. pertussis*, or *M. pneumoniae* because they are susceptible to erythromycin, and are difficult to grow in

MIC broth for susceptibility testing. *Streptococcus* is susceptible to penicillin.

Alternative procedures

In most cases of upper respiratory tract infections, a throat culture is more appropriate than a nasopharyngeal culture. However, the nasopharyngeal culture should be used in cases where throat cultures are difficult to obtain or to detect the carrier states especially meningococcal disease.

Preparation

The patient should clear their nose of excess secretions prior to sample procurement. To prevent contamination, the swab should not touch the patient's tongue or side of the nostrils.

Aftercare

None.

Complications

There is little to no risk of complications involved in a nasopharyngeal culture.

Results

Preliminary results may be reported in one or two days followed by confirmation which usually takes additional time depending upon the organisms isolated. Bacteria that normally grow in the nasal cavity will be identified by a nasopharyngeal culture. These include nonhemolytic streptococci, alpha-hemolytic streptococci, some *Neisseria* species, diphtheroids, and some types of staphylococci.

Pathogenic organisms that might be identified by this culture include:

- group A beta-hemolytic streptococci
- *Bordetella pertussis*, the causative agent of whooping cough
- *Corynebacterium diphtheriae*, the causative agent of diphtheria
- *Neisseria gonorrhoeae*, the causative agent of gonorrhea which may be isolated from persons who have engaged in oral sex
- *Chlamydia trachomatis*, the causative agent of pelvic inflammatory disease and urethritis which may cause a nasopharyngeal infection in the neonate from transmission in the womb

In addition, some bacteria normally present in the nasal cavity may be the cause of infection or disease when they are present in large amounts. These include:

- *Haemophilus influenzae*, a causative agent of bronchitis, inner ear infection, and meningitis
- *Streptococci pneumoniae*, a causative agent of pneumonia
- *Candida albicans*, the causative agent of thrush

Asymptomatic carriers may contain the following organisms in the nasopharynx:

- *Neisseria meningitidis*, a causative agent of meningitis
- *Streptococci pneumoniae*, a causative agent of pneumonia
- *Staphylococcus aureus*, the causative agent of many Staph infections

Health care team roles

A physician orders a nasopharyngeal culture. A physician, physician assistant, or nurse collects the specimen. A clinical laboratory scientist/medical technologist who specializes in microbiology performs the culture and antibiotic sensitivity test when required. The physician determines the appropriate antimicrobial treatment.

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Victoria E. DeMoranville

NCV see **Electromyography**

Nearsightedness see **Myopia**

Near-drowning

Definition

Near-drowning is the term used for survival after suffocation caused by submersion in water or other fluid or liquid.

Description

An estimated 15,000–70,000 near-drownings occur in the United States each year; insufficient reporting prevents a more precise estimate. A typical person experiencing near-drowning is young and male. Nearly half of all drownings and near-drownings involve children less than four years old. Because home swimming pools are the sites for 60–90% of drownings in the 0–4 age group, they pose the greatest risk for children. Teenage boys are also at heightened risk for drowning and near-drowning; drugs and alcohol are implicated in 40–50% of teenage drownings. Overall, roughly four out of five drowning victims are males.

Causes and symptoms

On many occasions, near-drownings are secondary to an event such as a heart attack that causes unconsciousness or a head or spinal injury that prevents a diver from resurfacing. Near-drownings, moreover, can occur in shallow as well as deep water. Small children have drowned or almost drowned in bathtubs, toilets, industrial-size cleaning buckets, and washing machines. Bathtubs are especially dangerous for infants between six months and one year of age, who can sit up straight in a bathtub but may lack the ability to pull themselves out of the water if they slip under the surface.

A reduced concentration of oxygen in the **blood** (hypoxemia) is common to all near-drownings. When drowning begins, the larynx (air passage) closes involuntarily, preventing both air and water from entering the **lungs**. In 10–15% of cases, hypoxemia results because the larynx stays closed; this is called dry drowning. Hypoxemia also occurs in wet drownings, the 85–90% of cases where the larynx relaxes and water enters the lungs. Only a small amount of either freshwater or saltwater is needed to damage the lungs and interfere with the body's oxygen intake. Within three minutes of submersion, most people are unconscious. Within five minutes, the **brain** begins to suffer from lack of oxygen. Abnormal **heart** rhythms (cardiac dysrhythmias) often occur in near-drowning cases, and the heart may stop pumping (cardiac arrest). An increase in blood acidity (acidosis) is another consequence of near-drowning and, under some circum-

KEY TERMS

Acidosis—An increase in acid content of the blood manifested by a decrease in blood pH below 7.40.

Cardiac arrest—Cessation of heartbeats.

Cardiac dysrhythmias—Abnormal heart rhythms.

Cyanosis—A blue color of the skin caused by inadequate oxygen in the blood.

Dry drowning—Hypoxemia due to closure of the larynx.

Endotracheal intubation—Inserting a tube in the trachea to maintain an open airway.

Hypothermia—A decrease in the internal temperature of the body to a core temperature below 96°F (35.6°C).

Hypoxemia—A reduced concentration of oxygen in the blood.

Tachycardia—Rapid heart rate.

Tachypnea—Rapid breathing.

Trachea—Windpipe.

Wet drowning—Water entering the lungs due to relaxation of the larynx.

stances, near-drowning can cause a substantial increase or decrease in the volume of circulating blood. Many individuals experience a severe drop in body temperature (hypothermia).

The signs and symptoms of near-drowning can differ widely from person to person. Some people are alert but agitated, while others are comatose. Breathing may have stopped in one person, while another may be gasping for breath. Bluish skin (**cyanosis**), coughing, and frothy pink sputum (material expelled from the respiratory tract by coughing) are often observed. Rapid breathing (tachypnea), a rapid heart rate (tachycardia), and a low-grade **fever** are common during the first few hours after rescue. People who have experienced near-drowning but remain conscious may appear confused, lethargic, or irritable.

Diagnosis

Diagnosis relies on a **physical examination** and on a wide range of tests and other procedures. Blood is taken to measure oxygen levels. Pulseoximetry is another way of assessing oxygen levels. An electrocardiograph is used to monitor heart activity. X rays, computed tomography

(CT) scans, or **magnetic resonance imaging** (MRI) scans can detect head and neck injuries and excess tissue fluid (**edema**) in the lungs.

Treatment

Treatment begins with removing the victim from the water and performing **cardiopulmonary resuscitation** (CPR). One purpose of CPR is to bring oxygen to the lungs, heart, brain, and other organs by breathing into a person's mouth. When someone's heart has stopped, CPR also attempts to get the heart pumping again by pressing down on the chest. After CPR has been performed and emergency medical help has arrived on the scene, oxygen is administered. If the person's breathing has stopped or is otherwise impaired, a tube is inserted into the windpipe (trachea) to maintain the airway (endotracheal intubation). The person is also checked for head, neck, and other injuries, and intravenous fluids are given. Hypothermia cases require careful handling to protect the heart.

In the emergency department, victims who have experienced near-drowning continue receiving oxygen until blood tests show a return to normal. About one-third of the patients are intubated and initially need mechanical support to breathe. Re-warming is undertaken when hypothermia is present. People may arrive requiring treatment for cardiac arrest or cardiac dysrhythmias. Comatose patients present a special problem. Although various treatment approaches have been tried, none have proved beneficial. Many of these patients die.

People can be discharged from the emergency department after four to six hours if their blood oxygen level is normal, and no signs or symptoms of near-drowning are present. Because lung problems can arise 12 or more hours after submersion, the medical staff must emphasize that the individuals must seek further medical help, if necessary. Admission to a hospital for at least 24 hours for further observation and treatment is a must for people who do not appear to recover fully in the emergency department.

Prognosis

Neurological damage is the major long-term concern in the treatment of people experiencing near-drowning. Those who arrive at an emergency department awake and alert usually survive with brain function intact, as do about 90% of those who arrive mentally impaired (lethargic or confused) but not comatose. Death or permanent neurological damage is very likely when individuals arrive in a comatose condition. Early rescue of people experiencing near-drowning (within five minutes of sub-

mersion) and prompt application of CPR (within less than 10 minutes of submersion) seem to be the best predictors of a complete recovery.

Health care team roles

First aid can be administered by anyone with proper training. This may include CPR. Paramedics may provide support during transport to a hospital. Physicians commonly evaluate and provide treatment in an emergency department. Nurses provide emergency and supportive care. Therapists may be called upon to provide follow-up counseling.

Prevention

Prevention depends on educating parents, other adults, and teenagers about water safety.

Parents must realize that young children who are left in or near water without adult supervision, even for a short time, can easily get into trouble. Experts consider putting up a fence around a home swimming pool an essential precaution, and estimate that 50–90% of child drownings and near-drownings could be prevented if fences were widely adopted. The fence should be at least five feet (1.5 m) high, have a self-closing and self-locking gate, and completely surround the pool.

Pool owners and all other adults should consider learning CPR. Everyone should follow the rules for safe swimming and boating. Those who have a medical condition that can cause a seizure or otherwise threaten safety in the water are advised always to swim with a partner. People need to be aware that alcohol and drug use substantially increase the chances of an accident.

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American College of Emergency Physicians. P.O. Box 619911, Dallas, TX 75261-9911. (800) 798-1822. (972) 550-0911. (972) 580-2816. <<http://www.acep.org/>>. info@acep.org.

American College of Osteopathic Emergency Physicians. 142 E. Ontario Street, Suite 550, Chicago, IL 60611. (312) 587-3709. (800) 521-3709. (312) 587-9951. <<http://www.aoep.org/>>.

National Safe Kids Campaign. 1301 Pennsylvania Avenue, Suite 1000, Washington, D.C. 20004-1707. <<http://pedscm.wustl.edu/AllNet/english/neurpage/protect/drown.htm>>.

Search and Rescue Society of British Columbia. P.O. Box 1146, Victoria, BC Canada V8W 2T6. (250) 384-6696. <<http://www.sarbc.org/homepage.html>>. sarbc@sarbc.org.

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L. Fleming Fallon, Jr., M.D., Dr.P.H.

Neck pain, physical therapy for see **Back and neck pain, physical therapy for**
Needles see **Syringe and needle**

Neonatal care

Definition

Neonatal care refers to that care given to the newborn infant from the time of delivery through about the first month of life. The term “neonate” is used for the newborn infant during this 28-30 day period.

Purpose

The purpose of neonatal care in the delivery room and newborn nursery is to:

- Assess and evaluate the newborn as s/he transitions from intrauterine life to extrauterine life.
- Evaluate and monitor the newborn system-by-system for normal versus abnormal functioning, providing maintenance of normal and potential treatment of abnormal findings.
- Foster bonding between infant and parent/s.
- Provide a safe environment at all times.

Description

Neonatal care begins as soon as the baby is born. In fact, suctioning of the nose and mouth may take place as the baby is in the process of being delivered—with the head out, and while the mother is taking a pause before the next push. *In utero* the infant is swimming in amniotic fluid. As he or she comes down the birth canal, the contractions exert pressure on the body and push some of the amniotic fluid out of the **lungs**. It is this fluid that is suctioned out during those first few moments. Shortly after delivery, the umbilical cord is clamped and then cut. Shortly after clamping, the cord will be checked for the presence of two arteries and one vein. Once the cord is clamped, the baby must breathe and function independently from the mother. The first few breaths cause several internal changes to occur. These will be discussed in the Results section below.

Because of the internal environment, the baby is very wet when born. Drying the baby off right away is critical, as the baby can lose considerable body heat through evaporation, convection, radiation, and conduction. This is especially true of the head, which has a large surface area in relation to the rest of the body. Also, head hair retains considerable moisture if not well dried. A cap placed on the head once it has been dried helps to maintain body temperature. The nurse may place the newborn on the mother’s skin while drying the skin, both to begin the bonding process as well as to allow the mother’s body heat to warm the infant. The rubbing that takes place to

dry the infant provides tactile and sensory stimulation. The neonate may cry, bringing more oxygen into the lungs. A certain amount of pressure is needed in the **heart** and lungs in order to convert from fetal circulation to neonatal circulation. A color change is noticeable as the infant’s skin changes from a bluish hue to pink. In some circumstances, oxygen from a mask may be placed near the mouth while the infant is being dried off to increase the initial intake of oxygen. Once dry, the infant is wrapped in several warm receiving blankets and may be placed at the mother’s breast for an initial breastfeeding. If the mother will not be breastfeeding, she may choose to hold the newborn at this point.

The first breastfeeding helps to trigger the involution process of the uterus, as it stimulates the production of natural oxytocin, which helps the uterus contract. Also, in the first hour or so after birth, the neonate is usually quite alert, unless the mother was given **pain** medications late in labor.

While the infant is being dried off, the mother is delivering the placenta. The amniotic fluid is clear, perhaps tinged with **blood**. If it appears murky in any way, the baby most likely had a bowel movement during the stressful labor and delivery process. This first bowel movement is called meconium. If present in the amniotic fluid, it is possible that the infant inhaled some into its lungs. This is called meconium aspiration. The neonate with meconium in the amniotic fluid may be intubated to avoid aspiration. Meconium aspiration can lead to tachypnea (rapid respirations) and also **pneumonia**, and may require the neonate to spend some time under observation in the neonatal intensive care unit (NICU), instead of being kept with its mother. As the infant is being suctioned, assessed and dried, it may be placed in a slight Trendelenburg position, depending on the hospital. This downward slant of about 10 degrees allows gravity to assist in draining mucous.

At one and five minutes after birth the neonate is assessed for Apgar scores. The infant’s heart rate, respiratory effort, muscle tone, reflex, irritability, and color are each given a score of 0, 1, or 2. Each score is then added together for a highest possible score of 10. The normal range is 7-10. It is rare to receive a 10, as some **cyanosis** in the hands and feet (called acrocyanosis) is quite normal.

In the birthing room a rapid **physical examination** is performed to assess any gross abnormalities as well as any heart-related problems, and to determine the need for any immediate intervention. The spine will be assessed, and should be free of any openings or dimpling. It will be flat, as the lumbar and sacral curves develop later when the child learns to sit and walk. A more detailed exami-

nation will take place about 24 hours later. The umbilical cord and placenta will also be examined for any abnormalities. Any medications given to the mother during labor and delivery are recorded in the neonate's chart, as the medication could affect the infant's respirations and its own ability for tissue oxygenation. The physician or nurse-midwife will also make sure the entire placenta has been expelled to avoid the risk of **infection** for the mother due to any retained tissue.

Because the neonate has difficulty maintaining its temperature, any examination that is immediately needed usually takes place under a source of radiant heat. During the first 24 hours the neonate is adjusting to extrauterine life and some normal fluctuations are expected. It is for this reason that the more thorough examination will take place a bit later on, once the initial fluctuations stabilize. The expected findings of the head-to-toe neonatal assessment will be discussed in the Results section below.

Before leaving the delivery room the nurse will:

- Place an identification band on the neonate's hands and feet.
- Place an ID band with the same number as the baby's on the mother's (and in some hospitals) on the father's wrist.
- Take a foot print of the infant (in some hospitals).
- Give an intramuscular (IM) injection of **vitamin K** to the neonate.
- Administer an antibacterial eye ointment into both eyes.

To assist the neonate's blood's ability to clot in its early life, infants receive an IM injection of vitamin K in the delivery room. The injection is usually given in the thigh muscle, as this is the largest and safest muscle in which to give an infant an injection. The antibacterial eye ointment used prevents contracting an infection from one present in the birth canal, such as gonorrhea or chlamydia.

Hospitals differ in which identification system they use, but the premise is the same: before the infant leaves the delivery room, he or she should receive an ID band with a number on it. The same ID number is on a band for the mother, as well as possibly for the father. Before leaving the baby with the parents, the bands should be checked by the nurse or nursing student to avoid any mix-up. Some hospital ID bands contain a microchip in it that causes an alarm bell to ring if the infant is taken out of a certain area. Also, some hospitals require that if the mother is going to take a nap or a shower, the infant must be returned to the nursery so that the infant is not unattended in the mother's room. Some hospitals use a band on each of the baby's hands and feet, so that if one or two

fall off, proper ID still remains on the neonate. In addition to the ID band, a print of the infant's foot is made along with the mother's fingerprint. Both are recorded on the same sheet of paper.

If the neonate appears physiologically unstable, she will be taken either to the nursery or to the NICU for further evaluation or treatment. Once the mother's condition is stable, she may be wheeled to the infant's location if she desires.

Weight and length are measured, either in the birthing room or in the newborn nursery, **vital signs** are closely monitored and skin color is assessed for signs of **jaundice**. Jaundice that appears in the first 24 hours is of a different nature than that which sets in after 24 hours. If undressed, the infant is kept under radiant heat to assist in maintaining proper body temperature. Temperature may be regulated for several hours with a monitor attached to the chest skin. A rectal temperature may be taken to check for a patent anus. After any examinations, the infant will be swaddled in several layers of receiving blankets, a cap will be placed on the head to further reduce loss of body heat, and the newborn is placed in a bassinet either on its side, with a rolled blanket behind the back to prevent tipping, or on its back. To prevent sudden infant death syndrome (SIDS), infants should not be placed on their **stomach**.

Most insurance plans allow hospital stays of only 48 hours after an uncomplicated vaginal delivery, so much takes place within that time. Twenty-four to seventy-two hours after the neonate's first intake of protein her blood is checked via a heel-stick for the presence of phenylketonuria (PKU), a protein **metabolism** disorder that requires strict nutritional guidelines for treatment to avoid **central nervous system** (CNS) damage. Neonates whose mothers had **gestational diabetes** will have their blood sugar monitored in the nursery. During the second day of life the infant will have a detailed physical assessment done cephalocaudal (head-to-toe). The normal ranges for this will be discussed in the Results section. Parents who wish to have their male infants circumcised in the hospital will make those arrangements. The nursery nurses will monitor the circumcised infant for any signs of infection or abnormal bleeding.

Hospitals may differ in terms of how much time the infant spends with the mother in her room. The aim is for a balance between the mother's need for rest to ensure more rapid healing, the need for the parents and baby to form a strong bond, and the safety of the infant if unattended. Most hospitals bring the breast-feeding infant to the mother on demand. Formula-fed babies may spend more time in the nursery with staff feeding the baby, if the mother needs more rest time after a difficult delivery.



A newborn girl receives a bath. (Photograph by James Stevenson. Science Source/Photo Researchers. Reproduced by permission.)

In July 1999 the Centers for Disease Control (CDC) determined that hepatitis B immunizations, which had been routinely given to newborns, should no longer be administered to neonates until the preservative thimerosal is removed from vaccines. Since thimerosal is derived from ethylmercury, and even though there is no evidence that exposure to low levels of thimerosal is harmful, concerns about the exposure to mercury compounds led to the decision as a precautionary measure.

Results

The clamping of the umbilical cord signals the neonate's abrupt transition from intrauterine to extrauterine life. *In utero* the fetus's blood was oxygenated through the placenta and the mother's circulation. Now the neonate's lungs must take over. With the first breath, the lungs expand and create a pressure difference in the chest, pulmonary artery and heart. This leads to the closing of the *ductus arteriosus* and the *foramen ovale*. The blood flow through the cord stops and any blood within the cord will clot, causing the vessels to dry out, allowing the cord to fall off within about 10 days. Assessment of the cord area can be done with each diaper change.

The cord site should remain dry, with no evidence of redness, bleeding or discharge.

Infants born by cesarian section do not have the force of the birth canal pushing amniotic fluid out of the lungs. Because of this, some infants may have some initial difficulty with respirations, due to the excess of fluid still remaining in their lungs.

During the first hour after birth, the neonate is very alert. He or she may be interested in nursing, or may spend time just gazing at the mother or parents. The initial breastfeeding establishes the neonate's ability to coordinate breathing, sucking and swallowing.

Variability is normal in the newborn, so pulse and respirations should be monitored for an entire minute. If abnormal values are noted, yet the infant does not appear in distress, wait a minute or two and then recheck. Normal values for the neonate include:

- Apical pulse (recorded over the heart) between 120 and 160. The sleeping newborn may have a pulse of 100, the crying infant may have a pulse of 180. Rates below 100 and above 180 should be investigated.

- Respirations range from 30 to 60 breaths per minute. Infants are nose-breathers, so a clear nasal passage is critical. Poor breastfeeding position can block the nose and requires repositioning. Respirations can be counted by watching the abdomen move up and down. While short periods of crying can be beneficial in bringing more oxygen into the lungs, long periods of crying exhausts the neonate's **cardiovascular system** and should be avoided.
- The average weight of a newborn is 7.5 pounds (3.4 kg), with a normal range of 5.5 to 8.5 (2.5-3.8 kg). A weight above 10 pounds (4.5 kg) may indicate that the mother had gestational diabetes. The average length of the newborn is 20-21 inches (50-53 cm) long.
- Initially, the newborn is very sensitive to temperature changes, as her ability to regulate her temperature is not yet well developed. A normal rectal temperature ranges from 97.8-99°F (36.5-37.2°C). A newborn experiencing heat loss will increase his or her respirations.
- Within the first 24 hours, the newborn should void and pass meconium, a sticky, tar-like first stool. The neonate does not take in a great deal within the first few days, but intake and output should increase after the first few days. Bowel sounds are present.

A head-to-toe assessment is usually done without the parents present, but can be very helpful if done in front of the first-time parent for reassurance. The head will appear large in relation to the body. Average head circumference is about 13.5–14 inches (34–35 cm) in diameter. A circumference of less than 33 cm or greater than 37 cm may indicate a neurological abnormality and warrants further evaluation. The head of a baby born vaginally may look misshapen at first. This is called molding. The baby's **skull** allows for movement so that it can pass through the birth canal. Within a few days it takes on its normal shape. Infants delivered with the help of forceps or vacuum aspiration may have bruising on the head, or even a cephalhematoma. Cephalhematoma is a collection of blood under the scalp, such as can result from **blood vessels** that have ruptured during birth. It does not cross the midline of the skull. Caput succedaneum is an area of **edema** under the scalp. It may cross the midline. These will resolve over time, although the increased amount of blood being processed from the cephalhematoma may result in jaundice. Infants born by cesarian delivery have normally shaped heads right at birth if it is a scheduled caesarian delivery. If the mother has been in prolonged labor and a caesarian delivery is deemed necessary, the newborn's head may still be molded. Newborns may have a full head of hair, although most often falls out during the first month. The two soft spots on top of the head are called fontanels. The anterior fontanel should close after

12 to 18 months; the smaller, posterior fontanel should close by the third month. A bulging fontanel in a quiet infant indicates increased intracranial pressure. A depressed fontanel indicates **dehydration**. It is normal to be able to feel the pulsing of each heart contraction at the anterior fontanel. The eyes and ears should be in good proportion. Low-set ears indicate a chromosomal abnormality, such as trisomy 13 or 18. The nose, which is large at this age for the face, may have little white dots called milia. These are blocked sebaceous glands, and will disappear in a few weeks. These should not be squeezed or scratched, to avoid creating a portal for infection. The mouth should have an intact palate. Small round dots may be present and are called *Epstein pearls*. They are a form of **calcium** deposit and will disappear. Parents may confuse them with white patches of thrush, which is a *Candida* infection.

Newborn skin may be somewhat mottled, and early acrocyanosis in the hands and feet is common. Central cyanosis in the trunk should be investigated, as it indicates decreased oxygenation. Jaundice that sets in after the first 24 hours is common, but the bilirubin level should be closely monitored if the jaundice travels below the nipple line. Birthmarks, or hemangiomas, are common. Some are flat and reddish-purple in color. They may fade or disappear over time, but some larger ones may remain. Laser treatment in later life is becoming more common to remove those marks that are large or prominent enough to interfere with an individual's self-esteem. Raised, cavernous hemangiomas may indicate similar lesions on internal organs which can rupture and bleed with a blow to the child's abdomen. Mongolian spots are gray-purple-blue patches seen on children of Asian, Mediterranean, or African descent. They can resemble bruises, and are usually found on the buttocks and sacrum.

Newborns may be covered in *vernix caseosa*, a waxy substance that acts as a skin lubricant. It is especially noticeable in skin folds. Babies born post-dates (over 40 weeks) have very dry skin and may have cracks in the skin folds. The color of the vernix is an indicator of intrauterine life. It may be green-tinged, indicating the presence of meconium in the amniotic fluid. Yellow vernix indicates bilirubin. Lanugo is a fine, downy hair that may cover the shoulders, back, and upper arms. **Premature infants** have more lanugo; post-dates infants usually have none at all. The neonate's skin is sensitive and may respond to washing products with a rash.

The hormones circulating in the mother are passed into the fetus. Newborns may have enlarged genitalia in response to the circulating maternal hormones. Female neonates may have some white or blood-tinged discharge

KEY TERMS

Acrocyanosis—The slight cyanosis of the hands and feet of the neonate is considered normal and is due to an immature circulatory system which is still in flux.

Ductus arteriosus—The ductus arteriosus is a vessel connecting the pulmonary artery to the aorta in the fetus. After birth, this begins to constrict and the neonate's blood now leaves the heart via the pulmonary artery, going into the lungs to be oxygenated. Once fully constricted, it becomes a ligament.

Foramen ovale—The foramen ovale is a fetal cardiac structure that allows the blood in both upper chambers (atria) of the heart to mix. After birth, the pressure rises in the left atrium pushing this opening closed, allowing the heart to function in a two-sided fashion: the right side carries the unoxygenated blood to the lungs, and the left side pumps the oxygenated blood out into the body.

Trendelenburg—In the Trendelenburg position the body is at a slant with the head below the heart. For suctioning purposes, the neonate is placed in a slight Trendelenburg position, of about 10 degrees. This allows the force of gravity to assist in expelling amniotic fluid and mucus.

from the vagina for a week or so after birth. There should be no evidence of trauma, however.

The neonate is able to move her arms and legs symmetrically. Lack of movement or limpness indicates an injury and needs careful evaluation. A broken clavicle may be the result of a difficult birth, but should heal to full movement. The examiner will check for extra digits, or fused/webbed digits. The legs are normally bowed at this time, and will straighten with growth. Feet may appear twisted, due to a long-held intrauterine position. If they can be easily brought into alignment, this will usually revert to normal with growth and weight bearing. A foot that does not come into alignment may indicate talipes, or clubfoot. Early treatment brings the best success. The hips are checked for symmetrical abduction. Clicking heard during examination may indicate subluxation, and treatment is usually begun right away.

Neonatal **reflexes** are checked to assess for any neuromuscular abnormalities. Intact reflexes provide a safety/survival mechanism for the newborn. These reflexes include:

- **Rooting**; present from birth until about six weeks of age. To elicit the reflex, stroke the corner of the mouth. The neonate should turn his head in that direction. This reflex assists the infant in finding the breast.
- **Sucking**; from birth until about six months of age. Touching the lips begins the sucking reflex. When the lips are touched by the breast or bottle nipple, the infant begins to suck, taking in nourishment.
- **Swallowing**; as food reaches the back of the tongue, the swallowing reflex is elicited and the food is swallowed.
- **Palmar grasp**; disappears by three months of age. Placing an object, such as a finger, into the neonate's palm elicits this reflex. The infant will grasp tightly onto whatever has been placed into her hand.
- **Stepping**; present from birth until about three months of age. Hold the infant upright with his feet just touching a flat surface. The infant will take small weight-bearing "steps." These are not true steps, and the infant must be fully supported.
- **Babinski**; present until about three months of age. To elicit the response, stroke the sole of the neonate's foot, starting at the heel. The newborn will curl and fan his toes upward and outward. Once the reflex disappears, the same motion should cause the toes to flex, as in the neurologically intact adult.
- **Moro**; strongest from birth through two months of age, then fades until it disappears around the fifth month. This is a startle reflex, so evaluation is done somewhat gently. One method is for the examiner to clap her hands near the newborn, but out of eyesight. Another method is to hold the infant above a padded mat, then either let the head fall backwards by an inch or so, or quickly lower the infant's body towards the mat. This gives the infant a sense of falling. The reflex action is for the neonate to first extend both arms and legs, then to pull his legs up towards his abdomen while making the shape of a "C" with his fingers. For some very sensitive infants, walking quickly down the stairs may elicit this response. Such infants may feel more comforted being swaddled.

A neonate's **hearing** and **vision** will be assessed. The fetus is able to hear inside the uterus, and after birth it will clearly respond to the voices of the mother and father but may ignore unfamiliar voices. The neonate focuses best on an object 9-12 inches (23-30 cm) away. This is approximately the distance between its face and the face of the mother when held in a breastfeeding position. There should be no redness or drainage from the eye on inspection. The blink reflex should be intact, elicited by briefly shining a bright light at the eye. Depending on the birthing position, there may be edema around the eye,

although this fluid should reabsorb in a few days after birth.

Health care team roles

At birth, the physician or nurse-midwife is in attendance, along with the labor and delivery nurse. If the fetus has been in distress, a neonatologist may also be present. After birth the newborn is handed to the nurse who begins the drying off of the newborn, and addresses the other issues mentioned above. Nurses perform the neonatal care tasks discussed above in the nursery. Blood drawn from the neonate's heel is usually done by the nursery nurse, and then sent to the laboratory for processing by the laboratory technicians. In some hospitals nurses may care for both the newborn and the mother as a unit. Nurses provide all the necessary teaching provided to the new mother.

Neonatal care continues through about the fourth week after birth. During this time the infant and mother may receive a home nursing visit to ensure that breastfeeding is well established, that no jaundice is present in the neonate, and that the mother is healing well from the delivery. At the follow-up office visit, the nurse or medical assistant will weigh and measure the length of the infant.

Patient education

Parent education, especially for the first-time parent is extremely important. Nurses or nurse-midwives will provide breastfeeding and postpartum teaching for the mother, as well as explaining the care needed for the newborn. This may include cord care, normal number of daily feedings and diapers, how to determine the presence of jaundice, how and when to bathe the infant, as well as answer any questions the new parents may have. A follow-up appointment is usually established before the infant leaves the hospital. The nurse will often be the one to ensure that a car seat is present and properly installed in the car before allowing the mother and baby to leave the hospital, as mandated by state law. Nurses also provide information when parents call with questions to the doctor's office.

Resources

BOOKS

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ORGANIZATIONS

The American Academy of Pediatrics. 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. <<http://www.aap.org>>.

Medscape, Inc. 20500 NW Evergreen Parkway, Hillsboro, OR 97124. (503) 531-7000. <<http://www.medscape.com>>.

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Neonatal jaundice

Definition

Neonatal **jaundice** and hyperbilirubinemia are terms used when a newborn has a higher-than-normal level of bilirubin in the **blood**. Bilirubin is an end-product of the breakdown of the hemoglobin present in the red blood cells at the end of their life cycle. Hemoglobin carries oxygen to tissues and cells. Before birth the placenta is not as efficient in providing oxygen as the baby's **lungs** will be after birth. Because of this, infants *in utero* have more red blood cells than they will need after birth to provide enough oxygen. Therefore, newborns have an excess of red blood cells that they need to process, and an immature **liver** with which to complete the job. Jaundice refers to the yellow discoloration of the skin and sclera (whites) of the eyes, which results as the breakdown of bilirubin goes faster than the rate at which it can leave the body, causing its level to rise in the blood.



A newborn receives home health care to treat jaundice with bilirubin lights. (Photograph by Cindy Roesinger, Photo Researchers, Inc. Reproduced by permission.)

Description

When the fetus is *in utero*, bilirubin is processed through the placenta and the maternal-fetal circulation. After birth, the infant's often-immature liver must take over this task. Clinical jaundice (serum bilirubin levels of 5-7 mg/dL and above) occurs in about 60-70% of term newborns, and about 80% of **premature infants**. Ever since hospital stays after delivery decreased to 24-48 hours postpartum, hyperbilirubinemia has become the leading cause of hospital readmissions in the first two weeks of life. The greatest concern with hyperbilirubinemia is that the unexcreted bilirubin will begin to deposit in the **brain** of the neonate, resulting in a serious, potentially life-threatening condition called kernicterus. Another term used for kernicterus is brain encephalopathy.

Causes and symptoms

An elevated bilirubin level may be due to its increased production, a decreased rate of conjugation, or abnormalities of the liver. In order for the bilirubin to be excreted in the urine and stool, it must be converted, or conjugated from a fat- or lipid-soluble form to a water-soluble form. Bilirubin that has not been excreted can be reabsorbed and contributes to increased blood levels.

Initial symptoms of a rising bilirubin level can be subtle, and usually include increased drowsiness, which leads to poor feeding, and the subsequent decreased urine and stool output. The diaper may contain orange spots, an indication of the presence of uric acid crystals, a sign of **dehydration**. A change in the infant's cry to a high-pitched tone may indicate early neurological damage.

There are several types of jaundice. The most common form of neonatal jaundice appears between the first

24-72 hours after birth and is usually considered a benign form. It is often referred to as early-onset breast milk jaundice, and is related to insufficient breastfeeding, which results in decreased nutritional intake and decreased stooling. With decreased stooling the bilirubin in the stool is not being excreted, and is also available for reabsorption. Increasing the feedings from six to 12 times a day, and checking for latching-on and a good suck and swallow pattern, can lead to a decreasing bilirubin level to within normal limits. To encourage adequate maternal milk production, supplementation with water or glucose is discouraged.

Late-onset breast milk jaundice may occur in 10-30% of breast-fed infants and appears in the second to sixth weeks of life. This form of jaundice is believed to be related to a substance present in the mother's milk that affects the infant's absorption of bilirubin.

Jaundice that sets in within the first 24 hours after birth is usually due to an **Rh factor** or ABO blood incompatibility between the mother and infant.

Risk factors for the development of hyperbilirubinemia include:

- premature birth
- Asian and Native American descent—including more rapid rise and higher peak levels of bilirubin
- maternal diabetes
- hemolytic disease in the neonate
- sepsis
- family history of jaundice
- presence of excessive bruising due to traumatic birth, and cephalhematoma
- oxytocin-induced delivery
- mother's use of sulfa medications during **pregnancy**
- history of familial liver disease
- delayed cord clamping
- thyroid gland abnormalities
- G6PD (glucose-6-phosphate dehydrogenase) deficiency

Diagnosis

Diagnosis of hyperbilirubinemia usually begins with the observation of jaundice at the time of **physical examination**. However, a delay in recognition of jaundice may occur since many infants have already gone home prior to its onset. Pediatric practices vary as to times of follow-up after hospital discharge. Parents may call their pediatric care provider's office because of jaundice, or because of a decreased ability of the infant to

feed. Examination of the infant is best done next to a window so that the jaundice can be assessed in natural light. Blood tests to check the bilirubin level, blood type, and for signs of dehydration will usually be ordered.

Treatment

Treatment is primarily focused on decreasing the bilirubin level to prevent the progression of the condition to kernicterus. In kernicterus, the bilirubin deposits in the brain. This leads to **central nervous system** damage, and can progress to **hearing loss**, seizures, and death.

Phototherapy

For many infants, increasing breastfeeding will be sufficient to bring about adequate hydration and an increase in gastric motility and stooling, so that the bilirubin is effectively excreted from the body. Some infants may need the additional assistance of **phototherapy**. The light source most effective in treating hyperbilirubinemia occurs in the blue-green spectrum. Phototherapy may be provided in the hospital. In the hospital the infant is usually placed in a special bassinet, with an overhead light source. The skin is uncovered, exposing as much surface area to the light. The infant's eyes and genitals are usually shielded from direct light and heat, depending on the intensity of the light. If the bilirubin level is under about 15–20 mg/dL, phototherapy may be administered via a fiberoptic source referred to as a blanket or belt in the home. The home unit is designed to encourage parent-infant bonding. The blanket/belt wraps around the infant's bare middle so that the cool light source is next to the skin. There is no need to shield the eyes from the light, and parents can hold, feed and interact with the infant as usual. Most insurance companies cover the cost of the home rental for the phototherapy equipment and the accompanying daily home nursing visits.

In 1994 the American Academy of Pediatrics (AAP) developed guidelines for care and management of neonatal jaundice. As of March 2001 these guidelines were being reviewed, but the 1994 guidelines remain in effect. In studies where experienced pediatric practitioners evaluated the same infants for jaundice, considerable discrepancies existed. Despite all the research done in this area, there are no consistent predictors of which infants will continue from benign jaundice to kernicterus. Research studies express concern over finding a balance between treating those that need treatment, without treating well infants unnecessarily.

KEY TERMS

Bilirubin—A yellowish-brown substance in the blood that forms as old red blood cells are broken down.

Jaundice—The yellow discoloration of the skin and sclera of the eyes as a result of poor liver function.

Kernicterus—A serious condition in which bilirubin deposits in the brain leading to permanent neurological damage and potentially death.

Prognosis

Jaundice addressed in its early stages rarely progresses to kernicterus, and therefore the prognosis for complete resolution of the problem is excellent. Phototherapy is extremely effective in bringing down the bilirubin levels. Some extreme cases may require a blood transfusion, but those situations are relatively rare. Infants who do develop kernicterus may continue to have long-term neurological effects present if the kernicterus was well established at the time of initiation of treatment.

Health care team roles

The nurse may participate in the care of the infant in the hospital nursery, where he or she may be the first to notice the jaundice. The nurse may also be the one to take the parent's call about the jaundice in the pediatric care provider's office. In the home setting, the nurse's role involves daily visits to the home for infant assessment and blood draws via a heel stick for bilirubin evaluation, parent teaching on bottle or breastfeeding and neonatal and postpartum issues. The nurse should inform the parents that phototherapy increases the baby's **metabolism**, resulting in increased output to clear the bilirubin. This means that the infant will require more feedings to compensate for the fluids lost. The nurse should also inform the parents that the stool containing bilirubin may be more loose than usual and of a greenish color. Some pediatric practices may have the parents bring the infant into the laboratory where the technician would be the one to draw the infant's blood for bilirubin evaluation. Heel sticks on an infant can be difficult when the infant is dehydrated. Ways to facilitate a more successful blood draw include:

- Use of a heel warmer to increase circulation to the foot.
- Having a parent hold the infant in a seated position so that the foot is below the level of the heart.
- Having the parent feed the infant prior to the lab visit.

Prevention

Primary prevention begins with addressing the risk factors mentioned above. Prevention of kernicterus requires early detection, monitoring and potential treatment of jaundice with rising bilirubin levels. Frequent feedings of ten or more per day help to ensure adequate hydration, **nutrition**, gastric motility, and stool and urine output.

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Esther Csapo Rastegari, R.N., B.S.N., Ed.M.

Neonatal respiratory care

Definition

Respiratory care of the newborn is the systematic process by which health care providers ensure consistent

and appropriate oxygenation levels through assessment and therapeutic intervention.

Purpose

Adequate respiratory function is of utmost importance in newborn care and must be assessed frequently.

Precautions

Health care providers should practice **universal precautions** when caring for newborns.

Description

Respiratory care is guided by the Apgar score which is obtained at one minute and five minutes after birth through observation of the newborn. The caregiver assesses the newborn for **heart** rate, respiratory effort, muscle tone, reflex irritability, and color. The newborn receives scores of 0, 1, or 2 for each category and all five scores are added together. An infant scoring less than 4 is in grave danger and requires immediate resuscitation. A score of 4 to 6 indicates that the newborn's condition is serious and that the baby may require clearing of the airway and **oxygen therapy**. A score of 7 to 10 indicates that the infant is doing well. The highest score a newborn can receive is 10.

Respiratory care of the newborn can be separated into two general categories: care of the healthy, term newborn and care of the high-risk newborn.

Respiratory care of the healthy, term newborn

RESPIRATORY EFFORT. A healthy, term newborn generally releases a lusty, spontaneous cry within 30 seconds after delivery. By one minute, the newborn normally maintains regular, but often rapid respirations. If the mother received large amounts of narcotic analgesia or a general anesthetic in labor or birth the baby's respirations might be depressed. The administration of a medication to counter this effect, such as naloxone (Narcan) may be indicated.

The newborn should be able to maintain a clear airway with little assistance and should have a respiratory rate of 30 to 60 breaths per minute. Physical signs of respiratory distress are retractions (the skin is pulling against the ribs), nasal flaring, and grunting. The **lungs** should sound clear when listened to with a **stethoscope** (auscultated).

Care of the normal newborn's respiratory status includes the following actions:



Newborns commonly have some amniotic fluid in their lungs, and it may need to be removed with suction through an endotracheal tube. (Photograph by David Nunuk. Science Source/Photo Researchers. Reproduced by permission.)

- Assess the baby's respiratory rate every 15 minutes for 1 hour. Observe for an increase in respiratory rate, the development of retractions, nasal flaring, or grunting.
- Position the newborn with the head down and on one side to aid in the drainage of secretions from the respiratory tract.
- Suction the baby's mouth first with a bulb syringe and then the nose. Suctioning the nose before the mouth can induce the aspiration of secretions through the mouth.
- Frequently change the baby's position to encourage the drainage of secretions thereby helping the lungs to aerate and expand.
- Keep the baby warm either by wrapping loosely with a blanket and placing a hat on the baby's head or by placing the baby under a radiant warmer. Check the baby's temperature frequently at first. A cold baby experiences an increase in metabolic rate that raises oxygen requirements resulting in a more rapid respiratory rate.

Respiratory care of a high-risk newborn

The high-risk newborn may be premature, may have a congenital condition, or may have experienced some

degree of asphyxia in utero from compression of the umbilical cord, maternal anesthesia or analgesia, **placenta previa**, or a partial separation of the placenta. The manner in which the first few moments of life are managed will determine the eventual outcome for the high-risk newborn. It is imperative that respirations are established within two minutes of birth or severe respiratory acidosis may develop that is difficult to reverse. Any baby that does not take a first breath or has difficulty breathing adequately requires resuscitative intervention.

Resuscitation of the newborn consists of three sequential steps:

ESTABLISHING AN AIRWAY. If the baby does not initiate spontaneous respirations, suction the mouth and nose with a bulb syringe. Stimulating the skin by rubbing the baby's back may initiate breathing. If the baby's skin color is not pink, hold an oxygen tube with warmed oxygen by the baby's nose or provide oxygen by face mask. If these interventions are ineffective, administer oxygen by a positive pressure bag and mask.

EXPANDING THE LUNGS. A baby who cannot sustain effective breathing may need oxygen via bag and mask. The mask should cover the mouth and the nose but

KEY TERMS

Acidosis—An abnormal pH of the blood characterized by reduced alkalinity.

Asphyxia—A deficiency of oxygen or state of carbon dioxide over-saturation within the body.

Meconium—The substance that forms in the baby's intestines starting at 16 weeks gestation. It is black or dark green. A physiological response can trigger the release of meconium in utero when the baby experiences a decrease in oxygenation. At birth, if the baby has meconium-stained amniotic fluid, he or she is at risk of aspirating the meconium into the lungs.

Naloxone (Narcan)—Pure narcotic antagonist; administered intravenously to counter the respiratory depression effects of opioid narcotic agents.

Placenta previa—A low implantation of the placenta on the uterus that may occlude the cervix resulting in complications during labor and delivery.

should not cover the eyes. The bag and mask deliver 100% oxygen and are compressed at a rate of 40 to 60 compressions per minute until the baby breathes spontaneously.

If the baby's Apgar score remains low, deeper suctioning with a suction catheter may be required. Position the infant on his or her back and place a folded towel beneath the baby's shoulders. Pass a catheter above the infant's tongue to the rear of the throat and suction for no longer than 10 seconds. A baby who initiates no respiratory effort is likely to require immediate placement of an endotracheal tube into the airway through a technique called intubation. The instrument used to open the airway so that the endotracheal tube can be placed in the airway is called a laryngoscope. After placement of the endotracheal tube, deeper suctioning of the trachea through the endotracheal tube is possible. A pressure bag can then be attached to the endotracheal tube and deliver 100% oxygen. The bag is compressed 40 to 60 times a minute.

If the amniotic fluid was meconium-stained, stimulation of the baby's breathing by rubbing the back or the administration of oxygen under pressure could cause the infant to aspirate meconium into the lungs. Instead, only provide oxygen therapy by mask without pressure. Passing a laryngoscope and suctioning the trachea should remove the meconium. Then tactile stimulation and oxygen therapy under pressure can be initiated.

MAINTAINING EFFECTIVE VENTILATION. All newborns, particularly those who encountered respiratory problems at birth, should be carefully assessed for several hours after birth. It is also of utmost importance to keep the baby warm. If the baby continues to produce copious secretions from the respiratory tract he or she should be suctioned out with a catheter or bulb syringe. If the baby is intubated, preventing with a bag means suctioning can be performed through the endotracheal tube. If the baby's respiratory status remains critical, administration of pressure and oxygen via a ventilator or by continuous positive airway pressure (CPAP) may be necessary.

Preparation

It is essential that a well stocked area for infant resuscitation be maintained and frequently checked. Necessary equipment includes oxygen; various sized laryngoscopes and endotracheal tubes for preterm to large infants; suction catheters of different sizes; bulb syringes; and blankets. Supplies are usually placed alongside a radiant warmer.

Health care team roles

Nurses, respiratory therapists, and physicians should become certified in neonatal resuscitation. Health care practitioners who are trained to intubate with a laryngoscope include: obstetricians, midwives, pediatricians, neonatologists, anesthesiologists, and neonatal nurse practitioners. At least one person who can intubate an infant should be present at every delivery of a high-risk infant.

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Nephrostomy tube care

Definition

A percutaneous nephrostomy tube (PNT) is a urinary diversion system comprised of a collection bag, a

nephrostomy tube at an exit site (usually in the skin over the flank area), and a nephrostomy tube that enters and ends in the renal pelvis of the kidney. This allows for direct drainage of urine from the kidney when normal urinary flow is impeded. The PNT is most often used for a urinary obstruction such as a calculus.

Purpose

The purpose of PNT care is to prevent complications when a PNT is in use.

Precautions

Aspiration of fluid from the nephrostomy tube is prohibited as such action will damage the renal pelvis. Gravity drainage is used to collect specimens, and the nurse should never use force when irrigating the tube. A tube should never be irrigated with more than 5 ml of solution, since the capacity of the renal pelvis is between 4 and 8 ml. The nurse must avoid dislodging the tube while removing the dressing.

Preparation

The nurse should wash hands prior to beginning the procedure, then assemble all of the following equipment:

- disposable underpad
- clean gloves
- measuring tape
- sterile gloves
- sterile cotton tip applicators (4)
- sterile 0.9% NaCl or povidone-iodine solution or sponges
- sterile 4x4 pad or transparent dressing
- sterile 2x2 pads
- tape
- pouch belt

Description

The nurse should provide privacy for the patient in preparation for the procedure. He or she should position the patient on the side opposite the tube site with the nephrostomy site up. This provides better viewing of the tube and allows an easier dressing change.

The nurse should put on clean gloves and place a disposable underpad beneath to the patient to absorb any drainage. To minimize tension at the site and to prevent dislodging, the nephrostomy tube should be anchored with a small piece of tape. The collection bag must be

emptied. The old dressing can be removed by carefully loosening the edges, and then moving to the center of dressing. Care should be taken to avoid dislodging the tube while removing the dressing. A sterile cotton-tip applicator placed on the catheter will help stabilize the catheter while removing the dressing. The site is then assessed for signs of **infection**, any moisture, or other drainage. The PNT is then measured from exit site to tip. If the PNT length is longer than the measurement at time of insertion, the catheter may have migrated out, and the physician should be notified at that point. The nurse should remove the soiled gloves at this time and replace with sterile ones. The exit site should be cleansed with the agent of choice (0.9% saline or povidone-iodine solution), using sterile 2x2 pads. Each pad can only be used once. Cleansing should start at the exit site and work outward in a circular motion; this action should be repeated twice. If there is any crusted matter at the site, this must be loosened and removed by using a cotton-tip applicator moistened with 0.9% saline. Then, sterile dressing should be applied. After removing the old tape, the tube must be secured with new tape to the skin below the dressing, approximately 2.5 inches (6.5 cm) from the exit site. The patient will need to be assisted in the application of the pouch belt. Anchoring the PNT with tape reduces trauma and minimizes the possibility of dislodging or kinking the tubing; adding the belt further secures the PNT. The nurse may remove gloves at this point and wash hands. The patient's dressing needs to be dated and initialed, and will need to be changed daily, or more often if necessary.

Aftercare

The used equipment needs to be disposed of properly. Upon completion of the procedure, the nurse should again wash hands. Then the nurse will need to document observations and the techniques used, including the assessment of the site, the external catheter length, the type of dressing applied, and the devices used to secure the PNT.

Complications

There is an increased risk of infection because the PNT provides a direct pathway to the kidney. There is also a risk for dislodging the PNT during this procedure.

Patient education

The patient may shower 48 hours post-insertion. The patient should be given all of the following instructions:

- Cover the dressing and exit site with a waterproof covering before showering.
- Empty the collection bag prior to showering.

KEY TERMS

Calculus—A stone, often composed of mineral salts.

Nephrostomy—Formation of an artificial fistula into the renal pelvis.

- Securely tape the PNT at the exit site and use a belt for the collection bag in the shower to prevent tube migration.
- Generally, after 14 days, if there are no complications, the site may be left uncovered when showering.

The patient should notify the doctor if any problems arise such as:

- signs of infection at the exit site of the PNT, including warmth, redness, swelling, tenderness, and discharge
- drainage from the PNT
- decreased urine output
- inability to flush the PNT
- presence of any bleeding, clots, stones, sediment, and odor
- incontinence or inadequate bladder emptying
- inadequate **pain** control, nausea, or vomiting
- fever
- accidental dislodgement of the PNT, or suspected migration of the PNT

Results

The site should not display any signs of infection. PNT measurement should be consistent with the baseline value. Abnormal findings are signs of infection, suspected migration, or a dislodged PNT. In the collection bag, any bleeding, clots, stones, sediment, and odor are all abnormal findings.

Health care team roles

Registered nurses (RNs) and licensed practical nurses (LPNs) may perform this procedure. After returning home, the patient may simply cleanse the insertion site with soap and water, and change the dressing daily. In an inpatient setting, an **aseptic technique** must be maintained.

Nurses are responsible for:

- dressing changes

- proper disposal of equipment
- documentation of the procedure
- **patient education**

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Maggie Boleyn, R.N., B.S.N.

Nerve conduction velocity testing see
Electromyography

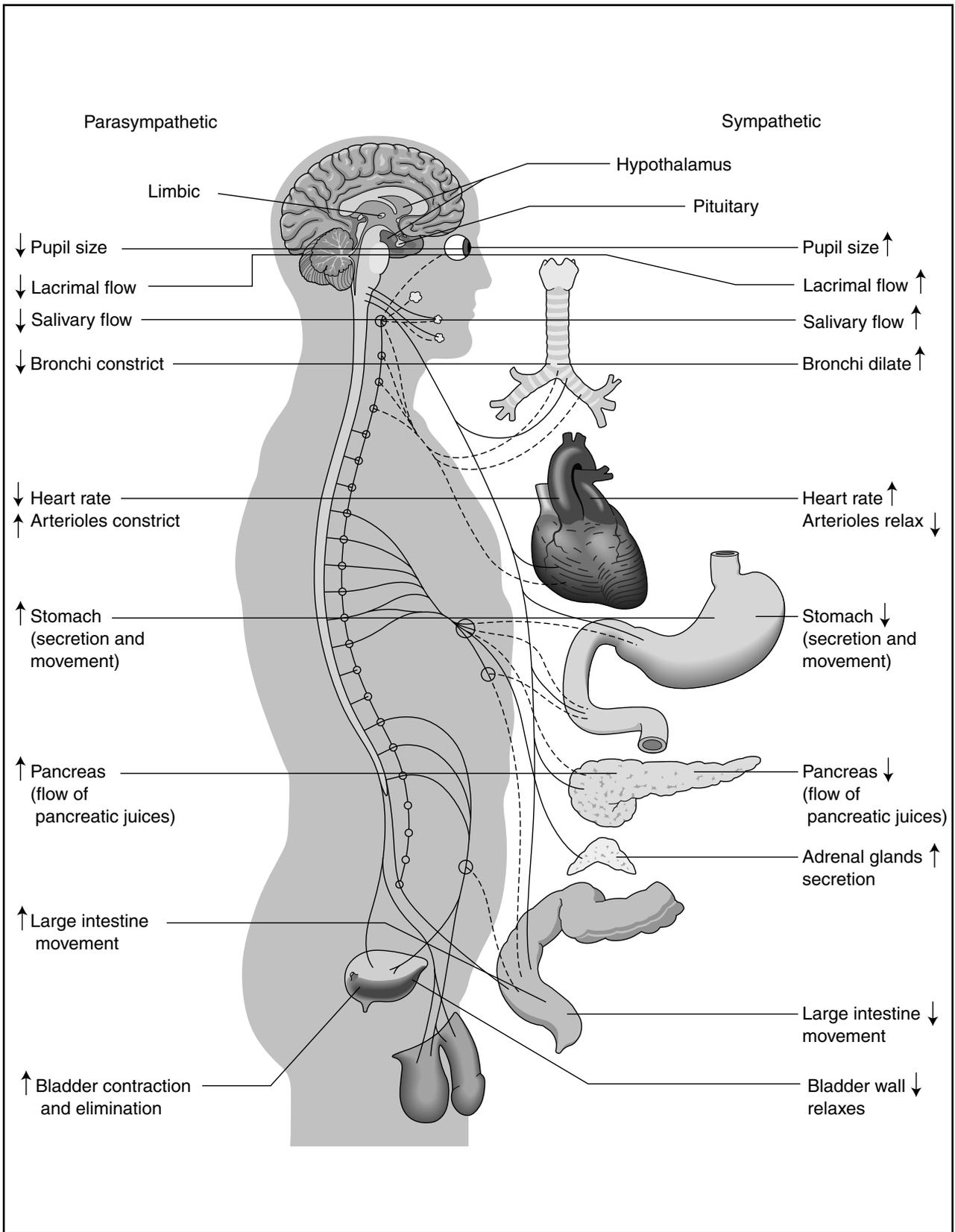
Nervous system, autonomic

Definition

The autonomic nervous system is a network of nerves that regulate involuntary control of cardiac muscle, organ smooth muscle, and glands such that basic biological processes such as digestion and breathing can occur without conscious thought.

Description

The peripheral nervous system consists of nerves that must travel outside of the **brain** and **spinal cord** in order to contact organs, glands, and muscles. Under the umbrella of the peripheral nervous system are the somatic and autonomic nervous systems. The **somatic nervous system** is responsible for controlling voluntary movements during activities such as walking while the autonomic nervous system regulates involuntary tasks such as food digestion. More specifically, the somatic division mediates voluntary or reflexive control of **skele-**



The autonomic nervous system (ANS). (Delmar Publishers, Inc. Reproduced by permission.)

tal muscles while the autonomic nervous system is responsible for the involuntary and reflexive control of glands, organ smooth muscle, and cardiac muscle.

The autonomic nervous system has three components:

- sympathetic nervous system
- parasympathetic nervous system
- enteric nervous system

The enteric nervous system is the less common of the three and is responsible for coordinating the digestive functions of the gastrointestinal tract, **pancreas**, and gall bladder. The two other subdivisions of the autonomic nervous system, parasympathetic and sympathetic, work in concert to subconsciously control other bodily functions, such as **heart** rate, **blood pressure**, digestion, **metabolism**, reproduction, breathing, excretion, sweating, and temperature.

The parasympathetic and sympathetic divisions have similar organizations but are distinguishable at the anatomical, biochemical, and functional levels. Both systems are organized into a two-neuron chain. The first neuron in this chain is referred to as a preganglionic neuron and the second as a postganglionic neuron. The nucleus containing cell bodies of preganglionic **neurons** are found in the brain and spinal cord of the **central nervous system**. The preganglionic neuron extends a fiber process, known as an axon, outside of the central nervous system to make contact with the cell body of the postganglionic neuron. The place where the axon of the preganglionic neuron meets the cell body of the postganglionic neuron is called a synapse. The synapses of the autonomic nervous system are outside of the brain and spinal cord of the central nervous system in specialized structures known as autonomic ganglia.

The preganglionic neurons of the parasympathetic nervous system originate in the brainstem and sacral spinal cord. These preganglionic neurons communicate with postganglionic neurons by extending very long axons that release the neurotransmitter, acetylcholine. The synapses of the parasympathetic ganglia are usually in or near the targeted organ. The postganglionic neuron expresses protein receptors on the surface that are capable of responding to acetylcholine. The postganglionic neurons have very short axons that release acetylcholine onto the targeted organ to modulate the intrinsic activity of that particular organ. These organs include the eye, lacrimal gland, salivary gland, heart, bronchi and **lungs**, **small intestine**, **stomach**, **gallbladder**, **liver**, pancreas, **large intestine**, rectum, genitalia, **blood vessels**, and bladder. Each of these targeted organs expresses acetyl-

choline receptors to respond to the parasympathetic nervous system.

The preganglionic neurons of the sympathetic nervous system originate in the thoracic and upper lumbar regions of the spinal cord. These preganglionic neurons send very short axons to synapse in the paravertebral or in the prevertebral ganglia. The paravertebral ganglia lie in close proximity to the spinal cord. The postganglionic neurons of the paravertebral ganglia send axons to the head, trunk, and limb regions. The other organs in the body receive inputs from the prevertebral ganglia which is further away from the spinal cord and closer to the target organ. An exception to organization is the adrenal gland which is directly contacted by preganglionic neurons of sympathetic nervous system. Identical to the parasympathetic nervous system, the preganglionic neurons of the sympathetic nervous system communicate by releasing the neurotransmitter acetylcholine. However, the postganglionic neurons of the sympathetic nervous system differ in that they release norepinephrine onto the targeted organ. An exception to this is in the sweat glands where sympathetic postganglionic neurons release acetylcholine instead of norepinephrine. The target organs of the sympathetic nervous system include many of the same ones as the parasympathetic nervous system.

Function

The autonomic nervous system maintains internal balance (homeostasis) but also enables humans to respond to changes in the environment. This is achieved because the parasympathetic and sympathetic divisions of the systems are antagonistic. The parasympathetic and sympathetic nervous system usually have opposing effects on target organs. The predominate resting tone of an organ is established by either the sympathetic or parasympathetic system. For example, the predominate resting tone of the eye pupil is constriction, maintained by the parasympathetic nervous system. However, a fearful situation may induce pupil dilation, mediated by the sympathetic nervous system. In other words, the autonomic nervous system enables humans to deviate from normal functions to respond to changes in the environment. The parasympathetic nervous system is often referred to as “rest and digest” and the sympathetic nervous system as “fight or flight.”

Each organ has a predominate resting tone that is influenced in a distinct way by the sympathetic and parasympathetic nervous systems. The sympathetic nervous system increases heart rate, while the parasympathetic slows it down. Likewise, the sympathetic system constricts **blood** vessels while the parasympathetic dilates them and therefore both systems influence blood pres-

sure. The sympathetic nervous system reduces motility of the stomach and intestines while the parasympathetic increases motility. Most of the organs and glands controlled by the autonomic nervous system have this dual but opposing mechanism of regulation.

In some situations it is beneficial to override the autonomic nervous system. The postganglionic neurons and the targeted organs express protein receptors that sense and respond to the neurotransmitters acetylcholine and norepinephrine. The practice of autonomic **pharmacology** uses drugs to modify these receptors to override the existing setting. In this manner, dysfunctions such as high blood pressure can be treated and maintained.

Role in human health

The autonomic nervous system has a crucial role in human health because it maintains the internal balance as well as allows the individual to respond to environmental stimuli. Problems can arise when this system is over- or underactive. The role of **stress** on the autonomic nervous system is of serious consequence. The autonomic nervous system is designed to respond to stress but too much stress can lead to abnormal resting organ tones. This is exemplified by heart disease and high blood pressure which can be treated by drugs that block the autonomic nervous system.

Common diseases and disorders

Holmes-Adie's syndrome

This is believed to be a disorder of the autonomic nervous system characterized by loss of the ability to constrict the eye pupil. This syndrome is also referred to as tonic pupil. The presenting patient maintains a dilated pupil and has decreased **reflexes**. The ciliary ganglion, where the parasympathetic pre- and postganglion fibers meet, has been observed to degenerate. This loss of the parasympathetic tone renders the patient unable to constrict the pupil in response to light and nearby objects. The underlying cause is unknown but possibilities include viral infections that induce inflammation of the ciliary ganglion.

Familial dysautonomia

Familial dysautonomia is also referred to as Riley-Day syndrome and is an inherited disorder of the autonomic nervous system. The inheritance is autosomal recessive with widespread prevalence in patients of Ashkenazi Jewish descent. It is characterized by an increase in **pain** sensation, decreased lacrimation, an inability to regulate temperature, excessive sweating, and

KEY TERMS

Acetylcholine—A chemical messenger of the nervous system that is also known as a neurotransmitter.

Norepinephrine—A chemical messenger of the nervous system that is also known as a neurotransmitter.

Parasympathetic—The “rest and digest” division of the autonomic nervous system.

Sympathetic—The “fight or flight” division of the autonomic nervous system.

hypertension. It is usually diagnosed early in life and impairs development. There is evidence that there are a decreased number of sensory and autonomic nervous system neurons. Recently, the gene has been mapped to chromosome 9 and codes for a protein called IKAP. The function of IKAP is unknown, but it is hypothesized to be involved in gene activation mechanisms.

Horner's syndrome

Horner's syndrome is characterized by a lack of sympathetic tone to one side of the face. Therefore, symptoms that present are dropping eyelids, pupil constriction, and dryness to the face. The underlying cause of this is not clear but may originate within the spinal cord due to injury or tumor formation.

Shy-Drager syndrome

Patients with Shy-Drager syndrome have general autonomic nervous system dysfunction as well as parkinsonian like symptoms. The autonomic symptoms included a decrease in blood pressure, orthostatic hypotension, constipation, urinary incontinence, and abnormal sweating. Some patients may also develop irregular heartbeats and have difficulty breathing. The parkinsonian like symptoms included, tremor, slowness of movement, and problems maintaining balance. A key feature of the syndrome is dizziness or fainting due to the inability to maintain blood pressure. The underlying cause of the disease is unknown but neurons in the spinal cord have been observed to degenerate.

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Susan M. Mockus, Ph.D.

Nervous system, somatic

Definition

The somatic nervous system (SNS) is a division of the peripheral nervous system (PNS). The SNS controls voluntary activities, such as movement of **skeletal muscles**. It includes both sensory and motor nerves. Sensory nerves convey nerve impulses from the sense organs to the **central nervous system** (CNS), while motor nerves convey nerve impulses from the CNS to skeletal muscle effectors.

Description

Nervous tissue

All nervous tissue—including that of the SNS—consists of two main cell types: neurons and glial cells. **Neurons** transmit nerve signals and are surrounded by glial cells, that provide mechanical and physical support as well as electrical insulation between neurons.

Neurons

A neuron consists of a cell body, the soma, which contains the nucleus and surrounding cytoplasm, several short thread-like projections, called dendrites, and of one long filament, called the axon. The dendrites receive information from other nearby cells and transmit the signals to the soma and the axon carries signals away from the neuron. Both axons and dendrites are surrounded by a white protective coating called the myelin sheath. The average adult **brain** contains about 100 billion neurons. Neurons are also the longest cells of the body, a single axon can be several feet long. There are two types of neu-

rons found in the SNS: sensory neurons, which typically have long dendrites and short axons, and carry messages from sensory receptors to the CNS, and motor neurons, which have a long axon and short dendrites and transmit signals from the CNS to muscles or glands.

The nervous system

The nervous system of the human body is divided into the central nervous system (CNS), consisting of the **spinal cord** and brain, and the peripheral nervous system (PNS), consisting of all the nerves that connect the CNS with organs, muscles, **blood vessels** and glands. The PNS is subdivided into the somatic nervous system (SNS) and the **autonomic nervous system** (ANS). The ANS is further divided by function into sympathetic and parasympathetic systems.

The somatic nervous system (SNS)

The somatic nervous system (SNS) consists of sensory and motor nerve divisions. The sensory division, also called the afferent division, contains neurons that receive signals from the tendons, joints, skin, skeletal muscles, eyes, nose, ears and tongue, and many other tissues and organs. These signals are conveyed to the cranial and spinal nerves. The motor division, also called the efferent division, contains pathways that go from the brain stem and spinal cord to the lower motor neurons of the cranial and spinal nerves. When these nerves are stimulated, they cause the skeletal muscles to contract. This is called voluntary contraction of the skeletal muscles.

The nerves of the sensory-somatic system are:

THE CRANIAL NERVES (12 PAIRS).

- olfactory nerve, a sensory nerve for the sense of **smell**
- optic nerve, a sensory nerve for **vision**
- oculomotor nerve, a motor nerve for eyelid and eyeball muscle control
- trochlear nerve, a motor nerve for eyeball muscle control
- trigeminal nerve, a mixed nerve, the sensory part for facial and mouth sensation and the motor part for chewing
- abducens nerve, a motor nerve for eyeball movement control
- facial nerve, a mixed nerve, the sensory part for **taste** and the motor part for the control of facial muscles and salivary glands
- auditory nerve, a sensory nerve for **hearing** and balance control

KEY TERMS

Axon—Long filament of a neuron that carries outgoing electrical signals from the cell body towards target cells. Each neuron has one axon, which can be longer than a foot. Neurons communicate with each other by transmitting signals from branches located at the end of their axons. At the end of the axons, nerve impulses are transmitted to other nerve cells or to effector organs.

Brachial plexus—A group of lower neck and upper back spinal nerves supplying the arm, forearm and hand.

Brain stem—Lowest part of the brain that connects with the spinal cord. It is a complicated neural center with several neuronal pathways between the cerebrum, spinal cord, cerebellum, and motor and sensory functions of the head and neck. It consists of the medulla oblongata, the part responsible for cardiac and respiratory control, the midbrain, which is involved in basic, involuntary body functions, and the pons, where some cranial nerves originate.

Central nervous system (CNS)—One of two major divisions of the nervous system. The CNS consists of the brain, the cranial nerves and the spinal cord.

Cranial nerve—In humans, there are 12 cranial nerves. They are connected to the brain stem and basically 'run' the head as well as help regulate the organs of the thoracic and abdominal cavities.

Dendrites—Threadlike extensions of the cytoplasm of a neuron.

Effector—Any molecule, chemical, organ, structure or agent that regulates a pathway by changing the pathway's reaction rate.

Ganglia—A mass of nerve tissue or a group of neurons.

Mechanoreceptors—Receptors specialized to detect mechanical signals and relay that information centrally in the nervous system. Mechanoreceptors include hair cells involved in hearing and balance.

Myelin—The substance making up the protective sheath of nerve axons.

Nervous system—The entire system of nerve tissue in the body. It includes the brain, the brain stem, the spinal cord, the nerves and the ganglia, and is divided into the peripheral nervous system (PNS) and the central nervous system (CNS).

Neurons—Cells of the nervous system. Usually consist of a cell body, the soma, that contains the nucleus and the surrounding cytoplasm; several short thread-like projections (dendrites); and one long filament (the axon)

Neuropathy—A general term describing functional disorders and/or abnormal changes in the peripheral nervous system. If the involvement is in one nerve it is called mononeuropathy, and if in several nerves, mononeuropathy multiplex.

Oculomotor nerve—Cranial nerve responsible for motor enervation of the upper eyelid muscle, the extraocular muscle and the eye pupil muscle.

Parasympathetic nervous system—One of the two divisions of the autonomic nervous system. Parasympathetic nerves emerge from the skull as fibres from the oculomotor, facial, glossopharyngeal and vagus nerves and from the sacral region of the spinal cord.

Peripheral nerves—The nerves outside of the brain and spinal cord, including the autonomic, cranial, and spinal nerves. These nerves contain cells other than neurons and connective tissue as well as axons.

Peripheral nervous system (PNS)—One of the two major divisions of the nervous system. The PNS consists of the somatic nervous system (SNS), which controls voluntary activities, and of the autonomic nervous system (ANS), which controls regulatory activities. The ANS is further divided into sympathetic and parasympathetic systems.

Plexus—A network or group of nerves.

Sensory cells—Cells that contain receptors on their surface.

Sensory nerve—A nerve that receives input from sensory cells, such as the skin mechanoreceptors or the muscle receptors.

Spinal cord—Elongated part of the central nervous system that lies in the vertebral column and from which the spinal nerves emerge.

Sympathetic nervous system—One of the two divisions of the autonomic nervous system. The sympathetic neurons have their cell bodies in the thoracic and lumbar regions of the spinal cord and connect to the paravertebral chain of sympathetic ganglia. They innervate heart and blood vessels, sweat glands, organs and the adrenal medulla.

- glossopharyngeal, a mixed nerve, the sensory part for taste and the motor part for the control of swallowing
- vagus, a mixed nerve, main PNS nerve that controls the gut, **heart** and larynx
- accessory, a motor nerve for swallowing and moving the head and shoulders
- hypoglossal, a motor nerve for the control of tongue muscles

THE SPINAL NERVES (31 PAIRS). All of the spinal nerves are mixed nerves containing both sensory and motor neurons. They consist of eight cervical, 12 thoracic, five lumbar, five sacral, and one coccygeal. In spinal nerves, some nerve fibers are ascending, meaning that they carry messages to the brain, while others are descending, meaning that they carry messages from the brain.

Sensory input to the nervous system occurs through the senses, which are: vision, taste, smell, touch and hearing, also called the *special senses*. Additional input is provided by the *somatic senses*, which are **pain**, temperature, and pressure. This sensory input uses sensors, also called sensory receptors. The major sensory receptors are:

- mechanoreceptors that respond to hearing and stretching
- photoreceptors that are sensitive to light
- chemoreceptors that respond mostly to smell and taste
- thermoreceptors that are sensitive to changes in temperature
- electroreceptors that detect electrical currents in the environment

Function

The major function of the SNS is the voluntary control of the muscle system of the body and the processing of sensory information to the CNS. All conscious knowledge of the external world and all the motor activity performed by the body to respond to it operates through the SNS.

Role in human health

The overall role of the nervous system is to act as an internal communications system that allows the body to react to environmental changes and to perform all activities required to maintain life. The PNS is the message carrier between the CNS and the rest of the body and it can not function with an impaired SNS. Thus, the role of the SNS in human health is crucial.

Common diseases and disorders

Somatic nervous system diseases are diseases of the peripheral nerves that are external to the brain and spinal cord. Thus, they include diseases of the nerve roots, ganglia, sensory and motor nerves. A functional disorder and/or abnormal change that occurs in any region of the peripheral nervous system is called a *neuropathy*. If the involvement is in one nerve only, it is called a mononeuropathy, and if in several nerves, mononeuropathy multiplex or polyneuropathy. The most common disorders are the following:

- Brachial plexus neuropathies: Diseases of the peripheral nerve components of the brachial plexus, a group of lower neck and upper back spinal nerves supplying the arm, forearm and hand. Symptoms include local pain, muscle weakness, and decreased sensation (hypesthesia) in the upper extremity.
- Cranial nerve diseases: Disorders and diseases of the cranial nerves.
- Cranial nerve neoplasms: Benign or cancerous growth in cranial nerve tissues. Examples are: acoustic neuroma, optic nerve glioma, optic nerve meningioma.
- Diabetic neuropathies: Peripheral and cranial nerve disorders that are associated with diabetes. A common condition associated with diabetic neuropathy includes third nerve palsy, which affects the oculomotor nerve.
- Guillain-Barre syndrome: An acute inflammatory autoimmune neuritis caused by the body attacking the myelin coating of its own peripheral nerves. The syndrome often occurs as a result of viral or bacterial **infection**, surgery, immunization, lymphoma, or exposure to toxins.
- Mononeuropathies: Disease or trauma involving a single peripheral nerve. Mononeuropathies result from a wide variety of causes such as traumatic injury; nerve compression, and connective tissue diseases.
- Myasthenia gravis (MG): MG (and also the less common Lambert-Eaton syndrome) are neuromuscular junction diseases, that is, diseases affecting how nerve impulses are transmitted to muscle at the neuromuscular junction. They are autoimmune diseases, meaning that the body generates an **immune system** attack against its own skeletal muscles.
- Nerve compression syndromes: These syndromes are due to the compression of nerves or nerve roots from internal or external causes and result in the blocking of nerve impulses due to myelin sheath or axon damage.
- Neuralgia: Neuralgias are disorders of the cranial nerves that result in intense or aching pain occurring along a peripheral or cranial nerve. Neuralgias are asso-

ciated with all of the cranial nerves: trigeminal neuralgia in the facial area, glossopharyngeal neuralgia in the throat, occipital neuralgia in the rear and side of the head, geniculate neuralgia in the ear, and vagal neuralgia in the jaw.

- **Neuritis:** Inflammation of a peripheral or cranial nerve.
- **Peripheral nervous system neoplasms:** Benign or cancerous growths that arise from peripheral nerve tissue. They include neurofibromas, granular cell tumors and malignant peripheral nerve sheath tumors.
- **Trigeminal neuralgia (TN):** Most common neuralgia. It affects the fifth cranial (trigeminal) nerve and causes episodes of intense, stabbing, electric shock-like pain in the areas of the face where the branches of the nerve are distributed, that is lips, eyes, nose, scalp, forehead, upper jaw, and lower jaw.

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Guillain-Barre Syndrome Foundation International, P.O. Box 262, Wynnewood, PA 19096. (610) 667-0131. Fax: (610) 667-7036.

National Institute of Neurological Disorders and Stroke. NIH Neurological Institute, P.O. Box 5801, Bethesda, MD 20824. (800) 352-9424.

Neuropathy Association. 60 East 42nd Street, Suite 942, New York, NY 10165-0999. (212) 692-0662; (800)-247-6968. info@neuropathy.org. <<http://www.neuropathy.org>>.

OTHER

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Monique Laberge, Ph.D.

Neural tube defect

Definition

Neural tube defects, or NTDs, are a group of severe birth defects in which the **brain** and **spinal cord** are malformed and lack the protective encasement of soft tissue and bone. They are called neural tube defects because they develop out of a tube formed in the early embryo by the closure of the outer germ layer of tissue. This tube later develops into the brain and spinal cord.

Description

Incomplete formation and protection of the brain or spinal cord with bony and soft tissue coverings that occur during the fourth week of embryo formation are known collectively as neural tube defects. These lesions may occur anywhere in the midline of the head or spine. Neural tube defects are among the most common serious birth defects, but they vary considerably in their severity. In some cases, the brain or spinal cord is completely exposed; in some cases it is protected by a tough membrane (meninges); and in other cases it is covered by skin.

Spina bifida is a congenital defect that accounts for about two-thirds of all neural tube defects. Its name comes from two Latin words that mean "cloven backbone." The spinal defect may appear anywhere from the neck to the buttocks. In its most severe form, termed "spinal rachischisis," the entire spinal canal is open, exposing the spinal cord and nerves. More commonly, the defect appears as a localized mass on the back that is covered by skin or by the meninges.

Anencephaly, the second most common neural tube defect, accounts for about one-third of cases. Two major subtypes occur. In the most severe form, all of the **skull** bones are missing and the brain is exposed in its entirety. The second form, in which only a part of the skull is missing and a portion of the brain exposed, is termed "meroacrania."

Encephaloceles are the least common form of neural tube defects, comprising less than 10% of the total. With encephaloceles, a portion of the skull bones is missing, leaving a bony hole through which the brain and brain coverings herniate, or protrude abnormally. Encephaloceles occur in the midline from the base of the nose to the junction of the skull and neck. As with spina bifida, the severity of encephaloceles varies greatly. At the mildest end of the spectrum, an encephalocele may appear as only a small area of faulty skin development with or without any underlying skull defect. At the severe end of the spectrum, most



An infant with spina bifida. (Photograph by Biophoto Associates, Photo Researchers, Inc. Reproduced by permission.)

of the brain may be herniated outside of the skull into a skin-covered sac.

Genetic profile

Most neural tube defects (80–90%) occur as isolated events. In the United States and Canada, NTDs occur in the Caucasian population in about 1.5 of every 1,000 live births. Neural tube defects of this variety are believed to arise through the combined influence of genetic and environmental forces. This multifactorial causation presumes that one or more predisposing genes collaborate with one or more environmental influences to result in the birth defect. Poor **nutrition** is believed to be an environmental risk factor; hereditary defects in the absorption and utilization of **folic acid** are presumptive genetic predisposing factors. After a couple has one infant with a neural tube defect, the risk of recurrence is 3–5%. After the birth of two infants affected with neural tube defects, the risk increases to 8–10%. A parent with a multifactorial NTD has a 3–4% chance of having a child with an NTD.

When neural tube defects occur concurrently with other malformations, there is a greater likelihood of an underlying specific genetic or environmental cause.

Genetic causes include chromosome aberrations and single gene mutations. Environmental causes include maternal **diabetes mellitus**, exposure to prolonged hyperthermia, and taking seizure medications during the early months of **pregnancy**.

Demographics

Neural tube defects occur worldwide. It appears that the highest prevalence (about one in 100 pregnancies) exists in certain northern provinces in China; an intermediate prevalence (about one in 300–500 pregnancies) has been found in Ireland and in Central and South America; the lowest prevalence (fewer than one in 2,000 pregnancies) has been found in the Scandinavian countries. In the United States, the highest prevalence tends to occur in the Southeast. Worldwide there has been a steady downward trend in prevalence rates over the past 50–70 years.

Causes and symptoms

Because of the incorrect development of the spinal cord and nerves, a number of consequences are commonly seen in spina bifida. As a rule, the nerves below the level of the defect develop in an abnormal manner

and fail to function, resulting in **paralysis** and loss of sensation below the level of the spinal lesion. Since most defects occur in the lumbar region, the lower limbs are paralyzed and lack normal sensation. Furthermore, the bowel and bladder have inadequate nerve connections, leading to the inability to control bladder and bowel function. Sexual function is likewise impaired. Hydrocephaly, which is an abnormal accumulation of fluid within the ventricles or cavities of the brain, develops in most of these infants either before or after surgical repair of the spine defect.

In anencephaly, the brain is destroyed by its exposure during intrauterine life. Most infants with anencephaly are stillborn or die within the first few days or weeks after birth.

Infants with encephaloceles have variable neurologic impairments depending on the extent of brain involvement. When only the brain covering is involved, the individual may escape any adverse effect. When the brain is involved in the defect, however, impairments of the special senses such as sight and **hearing**, as well as cognitive impairments, commonly result.

Diagnosis

At birth, the diagnosis of a neural tube defect is usually obvious based on external findings. Prenatal diagnosis may be made with ultrasound examination after 12–14 weeks of pregnancy. Screening of pregnancies can be carried out at 16 weeks by testing the mother's **blood** for the level of alpha-fetoprotein. Open neural tube defects leak this fetal chemical into the surrounding amniotic fluid, a small portion of which is absorbed into the mother's blood.

Treatment

No treatment is available for anencephaly. Aggressive surgical and medical management has improved survival and function of infants with spina bifida. Surgery closes the defect, providing protection against injury and **infection**. Walking may be achieved with orthopedic devices. A common complication that may occur before or after surgical correction is the accumulation of excessive cerebral spinal fluid (hydrocephaly) in the major cavities within the brain. Hydrocephaly is usually treated with the placement of a mechanical shunt, which allows cerebral spinal fluid from the ventricles to drain into the circulation or into another body cavity. A number of medical and surgical procedures have been used to protect the **urinary system**. Encephaloceles are usually repaired by surgery

KEY TERMS

Anencephaly—Absence of all or a portion of the bones of the skull.

Embryo—An organism during an early development period when organs and other specialized structures are being formed. In humans, the embryonic period is considered to be the first eight weeks after conception.

Encephalocele—A hole in the bony covering of the spinal cord through which portions of the brain, spinal cord or meninges may herniate.

Folic acid—A water-soluble vitamin that is essential to the formation of purine and thymine in the body. A deficiency of folic acid causes a form of anemia.

Herniate—To protrude abnormally through an opening in bone or surrounding tissues.

Hydrocephaly—An abnormal accumulation of cerebrospinal fluid in the cavities of the brain.

Meninges—The three-layered membrane that covers the brain and spinal cord.

Neural tube—A tube that forms in the early embryo when the outer germ layer of tissue (ectoderm) closes. The neural tube develops into the spinal cord and the brain.

Spina bifida—A congenital defect in the covering of the spine.

Spinal rachischisis—A lack of covering over the entire spinal canal, exposing the spinal cord and nerves.

soon after birth. The success of surgery often depends on the amount of brain tissue involved in the encephalocele.

It has been found that 400 mcg of folic acid taken for two to three months prior to conception and two to three months following conception protects the fetus against most neural tube defects. While there are a number of foods (green leafy vegetables, legumes, liver, orange juice) that are good sources of natural folic acid, synthetic folic acid is available in over-the-counter multivitamins and a number of fully fortified breakfast cereals.

In addition, a population-wide increase in folic acid intake has been achieved through the fortification of enriched cereal grain flours since January 1998, a measure authorized by the U.S. Food and Drug Administration. The increased blood levels of folic acid in the general

population achieved in recent years has likely resulted from the synergy of dietary, supplementation, and fortification sources.

Prognosis

The prognosis for infants with anencephaly is grim; they are usually stillborn or die within the first days of life. In contrast, 80–90% of infants with spina bifida survive with surgery. Paralysis below the level of the defect, including an inability to control bowel and bladder function, and hydrocephaly are complications experienced by most infants who survive. Intellectual function, however, is normal in most cases.

The prognosis for infants with encephaloceles varies considerably. Small encephaloceles may cause no disability whether surgical correction is performed or not. Infants with larger encephaloceles may have residual impairment of **vision**, hearing, nerve function, and intellectual capacity.

Health care team roles

Pediatricians, family physicians, obstetricians, or nurse midwives usually diagnose previously unknown neural tube defects at birth. Testing maternal blood for alpha-fetoproteins can often diagnose neural tube defects. Surgeons often repair neural tube defects. Physical therapists, social workers, and counselors may provide ongoing care to children with neural tube defects and their families. Support groups are often helpful to these families.

Prevention

Taking folic acid supplements (400 mcg per day) from two to three months prior to conception and the first trimester of pregnancy offers some protection against many neural tube defects. Pregnant women should be advised to avoid certain medications and recreational drugs, especially some anticonvulsants and hallucinogens.

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- American Academy of Neurology. 1080 Montreal Avenue, St. Paul, MN 55116. (651) 695-1940. Fax: (651) 695-2791. <<http://www.aan.com>>. info@aan.org.
- American Academy of Pediatrics. 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. Fax: (847) 434-8000. <<http://www.aap.org/default.htm>>. kidsdoc@aap.org.
- American Association for Clinical Chemistry. 2101 L Street, NW - Suite 202, Washington, DC 20037-1558. (800) 892-1400 or (202) 857-0717. Fax: (202) 887-5093. <<http://www.aacc.org>>. info@aacc.org.
- American Board of Obstetrics and Gynecology. 2915 Vine Street Suite 300, Dallas, TX 75204. (214) 871-1619. Fax: (214) 871-1943. <<http://www.abog.org>>. info@abog.org.

American College of Obstetricians and Gynecologists. 409
12th St., S.W., PO Box 96920, Washington, DC 20090-
6920. <<http://www.acog.org>>.

American Society for Reproductive Medicine. 1209
Montgomery Highway, Birmingham, AL 35216-2809.
(205) 978-5000. <<http://www.asrm.com>>.

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L. Fleming Fallon, Jr., MD, DrPH

Neuroleptics see **Antipsychotic drugs**

Neuromuscular physical therapy

Definition

Neuromuscular **physical therapy** involves the examination, treatment, and instruction of persons in order to detect, assess, prevent, correct, alleviate, and limit physical disability and bodily malfunction.

Purpose

The purpose of neuromuscular physical therapy is to help individuals experiencing structural distortion, biomechanical dysfunction, and the accompanying **pain** that is often symptomatic of the underlying problem. It is used to locate and release tissue spasms and hypercontraction; eliminate trigger points that cause referred pain; restore postural alignment, proper biomechanics and flexibility to the tissues; rebuild the strength of injured tissues and assist venous and lymphatic flow.

Precautions

A physician's referral is recommended.

Description

The practice of neuromuscular physical therapy includes the administration, interpretation, and evaluation of tests; measurements of bodily functions and structures; and the planning, administration, evaluation, and modification of treatment and instruction, including the use of physical measures, activities, and devices, for preventive and therapeutic purposes. Neuromuscular physical therapy may also be referred to as neuromuscular reeducation, physical therapy, or physiotherapy.

Neuromuscular physical therapy is employed to treat patients with a variety of health conditions and diseases including accident victims, and individuals with disabling conditions such as low back pain, arthritis, **heart disease**, **fractures**, head injuries, and **cerebral palsy**.

In an effort to restore, maintain, and promote overall fitness and health, neuromuscular physical therapists examine patients' medical histories, test and measure patients' strength, range of motion, balance, coordination, posture, muscle performance, respiration, and motor function. Neuromuscular physical therapists determine patients' ability to be independent and reintegrate into the community or workplace. Based on a patient's medical history and test results, therapists develop treatment plans that describe treatment strategy, purpose, and anticipated outcome.

Neuromuscular physical therapy treatment often includes **exercise** for patients who have been immobilized or who lack flexibility, strength, or endurance. As part of the treatment, patients are encouraged to improve flexibility, range of motion, strength, balance, coordination, and endurance. The goal is to improve an individual's function at work and home.

Neuromuscular physical therapy may involve the use of electrical stimulation, hot packs, cold compresses, or ultrasound to relieve pain and reduce swelling. Traction or deep-tissue massage may be employed to relieve pain. Patients are instructed in the use of assistive and adaptive devices including crutches, prostheses, and wheelchairs. Patients are often shown how to perform exercises to do at home.

During treatment, neuromuscular physical therapists document the patient's progress, conduct periodic examinations, and modify treatments when necessary. Therapists rely on this documentation to track the patient's progress, and identify areas requiring more or less attention.

Neuromuscular physical therapy may be used to treat a wide range of patients with conditions presenting in areas such as pediatrics, geriatrics, orthopedics, sports medicine, neurology, and cardiopulmonary physical therapy.

Length of treatment varies depending upon several factors, including the severity of the condition being treated. Treatment costs also vary depending upon a number of factors including geographic location and the diagnostic tests conducted. Many insurance policies cover neuromuscular physical therapy treatments provided that a physician's referral is obtained prior to treatment.

There are a number of alternative neuromuscular therapies. Among the most popular are the following:

Alexander technique

The goal of this discipline is to bring the body's muscles into natural harmony. Hence it can aid in the treatment of a wide variety of neurological and musculoskeletal conditions, including disorders of the neck, back and hip; traumatic and repetitive strain injuries; chronic pain; arthritis; breathing and coordination disorders; **stress** related disorders; and even migraine.

People with **sciatica**, **scoliosis**, **osteoporosis**, **osteoarthritis**, rheumatoid arthritis, and neck and low back syndrome may find the Alexander technique useful in improving overall strength and mobility. Others with Lyme disease, chronic fatigue syndrome, lupus, or **fibromyalgia** may use it for **pain management**. It is also used to improve functioning in people with **multiple sclerosis**, stroke, or **Parkinson's disease**. Because the technique requires active participation by the patient, it is impossible to test its effectiveness with conventional scientific procedures.

Aston patterning

This specialized program of physical training and massage is designed to relieve muscle tension and pain, speed recovery from injuries, and aid in general **relaxation** and stress reduction. It is particularly appropriate for such problems as back and neck pain, headache, and repetitive stress injuries like tennis elbow.

Like most forms of bodywork and movement training, Aston patterning does not lend itself to controlled clinical trials, and its effectiveness has therefore not been scientifically verified. Furthermore, it requires a significant patient commitment; it involves much more than a program of passive massage.

Feldenkrais

The Feldenkrais method is a supportive therapy that may help in situations where improved movement patterns (and awareness of those patterns) can help with recovery from illness or injury. Practitioners consider it useful for many types of chronic pain, including headache, temporomandibular joint disorder, other joint

disorders, and neck, shoulder, and back pain. It is sometimes used as supportive therapy for people with neuromuscular disorders, such as multiple sclerosis, cerebral palsy and stroke. It is also helpful for improving balance, coordination, and mobility. Many athletes, dancers, and other performers use the Feldenkrais method as part of their overall conditioning.

Hellerwork

Hellerwork is a combination of deep tissue massage and movement reeducation. It is advocated by its practitioners for a variety of problems related to muscle tension and stress. Hellerwork is said to relieve respiratory problems, **sports injuries**, and pain in the back, neck, and shoulders. Like most forms of bodywork, it has undergone little in the way of scientific testing.

Trager

This light, gentle form of massage seeks to release deeply ingrained tensions, promoting a sense of relaxation and freedom. It may be helpful for those with chronic neuromuscular pain, including back problems and sciatica, and it has also been advocated for stress-related conditions, high **blood pressure**, strokes, migraine, and **asthma**. Proponents say that it can benefit patients with polio, multiple sclerosis, and **muscular dystrophy** as well.

Preparation

There are no typical pre-treatment preparations. However, a physician's referral is recommended.

Aftercare

Patients are often shown how to perform exercises to do at home.

Results

There are a number of beneficial results realized through neuromuscular therapy, including decreased body toxicity, greater flexibility, greater freedom of movement, increased circulation, increased energy and vitality, increased sense of well-being, and improved postural patterns.

Health care team roles

Neuromuscular physical therapists often consult and practice with physicians, dentists, nurses, educators, social workers, occupational therapists, speech-language

pathologists, rehabilitation counselors, vocational counselors, and audiologists.

Neuromuscular physical therapists practice in hospitals, clinics, and private offices. They may also treat patients in the patient's home or at school.

Over two-thirds of neuromuscular physical therapists are employed in either hospitals or physical therapists' offices. Other work settings include home health agencies, outpatient rehabilitation centers, physicians' offices and clinics, and **nursing homes**. Some neuromuscular physical therapists maintain a private practice and provide services to individual patients or contract to provide services in hospitals, rehabilitation centers, nursing homes, home health agencies, adult daycare programs, or schools. They may be engaged in individual practice or be part of a consulting group. Some therapists teach in academic institutions and conduct research.

Neuromuscular physical therapists are required to pass a licensure exam after graduating from an accredited educational program before they can practice.

According to the American Physical Therapy Association, in 1999 there were 189 accredited programs. Of the accredited programs, 24 offered bachelor's degrees, 157 offered master's degrees, and eight offered doctoral degrees. By 2002 the Commission on Accreditation in Physical Therapy Education will require all physical therapist programs seeking accreditation to offer degrees at the master's degree level.

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American Physical Therapy Association, 1111 North Fairfax Street, Alexandria, VA 22314-1488.
<<http://www.apta.org>>.

Aston Training Center. P.O. Box 3568 Incline Village, NV 89450. 702-831-8228.

Feldenkrais Guild. P.O. Box 489 Albany, OR 97321. 503-926-0981 or 800-775-2118.

Hellerwork. 406 Berry St. Mount Shasta, CA 96067. 916-926-2500.

Trager Institute. 33 Millwood Mill Valley, CA 94941. 415-388-2688.

Bill Asenjo, PhD, CRC

Neuromuscular electrical stimulation see **Electrotherapy**

Neurons

Definition

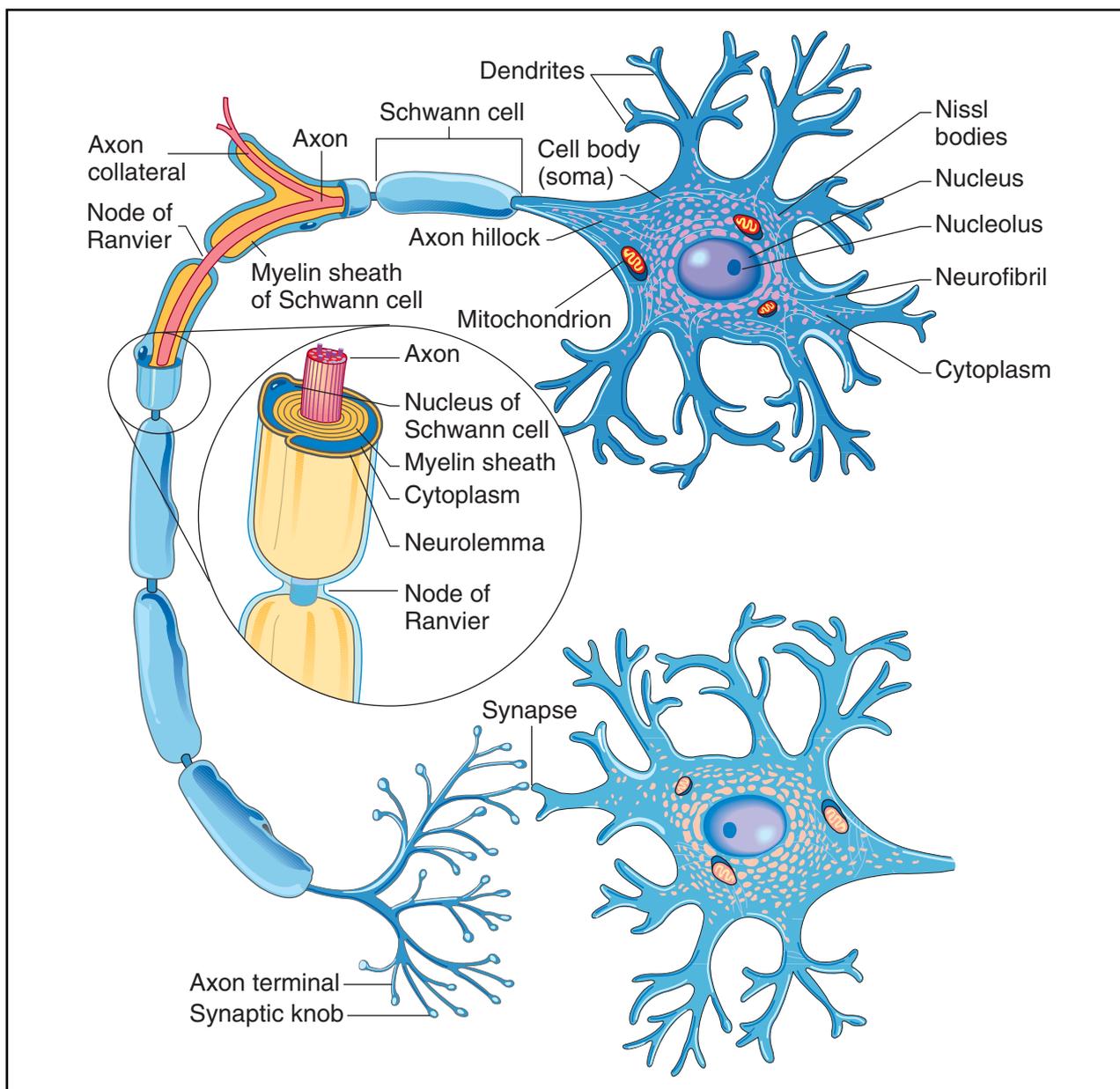
A neuron is a specialized cell of the nervous system designed to rapidly communicate with other neurons and organs by sending chemical and electrical signals.

Description

The nervous system contains two major types of cells, neurons and glia. Neurons are specialized cells of the central and peripheral nervous systems that play key roles in transmitting and propagating information from one neuron to another. The role of glial cells is less clear, but they are involved in supporting the functions of the neuron. There are many different types of neurons, such as motor neurons, sensory neurons, and interneurons. Each class of neuron is specially designed to perform certain functions, and therefore neuronal populations differ in structure and chemical composition. Most neurons are polarized, which means that fibers extend from the cell in a certain direction or orientation. Polarization is determined by the direction and length of structures unique to neurons, which are axons, dendrites, and the cell body.

Neurons are similar to other types of cells in that they contain all the basic cell organelles such as a nucleus, mitochondria, ribosomes, lysosomes, endoplasmic reticulum, and Golgi apparatus. However, neurons differentiate into polarized cells that contain three basic structural components: cell body (soma), axon, and dendrites. The cell body contains the nucleus and other cellular organelles and is the major place where protein synthesis occurs.

Dendrites are branched fibers extending from the cell body. The number and organization of dendrites is unique to each neural population and most neurons extend multiple dendrites that are relatively short processes. Dendrites contain small protrusions called spines. These spines express protein receptors on the sur-



Neuron. (Diagram by Hans & Cassidy. Courtesy of Gale Group.)

face that are capable of responding to chemical neurotransmitters such as acetylcholine. The dendritic spines contact axon terminals of other neurons at a connection point called a synapse. The dendrites send this chemical information to the cell body. The cell body integrates the chemical signal from all the dendrites and generates an electrical signal called an axon potential that is sent down the length of the axon to signal the next neuron.

The axon is a fiber neurite process that extends from the cell body and can be up to a meter in length. The axon protrudes from a bulge at the base of the cell body

at a region called the axon hillock. Most neurons have only one axon but may have hundreds of dendrites. The axon is specially designed to send electrical signals known as action potentials down the length of the axon to the axon terminals. The axon terminal releases chemical neurotransmitters in response to the action potential onto the dendrite of another neuron. The place where the axon terminal of one neuron meets the dendrite of another neuron is called a synapse. The axon contains a cytoskeletal structure designed to transport **proteins** and other molecules down the length of the axon to the axon terminal and from the axon terminal back up to the cell

KEY TERMS

Axon—A fiber process extended from the neuronal cell body that carries action potentials.

Dendrite—A branch-like projection from the cell body of a neuron.

Synapse—Meeting place between the axon terminal of one neuron and the dendrite of another neuron.

body. This cytoskeletal structure is composed of actin filaments, neurofilaments, and microtubules.

Function

Neurons are specially designed to communicate with other neurons by converting chemical signals into electrical ones. This is accomplished by the axon. A covering called myelin insulates the outside of the axon. Myelin is a sheath of stacked membranes and is very high in lipid. Axon myelination is conduction by the glia, oligodendrocytes, and Schwann cells. There are periodic interruptions in the myelin at the nodes of Ranvier. Electrical signals referred to as action potentials are rapidly transmitted down the axon by jumping from one node of Ranvier to the next. The action potential induces the release of chemical neurotransmitters from the axon terminal. The axon terminal contains vesicles containing packaged neurotransmitters. The action potential triggers the release of neurotransmitters onto the next neuron that then generates an axon potential to propagate the signal for cell-cell communication. This process allows signaling to occur over very long distances within milliseconds.

Common diseases and disorders

Neurons are implicated in numerous nervous system diseases from **Alzheimer's disease** to Huntington's disease to certain types of **brain cancer**. In many neural diseases, neurons degenerate due to abnormalities in basic cellular function. Populations of neurons can also become cancerous, such as in neuroblastomas.

Resources

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Neurophysiology

Definition

Neurophysiology is the study of the functions of the nervous system. Clinical neurophysiology is the study of the functions of the nervous system in the clinical setting, for diagnostics, treatment, and intensive care purposes.

Description

Neurophysiology is a broad field of study because many different levels are involved in the overall functioning of the nervous system and its components. For example, the transmission of a nervous impulse across the synapses, or the cleft that connects nerve cells, involves chemical reactions at the cellular level of organization. Understanding how messages are relayed from the **brain** to the hand is best explained at the system level. This involves studying the relationship and pathways between the brain and the organs of the body and the nerves that connect them, both sensory, meaning nerves that receive input from sensors, and motor, meaning the nerves that activate muscle. Thus, neurophysiology studies nervous function ranging from individual nerve cells to the complex behaviors of the **central nervous system**. Additionally, the nervous system not only functions at the cell and system levels of organization, but also at a mechanistic level, that involves the study of the control or regulatory processes that occur.

The neurophysiology of systems

A branch of neurophysiology describes the function of the major system components of the nervous system of the human body at the system level. The overall nervous system of the body consists of the central nervous system (CNS), and the peripheral nervous system (PNS). The neurophysiology of the CNS studies the function of the brain and **spinal cord** while that of the PNS studies the function of all the nerves that connect the CNS with organs, muscles, **blood vessels** and glands. The neurophysiology of the PNS further subdivides into the **somatic nervous system** (SNS) and the **autonomic nervous system** (ANS), with the ANS being further divided by function into the sympathetic and parasympathetic sys-

KEY TERMS

Axon—The part of the nerve cell used to carry impulses away from the cell body.

Electroencephalography (EEG)—Recording of electrical impulses that reflect brain function, used to diagnose extensive variety of nervous system disorders.

Electromyography (EMG)—Electrical testing of nerves and muscles, used to diagnose nervous disorders.

Evoked potentials (EP)—Electrical signals of the nerves, spinal cord and brain in response to light stimulation of the eyes, or sound stimulation of the ears or mild electrical stimulation of the nerves in the arms or legs, used to diagnose nervous system disorders, such as multiple sclerosis, hearing loss, and various spinal cord disorders.

Microneurography—Technique used primarily for research purposes that enable recording of electrical activity of a single axon from the peripheral nerves of awake human subjects.

Nerve conduction velocity (NCV)—Technique for studying nerve or muscle disorders, measuring the speed at which nerves transmit signals.

Neurophysiology—The study of the functions of the nervous system.

Polysomnography reduction—Technique used to monitor brain patterns, eye movements, muscle tension, air flow and respiratory effort, oxygen levels and heart beat during sleep to study sleep disorders.

tems. PNS nerves are of two types: the sensory—or afferent—nerves that transmit information from the sensory organs, muscles, joints, internal organs and all other parts of the body to the CNS, and the motor—or efferent—nerves that transmit signals from the CNS to the body, for example, to the muscles or to internal organs.

The neurophysiology of nerve cells

Neurophysiology is also the study of the physiology, structure and function of nerve cells, or **neurons**, meaning how individual neurons receive and transmit information using chemical and electrical signals. The most important feature of neurons as compared to other cell types in the body is their high degree of electrical excitability. The transmission of nervous signals is based

on changes in this electrical excitability, and neurophysiology studies these effects at the cellular level as well as the electrical properties of neurons. It also seeks to understand the differences between the excitability of muscle and nervous tissue. Examples are: the release of neurotransmitters, substances that are activated by the excitation of neurons; the specific chemical features of the various neurotransmitters; the study of the redistribution of charged ions inside and outside nervous cells, including the pumps used to transport them across **cell membranes**; and the properties of the various special channels used for this transport.

The neurophysiology of control mechanisms

The control activities of the nervous system are performed through very complex mechanisms and pathways. In the brain and the spinal cord there are complex regulatory pathways for functions like food and water intake, sleep, **pain**, and muscle control, to name a few. Investigations of such control systems are of central interest in neurophysiology. This includes, for example, the mechanisms involved in the regulation of sleep, pain, breathing, and the **cardiac cycle**. The understanding of these mechanisms provides a basis for understanding changes in the functions that may result in diseases. Also the treatment of diseases, for instance the use of drugs to correct dysfunctions, requires that the underlying mechanisms of the disorder be understood. One of the most important topics of neurophysiology is the study of **feedback systems** that constantly monitor and regulate numerous aspects of body function, such as the levels of oxygen and carbon dioxide, nutrients, hormones, and other chemical substances in the **blood**. Other higher functions, such as language, learning and **memory**, and emotions, while being mostly studied by neuropsychology, are also affected by neurophysiological mechanisms and these aspects are also included in neurophysiology.

Measurement techniques in neurophysiology

The electrical signals of the nervous system propagate throughout the body to control movement, breathing, **heart** rate, and the capacity to think and remember. Neurophysiology also includes all the electrical measuring techniques used to provide information on the function of the brain and nerves. These include:

- **Electroencephalography (EEG)**: EEG is a recording of electrical impulses that reflect brain function. It is used to test for a wide variety of disorders of the nervous system, such as tumor growth and infections as well as the development of the brain in babies and children. EEG is also used in the diagnosis of epilepsy and strokes. EEG is often performed during surgery on the

arteries of the neck to ensure that the blood flow to the brain is adequate.

- **Evoked potentials (EP):** This technique evaluates the condition of nerve pathways. EPs are electrical signals of the nerves, spinal cord, and brain in response to light stimulation of the eyes, sound stimulation of the ears, or mild electrical stimulation of the nerves in the arms or legs. EPs are used to diagnose disorders of the nervous system such as **multiple sclerosis, hearing loss**, and various spinal cord disorders. EPs are also used during neurosurgery to locate brain structures or check on the patient's response to surgery.
- **Polysomnography (PSG):** This technique monitors brain wave patterns, eye movements, muscle tension, air flow, respiratory effort, oxygen levels, and heart beat during sleep. It is mostly used to diagnose and treat various sleep disorders.
- **Electromyography (EMG):** EMG refers to electrical testing of nerves and muscles. The technique is used to diagnose nervous disorders such as muscle spasticity and pinched nerves in the back or neck as well as other nerve or muscle disorders.
- **Nerve conduction velocity (NCV):** NCV is another technique used to study nerve or muscle disorders, it measures the speed at which nerves transmit signals.
- **Microneurography (MN):** Microneurography is mostly used for research purposes, it is a technique that makes it possible to record the electrical activity of a single axon from the peripheral nerves of awake human subjects.

The spectacular advances in knowledge of the nervous system during the past decades and the promising developments in the treatment of nervous disorders have made neurophysiology one of the most active branches of modern biology and medicine. The understanding that neurophysiology provides about nervous system functions from the level of the cell to the level of the systems also makes it the foundation stone of other clinical fields like neurology and psychiatry. The development of drugs to control and cure disease also requires an understanding of how drugs affect the nervous system, which is only possible if the detailed neurophysiology of the systems they target is well understood. Neurophysiology research fulfills that role, thus creating a strong link to neuropharmacology and general health care practice.

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Newborn hearing screening

Definition

A newborn **hearing** screening assesses infants for adequate hearing levels.

Purpose

Three out of 1,000 babies are born with permanent **hearing loss**, making congenital hearing impairment the most common birth defect. Without screening, children with dysfunctions in hearing are usually not identified until two and a half to three years of age and many are not diagnosed properly until five to six years of age. A postponement in diagnosis results in considerable delays in the attainment of essential speech, language, social, cognitive, and emotional development skills that are central to later success in school and life. Even children with a hearing impairment in one ear suffer significant detrimental effects and are more likely to be held back at least one grade when compared with a group of children without hearing impairments.

Because simple, cost-effective technology now exists to detect hearing loss in newborns, many hospitals have implemented universal screening programs. When diagnosed shortly after birth, infants can start to wear amplification devices as early as one month of age. Children who were identified prior to six months of age and received early intervention and amplification devices were found to be one to two years ahead in language, cognitive, and social skills as compared to children who were not identified early.



The otoacoustic emission (OAE) test detects the response of the newborn's inner ear to sounds and registers them on the computer. The test can be administered while the baby sleeps. (Photograph by James King-Holmes. *Science Source/Photo Researchers*. Reproduced by permission.)

Description

In 1993, the National Institutes of Health concluded that all newborns should receive screening for hearing impairment. Screening was determined to be most appropriate prior to discharge from the hospital.

Some hospitals screen only newborns who are at risk of hearing loss—about 10% of the population. Risk factors include a history of childhood hearing impairment in the family, **infection** (cytomegalovirus, rubella, herpes, toxoplasmosis, or **syphilis**), congenital malformations of the head or neck, weight at birth less than 3.3 pounds (1,500 grams), severe **jaundice** (hyperbilirubinemia), **antibiotics**, bacterial **meningitis**, and severe asphyxia at birth. Because research has indicated that only about half of children identified as having congenital hearing loss had any risk factors, and because of the availability of

new screening techniques, many hospitals have adopted the universal hearing screening of newborns.

The majority of newborn hearing screening programs use one of three types of equipment: automated auditory brainstem response (AABR), distortion product otoacoustic emissions (DPOAE), or transient evoked otoacoustic emissions (TEOAE).

The general technique for the exam is to place an earphone or probe on the baby's ear and to attach an electrode to the scalp. A sound or click is then transmitted to the baby. A microcomputer or miniature microphone interprets the electrical potential created by the brainstem responding to the sound or the echo from the cochlea (located in the inner ear).

The cost of the equipment ranges from \$4,000 to \$25,000 for each individual unit. Training of personnel takes approximately two to four hours, and time involved to perform each test varies from 15 minutes to 40 minutes for each baby.

Preparation

If the environment is quiet and the baby is restful, testing results will be the easiest to obtain.

Aftercare

Infants who do not appear to have adequate hearing at the screening should obtain a follow-up hearing evaluation before six months of age.

Results

Results should be the detection of infant hearing loss. It is possible that mild hearing loss will not be detected.

Health care team roles

Any member of the health care team can be trained in administering the test. Generally, most hospitals have nurses involved in the screening process.

Resources

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ORGANIZATIONS

American Speech-Language-Hearing Association (ASHA). 10801 Rockville Pike, Rockville, MD 20852. (888) 321-ASHA. <<http://professional.asha.org/index7.htm>>.

National Center for Hearing Assessment and Management (NCHAM). Utah State University, 2880 Old Main Hill,

KEY TERMS

Asphyxia—A deficiency of oxygen or state of carbon dioxide over-saturation within the body.

Cochlea—A component of the bony labyrinth of the inner ear that is involved in hearing.

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Nadine M. Jacobson, R.N.

Newborn life support see **Ventilation assistance**

Niacin

Description

Niacin, also known as Vitamin B₃, is important for the normal function of many bodily processes. Like other B vitamins, it is water-soluble and plays a role in turning food into energy, as well as in the **metabolism** of **fats** and **carbohydrates**. Niacin can also act as an antioxidant within cells, which means it can destroy cell-damaging free radicals. In conjunction with **riboflavin** and **pyridoxine**, it helps to keep the skin, intestinal tract and nervous system functioning smoothly.

General use

The recommended daily allowance (RDA) of niacin for infants under six months is 5 mg. Babies from six months to one year of age require 6 mg. Children need 9 mg at one to three years of age, 12 mg at four to six years, and 13 mg at seven to 10 years. Women need 15 mg at 11–50 years, and 13 mg thereafter. Somewhat more is

required for **pregnancy** (17 mg) and **lactation** (20 mg). Men require 17 mg from 11 to 14 years of age, 20 mg from 15 to 18 years, 19 mg from 19 to 50 years, and 15 mg at 51 years and older.

Niacin, in the form of nicotinic acid, can be taken in very large doses to decrease cholesterol and reduce the risk of **heart** attack. The amount required is between 2 and 3 g. This is not a therapy that should be undertaken without professional medical advice and supervision. Certain conditions preclude the use of high doses of niacin. These include **gout**, diabetes, peptic ulcer, **liver** or kidney disease, and high **blood pressure** requiring medication. Even in the absence of these conditions, a patient on high doses of niacin should be closely monitored to be sure the therapy is both effective and without complications. A frequent side effect of this therapy is extreme flushing of the face and neck. It is harmless, but can be unpleasant. An alternative form of nicotinic acid that does not cause flushing is inositol hexaniacinate. “Slow release” niacin also causes less flushing, but should not be taken as there is higher risk of liver inflammation.

There is some evidence that niacinamide used on a long-term basis can prevent the onset of juvenile diabetes in many susceptible children. Those who have been newly diagnosed with juvenile diabetes may also benefit by extending the time that the **pancreas** continues to produce a small amount of insulin. The advice of a health care provider should be sought for these uses.

Inositol hexaniacinate can be helpful for people suffering from intermittent claudication. This condition causes leg **pain** with **exercise** due to poor **blood** flow to the legs. Dilation of the **blood vessels** caused by the inositol hexaniacinate relieves this condition to some extent, allowing the patient to walk farther with less pain.

Other conditions that may be benefited by supplemental niacinamide include vertigo, tinnitus, premenstrual syndrome (PMS) headaches, and **osteoarthritis**. Raynaud’s phenomenon reportedly may be improved by large doses of inositol hexaniacinate. A health care provider should be consulted for these uses. Niacin is not effective for the treatment of **schizophrenia**.

Preparations

Natural sources

Tuna is one of the best sources of niacin, but many foods contain it. Most processed grain products are fortified with niacin, as well as other B vitamins. Although niacin is not destroyed by cooking, it does leach into water, so cooking with minimal liquid best preserves it. The amino acid tryptophan is widely found in foods high

KEY TERMS

Antioxidant—Any one of a group of substances which function to destroy cell-damaging free radicals in the body.

Gout—A painful condition of joints, especially the feet and hands, caused by the presence of uric acid crystals.

Myopathy—A disease of muscle tissue.

Sprue—A chronic disease of malabsorption characterized by diarrhea.

in protein, and about half of the tryptophan consumed is used to make niacin. Cottage cheese, milk, fowl, and tuna are some of the foods that are highest in tryptophan.

Supplemental sources

Niacin can be purchased as an oral single vitamin product. A balanced B complex supplement is preferred over high doses of an individual vitamin unless there is a specific indication. Supplements should be stored in a cool, dry place, away from light, and out of the reach of children.

Deficiency

A serious deficiency of niacin causes a condition called pellagra. Once quite common, it has become rare outside of areas where poor **nutrition** is still the norm. The symptoms include dermatitis, **dementia**, and **diarrhea**.

Milder deficiencies of niacin can cause similar, but less severe symptoms. Dermatitis, especially around the mouth, and other rashes may occur, along with fatigue, irritability, poor appetite, indigestion, diarrhea, headache, and possibly delirium.

Risk factors for deficiency

Severe niacin deficiency is uncommon in most parts of the world, but some people may need more than the RDA in order to maintain good health. Vegans, and others who do not eat animal protein, should consider taking a balanced B vitamin supplement. Others that may need extra niacin and other B vitamins may include people under high **stress**, including those experiencing chronic illnesses, liver disease, sprue, or poor nutritional status. People over 55 years old are more likely to have a poor dietary intake. Certain metabolic diseases also increase the requirement for niacin. Those who abuse nicotine,

alcohol or other drugs are very frequently deficient in B vitamins, but use of niacin with alcohol can cause seriously low blood pressure. A health care professional can determine if supplementation is appropriate.

Precautions

Niacin should not be taken by anyone with a B vitamin allergy, kidney or liver impairment, severe hypotension, unstable angina, arterial hemorrhage, or **coronary artery disease**. Supplemental niacin can exacerbate peptic ulcers. Diabetics should use caution as supplements of either niacin or niacinamide can alter medication requirements to control blood glucose. Supplements can raise uric acid levels, and aggravate gout in people with this condition. Pregnant women should not take high doses of niacin, or any supplement, except on the advice of a health care provider.

Health care should be sought immediately if certain symptoms occur following niacin supplementation. These include abdominal pain, diarrhea, nausea, vomiting, yellowing of the skin, faintness, or headache. Such symptoms may indicate excessively low blood pressure or liver problems. Heart palpitations and elevated blood sugar are also potential effects.

Side effects

High doses of niacin can cause a harmless, but unpleasant, flushing sensation and darkening of the urine. The “no-flush” form can lessen this complication.

Interactions

Niacin supplements should not be taken by anyone on medication for high blood pressure, due to the potential for hypotension. Isoniazid, a drug used to treat **tuberculosis**, inhibits the body’s ability to make niacin from tryptophan. Extra niacin may be required. Supplements may also be needed by women taking oral contraceptives. Concomitant use of niacin with statin class drugs to lower cholesterol can cause myopathy. Cholestyramine and cholestipol, older medications to lower cholesterol, should be taken at a different time than niacin or they will reduce its absorption. Transdermal nicotine used with niacin is likely to cause flushing and dizziness. Carbamazepine, an antiseizure medication, is more likely to cause toxicity in combination with niacin.

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Judith Turner

Nightmares see **Sleep disorders**

Nitrite test see **Urinalysis**

Nitrous oxide

Definition

Nitrous oxide is a colorless, sweet-smelling gas used as an anesthetic, most commonly during dental procedures.

Purpose

Nitrous oxide, also called laughing gas, is the weakest form of sedation to aid in the **relaxation** of the anxious dental patient. When inhaled, nitrous is absorbed by the body and has a quick-acting calming effect on the patient.

Description

The nitrous gas used in dental offices is actually a blend of two gases: oxygen and nitrous oxide. Mixed together it has a sweet-smelling aroma that gives a sense of well-being and aids in relaxation of the entire body. It causes light, conscious sedation, while the patient still retains the ability to respond to verbal commands.

Nitrous oxide has three kinds of sedative characteristics, including:

- **Conscious sedation:** Being awake and able to interact vocally with the dental staff, but feeling completely relaxed.
- **Inhalation sedation:** Becoming sedated through inhalation with the nose or mouth with a sedative agent such as nitrous oxide.
- **Psychosedation:** Nitrous oxide acts on the psyche or the **central nervous system** in such a way that **pain**

KEY TERMS

Anesthesia—A complete or partial loss of sensation.

Conscious sedation—Being awake during a procedure, able to respond to questioning, but completely relaxed.

General sedation—Being completely asleep during the procedure.

Inhaled sedation—Reaching a sedated state through inhalation of the nose or mouth with a sedating agent, such as nitrous oxide.

Sedative—An agent having a calming, relaxing effect.

impulses are not relayed to the cerebral cortex or their interpretation is altered.

According to the American Academy of Pediatric Dentistry, nitrous oxide/oxygen is the safest sedative in dentistry. It is non-addictive, mild, and easily administered to the patient. It is a safe, effective technique for calming patient fears of the dental office and procedures to be performed.

Operation

The concentration of nitrous oxide in the oxygen mixture varies, allowing for a range from light to deep sedation, depending on the apprehension, **anxiety**, fear, and pain the patient is experiencing. Consideration of the patient risks due to health issues or age may determine the amount of gas used during the dental procedure. Commonly used first in the dental office as a calming agent before an injection of a local anesthetic, nitrous oxide is inhaled through a nosepiece attached to the patient's face. From two separate tanks, two tubes carry the oxygen and the nitrous oxide gases to the nosepiece, where they are combined into one gas. Each tank has separate controls that indicate how much oxygen and nitrous are being used at any given time. The minimum number of people involved in the administration of the gas should be two, the dentist or other licensed professional and an assistant trained to monitor the patient during the procedure to make certain the amount of gas flowing through both tubes is correct. The effectiveness of all procedures using nitrous oxide is greatly enhanced by a quiet environment. Near the end of the dental procedure the flow of nitrous oxide is shut off and the patient is allowed to inhale 100% oxygen. The body quickly dissipates the

nitrous oxide, and the patient begins to come out of the conscious sedated state.

Pregnant women should not use or handle nitrous oxide, because studies of pregnant mice and rats exposed to nitrous oxide have linked the use of the gas with birth defects.

Maintenance

Monitoring the control panels from each tank of oxygen and nitrous oxide at the beginning of each day is essential for safe practice. Daily checking of the tubes and nosepiece is vital to make certain they are free of blockages and small tears.

The tanks of oxygen and nitrous oxide should have an oxygen fail-safe system that is calibrated weekly. All emergency equipment should be functional and within reach.

Health care team roles

The dental office staff, including the dentist, dental hygienist, and dental assistant working as team, help create a calm environment. To ensure an adequate supply, the supervising dental assistant should monitor the amount of gas in each tank of oxygen and nitrous oxide, and schedule tank replacements as necessary. At least one back-up tank of each gas should be on hand, in addition to the ones being actively used with patients.

The front office staff maintains a current **health history** on each patient seen in the office. This health history has all known **allergies** or medical problems kept up to date for the dentist to refer to when deciding if nitrous oxide is safe for a particular patient.

The dental assistant in charge of the patient during the conscious sedation needs to document the **heart rate**, **blood pressure**, respiratory rate, and responsiveness of the patient periodically during the procedure, including the few minutes of recovery period when the patient is inhaling 100% oxygen.

Training

Many state laws require dental offices to have a license for housing a nitrous oxide unit and administering the gas. Dentists and dental hygienists receive training for using the gas in their degree courses. Continuing education courses on how to administer nitrous oxide are offered for the dental assistant. However, the dental assistant can only monitor the patient under the guidance of a licensed general dentist or licensed dental hygienist. A separate test is required to become fully licensed for use without supervision.

Resources

PERIODICALS

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ORGANIZATIONS

Academy of General Dentistry (AGD). 211 East Chicago Ave., Chicago, IL 60611. (312) 440-4300. <<http://www.agd.org>>.

American Academy of Pediatric Dentistry. 211 East Chicago Avenue, Suite 700. Chicago, IL 60611-2663. <<http://aapd.org>>.

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NMES (Neuromuscular electrical stimulation) see **Electrotherapy**

NMR see **Magnetic resonance imaging**

Non-Hodgkin's lymphomas see **Malignant lymphomas**

Nonsteroidal anti-inflammatory drugs

Definition

Nonsteroidal anti-inflammatory drugs are medications other than **corticosteroids** that relieve **pain**, swelling, stiffness, and inflammation.

Purpose

Nonsteroidal anti-inflammatory drugs (NSAIDs) are prescribed for a variety of painful conditions, including arthritis, **bursitis**, tendinitis, **gout**, menstrual cramps, sprains, strains, and other injuries.

Description

The nonsteroidal anti-inflammatory drugs are a group of agents inhibiting prostaglandin synthetase, thereby reducing the process of inflammation. As a group, they are all effective **analgesics**. Some, including the salicylates, ibuprofen, and naproxene, are also useful antipyretics (fever-reducers).

Although the NSAIDs fall into discrete chemical classes, they are usually divided into the nonselective NSAIDs and the COX-2 specific agents. Among the non-specific NSAIDs are diclofenac (Voltaren), etodolac (Lodine), flurbiprofen (Ansaid), ibuprofen (Motrin, Advil, Rufen), ketorolac (Toradol), nabumetone (Relafen), naproxen (Naprosyn), naproxen sodium (Aleve, Anaprox, Naprelan), and oxaprozin (Daypro). The COX-2 specific drugs are celecoxib (Celebrex) and rofecoxib (Vioxx).

Nonselective NSAIDs inhibit both cyclooxygenase 1 and cyclooxygenase 2 (COX-2). Cyclooxygenase 1 is important for homeostatic maintenance, such as platelet aggregation, the regulation of **blood** flow in the kidney and **stomach**, and the regulation of gastric acid secretion. The inhibition of cyclooxygenase 1 is considered the primary cause of NSAID toxicity, including gastric ulceration and **bleeding disorders**. COX-2 is the primary cause of pain and inflammation. Note that both celecoxib and rofecoxib are relatively selective, and may cause the same adverse effects as the nonselective drugs, although with somewhat reduced frequency.

The analgesic activity of NSAIDs has not been fully elucidated. Antipyretic activity may be caused by the inhibition of prostaglandin E2 (PGE2) synthesis.

Although not all NSAIDs have approved indications for all uses, as a class, they are used for:

- ankylosing spondylitis
- bursitis
- fever
- gout
- headache
- juvenile arthritis
- mild to moderate pain
- osteoarthritis
- PMS
- primary dysmenorrhea
- rheumatoid arthritis
- tendinitis

Recommended dosage

Recommended doses vary, depending on the patient, the type of nonsteroidal anti-inflammatory drug prescribed, the condition for which the drug is prescribed, and the form in which it is used. Consult specific sources for detailed information.

Common nonsteroidal anti-inflammatory drugs (NSAIDs)

Generic name (trade name)	Comparison to other NSAIDs
Aspirin (many trade names)	Most widely used NSAID for analgesic and anti-inflammatory effects; also used frequently for antipyretic and anticoagulant effects.
Diclofenac (Voltaren)	Substantially more potent than naproxen and several other NSAIDs; adverse side effects occur in 20% of patients.
Diflunisal (Dolobid)	Has potency 3–4 times greater than aspirin in terms of analgesic and anti-inflammatory effects but lacks antipyretic activity.
Etodolac (Lodine)	Effective as analgesic/anti-inflammatory agent with fewer side effects than most NSAIDs; may have gastric-sparing activity.
Fenoprofen (Ansaid)	Similar to aspirin's benefits and side effects; also available as topical ophthalmic preparation (Ocufen).
Ibuprofen (Motrin, Rufen, others)	First nonaspirin NSAID also available in nonprescription form; fewer GI side effects than aspirin but GI effects still occur in 5–15% of patients.
Indomethacin (Indameth, Indocin)	Relative high incidence of dose-related side effects; problems occur in 25–50% of patients.
Ketoprofen (Orudis)	Similar to aspirin's benefits and side effects but has relatively short half-life (1–2 h).
Ketorolac (Toradol)	Can be administered orally or by intramuscular injection; parenteral doses provide postoperative analgesia equivalent to opioids.
Nabumetone (Relafen)	Effective as analgesic/anti-inflammatory agent with fewer side effects than most NSAIDs.
Naproxen (Anaprox, Naprosyn)	Similar to ibuprofen in terms of benefits and adverse effects.

SOURCE: Rothstein, J.M., S.H. Roy, and S.L. Wolf. *The Rehabilitation Specialist's Handbook*. 2nd ed. Philadelphia: F.A. Davis Co., 1998.

Precautions

The most common hazard associated with NSAID use is gastrointestinal intolerance and ulceration. This may occur without warning, and is a greater risk among patients over the age of 65. The risk appears to rise with increasing length of treatment and increasing dose. Patients should be aware of the warning signs of gastrointestinal (GI) bleeding.

Allergic reactions are rare, but may be severe. Patients who have allergic reactions to aspirin should not be treated with NSAIDs.

Because NSAID metabolites are eliminated by the kidney, renal toxicity should be considered. Clinicians should monitor kidney function before and during NSAID use.

KEY TERMS

Bursitis—Inflammation of the tissue around a joint.

Inflammation—Pain, redness, swelling, and heat that usually develop in response to injury or illness.

Salicylates—A group of drugs that includes aspirin and related compounds. Salicylates are used to relieve pain, reduce inflammation, and lower fever.

Tendinitis—Inflammation of a tendon—a tough band of tissue that connects muscle to bone.

Among the NSAIDs that are classed as **pregnancy category B** are ketoprofen, naproxen, naproxen sodium, flurbiprofen, and diclofenac. Etodolac, ketorolac, mefenamic acid, meloxicam, nabumetone, oxaprozin, tolmetin, piroxicam, rofecoxib, and celecoxib are category C. Breastfeeding is not advised while taking NSAIDs.

Many other rare but potentially serious adverse effects have been reported with NSAIDs. Consult specific references.

Drug interactions

Many **drug interactions** have been reported with NSAID therapy. The most serious are those that may affect the bleeding hazards associated with NSAIDs. A partial list of interacting drugs follows. Consult specific references for further information.

- blood thinning drugs, such as warfarin (Coumadin)
- other nonsteroidal anti-inflammatory drugs
- heparin
- tetracyclines
- cyclosporine
- digitalis drugs
- lithium
- phenytoin (Dilantin)
- zidovudine (AZT, Retrovir)

Samuel D. Uretsky, Pharm.D.

Nonsurgical periodontal therapy

Definition

Nonsurgical treatment of periodontal disease is the management of gum disease with cleanings and **antibiotics**. Both of these modalities can be implemented by a general dentist or a periodontist (a dentist specially trained in the periodontal field), who also prescribe any necessary antibiotics.

Purpose

The primary goals of periodontal treatment are the eradication of the disease process from the gums, ligaments, and bones that surround the teeth, and restoration of health that can be maintained on a daily basis. This nonsurgical approach is the conservative method of treating periodontal disease; it is for the patient who is fearful of surgery or wants the most conservative, noninvasive treatment. This approach is also used for the patient who presents a case of mild-to-medium severity of periodontal disease.

Precautions

The patient medical history is vital information that should be known by the entire dental staff. For example, it is crucial for them to know if the patient has **allergies** to certain medications—especially antibiotics—which cannot be tolerated, or will not mix well with prescriptions the patient is already taking. A nonsurgical treatment will be chosen by some patients, even after surgery has been recommended by the dentist or periodontist because it is the optimal treatment.

Description

Periodontal disease is the number one chronic infectious disease in the world. Surveys and studies show that over 50% of the American adult population have **gingivitis** and that 36% have periodontal disease. Periodontal disease increases with age. Most children and teenagers show some forms of gingivitis, but the harmful **bacteria** linked to gum disease is not present in young children. **Periodontitis** affects 1% of American teenagers and 3.6% of young adults aged 18–34. Among people aged 70 years or older, the rate of periodontitis increases to 86% due to the bacteria linked to this disease. It is the leading cause of tooth loss, and begins as a painless **infection** in the gums that is caused by buildup of bacteria. The bacteria buildup becomes dental plaque. If left untreated, pockets of plaque form around the gum

tissue and plaque continues to accumulate below the gum line. Inflammation results, destroying the soft tissue and bone that support the teeth. Dr. Robert Schoor, the former president of the American Academy of Periodontology (AAP), has concluded that this bacteria can travel into the bloodstream and other parts of the body, putting a person's health at risk.

Treatment for periodontal disease differs depending on the severity of the case the patient presents to the office. Nonsurgical therapy for periodontal disease needs to be taken in steps and cannot be treated in a one visit trip to the dentist. The periodontist will divide the mouth into four quadrants—upper left; lower left; upper right; and lower right. Each quadrant is treated during a single visit. Different nonsurgical approaches to treating this disease are:

- **oral hygiene** instruction
- scaling and tooth planing
- systemic antibiotic therapy (medication taken by mouth)
- topical and local antibiotic therapy

Oral hygiene instruction is a procedure designed to educate the patient on its importance, and to train the patient, via a hands-on approach, how to properly clean and brush the teeth.

Scaling and root planing, also known as deep cleaning, is the conservative approach to the removal of plaque from and the prevention of infection beneath the gum line. During the scaling, a vibrating ultrasonic unit is used to clean tartar and visible particles from the teeth. Scaling removes deposits of bacterial plaque, food debris, and any pus that has accumulated in the infected pocket as a result of periodontitis. For areas that are more difficult to reach, a curet is used. This probes and cleans the pockets that the receding gums form around the teeth. Root planing smooths and cleans the root of the tooth so that the gum tissue may heal next to the tooth. The curette is used to plane the tooth root to make the surface smooth.

This procedure also removes the source of bacteria from the pockets around the tooth. It is helpful in reducing the opportunity for more bacteria to invade as a result of an inherent characteristic of plaque: it does not adhere well to smooth surfaces.

Scaling and root planing are done one quadrant at a time, and thus require several visits to the dental office to have the other quadrants treated. A local anesthetic can be used if there is any discomfort or **pain**. Scaling and root planing treatment are often effective in allowing the healing of early stages of periodontitis, and can help to reduce time spent in subsequent surgical treatment.

Systemic antibiotics (antibiotics taken by mouth) may be used in conjunction with other treatments to help rid the mouth of the bacteria causing periodontitis. Systemic antibiotics, however, are used conservatively because of the danger of a patient developing antimicrobial resistance. In fact, topical antibiotics are used more frequently than systemic antibiotics. Studies by the AAP reveal that taking antibiotics after undergoing scaling and root planing reduce the need for surgery by stopping the progression of the disease.

Systemic antibiotic administration may include the use of:

- Augmentin 500 mg: taken twice daily for at least eight days.
- Metronidazole (Flagyl), 500 mg: taken twice daily for at least eight days.
- Clindamycin (for penicillin-allergic patients), 300 mg: twice daily for at least eight days.
- Tetracycline 500 mg: taken for at least 14 days.
- Doxycycline 100 mg: taken twice daily for at least 14 days.

As mentioned previously, topical, or local antibiotic therapy, is another method of delivering antibiotics to the infected space in the gum tissue of the affected teeth. Here, the medication is applied directly to the affected area(s). This nonsurgical treatment approach is used mainly when scaling and root planing are considered insufficient to treat the infected tissue. The drugs that may be used include:

- Atridox (block drug)
- PerioChip (chlorhexidine)
- Periostat

Atridox was approved by the U.S. Food and Drug Administration (FDA) in late 1998 as the first and only locally delivered antibiotic treatment for periodontal disease. It contains the antibiotic “doxycycline,” a proven antibiotic that kills bacteria associated with periodontal disease. The American Dental Association (ADA) awarded Atridox their Seal of Approval in 2000. Atridox gives dental professionals a practical, highly effective, and pain-free therapeutic option for treating moderate-to-severe periodontal disease before costly and invasive treatments become necessary. This type of treatment is used in conjunction with scaling and root planing. Anesthetics are not needed.

PerioChip treatment releases chlorhexidine as the antibiotic to fight against the disease. The entire chip must be used to insure adequate concentration of chlorhexidine for the seven to ten day treatment period. The PerioChip has three considerations during usage.

KEY TERMS

Adjunct—One connected to the other in a dependent or subordinate nature.

Calculus—Calcium deposits on teeth from the buildup of plaque that has not been removed.

Conjunction—In combination or association with.

Local or topical antibiotics—Method of therapy that delivers medications to local area of the body.

Periodontal—Tissue and structures that surround and support the teeth.

Periodontist—A dentist with specialized training for periodontal treatment and care.

RDA—Registered dental assistant. Individual trained to assist the dentist in dental procedures.

RDH—Registered dental hygienist. An individual trained for the specific purpose of oral hygiene, which includes the performance of teeth cleanings and home care instruction.

Root planing—Making the tooth smooth by removing built up calculus and tartar from below the gum tissue.

Scaling—The removal of food and debris from the portion of the tooth above the gum line.

Systemic antibiotics—Antibiotic medications that affect the whole body.

First, it is designed to be placed in a periodontal pocket of 5 mm or more. It is 5 mm long and 4 mm wide, with a curved end. This end is inserted into the pocket, into which it completely disappears. A patient who might be a candidate for this treatment approach might be one who is medically compromised in some way; someone in for whom surgery is contraindicated. Lastly, the PerioChip can be used where probing produces bleeding—where other forms of care have been unsuccessful, but root planing has been achieved. Initially, the area to be treated should be scaled and root planed; any subgingival plaque must be removed.

Published studies by the AAP have indicated the subgingival administration of this drug in a controlled release device reduces the bacteria and improves gingival health. Controlled clinical trials compared the benefits of scaling and root planing (SRP) alone to that of scaling, root planing and the use of the PerioChip, and revealed statistically significant benefits of adjunctive chip use

with regard to reducing probing pocket depths (0.65 mm versus 0.95 mm) and a gain of clinical attachment (0.58 mm versus 0.78 mm). The changes were small, but change did occur. Currently in studies performed by the AAP, two-chip applications have produced a result if any result is going to be seen. If no clinical result is seen after the two-chip application, additional chip therapy may be limited, but not produce any results at all. No data to date have been found by the AAP regarding further need of surgical or non-surgical treatment of sites after PerioChip treatment.

Periostat therapy, available in a 20 mg capsule as doxycycline hyclate (tetracycline) for oral administration, is indicated as an adjunct to scaling and root planing. It has been available in pharmacies since November 1998. It is listed under local and topical antibiotic treatment rather than systemic antibiotic treatment because its use is only for the treatment of periodontal disease and no other. Periostat works by attacking the enzymes that are produced by the cells within the pockets and inside the gum tissue itself. These enzymes are produced in response to a bacterial invasion of the gum and pockets with adult periodontitis. Periostat is the only treatment that suppresses the pathologically elevated levels of tissue-destroying enzymes that may lead to tooth loss in adult periodontitis. Periostat treats all periodontal pockets throughout the mouth simultaneously and therefore may be called a systemic type of therapy. Periostat administered for nine months revealed statistically significant benefits of adjunctive Periostat use with regard to reducing probing pocket depths from 1.48 mm to a gain of 1.17 mm pocket attachment and depth of 1.36 mm to a gain of 0.86 mm pocket depth. The magnitude of these changes is quite small (0.17 mm to 0.48 mm) and patients were required to use Periostat for the duration of the study. Periostat can be taken for a period of three to nine months. The length of duration depends upon the treating periodontist and the severity of the periodontal disease being treated. The AAP found no data regarding further need of surgical or non-surgical treatment of sites after using Periostat.

Preparation

Preparation for nonsurgical treatment of periodontal disease is limited to reading the medical history of the patient if any allergies to antibiotics exist and if the patient has any sensitivity to the medication prescribed. It is vital to know all existing medical conditions of the patient and what other medications being taken, especially in older patients with advanced periodontal disease. A need to know what type of medications might interact

with ones prescribed is also vital knowledge in preparing for nonsurgical treatment.

Aftercare

Since periodontal treatment is done in quadrants, root planing and scaling can leave the gums and teeth tender to the touch. Chewing soft foods and rinsing with salt-water rinses will help heal the tissue. If treatment is accomplished using systemic antibiotics, aftercare is limited to following the prescription directions prescribed by the periodontist. If topical or local antibiotic treatment has been performed in quadrants, eating soft foods and light use of the quadrants will be advised. Brushing is recommended, but using a soft bristle toothbrush will be advised. If Atridox or the PerioChip have been used during treatment, flossing will not be advised until the treatment is completed.

Maintenance of periodontal disease is ongoing to prevent recurrence of the disease. Visits to the dental office for evaluations and checkups should occur on a regular basis. The examination should include observation of the gums, checking the bite, and removing any new plaque and tartar. How often the appointments are made depends upon the patients' willingness to control the disease. Most maintenance is practicing good daily hygiene habits at home. All patients should go back to the basics with regard to toothbrushing, flossing, and rinsing.

Complications

There are some concerns by the ADA that use of systemic therapy should be reserved for patients with continuing periodontal breakdown. The concern stems from the frequent use of antibiotics, because bacteria are increasing developing strains that are resistant to systemic therapy. This will make treating the disease harder, and is a growing health concern around the world. Incorporating this type of therapy into a routine management for adult periodontitis is not justified at this time. Periostat offers some solution because the antibiotic dosage level is very low, but it still poses some concern.

Results

Periodontal disease can be eradicated with the help and cooperation of the patient.

Health care team roles

A recent poll done by the AAP of 165 periodontists found that half of the patients seen in the offices reported feeling fearful of pain before they were treated, but only 10% reported feeling extreme discomfort or pain during

treatment. Most patients making appointments with a periodontist are being referred by their general dentist and are aware of the periodontal disease they present. It is vital that periodontal office have a good rapport with local general dental offices to keep a specialty office running.

As a health care team, all areas of the office are helpful to the treating and healing of a patient. A registered dental hygienist (RDH) is most often seen by patients for root planing and scaling. Pocket depth charting is accomplished by the RDH and then relayed to the periodontist, who then plans the treatment with the patient. The registered dental assistant (RDA) assists the periodontist in organizing and sterilizing the instruments. The RDA keeps the patient flow running smoothly. A patient is greeted by the receptionist, who is also the last to see the patient. A warm and courteous front office staff is vital to the operation of any dental office at which the patient's disease is managed and his or her healing is accomplished.

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Nose packing see **Nasal packing**
 Nosocomial infections see **Cross infection**
 NSAIDs see **Nonsteroidal anti-inflammatory drugs**
 Nuclear magnetic resonance see **Magnetic resonance imaging**

Nuclear medicine technology

Definition

Nuclear medicine technology is the medical specialty concerned with the use of safe and small amounts of radioactive material for diagnostic, therapeutic, and research purposes. Nuclear medicine involves using radioactive materials to perform body function studies and organ imaging, analyze biologic specimens and to treat, manage, and prevent serious disease. Nuclear medicine allows for early detection that can result in more effective treatments and better prognosis.

Description

Nuclear medicine imaging techniques combine the use of radioactive substances, detectors, and computers to provide physicians with a way to see inside the human body. Specific techniques include **positron emission tomography (PET)** and single photon emission computed tomography (SPECT). Nuclear medicine imaging is useful for detecting tumors, irregular or inadequate **blood** flow to various tissues, blood cell disorders, and inadequate functioning of organs. During diagnostic procedures, the patient experiences little or no discomfort, and the radiation dose is small.

Nuclear medicine technologists are highly skilled individuals who work closely with nuclear medicine physicians. Responsibilities include in vivo procedures, performing radiation safety and quality control procedures, operating the cameras that create images, and patient positioning and education. The technologist also collects, prepares, and analyzes biologic specimens, and prepares data for the physician's interpretation.

In nuclear medicine, radioactive materials, or radiopharmaceuticals, are used to diagnose and treat disease. Radiopharmaceuticals are attracted to specific organs, bones, or tissues and emit gamma rays that can be detected externally by scintillation cameras. Images are created by computers and provide data and information about

the area of the body being imaged. The amount of radiation from a nuclear medicine procedure is comparable to that received during a diagnostic x ray.

Before the procedure, the nuclear medicine technologist explains the test procedure to the patient. The technologist then prepares a dosage of the radiopharmaceutical, which can be administered intravenously, orally, or by inhalation. When preparing radiopharmaceuticals, technologists adhere to safety standards that keep the radiation dose as low as possible. After positioning the patient for imaging, the technologist starts a gamma scintillation camera that scans the radioactive material and creates images of its distribution as it localizes in and emits signals from the patient's body.

Nuclear medicine technologists also perform radioimmunoassay studies. These studies assess the behavior of a radioactive substance inside the body. For example, technologists may add radioactive substances to blood or serum to determine levels of hormones or therapeutic drug content.

Work settings

Nuclear medicine technologists work in a variety of clinical settings including community hospitals, university-affiliated teaching hospitals, research institutions, imaging centers, **public health** institutions, and physicians' offices. Some technologists find work outside the medical profession as sales or training representatives for medical equipment and radiopharmaceutical manufacturing firms, or as radiation safety officers in regulatory agencies or hospitals.

Risks for radiation exposure do exist in the workplace, but it is kept to a minimum by adherence to strict safety guidelines in the field. These include the use of shielded syringes, gloves, and other protective devices. Technologists also wear badges that measure radiation levels.

Education and training

Individuals seeking to go into nuclear medicine need a strong background in anatomy, physiology, mathematics, chemistry, physics, radiation safety, clinical nuclear instrumentation, and laboratory technique.

Nuclear medicine technology programs vary in length from one to four years. Depending on the program, an individual can earn a certificate, associate's degree or bachelor's degree. Generally, healthcare professionals like radiologic technologists will enter a one-year certificate program when they want to specialize in nuclear medicine. Certificate programs are offered in

hospitals and community colleges, as well as in bachelor's programs at four-year colleges and universities. A curriculum usually includes physical sciences, the biological effects of radiation exposure, radiation protection and procedures, the use of radiopharmaceuticals, imaging techniques, and computer applications. The Joint Review Committee on Education Programs in Nuclear Medicine Technology accredits most formal training programs in nuclear medicine technology.

Program graduates take two national certification exams: the American Registry of Radiologic Technologists (ARRT) and the Nuclear Medicine Technologist Certification Board (NMTCB). Upon successful completion of the exams, the individual will be a certified nuclear medicine technologist (CNMT).

All nuclear medicine technologists must meet the minimum federal standards on the administration of radioactive drugs and the operation of radiation detection equipment. Licensure is required in about half of the 50 U.S. states.

Advanced education and training

Certified nuclear medicine technologists can continue their education to earn an associate in science degree or enter a baccalaureate degree program at an area university. Some technologists seek to specialize in a clinical area such as nuclear cardiology or computer analysis. Technologists seeking to advance their careers or to become instructors or directors for nuclear medicine technology programs will pursue a bachelor's degree or a master's in nuclear medicine technology. Continuing education allows individuals to advance into positions such as supervisor, chief technologist, department administrator, or department director.

Future outlook

The number of job openings each year in nuclear medicine technology is relatively low because the field is not large. However, technological innovations in the field may spur an increased demand for nuclear medicine technologists. Also, more opportunities may arise with the development of new radiopharmaceuticals and with the wider application of nuclear medical imaging in areas like neurology, cardiology, and oncology. Still, there will be more competition for jobs as many hospitals are combining their nuclear medicine and radiologic departments. Therefore, technologists who can perform both

KEY TERMS

Gamma camera—The basic instrument used to produce a nuclear medicine image.

In vivo—*In vivo* procedures involve trace amounts of radiopharmaceuticals given directly to a patient. The majority of nuclear medicine procedures are *in vivo*.

Positron emission tomography (PET)—A technique that produces three-dimensional computer-reconstructed images that measure and determine the biochemistry or physiology in a specific organ or site.

Radiopharmaceutical—Also called a tracer, it is the radioactive compound necessary to produce a nuclear medicine image.

Scan—The images produced as the result of a nuclear medicine procedure, often referred to as the actual procedure, examination, or test.

Single photon emission computed tomography (SPECT)—A technique that provides three-dimensional computer-reconstructed images of multiple views and function of the organ being imaged.

nuclear medicine and radiologic procedures will have the best prospects.

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Daniel J. Harvey



A nurse anesthetist prepares a child for surgery in the operating room. (Science Source/Photo Researchers. Reproduced by permission.)

Nurse anesthetist

Definition

Nurse anesthetists, or certified **registered nurse anesthetists (CRNAs)**, are advanced practice registered nurses with specialized graduate level education, training, and certification in anesthesiology.

Description

CRNAs provide services similar to those provided by anesthesiologists. CRNAs have administered anesthesia for over 100 years in the United States, and they administer the majority of anesthetics in the United States.

The majority of CRNAs work in conjunction with anesthesiologists (MDs). Their responsibilities, whether in collaboration or functioning independently, are largely related to operative procedures. As the scope of practice for anesthesiologists broadens, so does that of CRNAs. **Pain management** teams established in most hospitals now have CRNA members. The newest Joint Commission on Accreditation of Health Organizations

(JCAHO) accreditation regulations mandate that acute care institutions have a **pain** management (assessment and intervention, with outcomes evaluation) system in place. The CRNA is part of that team. Laws regarding the level of collaboration required between physicians and CRNAs vary from state to state.

The first step in a CRNA's role in the operative setting is evaluation of the patient prior to anesthesia. This includes reviewing the patient's history, ordering diagnostic tests and consultations, interviewing the patient, discussing the anesthesia with the patient, obtaining **informed consent** for anesthesia or assuring that informed consent has been obtained, and ordering preoperative medications and fluids.

The CRNA is responsible for the formulation and implementation of an anesthesia care plan, which should detail the needs, treatment, and expected outcomes for the patient. The CRNA must choose the appropriate mode of anesthesia for the needs of the patient. **Local anesthesia** is numbing of a small, specific area so that a patient can have a procedure free of pain. Sedation alters the patient's level of consciousness so that the patient is more relaxed and less aware of uncomfortable sensations. Regional anesthesia (i.e., spinal blockade, axillary blockade, etc.) causes a loss of sensation to a specific region of the body. **General anesthesia** results in a loss of consciousness and lack of sensation throughout the body and as such carries the greatest risk of all anesthetics for the patient. The CRNA must assess the risks and benefits of each type of anesthesia in the context of the individual patient.

During the course of the operative procedure, the CRNA administers anesthetics and any adjunctive medications or fluids needed to induce and maintain anesthesia and patient homeostasis. Managing the patient's pulmonary status and oxygen saturation is one of the chief responsibilities of the CRNA, as **respiratory failure** or compromise is a key risk associated with anesthesia or sedation. The CRNA must confirm that the airway remains patent and that ventilation and oxygen equipment is working correctly. Techniques such as endotracheal intubation and extubation, mechanical ventilation, pharmacologic treatment, and **respiratory therapy** help to maintain a patent and functioning pulmonary system. The CRNA is also responsible for carefully checking equipment such as the anesthesia machine, mechanical ventilator, and oxygen equipment for safety and functionality prior to any procedures.

The patient's physiologic status, especially hemodynamics, must be monitored at all times during anesthesia. **Vital signs**, pulse oximetry, **heart** monitors, and monitors on oxygen and ventilation systems are examples of meth-

ods for monitoring the patient's response and status of equipment. Neuromuscular function and status must also be monitored when neuromuscular-blocking drugs are administered. The patient's position may need to be shifted during lengthy procedures in order to prevent injuries related to anesthesia-induced immobility, but prevention of anticipated pressure points is the first step. The CRNA is responsible for prevention or correction of any abnormal response to anesthesia. For example, an episode of respiratory compromise may lead to an acid-base imbalance. Symptoms of respiratory compromise or acid-base imbalance can be detected through physiologic changes such as **cyanosis** or hyperventilation and tests such as arterial **blood gases** and oxygen saturation. The CRNA is trained to quickly detect and correct this problem. There are two key abnormal responses that could prove fatal to the patient without early recognition and appropriate intervention by the CRNA: malignant hyperthermia and **anaphylaxis** (systemic allergic response). Both have cardinal signs and prescribed intervention procedures.

Even after the procedure is complete, the CRNA remains involved in extubation, assessing emergence, and initial recovery from anesthesia. The CRNA will follow up postoperatively to evaluate and treat any anesthesia side effects, determine when the patient is safely recovered from anesthesia, and discharge the patient from the postanesthesia care unit (PACU) or recovery room when appropriate.

In addition to the more traditional roles related to surgery, CRNAs are prepared to administer emergency care in any setting, including **airway management**, fluid and medication administration, and other interventions requiring advanced cardiac life support (ACLS) skills.

CRNAs also practice in the area of acute and chronic pain management through specialized techniques using drugs, regional anesthetics, or devices (such as a patient controlled anesthesia pump). They may also be asked to consult in the areas of respiratory care and are required to respond to cardiac arrest codes, especially when they occur with patients in the emergency department.

CRNAs may also choose to specialize in specific patient populations such as pediatrics, geriatrics, cardiovascular, neurology, or obstetrics.

It is important that the CRNA document in the chart descriptions of any of the above roles, providing details about the procedure, techniques, equipment, clinical situation, and patient outcomes.

Work settings

Practice settings for CRNAs include independent or group practice in hospitals (i.e., surgical suites or obstet-

KEY TERMS

Arterial blood gases—Measurement of oxygen, carbon dioxide, pH, bicarbonate, and their chemical relationships in the arterial blood in order to determine oxygenation and acid-base balance.

Cyanosis—Blue coloring of the skin around the eyes, lips, or fingers that signals low blood oxygen levels.

Extubation—Removal of an endotracheal tube.

Homeostasis—A state of physiologic balance.

Intubation—Insertion of an endotracheal tube to protect or restore the airway.

Mechanical ventilation—The use of a respirator or manual method to assure that the patient receives adequate oxygenation.

Patent—Open or unobstructed.

Pulse oximetry—Measurement of oxygen levels and heart rate through a device worn on the finger or ear lobe.

rical delivery rooms), outpatient surgery facilities, and dental, ophthalmology, podiatry, or plastic surgery offices. Military treatment facilities often use CRNAs as the chief anesthesia providers in facilities such as mobile care units or veterans hospitals. CRNAs may also work in the areas of research, quality assurance, critical care management or oversight, and administrative roles. Currently there are some states where CRNAs are granted the right to independent practice without physician supervision.

Education and training

There are over 80 university-affiliated educational programs for nurse anesthetists in the United States. In order to qualify for CRNA education, the nurse must have a bachelor of science in nursing degree or another science or health care-related baccalaureate-level degree, a current registered nurse license, and a minimum of one year acute care experience. Some CRNA programs require two years experience in either the operating room or critical care. Accredited CRNA programs require a 24- to 36-month program that includes a graduate degree and clinical training. After this training is complete, the nurse anesthetist must pass a national certification exam in order to become a CRNA. CRNAs must be recertified every two years and that requires continuing education credits specific to the specialty as well as proof of a des-

ignated number of hours spent giving anesthesia to patients.

Future outlook

It has been projected that more CRNAs will be required and utilized in the future. According to the American Association of Nurse Anesthetists (AANA), 50% of hospitals and 65% of rural hospitals currently use nurse anesthetists as their sole anesthesia providers. Furthermore, the AANA has summarized reports by organizations including the National Academy of Sciences, the Centers for Disease Control, and the US House of Representatives and concluded that CRNAs are a cost-effective and equally safe alternative to anesthesiologists. There is an ongoing controversy between the American Society of Anesthesiologists and the AANA, in the face of requests of managed care companies to cut costs, that contests the independent practice option for CRNAs. The contention by the physician's group is that CRNA independent practice is not as safe for patients as MD supervision would be, but, to date, that has not been proved to the satisfaction of regulatory agencies. The needs for available, safe, and effective care ensure the ongoing need for CRNAs in the health care environment especially in areas where there is a scarcity of anesthesiologists, such as remote centers and rural populations.

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Nurse midwifery

Definition

Nurse midwifery is a profession that independently functions within the health care system. Nurse midwives manage the different stages of women's health from

pregnancy, to **childbirth**, through the postpartum period, as well as meeting women's gynecological needs during the menopausal and post-menopausal periods. Nurse midwives additionally may provide newborn care and will occasionally provide prenatal education, all as a part of their philosophy of family-centered care. A nurse midwife is a person trained in the two professions of nursing and midwifery as compared to a certified midwife (CM) who is trained in midwifery but not through the profession of nursing.

The certified nurse midwife (CNM) is an individual who has successfully completed an approved course of study in nurse midwifery and practices in compliance with the *Standards for the Practice of Nurse Midwifery* as defined by the American College of Nurse Midwives (ACNM). Midwives have attended births in America since colonial times, but the actual profession of nurse midwifery was not officially recognized in the United States until the early 1920s.

Description

The nurse midwife provides women during pregnancy with appropriate supervision, care, and advice. During labor and the postpartum period, the nurse midwife performs vaginal deliveries and may care for the newborn while facilitating family involvement, particularly of fathers and siblings. Nurse midwives foster an environment that facilitates minimal intervention while continuously assessing for abnormal conditions in the mother and child that would necessitate medical assistance or emergency procedures.

Nurse midwives promote family-centered maternity care that incorporates counseling and education for the woman and the family. The occupation stresses the importance of antenatal education and preparation for parenthood. The nurse midwife acts as a kind of primary-care provider by providing the woman with family planning and a range of gynecological care.

Many of the clients that a nurse midwife cares for can be classified as "vulnerable" by one or more of the subsequent criteria: less than 16 years of age; level of education less than eight years; race and ethnicity other than white; and source of payment through public programs such as **Medicaid**, **Medicare**, and the Indian Health Service or free/self-pay. Women and infants seen by nurse midwives live disproportionately in areas where a higher than average number of people live below the poverty level.

The ACNM is the main professional organization in the United States representing CNMs and CMs. The group is the oldest women's health organization in the United States with roots back to the 1920s. ACNM con-



A nurse midwife examines a newborn after a home birth. (Photograph by Michelle del Guercio. Science Source/Photo Researchers. Reproduced by permission.)

ducts research in midwifery practice; accredits midwifery schools; coordinates and administers continuing education programs; develops clinical practice standards of care; and works with state and federal agencies and members of Congress in promoting midwifery.

Work settings

The practice of nurse midwifery is legal in all 50 states and the District of Columbia. Most nurse midwives function in a hospital or physician practice and attend deliveries in hospital settings. In 1997, 96% of nurse midwives delivered in hospitals, 2.4% delivered in separate birth centers and 1% delivered in a home setting.

Hospitals

Nurse midwives have various roles in the care facility, from providing solely intrapartum care to antepartal care to well-woman care to all of these combined. One of the more recent developments in hospital labor and delivery is the creation of birthing rooms that provide a more comfortable, home-like ambiance. Comfort features include showers or Jacuzzis, and beds that convert to

birthing beds in which a woman can labor, deliver, and recover. Nurse midwives have been strong proponents of such advances and find them very useful in their practice.

Health maintenance organizations (HMOs) and managed care

Nurse midwives fit well into the model of managed care, which emphasizes cost-effective care focusing on prevention. They provide OB/GYN care as well as family planning. In 1992, Kaiser Permanente, a California-based HMO, reported that nurse midwives handled 70% of the low-risk obstetrical patients and had contributed to lowering the cesarean section rate to 12%. The national average for cesarean sections is 23.5%.

Private practices

A great number of nurse midwives work in private practices of different sorts. Some practice in private OB/GYN practices with physicians, others in private nurse midwife only practices with physician consultation available, some in freestanding birth centers and a few perform home births. Private practices give nurse midwives greater

KEY TERMS

Antepartum—Refers to period of time prior to labor and delivery during which a pregnant woman should receive prenatal care.

Intrapartum—Refers to labor and delivery.

Postpartum—Refers to the six-week period after childbirth.

autonomy, allowing them to utilize the fullest extent of their training.

Birth centers

Freestanding birth centers offer the patient and her family a place to give birth that is a compromise between the hospital and home. In birthing centers, the nurse midwife tries to foster a home-like atmosphere as much as possible but still has the advantages of specialized equipment and proximity of emergency transportation.

Clinics

Nurse midwives make a major contribution to caring for indigent and under-served populations in **public health** clinics—both independent clinics and those affiliated with a hospital. In these settings, nurse midwives attend to women that are susceptible to poorer than average outcomes of childbirth due to age, socioeconomic status, refugee status, and ethnic background.

Home births

Nurse midwives who assist in home births ensure the patient's and baby's safety while delivering personalized care and emotional support. A woman delivering in her own home experiences a familiar environment that is conducive to the woman retaining control of her birthing experience.

International health

Before nurse midwifery was generally accepted in the United States, a large number of nurse midwives focused on the improvement of maternal-child health on a global level. A large number of international health organizations fund projects for nurse midwives in an effort to improve the health status of women and children throughout the world.

Education and training

The education of nurse midwives consists of a thorough foundation in the health sciences and extensive clinical preparation. Clinical training concentrates on the acquisition of knowledge, decision-making ability, and skills required to provide primary care and independent management of women and newborns. Students learn to function within a health care system where they can obtain medical consultation if necessary, where they can manage patients collaboratively and where they can refer when needed. The ACNM defines the scope of practice of a nurse midwife to include antepartum, intrapartum, postpartum, newborn, family planning, gynecology, and primary care.

The numbers of patient visits and experiences below represent suggested guidelines for nurse midwifery educational programs from the ACNM:

- 10 preconception care visits
- 15 new antepartum visits
- 70 return antepartum visits
- 20 labor management experiences
- 20 births
- 20 newborn assessments
- 10 breastfeeding support visits
- 20 postpartum visits (0-5 days)
- 15 postpartum visits (4-8 weeks)
- Primary care visits:
 - 40 common health problems
 - 20 family planning visits
 - 20 gynecologic visits
 - 20 perimenopausal/postmenopausal visits

Nurse midwifery students matriculate in a variety of academic programs and have various options including: diploma or associate degree (AD) **registered nurse (RN)** to certified nurse midwife (CNM) programs; BA/BS to RN/CNM-graduate programs; post-secondary programs; distance education; master's completion programs; and post-master's certificate programs.

Advanced education and training

The ACNM defines continuing education as an educational experience that goes beyond basic midwifery education. Nurse midwives may complete a variety of educational activities, including taking a national certification exam, attending workshops, and completing home study units of study.

Future outlook

The popularity and acceptance of nurse midwifery increased dramatically in the 1970s and 1980s. The number of nurse midwife attended births has steadily increased from year to year. Many more obstetricians and other healthcare providers have concluded that nurse midwifery is a safe, cost-effective way of managing normal pregnancies and deliveries. They are also coming to be accepted as primary care providers in managing women's health.

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Nursing assessment see **Nursing diagnosis**

Nursing diagnosis

Definition

In 1990, the North American Nursing Diagnosis Association (NANDA) defined nursing diagnosis as "a clinical judgement about individual, family, or community responses to actual or potential health problems/life processes. Nursing diagnoses provide the basis for selection of nursing interventions to achieve outcomes for which the nurse is accountable."

Purpose

The first conference on nursing diagnosis was held in 1973 to identify nursing knowledge and establish a classification system to be used for computerization. At this conference, the National Group for Classification of Nursing Diagnosis was founded; this group was later

renamed the North American Nursing Diagnosis Association (NANDA). In 1984, NANDA established a Diagnosis Review Committee (DRC) to develop a process for reviewing and approving proposed changes to the list of nursing diagnoses. The American Nurses Association (ANA) officially sanctioned NANDA as the organization to govern the development of a classification system for nursing diagnosis in 1987. However, the ANA also recognizes the Omaha system and the Home Health Classification system as two additional nursing diagnosis systems currently in use.

The purpose of the NANDA diagnosis list is three fold. First, it provides nurses with a common frame of reference and standardizes language that improves communication among nurses, helps organize research, and is useful in educating new practitioners. Second, nursing diagnoses provide a classification system to describe the scientific foundation of nursing practices—a major criterion necessary for nursing to be recognized as a separate profession, differentiated from medicine and other health care professions. Third, the NANDA diagnosis system has the potential for computer use and may, in the future, provide nomenclature for the reimbursement of nursing activities, not unlike DRGs and ICDs do for medicine.

Precautions

It is important to distinguish nursing diagnoses from medical diagnoses. The two are similar because they are both designed to plan care for a patient. However, nursing diagnoses focus on human response to stimuli, while medical diagnoses focus on the disease process. An example of this difference is the different diagnoses given by a nurse and a doctor to a patient who exhibits difficulty breathing, a productive cough, and crackles throughout lung fields. This patient might be medically diagnosed as having **pneumonia**. Some nursing diagnoses that might be made for this particular patient, however, include activity intolerance, impaired **gas exchange**, and fatigue.

Another feature that is unique to nursing diagnoses is the identification of potential problems. The diagnosis of "at risk for aspiration" is an example of a diagnosis that recognizes the potential for a given problem to occur. In order for a risk diagnosis to be made, risk factors must be present and identified upon assessment. In the above example, the absence of the gag reflex, and the presence of facial droop or **paralysis** may be among the risk factors for impaired swallowing that would lead a nurse to make the diagnosis of "at risk for aspiration." These diagnoses are important because they allow nursing to take a preventive approach to patient care.

KEY TERMS

Expected outcome—A measurable individual, family, or community state, behavior, or perception that is measured along a continuum and is responsive to nursing interventions.

Medical diagnosis—A medical determination of disease or syndrome performed by a physician. The focus is on the disease process and the physical, genetic, or environmental cause of that process.

NANDA, North American Nursing Diagnosis Association—Formed in 1973, this group is responsible for developing a classification system of nursing diagnoses.

NIC, Nursing Interventions Classification—Developed by the Iowa Intervention Project, this is a collection of nursing interventions linked to the NANDA diagnoses. The 2000 publication includes approximately 500 interventions.

NOC, Nursing Outcomes Classification—Developed by the Iowa Outcome Project, this is a comprehensive, standardized classification of patient outcomes developed to evaluate the effects of nursing interventions. The outcomes may be linked to the NANDA diagnoses and other diagnoses systems. The 2000 publication includes 260 outcomes.

Nursing assessment—The way in which a nurse gathers and evaluates data about a client (individual, family, or community). The assessment includes a physical examination, interviewing, and observations. Assessment is also the first step in the nursing process.

Nursing diagnostic statement—The formal, written documentation of a nursing diagnosis. It includes the label or diagnosis, the etiology, and the indicators. In the statement, the etiology is preceded by the phrase “related to.” The indicators are the assessment data that led to the diagnosis. They are preceded by the phrase, “as evidenced by.”

Nursing intervention—Any treatment that a nurse performs on a patient in response to a nursing diagnosis to reach a projected outcome.

Risk diagnosis—A nursing diagnosis that recognizes a potential problem not an existing problem. The indicators for risk diagnoses are risk factors that are identified through assessment.

Description

The term “nursing diagnosis” refers to items on the NANDA list of approved diagnoses, such as **anxiety**. The term “nursing diagnostic statement” refers to the approved or accepted way in which a nursing diagnosis is written in practice. Gordon identifies three structural components of a nursing diagnostic statement: the problem, the etiology (cause), and the signs and symptoms. An example of a nursing diagnostic statement would read, “Anxiety related to hospitalization as evidenced by verbal comments, and increased **heart rate**.” When writing an “at-risk” nursing diagnostic statement, the signs and symptoms are replaced by the list of risk factors present for a particular response.

Nursing diagnoses may be made for an individual, a family, or a community. An example of a family nursing diagnosis is “risk for altered parent-infant attachment.” The nursing diagnostic statement in this case might read, “risk for altered parent-infant attachment related to maternal distancing as evidenced by lack of eye contact between mother and infant.” “Management of therapeutic regimen, ineffective: community,” is an example of a nursing diagnosis for a community. The nursing diagnostic statement in this case may read, “Management of therapeutic regimen related to prevention of teen **pregnancy**, ineffective in the community, as evidenced by higher rate of teen pregnancy than surrounding communities.”

Preparation

In order to make an appropriate nursing diagnosis, the practitioner must conduct an in-depth interview, physical assessment, and critical observation of the individual, family, or community for which the diagnosis is being made. A complete nursing assessment includes: the patient’s current health status, signs and symptoms, strengths, and problem areas. The patient (who can be an individual, a family, or a group) should be the primary source of assessment data.

After compiling data through assessment, the data are grouped or organized into categories that will assist the nurse in identifying appropriate diagnoses. A variety of organizing frameworks exist to assist the nurse in organizing the data, including **Maslow’s hierarchy of needs**, NANDA’s human response patterns, and Gordon’s functional health patterns.

Aftercare

Diagnosis is the second step in the nursing process, following assessment. Once an in-depth assessment has been completed and the appropriate nursing diagnoses are made, the steps of planning and implementing nurs-

ing interventions and subsequently evaluating the outcomes based on treatment goals must be undertaken. In planning nursing intervention, priorities must be set and expected measurable outcomes or objectives must be specifically stated.

In 1987, a program begun at the University of Iowa for treatment goals became known as the Iowa Intervention Project. This was a large research project from which the Nursing Interventions Classification system (NIC) was produced. In 2000, the third edition of NIC was published. It included almost 500 nursing interventions. NIC provides a link to the NANDA diagnoses. Using NIC, nurses may look up a NANDA diagnosis and be directed to appropriate nursing interventions for that diagnosis.

Research for the development of the Nursing Outcomes Classification (NOC) began in 1991. The second edition of NOC was completed by the Iowa Outcomes Project in 2000 and contains 260 outcomes. Each outcome has a definition, list of indicators, and a five-point Likert scale to assess patient status. NOC has been linked to the NANDA diagnoses, the NIC interventions, Gordon's functional patterns, the Omaha system of problems, resident admission protocols (RAPs) used in **nursing homes**, and to the OASIS system used in **home care**.

Results

Nursing diagnoses are made to identify current and potential problems for individuals, families, and communities, and to communicate these problems to other practitioners in a standard form. Once a nursing diagnosis is made, it is anticipated that the appropriate nursing interventions will be implemented to either correct or prevent the problem.

Health care team roles

Although nursing diagnoses are almost exclusively generated and used by nurses, members of the nursing profession hope these diagnoses will become more widely recognized and adopted by other health care professions. Using the standardized language that NANDA provides facilitates communication between health care professionals.

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Nursing education

Definition

Nursing education refers to formal learning and training in the science of nursing. This includes the functions and duties in the physical care of patients, and a combination of different disciplines that both accelerates the patient's return to health and helps maintain it.

Description

Nursing and nursing education have undergone striking changes over the centuries. This history reveals a constant struggle for autonomy and professionalism. There have been many influences on nursing practice in the past, including women's struggle for professional acceptance and status, religion, war, technology, and societal attitudes. These factors still influence nursing today. During the past decades, the profession worked to improve its image.

Nursing education in the United States had its beginnings in Europe. In 1836, in Kaiserwerth, Germany, Theodor Fliedner opened a small hospital and training school called the Order of Deaconesses. Florence Nightingale, the founder of modern nursing, received her formal training at this school. In 1859, she published *Notes on Nursing: What It Is and What It Is Not in*

London. This was not intended as a text for nurses but for the ordinary woman who was the nurse for her family. In 1869, voting rights for women were promoted with the organization of the National Women's Suffrage Association and Lavinia Dock, a nurse, used the organization to promote and expand nurses' rights.

The first training schools in the United States were opened in 1872 in Philadelphia at the Women's Hospital, and in Boston at the New England Hospital for Women and Children in Boston. Linda Richards, American's first trained nurse, graduated from the latter in 1873. The American National Red Cross was organized by Clara Barton in 1882, and in 1885 Clara Weeks Shaw published the first textbook written by an American nurse: *Textbook of Nursing for the Use of Training Schools, Families, and Private Students*. The first home visiting nursing organization in the United States, the Henry Street Settlement in New York, was founded by Lillian Wald and Mary Brewster in 1893. In that same year, the American Society of Superintendents of Training Schools for Nurses (renamed the National League of Nursing Education in 1912), was established.

The Nurses' Associated Alumnae of United States and Canada was established in 1897 and renamed the American Nurses Association in 1911. North Carolina, New Jersey, Virginia, and New York established the first Nurse Practice Acts in 1903. In a study funded by the Rockefeller Foundation in 1920, the Goldmark Report recommended that nursing schools become independent of hospitals, and that students should not be a source of cheap labor. It also advocated financial support of university-based nursing schools.

During the Great Depression, many nurses were unemployed and the number of schools declined, but the outbreak of World War II brought a huge increase in nursing demand. During the war years, new students were still taught by experienced nurses in hospital-based programs called diploma schools of nursing.

In 1948 the Brown Report recommended that education for nursing take place in colleges and universities, not hospitals. In the same year, the National League of Nursing Education established the National Nursing Accrediting Service for nursing educational programs. In 1951, Dr. Mildred Montag suggested that one way to increase the number of nurses was to shorten their education period. She also recommended that they be trained in colleges and universities instead of diploma schools. In her dissertation "The Education of Nursing Technicians," she proposed a two-tiered system in which "technical" nurses, who would be trained for two years, largely in community colleges, would assist "professional" nurses, who would receive four-year degrees.

Although the model was not adopted at that time, Dr. Montag's paper is credited with creating the associate degree in nursing.

In 1965, the American Nurses' Association (ANA) published a position paper urged that all nursing education should take place in institutions of higher learning. As a result, many diploma schools closed and nursing education began its move to collegiate programs. At this time, the ANA also echoed Dr. Montag's proposal that nursing practice consist of two levels: a professional nurse, who would hold a baccalaureate or higher degree, and a technical nurse, who would have an associate degree and would work under the direct supervision of the professional nurse. Since then, as medical knowledge advanced, nurses have had to keep up with new medications, technology, and a rapidly changing health care system as well as appropriate nursing care.

Degree programs

Associate degree programs were originally introduced in the United States in 1952 and are primarily offered by community colleges. This is a two-year program emphasizing technical skills with a foundation in behavioral and biological science. Associate degree graduates take a state licensing examination and are entitled to practice using the initials RN. Since the 1950s, the National League for Nursing (NLN) has been the accrediting body for two and four-year nursing colleges. In recent years, though, four-year colleges have turned to the American Association of Colleges of Nursing (AACN) for their accreditation, an association that does not allow two-year colleges to join.

The baccalaureate program, found in universities and colleges across the United States, takes four years to complete. It provides an education in the arts, sciences, and humanities. Although the program teaches bedside care, the emphasis is placed on leadership and management, community health nursing, and research. These graduates also take the licensing examination and receive the designation of RN.

Advanced practice nurses are RNs who specialize in one of several fields, which include nurse practitioner (NP), certified nurse midwife (CNM), certified **registered nurse** anesthetist (CRNA), and **clinical nurse specialist** (CNS). These nurses have four-year degrees with at least some postgraduate study; most hold master's degrees. Like RNs, advanced practice nurses are licensed and certified.

To obtain a master's or doctoral degree, a student is required to hold a baccalaureate degree from an accredited college or university. Graduate programs emphasize

advanced clinical practice, research, and prepare students for roles as educators and administrators.

Nurses can also serve without a college degree. Becoming a practical nurse takes about one year and is comprised of training in a hospital along with classroom work. After graduating from a practical nursing program, students must pass a licensing examination, after which they can use the initials LPN (**licensed practical nurse**) or LVN (licensed vocational nurse) and practice under the supervision of a registered nurse. Compared to RNs, however, LPNs make less money, have less responsibility, and usually are not promoted to supervisory roles.

Of the 2.6 million registered nurses in the United States, 32% have an associate's degree, 27% have a diploma, and 31% have a baccalaureate degree as their highest degree. In 1995, 61% of all new nursing graduates were from associate degree programs, slightly more than 9% had master's degrees and less than 1% held doctorates. In 1998, the Veteran's Administration, one of the nation's largest employers of nurses, stated that they preferred to hire nurses with baccalaureate degrees, but would not require one for entry-level positions. In that year, the VA set aside \$10 million for each of the following five years to help associate degree nurses on staff go back to school to obtain a baccalaureate degree. Although many nurses consider their associate degree a valuable first step, higher degrees are necessary to enhance their prospects for advancement.

The nursing shortage

Health care has become a complex business; nurses are becoming managers who are expected to have the education and skill to provide leadership in administrative settings. At the same time, their workloads have increased and the patients for whom they care are more ill. In addition, many other professions are now open to women, diluting the pool of available candidates. The profession is also facing a shortage of nursing faculty. As a result, the number of nurses in the field is dropping, creating a significant shortage.

The average age of all RNs in 1996 was 44.3 years; for practicing nurses, 42.3 years. Worse still, the average age continues to increase at the same time that enrollment in baccalaureate programs is decreasing. Federal figures project that if current trends continue, rising demand will outstrip the supply of RNs in or about the year 2010. According to a U.S. Department of Health and Human Services Division Of Nursing projection, 114,000 jobs for full-time RNs will go unfulfilled in the year 2015.

To meet these future needs, hospitals and other employers have stepped up recruitment. The nursing practice has also been moving away from the acute care

setting. Nurses have more opportunities in the community, advanced practice settings, health maintenance organizations, insurance companies and home health, and administrators are now requiring new employees to be bachelor's prepared.

Viewpoints

Changing curriculum

The capacity to develop critical thinkers and proactive professional nurses is driving all aspects of the education process. The scope is broad and highly technical, while requiring knowledge of social change and community development and all specialties in between. Theory and practice are also changing at rates that require nurses to continue their education throughout their careers along with retaining basic nursing values. Nursing practice should foster these attributes in a health care system of challenge and change.

Leading nursing organizations view a bachelor of science degree in nursing as the first step towards a career in professional nursing, and as a requirement for anyone seeking a position as nurse manager or supervisor. Nurses with a baccalaureate degree are prepared to practice in all health care settings, giving graduates a broader employment choice. This level of education includes health care policy, economics, research, outcome measures, quality indicators, fiscal management, legislative advocacy, and managing information systems.

LONG-DISTANCE LEARNING. Nursing students can now obtain an education from anywhere in the world, increasing competition and pressure for quality teaching. The Internet offers a wide range of information, available faster than ever before, along with a choice of curricula, with clinical practice based in the student's community. In addition, today's more diverse and demanding student body expects choices and educational methods that fit in with all aspects of their lives. As institutes of higher learning become increasingly more responsive to education consumers, students will expect flexible learning opportunities in settings that fit their multiple roles as employees, homemakers, and members of communities. Needless to say, all nursing education programs, whatever their format, should foster collaboration, nourish racial and ethnic diversity, and encourage men to enter nursing programs. Mentoring programs starting at the high school level would also encourage more nurses to join the profession.

Professional implications

Nurses at all levels are required to deliver high-quality service while containing costs. To this end, nursing

education must foster innovation and prepare students to be critical thinkers and problem solvers. Nursing professionals must be able to search for new solutions, be proactive, and entrepreneurial. Continuous learning for the professional nurse is no longer just a task needed for license renewal, but is critical to staying current in today's nursing workforce.

Legislation is constantly changing the scope of nursing practice, and educators should reflect this in their curriculum. Nursing education shapes practice—it doesn't simply react to changes in government and care environments. Collaboration between nursing educators and practicing nurses to shape nursing curriculum should reflect nursing core values and ethics. Nurses who possess analytical, communicative, and negotiating skills can help improve the health care system by educating both the public and government policymakers.

Teachers must prepare nurses to work in highly technical settings, to be computer literate, and to be highly organized and self-directed. Knowledge of today's advanced medical science is communicated in complex and sophisticated ways, requiring all nursing professionals to have the ability to manage, retrieve, and interpret data, and to be autonomous and flexible. Educators will be obliged to teach technology solutions as well as enhanced personal services. Both students and teachers must be flexible in the ways they teach and learn.

There is also greater demand for nurses in specialty areas: critical care, operating room, radiology special procedures, neonatal, and emergency. Therefore, delivering a more complex level of care is extremely important. Nurses with advanced clinical skills will have greater opportunity in their choice of clinical environments, though they may have to pursue employment in a region other than their own community. Advanced practice nurses are in increasing demand across the United States and in other countries.

Educating future generations of nursing professionals will be a unique challenge in the next decade. While the nursing shortage is just beginning to be felt, nursing faculty may face a decrease as profound as the general nursing shortage. If and when a new generation of students can be persuaded to join the profession, an associate's degree would be the fastest and most economical way into the profession. If only a limited number of faculty are available, this will perpetuate the general shortage. Nursing roles in leadership and legislation will also be severely curtailed.

Many strategies have been suggested to counter the nursing and faculty shortage. Recruiting and retention committees are the focus of many educational institutions and health care facilities in the United States and

internationally. Both shortages must be addressed because one can not be maintained without the other. The challenge will be a unique and challenging endeavor for the future of nursing education and will doubtless have a major global impact on health care.

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- American Association of Colleges of Nursing. 1 Dupont Circle, NW, Suite 530, Washington, DC 20036. (202) 463-6930.

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Nursing ethics see **Code of ethics for nurses**

Nursing homes

Definition

A nursing home is a long-term care facility that offers room and board and health care services, including basic and skilled nursing care, rehabilitation, and a full range of other therapies, treatments, and programs. People who live in nursing homes are referred to as residents.

Description

Nursing homes are often the only alternative for patients who require nursing care over an extended period of time. They are too ill to remain at home, with fam-

ilies, or in less structured long-term facilities. These individuals are unable to live independently and need assistance with activities of daily living (ADL). Nursing homes are largely populated by the elderly. Some nursing homes offer specialized care for certain medical conditions such as **Alzheimer's disease**.

Commonly, nursing home residents are no longer able to participate in the activities they once enjoyed. However, it is required by law that these facilities help residents achieve their highest possible quality of life. It is important for residents to have as much control as possible over their everyday lives. Laws and regulations exist to raise nursing home quality of life and care standards.

By law, nursing homes cannot use chemical or physical restraints unless they are essential for treating a medical problem. There are many dangers associated with the use of restraints, including the chance of a fall if a resident tries to walk while restrained. The devices may also lead to depression and decreased self-esteem. A doctor's order is necessary before restraints can be used in a nursing home.

Licensing

The Joint Commission on the Accreditation of Health Care Organizations (JCAHO) offers accreditation to nursing homes through the Long Term Care Accreditation Program established in 1966. This group helps nursing homes improve their quality of care. The JCAHO periodically surveys nursing homes to check on quality issues.

A nursing home may be certified by **Medicare** or **Medicaid** if it meets the criteria of these organizations. Families should be informed of the certifications a nursing home holds. Medicare and Medicaid are the main sources of financial income for nursing homes in the United States.

The state where a nursing home is located conducts inspections every nine to 15 months. Fines and other penalties may be enforced if the inspection reveals areas where the nursing home does not meet requirements set by that state and the federal government. Problem areas are noted in terms of scope and severity. The scope of a problem is how widespread it is, and the severity is the seriousness of its impact on the residents. When a nursing home receives an inspection report, it must post it in a place where it can be easily seen by residents and their guests.

Contract

When a resident checks into a nursing home, a contract is drawn up between him or her and the facility. This document includes information regarding the rights of the residents. It also provides details regarding services provided and discharge policies.

Resident decision-making

Decisions are made by each nursing home resident unless he or she has signed an Advanced Directive giving this authority to someone else. In order for health care decisions to be made by another person, the resident must have signed a document called a Durable Power of Attorney for Health Care.

Costs

Nursing home care is costly. The rate normally includes room and board, housekeeping, bedding, nursing care, activities, and some personal items. Additional fees may be charged for haircuts, telephones, and other personal items.

Medicare covers the cost of some nursing home services, such as skilled nursing or rehabilitative care. This payment may be activated when the nursing home care is provided after a Medicare qualifying stay in the hospital for at least three days. It is common for nursing homes to have only a few beds available for Medicare or Medicaid residents. Residents relying solely on these types of coverage must wait for a Medicare or Medicaid bed to become available.

Medicare supplemental insurance, such as Medigap, assists with the payment of nursing home expenses that are not covered by Medicare.

Medicaid qualifications vary in each state. Families of potential residents should check with their state government to determine coverage options. According to a federal law, a nursing home that drops out of the Medicaid program cannot evict current residents whose care is supported by Medicaid.

Private insurance, such as **long-term insurance**, may cover costs associated with a nursing home. People may enroll in these plans through their employers or other group insurance policies.

In many cases, nursing homes are paid for by the residents' personal funds. When these funds are exhausted, the residents sometimes become eligible for Medicaid assistance.

KEY TERMS

Long-term care—Residential care over a period of time. A nursing home is a type of long-term care facility that offers nursing care and assistance with daily living tasks.

Restraint—A physical device or a medication designed to restrict a person's movement.

Viewpoints

The quality of care in nursing homes is an important issue. Quality issues include:

- Ratios of staff to patients. Advocacy groups are pushing for increased staff-to-patient ratios in nursing homes. The National Citizens' Coalition for Nursing Home Reform recommends one direct care staff (R.N., L.V.N., or C.N.A.) per five residents during the day shift, 10 residents during the evening shift, and 15 residents during the night shift.
- Elder abuse. It is important for nursing home personnel to look for signs of abuse or neglect when a resident checks in and during a resident's stay. Signs of abuse include bodily injuries that appear suspicious, visible harm to the wrist or ankles that may indicate the use of restraints, skin ulcers that seem neglected, poor hygiene, inadequate **nutrition**, unexplained **dehydration**, untreated medical problems, or **personality disorders** such as excessive nervousness or withdrawal. The nurse or allied health professional is to report any signs of abuse to the supervisor or physician.
- Nurses' salaries. Salaries may be lower in long-term facilities than in acute care hospitals.
- Reimbursement. Nursing home administrators report that reimbursements do not cover the expenses, while nursing home advocates would like a higher portion of revenues to be allocated for direct patient care.

Professional implications

Long-term care is a growing trend, making nursing homes a viable career alternative for nurses and allied health professionals. Approximately one out of twenty Americans over age 65 live in nursing homes, although younger adults may require the special services a nursing home offers. There are about 17,000 nursing homes in the United States caring for over 1.5 million people. Nursing homes have an average occupancy rate of 80 percent.

Nursing homes must meet the physical, emotional, and social needs of its residents. The leadership staff may include an administrator, medical director, director of nursing, and directors for other allied health services. It is important for nursing home staff to understand the policies regarding care in these types of facilities.

These professionals provide care and treatments in nursing homes:

- physicians
- nurses
- nursing assistants
- dietitians
- physical, occupational, and speech therapists
- pharmacists
- social activities staff
- dentists
- social workers or psychological counselors
- other staff, such as custodians and office personnel

Required care plans

There are federal laws regarding the care given in a nursing home, and it is essential that staff members become aware of these regulations. It is required that staff conduct a thorough assessment of each new resident during the first two weeks following admission. The assessment includes the resident's ability to move and his or her rehabilitation needs, the status of the skin, any medical conditions that are present, nutritional state, and abilities regarding activities of daily living.

In some cases, the nursing home residents are unable to communicate their needs to the staff. Therefore, it is particularly important for nurses and other professionals to look for problems during their assessments. Signs of malnutrition and dehydration are especially important when assessing nursing home residents.

It is not normal for an elderly person to lose weight. However, some people lose their ability to **taste** and **smell** as they age and may lose interest in food. This can result in malnutrition, which can lead to confusion and impaired ability to fight off disease.

Older people are also more susceptible to dehydration. Their medications may lead to dehydration as a side effect, or they may limit fluids because they are too afraid of uncontrolled urination. It is very dangerous to be without adequate fluid, so the nurse and other staff must be able to recognize early signs of dehydration.

When the assessment is complete, a care plan is developed. This plan is subject to change as changes in the resident's condition occur.

Patients' rights

It is important for the professionals working in nursing homes to be aware of the residents' rights. Residents are informed of their rights when they are admitted. Residents have the right to:

- Manage their finances.
- Have privacy (for themselves and their belongings).
- Make decisions (unless Advanced Directives or Durable Power of Attorney exist).
- See visitors in private.
- Receive information regarding their medical care and treatments.
- Have social services.
- Leave the nursing home after giving the required amount of notice. A stay in a nursing home is normally considered voluntary; however, the facility will consider a variety of factors before discharging a resident. These factors include the resident's health, safety and potential danger to self or others, as well as the resident's payment for services. The contract will state how much notice is required before a resident may transfer to another facility, return home, or move in with a family member.

Family involvement

In some cases, a nursing home is chosen after the family has only a short time to prepare for the change. For example, when a patient is unable to care for himself or herself due to a sudden illness or injury, the family must turn to nursing home care without having the luxury of researching this option over time. The nursing home's costs must be explained to the resident or family prior to admission. It is important for the nursing home staff to be willing to answer the family's questions and reassure them about the care their loved one will receive.

Nursing home professionals have an opportunity to continue to work closely with the resident's family and loved ones over the course of a resident's stay. In these facilities, concerned family members and friends of the resident are involved in his or her care, and may have guardianship or other decision-making responsibility. These individuals may voice their concerns through meetings between staff and family members. Those with legal guardianship are entitled to see a resident's **medical records**, care plans, and other related material.

Communication

As in other health care settings, communication among nursing home staff is very important. In nursing homes, the care is based on a team approach. Physicians, nurses, and allied health professionals work together to make sure the resident is able to experience the highest quality of life possible.

In many cases, physicians who have had a long-term relationship with a patient continue treatment after the patient has been admitted to a nursing home. It is important for the nursing home staff to leave blocks of time open in the schedule for physician visits. It is also the staff's duty to keep the personal physicians apprised of a resident's medical condition.

The resident, physician, and resident's legal guardian and family must be told immediately if any of the following situations arise: an accident involving the resident, the need for a major treatment change, and a decision regarding discharge or transfer. Unless an emergency arises, the nursing home must give 30 days written notice of discharge or transfer. The family may appeal the decision.

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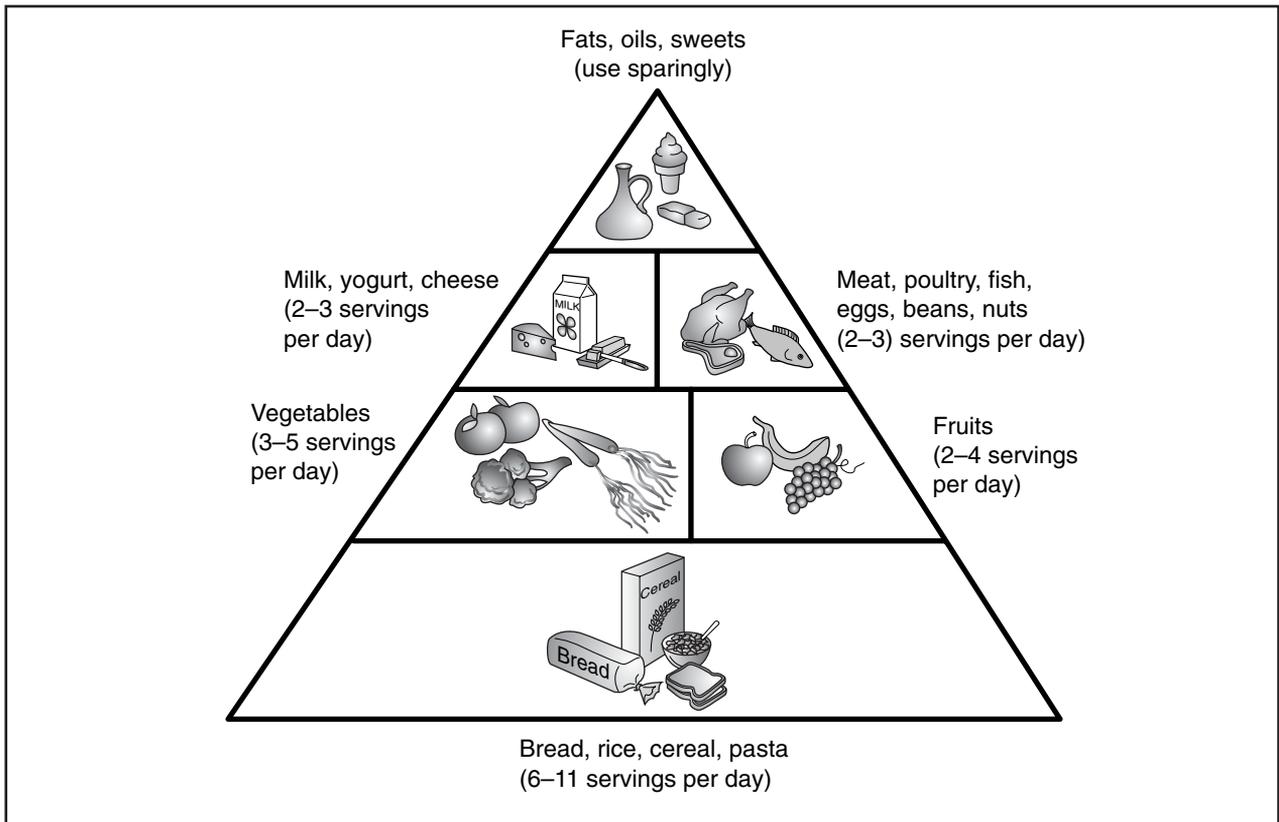
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The USDA Food Pyramid. (Illustration by Electronic Illustrators Group. Reproduced by permission.)

Nutrition

Definition

Good nutrition can help prevent disease and promote health. There are six categories of nutrients that the body needs to acquire from food: protein, **carbohydrates**, fat, fibers, **vitamins** and **minerals**, and water.

Proteins

Protein supplies amino acids to build and maintain healthy body tissue. There are 20 amino acids considered essential because the body must have all of them in the right amounts to function properly. Twelve of these are manufactured in the body but the other eight amino acids must be provided by the diet. Foods from an animal source such as milk or eggs often contain all these essential amino acids while a variety of plant products must be taken together to provide all these necessary protein components.

Fat

Fat supplies energy and transports nutrients. There are two families of fatty acids considered essential for the

body: the omega-3 and omega-6 fatty acids. Essential fatty acids are required by the body to function normally. They can be obtained from canola oil, flaxseed oil, cold-water fish, or fish oil, all of which contain omega-3 fatty acids, and primrose or black currant seed oil, which contains omega-6 fatty acids. The U.S. diet often contains an excess of omega-6 fatty acids and insufficient amount of omega-3 **fats**. Increased consumption of omega-3 oils are recommended to help reduce risk of cardiovascular diseases and **cancer** and alleviate symptoms of rheumatoid arthritis, premenstrual syndrome, dermatitis, and inflammatory bowel disease.

Carbohydrates

Carbohydrates are the body's main source of energy and should be the major part of total daily intake. There are two types of carbohydrates: simple carbohydrates (such as sugar or honey) and complex carbohydrates (such as grains, beans, peas, or potatoes). Complex carbohydrates are preferred because these foods are more nutritious yet have fewer calories per gram compared to fat and cause fewer problems with overeating than fat or sugar. Complex carbohydrates are also preferred over

simple carbohydrates by diabetics because they allow better **blood** glucose control.

Fiber

Fiber is the material that gives a plant texture and support. Although it is primarily made up of carbohydrates, it does not have a lot of calories and usually is not broken down by the body for energy. Dietary fiber is found in plant foods such as fruits, vegetables, legumes, nuts, and whole grains.

There are two types of fiber: soluble and insoluble. Insoluble fiber, as the name implies, does not dissolve in water because it contains high amount of cellulose. Insoluble fiber can be found in the bran of grains, the pulp of fruit and the skin of vegetables. Soluble fiber is the type of fiber that dissolves in water. It can be found in a variety of fruits and vegetables such as apples, oatmeal and oat bran, rye flour, and dried beans.

Although they share some common characteristics such as being partially digested in the **stomach** and intestines and have few calories, each type of fiber has its own specific health benefits. Insoluble fiber speeds up the transit of foods through the **digestive system** and adds bulk to the stools, therefore, it is the type of fiber that helps treat constipation or **diarrhea** and prevents colon cancer. On the other hand, only soluble fiber can lower blood cholesterol levels. This type of fiber works by attaching itself to the cholesterol so that it can be eliminated from the body. This prevents cholesterol from circulating and being reabsorbed into the bloodstream.

Vitamins and minerals

Vitamins are organic substances present in food and required by the body in a minute amount for regulation of **metabolism** and maintenance of normal growth and functioning. The most commonly known vitamins are A, B₁ (**thiamine**), B₂ (**riboflavin**), B₃ (**niacin**), B₅ (pantothenic acid), B₆ (pyridoxine), B₇ (**biotin**), B₉ (**folic acid**), B₁₂ (cobalamin), C (ascorbic acid), D, E, and K. The B and C vitamins are water-soluble, excess amounts of which are excreted in the urine. The A, D, E, and K vitamins are fat-soluble and will be stored in the body fat.

Minerals are vital to our existence because they are the building blocks that make up muscles, tissues, and bones. They also are important components of many life-supporting systems, such as hormones, oxygen transport, and enzyme systems.

There are two kinds of minerals: the major (or macro) minerals and the trace minerals. Major minerals are the minerals that the body needs in large amounts. The following minerals are classified as major: **calcium**,

phosphorus, magnesium, sodium, potassium, sulfur, and chloride. They are needed to build muscles, blood, nerve cells, teeth, and bones. They are also essential electrolytes that the body requires to regulate blood volume and **acid-base balance**.

Unlike the major minerals, trace minerals are needed only in tiny amounts. Even though they can be found in the body in exceedingly small amounts, they are also very important to the human body. These minerals participate in most chemical reactions in the body. They are also needed to manufacture important hormones. The following are classified as trace minerals: **iron**, **zinc**, iodine, **copper**, manganese, fluoride, chromium, selenium, molybdenum, and boron.

Many vitamins (such as vitamins A, C, and E) and minerals (such as zinc, copper, selenium, or manganese) act as antioxidants. They protect the body against the damaging effects of free radicals. They scavenge or “mop up” these highly reactive radicals and change them into inactive, less harmful compounds. In so doing, these essential nutrients help prevent cancer and many other degenerative diseases, such as premature aging, **heart disease**, autoimmune diseases, arthritis, **cataracts**, **Alzheimer’s disease**, and **diabetes mellitus**.

Water

Water helps to regulate body temperature, transports nutrients to cells, and rids the body of waste materials.

Origins

Unlike plants, human beings cannot manufacture most of the nutrients that they need to function. They must eat plants and/or other animals. Although nutritional therapy came to the forefront of the public’s awareness in the late twentieth century, the notion that food affects health is not new. John Harvey Kellogg was an early health-food pioneer and an advocate of a high-fiber diet. An avowed vegetarian, he believed that meat products were particularly detrimental to the colon. In the 1870s, Kellogg founded the Battle Creek Sanitarium, where he developed a diet based on nut and vegetable products.

Benefits

Good nutrition helps individuals achieve general health and well-being. In addition, dietary modifications might be prescribed for a variety of complaints including **allergies**, anemia, arthritis, colds, depressions, fatigue, gastrointestinal disorder, high or low **blood pressure**, insomnia, headaches, **obesity**, **pregnancy**, premenstrual syndrome (PMS), respiratory conditions, and **stress**.

Nutritional therapy may also be involved as a complement to the allopathic treatments of cancer, diabetes, and **Parkinson's disease**. Other specific dietary measures include the elimination of food additives for attention deficit hyperactivity disorder (ADHD), gluten-free diets for **schizophrenia**, and dairy-free for chronic respiratory diseases.

A high-fiber diet helps prevent or treat the following health conditions:

- High cholesterol levels. Fiber effectively lowers blood cholesterol levels. It appears that soluble fiber binds to cholesterol and moves it down the digestive tract so that it can be excreted from the body. This prevents the cholesterol from being reabsorbed into the bloodstream.
- Constipation. A high-fiber diet is the preferred non-drug treatment for constipation. Fiber in the diet adds more bulk to the stools, making them softer and shortens the time foods stay in the digestive tract.
- Hemorrhoids. Fiber in the diet adds more bulk and softens the stool, thus reducing painful hemorrhoidal symptoms.
- Diabetes. Soluble fiber in the diet slows down the rise of blood sugar levels following a meal and helps control diabetes.
- Obesity. Dietary fiber makes a person feel full faster.
- Cancer. Insoluble fiber in the diet speeds up the movement of the stools through the gastro-intestinal tract. The faster food travels through the digestive tract, the less time there is for potential cancer-causing substances to work. Therefore, diets high in insoluble fiber help prevent the accumulation of toxic substances that cause cancer of the colon. Because fiber reduces fat absorption in the digestive tract, it may also prevent **breast cancer**.

A diet low in fat also promotes good health and prevents many diseases. Low-fat diet can help treat or control the following conditions:

- Obesity. High fat consumption often leads to excess caloric and fat intake, which increases body fat.
- Coronary artery disease. High consumption of saturated fats is associated with coronary artery disease.
- Diabetes. People who are overweight tend to develop or worsen existing diabetic condition due to decreased insulin sensitivity.
- Breast cancer. A high dietary consumption of fat is associated with an increased risk of breast cancer.

Description

The four basic food groups, as outlined by the United States Department of Agriculture (USDA) are:

- dairy products (such as milk and cheese)
- meat and eggs (such as fish, poultry, pork, beef, and eggs)
- grains (such as bread cereals, rice, and pasta)
- fruits and vegetables

The USDA recommendation for adults is that consumption of meat, eggs, and dairy products should not exceed 20% of total daily caloric intake. The rest (80%) should be devoted to vegetables, fruits, and grains. For children age two or older, 55% of their caloric intake should be in the form of carbohydrates, 30% from fat, and 15% from **proteins**. In addition, saturated fat intake should not exceed 10% of total caloric intake. This low-fat, high-fiber diet is believed to promote health and help prevent many diseases, including heart disease, obesity, and cancer.

Allergenic and highly processed foods should be avoided. Highly processed foods do not contain significant amounts of essential trace minerals. Furthermore, they contain lots of fat and sugar as well as preservatives, artificial sweeteners and other additives. High consumption of these foods causes build up of these unwanted chemicals in the body and should be avoided. Food allergy causes a variety of symptoms including food cravings, weight gain, bloating, water retention. It may also worsen chronic inflammatory conditions such as arthritis.

Preparations

An enormous body of research exists in the field of nutrition. Mainstream Western medical practitioners point to studies that show that a balanced diet, based on the USDA Food Guide Pyramid, provides all of the necessary nutrients.

The Food Guide Pyramid recommends the following daily servings in six categories:

- Grains: Six or more servings.
- Vegetables: Five servings.
- Fruits: Two to four servings.
- Meat: Two to three servings.
- Dairy: Two to three servings.
- Fats and oils: Use sparingly.

Precautions

Individuals should not change their diets without the advice of nutritional experts or health care professionals. Certain individuals especially children, pregnant and lactating women, and chronically ill patients should only change their diets under professional supervision.

Side effects

It is best to obtain vitamins and minerals through food sources. Excessive intake of vitamins and mineral supplements can cause serious physiological problems.

The following is a list of possible side effects resulting from excessive doses of vitamins and minerals

- vitamin A: birth defects, irreversible bone and liver damage
- vitamin B₁: deficiencies in B₂ and B₆
- vitamin B₆: damage to the nervous system
- vitamin C: affects the absorption of copper; diarrhea
- vitamin D: hypercalcemia (abnormally high concentration of calcium in the blood)
- phosphorus: affects the absorption of calcium
- zinc: affects absorption of copper and iron; suppresses the immune system

Research and general acceptance

Due to the large volume of scientific evidence demonstrating the benefits of the low-fat, high-fiber diet in disease prevention and treatment, this diet has been accepted and advocated by most health care practitioners.

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American Dietetic Association. 216 W. Jackson Boulevard, Suite 800, Chicago, IL 60606-6995. (800) 366-1655. <<http://www.eatright.org/>>.

Mai Tran

Nutrition assessment see **Dietary assessment**

Nutrition counseling see **Dietary counseling**

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Obesity

Definition

Obesity is an abnormal accumulation of body fat, usually 20% or more over an individual's ideal body weight. Obesity is associated with increased risk of illness, disability, and death.

Description

Obesity is defined by both the U.S. Department of Agriculture and the U.S. Department of Health and Human Services as the presence of a Body Mass Index (BMI) greater than or equal to 30. BMI is a measure of body weight relative to height and is computed as weight/height², where weight is measured in kilograms and height in meters. Obesity is considered a subset of overweight, which is indicated by a BMI of 25 or higher.

Approximately 55% of the U.S. population is overweight, and almost one in five is obese. Excessive weight can result in many serious, and potentially deadly, health problems, including **hypertension**, Type II **diabetes mellitus** (non-insulin dependent diabetes), increased risk for coronary disease, increased unexplained **heart** attack, hyperlipidemia, **infertility**, and a higher prevalence of colon, prostate, endometrial, and, possibly, **breast cancer**. Approximately 300,000 deaths a year are attributed to obesity, prompting leaders in **public health**, such as former Surgeon General C. Everett Koop, M.D., to label obesity “the second leading cause of preventable deaths in the United States.”

Causes and symptoms

The mechanism for excessive weight gain is clear—more calories are consumed than the body burns, and the excess calories are stored as fat (adipose) tissue. However, the exact cause is not as clear and likely arises from a complex combination of factors.

Genetic factors significantly influence how the body regulates the appetite and the rate at which it turns food into energy (metabolic rate). Studies of adoptees confirm this relationship—the majority of adoptees followed a pattern of weight gain that more closely resembled that of their birth parents than their adoptive parents. Yet genetic factors do not explain the rapid increase in the prevalence of obesity in the U.S. and other industrialized countries in the past 10–15 years.

A genetic predisposition to weight gain, however, does not automatically mean that a person will be obese. Eating habits and patterns of physical activity also play a significant role in the amount of weight a person gains.

Recent studies have indicated that the amount of fat in a person's diet may have a greater impact on weight than the number of calories it contains. **Carbohydrates** (cereals, breads, fruits, and vegetables) and protein (fish, lean meat, turkey breast, skim milk) are converted to fuel almost as soon as they are consumed. Most fat calories are immediately stored in fat cells, which add to the body's weight and girth as they expand and multiply.

A sedentary life-style, particularly prevalent in affluent societies, such as in the United States, can contribute to weight gain. Psychological factors, such as depression and low self-esteem may, in some cases, also play a role in weight gain.

At what stage of life a person becomes obese can affect his or her ability to lose weight. Some studies suggest that during two critical periods of a person's life—in early childhood and **puberty**, excess calories are converted into new fat cells (hyperplastic obesity), while excess calories consumed in adulthood only serve to expand existing fat cells (hypertrophic obesity). Since dieting and **exercise** can only reduce the size of fat cells, not eliminate them, persons who were obese as children can have great difficulty losing weight, since they may have up to five times as many fat cells as someone who became overweight as an adult. An estimated 13% of



Measurement of triceps skinfold, which is an indicator of total body fat. (Delmar Publishers, Inc. Reproduced by permission.)

children ages 6–11 years and 14% of adolescents ages 12–19 years are currently overweight.

Obesity can also be a side-effect of certain disorders and conditions, including Cushing’s syndrome, a disorder involving the excessive release of the hormone cortisol; hypothyroidism, a condition caused by an underactive **thyroid gland**; neurologic disturbances, such as damage to the hypothalamus, a structure located deep within the **brain** that helps regulate appetite; and consumption of certain drugs, such as steroids or antidepressants.

The major symptoms of obesity are excessive weight gain and the presence of large amounts of fatty tissue. Obesity can also give rise to several secondary conditions, including arthritis and other orthopedic problems, such as lower back **pain**; heartburn; high cholesterol levels; high **blood pressure**; menstrual irregularities or cessation of menstruation (amenorrhea); shortness of breath that can be incapacitating; and skin disorders, arising from the bacterial breakdown of sweat and cellular mate-

rial in thick folds of skin or from increased friction between folds.

Diagnosis

Diagnosis of obesity is made by observation and by comparing the patient’s weight to ideal weight charts. Many doctors and obesity researchers refer to the body mass index (BMI), which uses a height-weight relationship to calculate an individual’s ideal weight and personal risk of developing obesity-related health problems.

Since this method can be misleading, due to its failure to account for body composition and muscle mass, physicians may also obtain direct measurements of an individual’s body fat content by using calipers to measure skin-fold thickness at the back of the upper arm and other sites. The most accurate means of measuring body fat content involves hydrostatic weighing, or having a person let as much air as possible out of his **lungs**, immersing him in water and measuring relative displacement; however, this method is very unpleasant and impractical, and is usually only used in scientific studies requiring very specific assessments. Women whose body fat exceeds 32% and men whose body fat exceeds 27% are generally considered obese.

Doctors may also note how a person carries excess weight on his or her body. Studies have shown that this factor may indicate whether or not an individual has a predisposition to develop certain diseases or conditions that may accompany obesity. “Apple-shaped” individuals who store most of their weight around the waist and abdomen are at greater risk for **cancer**, heart disease, stroke, and diabetes than “pear-shaped” people whose extra pounds settle primarily in their hips and thighs.

Treatment

Treatment of obesity depends primarily on how overweight a person is and his or her overall health. However, to be successful, any treatment must affect life-long behavioral changes rather than short-term weight loss. A report issued by the National Institutes of Health-sponsored group, the National Heart, Lung, and Blood Institute, *The Practical Guide to Identification, Evaluation, and Treatment of Overweight and Obesity in Adults*, recommends a combination of diet modification, increased physical activity, and behavior therapy as the means most likely to prove effective.

“Yo-yo” dieting, in which weight is repeatedly lost and regained, has been shown to increase a person’s likelihood of developing fatal health problems more than if the weight had been lost gradually or not lost at all. Behavior-focused treatment should concentrate on:

HEIGHT AND WEIGHT GOALS			
Men			
Height	Small Frame	Medium Frame	Large Frame
5'2"	128-134 lbs.	131-141 lbs.	138-150 lbs.
5'3"	130-136	133-143	140-153
5'4"	132-138	135-145	142-153
5'5"	134-140	137-148	144-160
5'6"	136-142	139-151	146-164
5'7"	138-145	142-154	149-168
5'8"	140-148	145-157	152-172
5'9"	142-151	148-160	155-176
5'10"	144-154	151-163	158-180
5'11"	146-157	154-166	161-184
6'0"	169-160	157-170	164-188
6'1"	152-164	160-174	168-192
6'2"	155-168	164-178	172-197
6'3"	158-172	167-182	176-202
6'4"	162-176	171-187	181-207
Women			
Height	Small Frame	Medium Frame	Large Frame
4'10"	102-111 lbs.	109-121 lbs.	118-131 lbs.
4'11"	103-113	111-123	120-134
5'0"	104-115	113-126	112-137
5'1"	106-118	115-129	125-140
5'2"	108-121	118-132	128-143
5'3"	111-124	121-135	131-147
5'4"	114-127	124-141	137-151
5'5"	117-130	127-141	137-155
5'6"	120-133	130-144	140-159
5'7"	123-136	133-147	143-163
5'8"	126-139	136-150	146-167
5'9"	129-142	139-153	149-170
5'10"	132-145	142-156	152-176
5'11"	135-148	145-159	155-176
6'0"	138-151	148-162	158-179

Source: Doctors On-Line, Inc. "Height and Weight Goals as Determined by the Metropolitan Life Insurance Company." <http://www.doli.com/weight.htm>. (Standley Publishing. Reproduced by permission.)

- What and how much a person eats. This aspect may involve keeping a food diary and developing a better understanding of the nutritional value and fat content of foods. It may also involve changing grocery-shopping habits (e.g. buying only what is on a prepared list and only going on a certain day), timing of meals (to prevent feelings of hunger, a person may plan frequent, small meals), and actually slowing down the rate at which a person eats.
- How a person responds to food. This may involve understanding what psychological issues underlie a person's eating habits. For example, one person may binge eat when under **stress**, while another may always use food as a reward. In recognizing these psychological triggers, an individual can develop alternative coping mechanisms that do not focus on food.
- How they spend their time. Making activity and exercise an integrated part of everyday life is a key to

achieving and maintaining weight loss. Starting slowly and building endurance keeps individuals from becoming discouraged. Varying routines and trying new activities also keeps interest high.

For most individuals who are mildly obese, these behavior modifications entail life-style changes they can make independently while being supervised by a family physician. Other mildly obese persons may seek the help of a commercial weight-loss program (e.g. Weight Watchers). The effectiveness of these programs is difficult to assess, since programs vary widely, drop-out rates are high, and few employ members of the medical community. However, programs that emphasize realistic goals, gradual progress, sensible eating, and exercise can be very helpful and are recommended by many doctors. Programs that promise instant weight loss or feature severely restricted diets are not effective and, in some cases, can be dangerous.

For individuals who are moderately obese, medically supervised behavior modification and weight loss are required. While doctors will put most moderately obese patients on a balanced, low-calorie diet (1200–1500 calories a day), they may recommend that certain individuals follow a very-low-calorie liquid protein diet (400–700 calories) for as long as three months. This therapy, however, should not be confused with commercial liquid protein diets or commercial weight-loss shakes and drinks. Doctors tailor these diets to specific patients, monitor patients carefully, and use them for only a short period of time.

In addition to reducing the amount and type of calories consumed by the patient, doctors will recommend professional therapists or psychiatrists who can help the individual effectively change his or her behavior in regard to eating. For individuals who are severely obese, dietary changes and behavior modification may be accompanied by surgery to reduce or bypass portions of the **stomach** or **small intestine**. Such obesity surgery, however, can be risky, and it is only performed on patients for whom other strategies have failed and whose obesity seriously threatens their health. Other surgical procedures are not recommended, including liposuction, a purely cosmetic procedure in which a suction device is used to remove fat from beneath the skin, and jaw wiring, which can damage gums and teeth and cause painful muscle spasms.

Appetite-suppressant drugs are sometimes prescribed to aid in weight loss. These drugs work by increasing levels of serotonin or catecholamine, which are brain chemicals that control feelings of fullness. Appetite suppressants, though, are not considered truly

effective, since most of the weight lost while taking them is usually regained after stopping them. Also, suppressants containing amphetamines can be potentially abused by patients.

While most of the immediate side-effects of these drugs are harmless, the long-term effects of these drugs, in many cases, is unknown. Two drugs, dexfenfluramine hydrochloride (Redux) and fenfluramine (Pondimin) as well as a combination fenfluramine-phentermine (Fen/Phen) drug, were taken off the market when they were shown to cause potentially fatal heart defects.

Other weight-loss medications available with a doctor's prescription include: sibutramine (Meridia), diethylpropion (Tenuate, Tenuate dospan) mazindol (Mazanor, Sanorex) phendimetrazine (Bontril, Plegine, Prelu-2, X-Trozone) and phentermine (Adipex-P, Fastin, Ionamin, Oby-trim).

Phenylpropanolamine (Acutrim, Dextarim) is the only nonprescription weight-loss drug approved by the FDA, but in November, 2000, the FDA announced that it was considering withdrawing its approval. These over-the-counter diet aids have been found to increase the risk of hemorrhagic stroke (bleeding into the brain or into tissue surrounding the brain) in women, and men may also be at risk.

Combined with diet and exercise and used only with a doctor's approval, prescription anti-obesity medications enable some patients to lose 10% more weight than they otherwise would. Most patients regain lost weight after discontinuing use of either prescription medications or nonprescription weight-loss products. Prescription medications or over-the-counter weight-loss products can cause: constipation, dry mouth, headache, irritability, nausea, nervousness, and sweating. None of them should be used by patients taking monoamine oxidase inhibitors (MAO inhibitors).

Doctors sometimes prescribe fluoxetine (Prozac), an antidepressant that can increase weight loss by about 10%. Weight loss may be temporary and side effects of this medication include **diarrhea**, fatigue, insomnia, nausea, and thirst.

Weight-loss drugs currently being developed or tested include ones that can prevent fat absorption or digestion; reduce the desire for food and prompt the body to burn calories more quickly; and regulate the activity of substances that control eating habits and stimulate overeating.

In April, 1999, the U.S. Food and Drug Administration (FDA) approved Xenical (orlistat), which works in the intestines, where it blocks some fat from being absorbed. This undigested fat is then eliminated in

the patient's bowel movements. Available only with a doctor's prescription, many gastrointestinal side-effects can occur with Xenical. This medication should not be used by patients who have problems absorbing food or have **gallbladder** problems.

The Chinese herb ephedra (*Ephedra sinica*), combined with **caffeine**, exercise, and a low-fat diet in physician-supervised weight-loss programs, can cause at least temporary weight loss. However, the large doses of ephedra required to achieve the desired result can also produce serious side effects including chest pain, **myocardial infarction**, hepatitis, stroke, seizures, psychosis, and death. Mixing this with caffeine (a diuretic) also promotes **dehydration**, which can cause a number of other health problems. Ephedra should not be used by anyone with a history of diabetes, heart disease, or thyroid problems.

Getting the correct ratios of protein, carbohydrates, and good-quality **fats** can help in weight loss via enhancement of the **metabolism**. Support groups that are informed about healthy, nutritious, and balanced diets can offer an individual the support he or she needs to maintain this type of eating regimen.

Prognosis

As many as 85% of dieters who do not exercise on a regular basis regain their lost weight within two years. In five years, the figure rises to 90%. Repeatedly losing and regaining weight (yo-yo dieting) encourages the body to store fat and may increase a patient's risk of developing heart disease. The primary factor in achieving and maintaining weight loss is a life-long commitment to regular exercise and sensible eating habits.

Health care team roles

Physicians diagnose obesity and prescribe drugs to control it, but others can also play a role in treatment. Nutritionists and dietitians design effective and safe meal plans while taking into account the person's individual needs. Registered nurses also make nutritional recommendations and monitor the person's daily dietary intake.

Many obese people with back or knee problems cannot exercise, exacerbating the weight problem. Physical therapists design exercise programs for these individuals to improve the body's physical functionality, so more exercise can be done at higher levels of intensity. Personal trainers and fitness instructors help with weight training and cardiovascular exercise, to increase the amount of lean muscle mass and decrease body fat.

KEY TERMS

Body Mass Index (BMI)—A way of computing an individual's relative weight to height ratio, used in determining the degree to which an individual may be overweight.

Obesity—An abnormal accumulation of body fat, usually 20% or more over an individual's ideal body weight.

Since obesity often causes self-esteem problems, psychiatrists and psychologists use therapies including hypnosis and imagery to help improve a person's emotional well being or body image. Psychologists prescribe drugs to treat depression and **anxiety** disorders resulting from obesity. Treatments such as sound therapy, **relaxation**, and **yoga**, monitored by holistic health professionals, also may be helpful.

Prevention

Obesity experts suggest that a key to preventing excess weight gain is monitoring fat consumption rather than counting calories, and the National Cholesterol Education Program maintains that only 30% of calories should be derived from fat. Only one-third of those calories should be contained in saturated fats (the kind of fat found in high concentrations in meat, poultry, and dairy products).

Because most people eat more than they think they do, keeping a detailed food diary is a useful way to assess eating habits. Eating three balanced, moderate-portion meals a day—with the main meal at mid-day—is a more effective way to prevent obesity than fasting or crash diets.

Exercise increases the metabolic rate by creating muscle, which burns more calories than fat. When regular exercise is combined with regular, healthful meals, calories continue to burn at an accelerated rate for several hours.

Finally, encouraging healthful habits in children is a key to preventing childhood obesity and the health problems that follow in adulthood.

Resources

ORGANIZATIONS

HCF Nutrition Research Foundation, Inc. P.O. Box 22124, Lexington, KY 40522. (606) 276-3119.

National Institute of Diabetes and Digestive and Kidney Diseases. 31 Center Drive, USC2560, Building 31, Room 9A-04, Bethesda, MD 20892-2560. Phone: (301) 496-3583. Website: <<http://www.niddk.nih.gov>>.

National Obesity Research Foundation. Temple University, Weiss Hall 867, Philadelphia, PA 19122.

The Weight-Control Information Network. 1 Win Way, Bethesda, MD 20896-3665. Phone: (301) 951-1120. Website: <<http://www.navigator.tufts.edu/special/win.html>>.

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Maia Appleby

Obstetric sonogram *see* **Pelvic ultrasound**

Occlusion *see* **Malocclusion**

Occult blood test *see* **Fecal occult blood test**

Occupational Safety and Health Act

Definition

The United States Congress passed the Occupational Safety and Health Act of 1970 to ensure that work environments are safe and free of dangerous hazards for both employees and their employers.

Description

When the Act was signed into law by President Richard M. Nixon on December 29, 1970, it called for the creation of the Occupational Safety and Health Administration (OSHA), the regulating governmental body that inspects workplaces for unsafe and unhealthy conditions. The first standards were adopted by OSHA in 1971. The Act also created the National Institute for

Occupational Safety and Health (NIOSH), a federal agency under the Centers for Disease Control (CDC) that researches work-related injuries and workplace hazards. NIOSH also is charged with making recommendations on how to prevent accidents in the workplace and, at the request of business owners or its employees, investigates businesses where hazards may exist. The agency is the clearinghouse for dissemination of workplace safety information and trains occupational safety and health professionals. NIOSH follows the National Occupational Research Agenda (NORA), a research agenda developed by 500 organizations that outlines the top 21 research priorities among workplace safety issues.

The law applies to all employers and employees in the United States, District of Columbia, Puerto Rico, and any other jurisdiction of the U.S. federal government. The law is not enforceable among federal or state employees, or farms where only immediate family members are employed. Those who are self-employed or whose workplaces are covered under other federal regulations, such as nuclear energy, mining, or nuclear weapons manufacturing, also are exempt from the Act.

Employers covered by the law are required to implement proper policies and procedures within their businesses that comply with the regulations. Regulations cover, but are not limited to, hazardous waste handling, fall protection at construction sites, asbestos, ergonomics, and respiratory protection. States have the option of enforcing the federal regulations or adopting their own job safety programs that are at least as strict as the OSHA regulations. In 1972, South Carolina, Montana, and Oregon were the first states to approve their own programs.

Employees who work in environments covered by the Act have certain rights under the law. Employees are permitted to file complaints with OSHA regarding the safety conditions of their workplaces. Complaints are kept confidential from employers. In order to enforce the Act, OSHA employs compliance safety and health officers (CSHOs) that are authorized to perform inspections of workplaces that are covered under the law. OSHA conducts two kinds of inspections, programmed and unprogrammed. Unprogrammed inspections are triggered when a fatality or catastrophe occurs, or if a complaint is filed.

Violations

A violation of an OSHA standard covered under the Act carry several penalties depending on the severity of the violation. Violations are classified as other than serious, serious, willful, or repeated.

Other-than-serious violation. An other-than-serious violation directly affects job safety, but likely would not cause serious injury or death. It is within the CSHO's discretion to impose up to a \$7,000 penalty for each violation. However, if the business owner shows a good-faith effort to make the appropriate corrections to comply with the law, the \$7,000 penalty can be reduced by up to 95%. The size of the business and whether there have been previous violations also are taken into consideration when reducing a penalty.

Serious violation. A serious violation occurs when it is likely that serious injury or death could occur because of a violation of an OSHA standard that the employer knew or should have known was harmful or hazardous. In cases of serious violations, up to a \$7,000 penalty can be imposed. But, again, the penalty can be decreased on the basis of previous violations, how serious the violation, good-faith effort to correct the problem, and the size of the business.

Willful violation. An employer willfully commits a violation when he or she is aware the violation exists. Either the employer knows a violation is being committed or does not try to eliminate a dangerous condition that exists. An employer who commits a willful violation faces a penalty of at least \$5,000 and not more than \$70,000. The only considerations taken into account when decreasing the penalty for a willful violation is the number of previous violations and the size of the business. If a death has occurred as a result of a willful violation, an employer could face up to six months of prison and/or a fine imposed by the courts. If criminal charges are levied and a conviction results, the employer's corporation could face a \$500,000 fine and the individual a \$250,000 fine, enforceable under the Comprehensive Crime Control Act of 1984.

Repeated violation. If upon reinspection by OSHA officers a similar violation is found, a \$70,000 penalty may be imposed.

Other violations. Once a violation is found, and a deadline imposed as to when the violation must be corrected, employers could face a \$7,000 penalty for every day the problem goes uncorrected. Additionally, employers found doctoring records or applications could face a fine of up to \$10,000 and/or six months in prison. Any kind of interference with an OSHA compliance officer who is attempting to perform an inspection, whether it be by resisting or intimidating the officer, is considered a crime and could carry up to a \$250,000 penalty for an individual and \$500,000 for a corporation.

KEY TERMS

Ergonomics—The study of the relationship between people and their working environment.

Musculoskeletal disorder—Injuries that affect the muscles and skeleton, such as repetitive stress injuries to the hand and wrist.

Viewpoints

One of the most controversial OSHA standards debated in Congress was the Ergonomics Rule issued by the agency in November 2000. The measure, which would have applied to 1.6 million employers in the United States, aimed to prevent nearly a half million musculoskeletal disorders (MSDs) in more than 102 million workers in the country's workplaces. The proposed standard would have affected manual handling, manufacturing, and occupational job sites where MSDs are reported. Employers would have been required to implement ergonomics programs that would decrease the risk of MSDs. However, many employers, particularly owners of small businesses, claimed the measure would be far too costly. OSHA reported that compliance with the regulation would cost businesses \$4 billion a year, but would be offset by eliminating the estimated \$20 billion a year spent on lost wages and medical costs of those absent from work because of MSDs and other workplace injuries. The National Coalition on Ergonomics (NCE), one of OSHA's staunchest opponents, estimated costs at \$26 billion a year for businesses.

After the 2000 election in which George W. Bush was elected President, the U.S. House of Representatives and the Senate voted to overturn the rule. Those voting to overturn the rule were most concerned about the cost of implementation, and the lack of sound scientific grounding for the standard. The U.S. Department of Labor began drafting a new ergonomics rule in early 2001.

Professional implications

When OSHA first proposed a new ergonomics rule, officials turned to occupational therapists because the discipline is the most appropriate in dealing with the application of workplace safety regulations. The American **Occupational Therapy** Association identified ergonomics and workplace safety consulting as a major emerging job market at the turn of the new millennium. Occupational therapists have a strong background in basic health education, physiology, and anatomy. Applying those skills in the workplace setting makes

occupational therapists the experts to turn to for consulting needs.

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ORGANIZATIONS

The American Occupational Therapy Association. 4720 Montgomery Lane, Bethesda, MD 20824-1220. (301) 652-2682. <<http://www.aota.org>>.

The Centers for Disease Control, National Institute for Occupational Safety and Health, 200 Independence Avenue, SW, Washington, DC 20201. (800) 356-4674. <<http://www.cdc.gov/niosh>>.

The Environmental Protection Agency. Ariel Building, 1200 Pennsylvania, NW, Washington, DC 20210. (202) 260-2090. <<http://www.epa.gov>>.

National Coalition on Ergonomics. 1615 H Street, NW, Washington, DC 20062. (202) 293-3384. <<http://www.ncergo.org>>.

The U.S. Department of Labor, Occupational Safety and Health Administration. 200 Constitution Avenue, NW, Washington, DC 20210. (202) 693-4650. <<http://www.osha.gov>>.

Meghan M. Gourley

Occupational therapy

Definition

Occupational therapy is a holistic, patient-centered, occupation-based approach to life skill development. This health profession helps people whose lives have been altered by physical or mental disease, injury, or other health problems. People of any age can benefit from occupational therapy to prevent injury and improve skills needed to perform everyday tasks or "occupations" at home, work, or school. Examples include activities of daily living such as dialing a phone, using a computer, writing a check, and driving a car.

Description

Occupational therapists first came onto the scene during World War I, when practitioners worked with sol-

diers suffering from shell shock, amputations, and other injuries. Also in the early 20th century, occupational therapists treated persons with **tuberculosis** and polio.

Today, the role of occupational therapists is varied and broad. For the last several decades, occupational therapists have treated patients suffering from physical and developmental disabilities such as **brain injury**, **spinal cord injury**, repetitive **stress** injury, stroke, Alzheimer's, diabetes, attention deficit disorder, mental retardation, and Parkinson's, among others. At the turn of the new millennium, however, practitioners began to prove their worth in areas such as **vision** treatment, mental health, ergonomics consulting, and home modification.

Through activities of daily living (ADL) evaluations, it is determined by the practitioner how independent a client is in performing his or her daily tasks at home, at work, and within his or her social environment. After evaluation, an occupational therapist may implement an intervention to facilitate a more independent lifestyle. The goal of occupational therapy practitioners is to facilitate the patients physical independence. One way that they do this is by implementing exercises that aid in mobility. When a patient has impaired vision, a therapist might analyze lighting and contrast needs in the home, and equip the patient with tools to make the home and work environment more functional. Such tools might include a magnifying glass, or auxiliary lighting. In ergonomics consulting, a therapist might advise businesses and industries about functional and comfortable work stations that minimize repetitive stress injuries caused by repetitive movements, such as typing or assembly line work. Interventions that help patients—such as those with developmental disabilities, or those in mental health settings—to function on a daily basis, such as stress management and communication skills, might also be facilitated by occupational therapists.

Work settings

Occupational therapy practitioners may work in a variety of settings; the scope of their practice may be vast. Traditional work settings are long-term-care (LTC) and skilled nursing facilities (SNFs), outpatient clinics, and other **nursing homes**, in which practitioners provide direct care to patients with physical and developmental problems (e.g., arthritis, hand injuries, and **dementia**). Occupational therapists and occupational therapy assistants have found their place in mental health facilities, home health agencies, and, more recently, community-based settings and private practice. No matter what the setting in which a practitioner practices, the approach is patient-centered; the patient's needs and the environment



A therapist works with a patient recovering from a stroke. (Photograph by Will & Deni McIntyre. Science Source/Photo Researchers. Reproduced by permission.)

in which the patient lives are considered when developing a treatment plan.

Many occupational therapy practitioners work with children in the school systems. The focus of a therapist in an educational environment may be to implement a handwriting intervention program, with the goal of improving finger dexterity in young children. According to a compensation survey of its members that the American Occupational Therapy Association (AOTA) conducted in 2000, nearly a quarter of members who responded are employed by school systems. Practitioners reported that they are also finding more opportunities in community-based settings, such as workplace ergonomics consulting and work rehabilitation programs.

Education and training

Current practitioners are credentialed as either occupational therapists, considered professionals after completing an accredited bachelor's degree program, or as occupational therapy assistants, who are considered at the technical level after completing a two-year associate program.

Prior to graduation, students must complete a supervised fieldwork program through their college or university program, and pass a national certification exam administered by the National Board of Certification in Occupational Therapy (NBCOT). The NBCOT is currently developing a recertification program.

The Accreditation Council for Occupational Therapy Education (ACOTE), following a resolution by the AOTA's Representative Assembly, moved to require a master's degree upon entry into the field of occupational therapy. By the year 2007, all educational institutions offering occupational therapy programs must do so under the standards of ACOTE's post-baccalaureate requirements. However, there are many practitioners in the field who have already earned master's and doctorate degrees. As of 2001, the number of practitioners with advanced degrees had nearly doubled (since 1990).

Licensure

The profession of occupational therapy is regulated in every state; in 43 states, as well as the District of Columbia, Puerto Rico, and Guam, occupational therapists are required to be licensed. Licensure is important because

KEY TERMS

Activities of daily living (ADL)—Activities of daily living are an individual's skills and practices that determine how well he or she can function in daily life and how well he or she relates to and participates in his or her environment.

Alzheimer's Disease—A progressive, neurodegenerative disease characterized by loss of function and death of nerve cells in several areas of the brain, leading to loss of mental functions, such as memory and learning. Alzheimer's disease is the most common cause of dementia.

Arthritis—Inflammation of one or more joints.

Attention deficit disorder (ADD)—A condition characterized by an attention span that is less than expected for the age of the person. There is often age-inappropriate hyperactivity and impulsive behavior, as well.

Ergonomics—The study of the relationship between people and their working environment.

Home modification—Altering the physical environment of the home so as to remove hazards and provide an environment that is more functional for the patient. Examples of home modification include the installation of grab bars and no-slip foot mats in the bathroom, to prevent falls.

Parkinson's disease—A disorder of the brain characterized by shaking and difficulty with walking, movement, and coordination. The disease is associated with damage to a part of the brain that controls muscle movement.

Stroke—A group of brain disorders involving loss of brain functions that occur when the blood supply to any part of the brain is interrupted.

it defines the scope of practice for therapists and provides guidance to facilities and health care providers on the appropriate application of occupational therapy services.

The field of occupational therapy has been playing catch-up with its allied health counterparts, such as **physical therapy** and speech-language pathology. More sophisticated and specialized education was necessary for occupational therapists to remain competitive and prove their worth when interacting with consumers and other medical professionals. In the 2001 market, practitioners must be able to employ critical reasoning and develop innovative practice models.

Advanced education and training

Continuing education courses and additional training is necessary for practitioners to remain competent within the field; this must be done on a regular basis. Practitioners can utilize AOTA's continuing education courses, online courses, and annual conference and exposition workshops, as well as educational sessions that are offered by leaders in occupational therapy.

In 2000, AOTA's Council on Continued Competence in Occupational Therapy (CCCOT) implemented the Continuing Competence Plan for Professional Development, a comprehensive plan that guides practitioners in developing and maintaining competent skills. The NBCOT, through which practitioners must become certified and eventually recertify, agreed to work in coordination with the AOTA to develop a recertification program that agrees with the principles set forth in the CCCOT's plan.

Future outlook

As health care delivery has changed dramatically with the advent of managed care, the roles of occupational therapists and occupational therapy assistants have expanded, due mostly in the United States to **Medicare** provider payment cutbacks mandated by the Balanced Budget Act (BBA) of 1997. Many jobs were cut in SNFs, leaving occupational therapists out of work. This change forced practitioners to consider other markets that might value their services.

The occupational therapy profession, however, was granted a reprieve when the U.S. Congress made several changes to the Balanced Budget Act. The Balanced Budget Refinement Act of 1999 called for a suspension of a capitation on rehabilitation services. Congress agreed to suspend the capitation because of the controversy surrounding combining occupational therapy, physical therapy, and speech-language pathology.

For occupational therapy to survive, new markets had to emerge. Practitioners proved their worth in less traditional roles and work settings. While therapists still have a place in LTC facilities, they are carving a niche in school systems—the most popular work setting, according to a 2000 survey conducted by AOTA—as well as business-to-business consulting firms that specialize in ergonomics, home modification, and/or assistive devices, wellness education programs, community-based mental health programs, and a variety of specialties in private practice.

It was reported by the U.S. Department of Labor's 2001 *Occupational Outlook Handbook* that the occupational therapy field is expected to grow at a faster rate

than any other occupation through 2008. These gains, however, are expected to be made in the years closer to 2008 due to congressional cuts, detailed above.

The increasing demand for occupational therapists is expected, in large part, because of the emerging markets, as well as the increase in those requiring the type of services occupational therapists provide. As baby boomers (those born between 1945 and 1965) age, occupational therapy practitioners will have an even bigger market for home modification, so that the elderly, for example, can remain in their homes longer than normally expected. Advancement in medical technology continues to allow people to live longer, despite serious illness and disability, and occupational therapists can facilitate their independence in daily living and working.

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ORGANIZATIONS

The American Occupational Therapy Association, Inc. 4720 Montgomery Lane, Bethesda, MD 20824-1220. (301) 652-2682. <<http://www.aota.org>>.

The National Board for Certification of Occupational Therapy, Inc. 800 S. Frederick Ave., Ste. 200, Gaithersburg, MD 20877-4150. (301) 990-7979. <<http://www.nbcot.org>>.

The U.S. Department of Labor, Bureau of Labor Statistics, Division of Information Services. 2 Massachusetts Ave. NE, Room 2860, Washington, DC 20212. (202) 691-5200. <<http://www.bls.gov>>.

Meghan M. Gourley

Occupational therapy interviews

Definition

The **occupational therapy** interview is the initial fact-finding session between an occupational therapy practitioner and a patient to determine the patient's problem(s) and to discuss possible intervention and treatment.

Purpose

The interview is the first opportunity for the occupational therapy practitioner to get a complete picture of the problems, concerns, and limitations of the patient. All of the information gathered is used toward defining a treatment plan. During the interview, the therapist should learn about how the patient perceives himself or herself in various roles at home, school, work, and during leisure time. The patient also should express goals he or she would like to achieve and what needs should be met.

However, the initial interview should not only be an information-gathering experience for the therapist, but also for the patient. The interviewer should explain his or her role as an occupational therapist and how he or she will facilitate an independent and functional life for the patient. It is the initial interview that helps to set the stage for treatment and becomes the foundation on which the practitioner-patient relationship is based.

Precautions

The therapist should be prepared to gather information about the patient, such as the patient's needs or lifestyles, that the therapist may not agree with. Occupational therapy practitioners need to remain open-minded in any evaluation process and recognize that patients may have differing moral and philosophical views.

KEY TERMS

Assessment—A specific test developed to measure a particular function or role of a patient. In occupational therapy, the words assessment and evaluation are not used interchangeably.

Evaluation—Determination of a person's ability or function using an assessment.

Narrative—A detailed account of an event or experience.

Description

Interviews between the occupational therapy practitioner and patient may begin by the therapist explaining the meaning of the occupational therapy profession and what the therapist hopes to achieve through the rehabilitation process. It is important for the patient to understand what is expected of him or her, and understand that the mission of occupational therapy is to facilitate independence and function within the client's life. The therapist also should cover areas of rehabilitation that pertain directly to the patient's needs, such as physical or mental disability, arthritis, **sexual dysfunction**, or a learning disability.

An effective form of interviewing is the narrative interview where the patient is permitted to speak at length and in depth about his or her life, problems, concerns, or any other topic. This allows the patient to speak freely about whatever topic that troubles or interests him or her most. In any type of interview and throughout the rehabilitation process, the occupational therapy practitioner should employ good listening skills and answer questions with great thought. Therapists should not ignore the use of metaphors during the interviewing process. Studies have shown that it is not uncommon for patients to use symbolic images that represent a feeling in their lives, such as entrapment or fear.

In occupational therapy, several assessments exist in which the patient's occupational performance is measured. They include, but are not limited to, the Canadian Occupational Performance Measure (COPM), the Assessment of Occupational Functioning (AOF), the Occupational Performance History Interview (OPHI), and the Activity Configuration. Each of these assessments yield information on education, work, leisure, activities of daily living, and a patient's satisfaction in his or her performance in daily activities. Several specific areas of the interview should include:

- Education: type of school the patient attended, highest level achieved, grades, social clubs involved in, and career aspirations.
- Work history: past and present jobs, likes and dislikes about job, desirable type of job, preferences of working alone or with others, and plans for future jobs.
- Leisure activities: involvement or interest in sports and hobbies, and whether the patient has a desire to get involved in sports and/or hobbies.
- Culture: what cultural group does the patient identify with, and what customs does the patient engage in, if any.
- Daily schedule: roles and the balance between all roles.

Preparation

In order to sufficiently prepare for the initial interview, the occupational therapy practitioner should plan ahead. The practitioner should arrange for an environment that is conducive to a private interview. Because the therapist's goal is to facilitate openness, the patient should be made to feel comfortable and assured that the information relayed will be kept confidential. The therapist should plan at least several questions in advance that are open-ended and allow for sharing. The practitioner also should plan on taking notes and/or recording the interview. However, they should keep in mind that note-taking and recording can make some clients uncomfortable, so the therapist should explain why it is important to thoroughly document all information shared during the interview so that a comprehensive treatment plan can be formed.

Aftercare

It may be beneficial for the practitioner to seek out the client's family members, friends, or co-workers to gather more information following the initial evaluation with the client.

Results

The occupational therapy practitioner assumes many roles when beginning treatment with a patient: counselor, caregiver, evaluator, researcher, and advocate. The practitioner's comprehensive approach to treatment is imperative to a patient's success.

Health care team roles

A patient seeking occupational therapy services almost always will have contact with other health care professionals who should factor in to the patient's treat-

ment program. Physicians should be kept abreast of ongoing progress. It is always possible that the occupational therapy practitioner will refer a patient for further treatment; for example, mental health counseling that is more specialized. Occupational therapy practitioners must work collaboratively with physical therapists, speech pathologists, and any other health professional the patient has consulted.

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Meghan M. Gourley

Operating room technology *see* **Surgical technology**

Ophthalmologic ultrasounds

Definition

Ophthalmologic ultrasound is a noninvasive technique that uses high frequency sound to “visualize” structures of the eye. It is the simplest method of imaging the eye in the presence of opacities such as a cataract or vitreous hemorrhaging. Ophthalmologic ultrasound usually employs frequencies of up to 10 million Hertz (10 MHz), but frequencies in the range of 50 to 100 MHz are used in ultrasound biomicroscopy of the eye. Humans cannot hear sounds that emit a frequency of greater than 20,000 Hertz. In order that an ultrasound image can be formed, a transducer or probe transforms electric energy to sound energy, which then penetrates the ocular tissue.

The energy is not absorbed by the tissue as heat, nor is it scattered within the tissue, but is reflected off the tissue, forming the ultrasound image.

Purpose

The purposes of ophthalmologic ultrasound are to study ocular anatomy and to diagnose pathology of the eye. There are many different types of ophthalmologic ultrasound. They include A-scans, B-scans, 3-D scans, duplex ultrasonography, and ultrasound biomicroscopy.

The A-scan ophthalmologic ultrasound is used to measure the axial length of the eye and the thickness of the lens of the eye. The most common use of an A-scan, along with keratometry, which measures the curvature of the anterior surface of the cornea, is to determine the power of the intraocular lens to be implanted following cataract extraction.

A B-scan ophthalmologic ultrasound gives images of the structures throughout the orbit. The B-scan is used by the ophthalmologist in some intraocular surgeries, such as in placement of a radioactive plaque to treat a retinal tumor, and in the extraction of a foreign body that has penetrated the globe. In cryotherapy, the clinical use of low temperatures, ophthalmologic ultrasound imaging helps guide the probe used to treat retinal tears in the presence of vitreous hemorrhaging. It is also used preoperatively in patients with dense **cataracts** to rule out pathology of the posterior pole, and to evaluate resorption of vitreous hemorrhages in diabetic retinopathy. B-scan ultrasonography can locate retinal and choroidal detachments and is used to assess drusen, or **calcium** deposits on the optic nerve and to locate intraocular tumors. The B-scan also can detect changes in structure of the posterior sclera, but because of its limited resolution, anterior scleral pathology is difficult to assess. The new-generation B-scans can assess optic nerve cupping, changes of the optic nerve seen in **glaucoma**.

Color doppler and duplex ophthalmologic ultrasonography are helpful in the assessment of glaucoma, and in diagnosis of ocular tumors and diseases of the anterior segment. Since they evaluate **blood** flow and resistance through the intraocular **blood vessels**, Doppler and duplex ultrasonography can be employed in the diagnosis of a central retinal artery or vein occlusion, and in the diagnosis of temporal arteritis. Temporal arteritis is an inflammation of the temporal artery which can affect **vision**. Restriction of blood flow through other ocular vessels affected in temporal arteritis can also be observed by duplex ultrasonography.

A 3-D ophthalmologic ultrasound gives the eye care practitioner a 3-D image of the eye, facilitating the diag-

KEY TERMS

Adnexa—Structures outside the orbit of the eye that include the lacrimal glands, the lacrimal ducts, the extraocular muscles and the eyelids.

Angle—Part of the eye through which fluid leaves the eye.

Anterior segment—The front part of the eye, that includes the sclera, the cornea, the tear film, the angle of the eye, the iris, and the ciliary body and its processes.

Cataract—Opacification (clouding) of the lens of the eye which occurs as a result of aging, disease, or trauma.

Choroid—Layer of the eye, rich in blood supply, that is found between the retina and the sclera.

Ciliary body processes—Structures of the eye which form the fluid of the anterior chamber and the vitreous.

Cornea—Transparent tissue on the front of the eye that focuses light into the eye through the pupil.

Extraocular muscles—The six muscles which are used to voluntarily move the eye.

Glaucoma—An ocular disease characterized by loss of visual field and damage to the optic nerve. It is often associated with increased intraocular pressure, but not in all cases.

Intraocular—Within the eyeball.

Lens—Intraocular structure in the eye that focuses light onto the retina.

Ophthalmologist—A medical doctor with residency training in medical and surgical management of eye disease.

Optic nerve—Large nerve in the back of the eye through which visual stimuli leave the orbit, to the occipital lobe where vision is processed.

Optometrist—An eye care doctor specifically trained in all aspects of vision and eye care. Optometrists are licensed in all states to diagnose and treat eye disease.

Orbit—The bony cavity of the skull that holds the eyeball.

Posterior pole—The posterior part of the eye that includes the retina and the vitreous.

Radiologist—A physician trained in radiology, the use of radiant energy, to diagnose and treat diseases.

Retina—The inner part of the eye where the photoreceptors are located.

Sclera—Tough white membrane covering the outer part of the eye, not covered by the cornea. It encircles the inside of the eye and is continuous with the optic nerve.

Vitreous—A nonvascular gelatinous material found behind the posterior capsule of the lens.

nosis of a retinal detachment, intraocular tumors, or enlargement of the extraocular muscles. The 3-D ultrasound can be utilized prior to refractive surgery, to assess corneal thickness and irregularities in the corneal surface, and to determine with accuracy the depth of the anterior chamber before implantation of an intraocular lens.

Ultrasound biomicroscopy is employed to assess the normal spatial relationships among anterior segment structures of the eye such as the iris, ciliary processes, and the layers of the cornea. It is also used to assess pathology of the eye and adnexa. Applications of ultrasound biomicroscopy include: calculations of corneal thickness and endothelial cell count, assessment of the cornea after refractive surgery, angle assessment in pupillary block, and elucidation of the causes of glaucoma. Ultrasound biomicroscopy can image the position of implants such as an intraocular lens placed in the eye after cataract surgery, or a filtering bleb, placed intraocu-

larly after glaucoma surgery. It can image tumors of the iris and ciliary body, detect anterior segment abnormalities, and isolate **foreign bodies** that penetrate the globe. With the higher resolution of ultrasound biomicroscopy, scleral pathology, such as scleritis, an inflammation of the sclera, is detectable.

Telesonography is a method of using ultrasound to diagnose medical conditions from a remote site. Ophthalmologic ultrasound images can be transmitted via the Internet with this technology.

Description

The images formed by ophthalmologic ultrasound must be resolvable. Resolution is the ability of the eye to distinguish between objects. Resolution can be linear, which determines how far apart two objects are from each other, or contrast, which determines the differences

of shades of gray between objects. The higher the frequency employed, the greater the resolution, i.e. smaller objects can be discerned. A frequency of 10 Mhz gives a resolution of 150 micrometers, but resolution as small as 20 micrometers is possible with a 100 Mhz transducer.

An A-scan ophthalmologic ultrasound produces a one dimensional display of intraocular structures. It can employ either applanation or water immersion techniques. The applanation probe, or transducer, touches the cornea of the eye, while the immersion probe is mounted in a water bath surrounding the eye and never compresses the globe. Because the applanation probe applies more pressure to the eye, it can underestimate axial length. Since the probe of the water immersion unit is not in direct contact with the eye, and the sound waves must pass through water before reaching the back of the eye, it is more difficult to judge the layers of the internal eye with this technique, especially when a dense cataract is present.

The B-scan ophthalmologic ultrasound produces a two dimensional real time image. Usually an applanation probe is used, but a water bath technique may give better resolution, important in location of small foreign bodies. In B-scan ultrasound exams the probe is oriented perpendicular to the structure being examined. The images of B-scans are displayed on a video monitor, and can be recorded.

The 3-D ophthalmologic ultrasound produces its image as the probe passes over the eye at numerous angles, and then combines these slices of the eye to produce an image larger than that formed by the B-scan. A 3-D ultrasound can reproduce an image in less than 12 seconds, but it is not a real time image. The anterior segment cannot be imaged well by 3-D ultrasonography.

Doppler ultrasonography assesses blood flow in the eye. Duplex ultrasonography combines the B-scan with the Doppler ultrasonography. The color duplex ultrasound is superimposed with color, allowing the examiner to assess blood flow direction, identify blood vessels, and calculate velocity of blood flow. These techniques, when applied to the eye, assess blood flow through ocular blood vessels.

Ultrasound biomicroscopy uses higher frequencies and thus can image the structures of the eye with greater resolution than a B-scan ultrasound and gives the eye care practitioner a real-time image. Ultrasound biomicroscopy can penetrate the eye only up to 5 mm and thus cannot image the posterior pole. The average length of the eye is 25 mm.

Precautions

Special care is needed when performing an ophthalmologic ultrasound on a ruptured globe.

Preparation

Ophthalmologic ultrasounds are usually performed in the supine position (lying down) and in dim light.

Prior to using the applanation A-scan measurement, an anesthetic drop is instilled in the patient's eye and the patient looks at a target at the end of the probe which gently touches the cornea. An eye cup may keep the eye open or the probe may be held against the eyelid. With the water immersion technique a plastic bag with a hole large enough for the eye and lids to protrude, is placed around the eye.

Prior to a B-scan ultrasonography, an anesthetic is applied to the eye and the patient's eye is held open with an eye cup filled with methyl cellulose. A protective contact lens may be placed on the eye. The patient is given a target on the ceiling on which to fixate, with the eye not being examined. The probe is covered with a coupling gel, and then applied in various directions across the eye, perpendicular to the internal structures of interest. An eye cup, filled with the methyl cellulose, can be held over parts of the ocular adnexa, such as over a closed eye for examination of the lids, when structures external to the globe are examined.

Aftercare

The patient should be instructed not to rub the eyes for 20 to 30 minutes after an ophthalmologic ultrasound and warned that his vision might be slightly compromised for the same time frame.

Complications

There are no known complications from ophthalmologic ultrasound when used for these time periods, and at levels indicated for ultrasound of the orbit and when performed by trained personnel.

Results

The results of ophthalmologic ultrasounds are immediately available to the doctor. Abnormal results indicate an underlying problem and may require further testing and treatment.

Health care team roles

A sonographer, a medical professional trained in sonography, can do an ophthalmologic ultrasound, but in an ophthalmic practice the ultrasound is done by an ophthalmic technician or the doctor. The ultrasound image is always interpreted by a doctor, such as an ophthalmologist, an optometrist, or a radiologist.

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Ophthalmoscopic examination see **Eye examination**

Opticianry

Definition

Opticianry is the profession where opticians verify and dispense lenses, frames and other optical devices, such as **contact lenses**. In some instances, opticians also grind the lenses for the frames.

Description

Opticians work in tandem with ophthalmologists (M.D.s) and optometrists (O.D.s) to fit eyeglasses and contact lenses. The dispensing opticians use prescriptions determined by eye doctors to assist customers in choosing suitable frames. Part of ensuring a proper fit includes measuring the distance between the centers of the pupils and the distance between the eye surface and the lens.

Opticians help the patient choose frames that are not only fashionable, but will work well with the patient's prescription. For example, some strong prescriptions require thick lenses that cannot fit into a small, wire frame. The optician will recommend thinner, high index lenses if the patient desires smaller frames, or the optician may suggest a larger plastic frame to accommodate the prescription. It is this aspect of the profession that requires the optician to be a skilled technician, a savvy retailer, and a tactful consultant. Patients are also usually asked about their professions or hobbies to see if a special frame or lens is needed. If a patient plays basketball, for example, the optician may recommend polycarbonate lenses in his eyeglasses or protective eyewear.

Once a suitable frame is chosen, opticians create work orders for laboratory technicians who grind and insert lenses into the selected frame. The information includes the prescription, lens material, and lens size. Some opticians, also known as manufacturing opticians or ophthalmic laboratory technicians, produce the lenses. They take the work orders given by the dispensing optician and grind, cut and edge the lenses to the correct prescription, and size for the frame. After the lens is complete, the manufacturing optician inserts it into the correct frame.

The dispensing optician works with the patient to ensure optimal **vision** with the patient's new eyeglasses. The optician may use pliers, files, or screwdrivers to adjust the frame to sit properly on the patient's face. The optician will make sure the lens is sitting in the correct position. If it is not, the patient's vision could be distorted. Before the patient leaves with his new eyeglasses, the optician will direct the patient on proper lens care and cleaning. For example, some anti-reflective coating lenses are to be cleaned only with special cloths and solu-

tions. The patient may return to the optician for eyeglass adjustments as needed.

For customers who prefer contact lenses, opticians measure the size and shape of the eyes, select proper lenses, and give instructions about lens wear and maintenance. Contact lens fitting requires a higher degree of skill, and in some states, opticians are prohibited from this task unless under the immediate supervision of an O.D. or M.D. In many cases, a physician has already recommended the type of contact lens for the patient, and the optician measures the eyes and works with the patient to ensure the proper fit.

Some specialized opticians, called ocularists, help create artificial eyes and shells for patients who may have been injured in accidents or have lost an eye due to disease. Some opticians also specialize in optics, focusing on nonprescription products such as binoculars or microscopes.

Work settings

An optician can work in an ophthalmologist's or optometrist's office, clinic, an optical shop, retail eyeglass chain store, or department store. Other optical shops cater to more elite clientele and are sometimes called "boutiques." These shops feature more expensive, designer frame collections. In these settings opticians are expected to know not only how to correctly fit the lens prescription into the frame, but also be aware of the latest fashion trends.

Because dispensing opticians often work in retail settings, they are required to work weeknights and weekends. Even opticians employed by physicians may have to work evening hours a few nights a week to keep up with patient demand.

Education and training

Some opticians are trained through an apprenticeship under the supervision of a licensed optician, or complete years of on the job training at a clinic or optical shop. In recent years, however, opticians with more formal training are in demand and can command higher salaries.

Community colleges and some universities offer an associate in science degree for opticians. Some technical schools also offer one-year training programs in opticianry. Secondary education opticianry candidates should be proficient in geometry, general sciences, math, and mechanical drawing. The two-year programs include studies in psychology, ophthalmic materials and dispensing, eye anatomy, technical physics, and college level geometry and trigonometry, plus electives.

As of 2001, opticians in 26 states were required to pass the National Opticianry Competency Examination developed by the American Board of Opticianry/National Contact Lens Examiners (ABO/NCLE). Opticians in these states who want to dispense contact lenses must take an additional test, The Contact Lens Registry Examination, before dispensing lenses.

Advanced education and training

Opticians who did not complete a college program may wish to do so, as opticians with more formal education are in higher demand. Certified opticians need to renew their certification every three years. The ABO/NCLE also offers advanced certification that focuses specifically on the advanced level knowledge and skills needed for ophthalmic dispensing: providing spectacle, contact lens, and refraction services.

The ABO also has a master's program which requires candidates to write a technical thesis of at least 2,000 words. Candidates must already have completed the advanced certification program. Once the thesis is completed, it must be reviewed and approved by the masters committee. Upon approval of the thesis by this committee, the title of ABO Master (ABOM) is conferred.

Future outlook

Enrollment in opticianry programs is down as of 2001. There currently is a shortage of dispensing opticians, and that shortage is expected to worsen as the United States' population grows older and has more need of opticianry services. As people age, they need corrective lenses for **presbyopia**, **cataracts**, and other age-related disorders. With these more complicated refractions, opticians with secondary education and a strong knowledge of optics are likely to be in more demand than ever. Also, knowledgeable consumers are more aware of the importance of a good eyeglass and contact lens fit. As this consciousness grows, opticians with more education will be sought out by patients as well as employers.

Current trends also play a part in the demand for opticians. In recent years, eyewear has become more of a fashion statement than ever before. Patients will look to the optician to find the correct frame and lens that will let them see well and look stylish at the same time. Skilled opticians will be able to provide the patient with frames that offer the correct optics for these newer styles.

Opticians who dispense contact lenses will also be in higher demand as the types of lenses available to patients continue to increase. Patients who were once restricted from wearing contact lenses, such as those who need bifocals or have **astigmatism**, now are able to success-

KEY TERMS

Cornea—The clear outer covering of the front of the eye.

Lens—A device that bends light waves.

Ophthalmologist—A medical doctor who specializes in diseases of the eye and eye surgery.

Optometry—The profession of examining the eye for defects, diseases, or faults of refraction, and prescribing pharmaceuticals, corrective lenses, or exercises to treat these conditions. Optometrists (O.D.s) are trained and licensed to detect and treat ocular symptoms and diseases.

Polycarbonate—A very strong type of plastic often used in safety glasses, sport glasses, and children's eyeglasses. Polycarbonate lenses have approximately 50 times the impact resistance of glass lenses.

Presbyopia—A condition affecting people over the age of 40 where the system of accommodation that allows focusing of near objects fails to work because of age-related hardening of the lens of the eye.

Refraction—Method of determining the optical status of the eyes. Lenses are placed before the patient's eyes while reading from an eye chart. The result is the eyeglass or contact lens prescription.

fully wear contact lenses. These and other innovations will require more experienced contact lens fitters to meet the demands of these patients.

As of 2001, opticians are lobbying in several states to receive permission to increase their scope of practice to include refraction. If they are allowed to do so, the need for new opticians would increase even further. Optical shops would likely grow larger to include tasks that previously only an ophthalmologist or optometrist could perform.

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- American Board of Opticianry. 6506 Loisdale Rd., Suite 209, Springfield, VA 22150. (703) 719-5800. <<http://www.ncleabo.org>>.
- Commission on Opticianry Accreditation. 7023 Little River Turnpike, Suite 207, Annandale, VA 22003. (703) 941-9110. <<http://www.coaccreditation.com>>.
- National Academy of Opticianry. 8401 Corporate Drive, Suite 605, Landover, MD 20785. (800) 229-4828. <<http://www.nao.org/home.htm>>.
- Opticians Association of America. 7023 Little River Turnpike, Suite 207, Annandale, VA 22003. (703) 916-8856. <<http://www.opticians.org>>.

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Optometry

Definition

Optometry is the profession of examining the eye for defects, diseases or faults of refraction, and prescribing pharmaceuticals, corrective lenses or exercises to treat these conditions. Doctors of optometry (O.D.s) are trained and licensed to detect and treat ocular symptoms and diseases.

Description

Doctors of optometry are primary health care professionals who examine, diagnose, treat, and manage diseases and disorders of the visual system, the eye, and associated structures, as well as diagnose related systemic conditions. They prescribe glasses, **contact lenses**, low **vision** rehabilitation, vision therapy, and medications, as well as perform certain surgical procedures. O.D.s need eight to 10 years of preparation for their profession—four years to earn the doctor of optometry



An optometrist uses a refractor to check a patient's eyesight and find the correct prescription. (Photograph by Andrew McClenaghan. Science Source/Photo Researchers. Reproduced by permission.)

degree, and one to two years of residency in training. Oklahoma, as of 2001, was the only state where O.D.s were allowed by law to perform laser refractive surgery. Other states also were considering similar measures.

The profession of optometry also routinely includes diagnosing and treating the ocular complications of diseases such as diabetes and **hypertension**; rehabilitating patients with **brain** injury or stroke; providing low vision services for the partially sighted. This includes vision therapy for patients with amblyopia and strabismus (crossed eyes). O.D.s also take an active co-management role with ophthalmologists (M.D.s) in the pre- and post-operative treatment of patients after laser refractive surgery and cataract surgery.

Primary care

All O.D.s treat diseases and dispense corrective lenses for **astigmatism**, **hyperopia**, and **presbyopia**. They monitor the patient's depth perception and ability to focus and see color. Many optometrists choose primary care or "family practice" because it gives them the biggest diversity of patients.

Some of these primary care O.D.s specialize in contact lens fittings. Recent advances have allowed patients previously restricted from wearing contact lenses to wear a number of types of lenses. Astigmatic and presbyopic patients require more specialized contact lens fitting which these specialists can provide. Sometimes other O.D.s or ophthalmologists will refer their patients to these contact lens specialists. These O.D.s also are more familiar with infections and irritants caused by contact lenses and how best to treat them.

Some O.D.s specialize in certain other areas of optometry, as well as in contact lenses. These specialties include:

Low vision/vision rehabilitation

Some O.D.s focus mainly on low vision services and work in tandem with ophthalmologists, rehabilitation specialists, and government and private agencies. They sometimes work together to determine the best optical devices that improve the quality of life for patients with limited vision. These patients are referred to these optometric specialists usually after a colleague has performed an initial evaluation. The O.D. and members of the spe-



Patient viewing an eye chart. (Delmar Publishers, Inc. Reproduced by permission.)

cialized team take the routine exam one step further by utilizing magnifiers, specialized charts, telescopes, colored filters, lenses, prisms, computerized devices, lights, and closed-circuit televisions designed to maximize vision. The low vision specialist is up-to-date on the latest vision aids and treatments so that his patients can lead more productive lives.

Vision therapy (developmental vision)

Vision therapy is a specialty where O.D.s concentrate on how eyesight affects human behavior. Vision therapy specialists work with physicians, psychologists, educators and parents to treat learning disorders, for example, dyslexia, by helping patients with hand-eye and other motor coordination. These specialists also treat patients suffering from amblyopia and strabismus. Some of these patients are adults; many are school-age children.

Pediatric optometry

This is a popular optometric specialty. Common vision problems in children include **myopia**, amblyopia and strabismus. These specialists work with parents and children, and school systems, counseling them on proper treatment as well as **nutrition**.

Geriatric optometry

As patients age, the frequency of ocular disease increases. Specialists can detect and treat **macular degeneration**, **glaucoma** and diabetic eye conditions. They also can detect **cataracts** and co-manage these patients post-operatively with an ophthalmologist.

With the geriatric population expected to increase dramatically due to aging baby boomers, more optometrists will find an expanding need to serve this population, and possibly increase the number of O.D.s who might decide to choose this specialty.

Some O.D.s focus on these patients in an existing practice, while others serve patients in **nursing homes** or clinics with large numbers of elderly patients.

Research and consulting

Some vision companies, especially contact lens manufacturers, seek out optometrists to help them with new product development or to refine existing products. Other optometrists conduct research in a clinical or educational setting.

Work settings

O.D.s may have private, group or partnership practices in hospitals and eye clinics. There are also commissioned posts for optometrists in the military. Government agencies seek advice from O.D.s for health advisory committees, and corporations rely on optometrists for consultation on new products.

Optometrists practice mainly in solo private practices or in a group private practice with other O.D.s. Their offices are located in office buildings, medical parks, storefronts and shopping malls. Some O.D.s opt for working for or franchising chain “superstores” that offer a big selection of frames and quick-turnaround for patients.

With the rise of laser refractive surgery, O.D.s are increasingly becoming a part of ophthalmologists’ group practices. In these instances, the O.D. is usually not a co-owner of the practice, but an employee instead. Some refractive laser centers keep O.D.s on staff strictly for co-managing the large volume of refractive surgery patients.

Education and training

O.D.s must complete high school and a bachelor's degree before admission to a four-year optometry school. The pre-optometry student's courses should include physics, organic chemistry, biology or zoology, physiology, statistics, geometry and calculus. These students also need to score in the top percentages of the Optometric Admissions Test before being accepted to an optometry program. Admission to these accredited programs is limited, so it is important for students to maintain a high undergraduate grade point average and achieve a high score on the admissions test to earn a slot at these schools.

The four-year programs focus mainly on clinical and practical teachings. In recent years a few programs have added practice management courses to help optometrists cope with managed care paperwork and increased competition from retail chains. First-year students study **human anatomy** and physiology and the basic principles of optics. Optometric sciences, ocular physiology and pathology, vision anomalies, and instruments of clinical practice are studied in the second year. Third-year students take those same topics to a higher level and begin studying contact lens fitting and general clinical practice. The student's last year of study includes treating patients under the guidance of teaching optometrists, usually at optometry-school run clinics. Student O.D.s during the fourth year prescribe and fit contact lenses, and diagnose and treat visual system conditions.

During the four years, optometry students also are offered a number of electives that include epidemiology, environmental vision, microbiology, and biostatistics.

Optometry schools usually operate clinics where patients need them most—in inner-city neighborhoods, nursing homes or correctional facilities. This enables care for patients in need while offering fourth-year students an opportunity to detect and treat a number of ocular conditions.

After optometry students complete a four year program but before they can begin practice, they must complete a series of written examinations—at least three written and one practical—for a license in order to practice. These licenses are granted by state boards of optometry. Each state has different requirements. While they are similar, graduating optometry students must check with each licensing board for specific requirements.

Advanced education and training

Recent optometry school graduates sometimes complete master's or doctorate degrees in related medical

specialties such as physiological optics, visual sciences or **public health**. Some of these doctors enter research or education.

Optometrists who want to specialize in certain areas complete a one-year residency after graduation at educational institutions or hospitals. These internships could include pediatric or geriatric optometry, low-vision rehabilitation or vision therapy.

State boards of optometry require a certain number of continuing education credits for practicing optometrists. This training is completed through specialized courses at meetings, optometry schools, optometric journals and the Internet. Continuing education credits must meet specific requirements of each state. The O.D. must check with the state licensing board for specific details.

Future outlook

More women are becoming optometrists than in years previous. As of 2001, about 25% of practicing optometrists were women. That number should rise since 50% of optometry students as of 2001 are women.

A comprehensive study by the American Optometric Association completed in 1997 predicted that there will be at least 4,000 more optometrists than needed by the year 2015. Several factors could affect that prediction.

- Geriatric population. The increasing number of elderly patients could mean a highly-increased number of office visits for optometrists. These elderly patients need more frequent examinations for myriad eye diseases and conditions.
- Vision plans. Managed care has brought more patients into optometrists' offices in recent years. Before managed care, many patients delayed regular eye exams because of cost. Because comprehensive vision plans routinely pay for regular eye exams, and in some cases contact lenses and eyeglasses, more patients routinely are being seen by O.D.s at a higher rate of frequency.
- Retail chains. More eye care patients are utilizing the convenience of these large "superstores" to fulfill their vision needs. These chains sometimes have several optometrists on staff. The need for "corporate optometrists" is expected to grow in the coming years. These positions do not pay as competitively as private practice; but they also do not incur the large debt that opening or purchasing a practice does.

KEY TERMS

Amblyopia—Decreased visual acuity, usually in one eye, in the absence of any structural abnormality in the eye.

Astigmatism—Asymmetric vision defects due to irregularities in the cornea.

Cataract—A cataract is a cloudiness or opacity in the normally transparent crystalline lens of the eye. This cloudiness can cause a decrease in vision and may lead to eventual blindness.

Glaucoma—Disease of the eye characterized by increased pressure of the fluid inside the eye. Untreated, glaucoma can lead to blindness.

Presbyopia—A condition affecting people over the age of 40 where the system of accommodation that allows focusing of near objects fails to work because of age-related hardening of the lens of the eye.

Refraction—Method of determining the optical status of the eyes. Lenses are placed before the patient's eyes while reading from an eye chart. The result is the eyeglass or contact lens prescription.

Resources

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American Academy of Optometry 6110 Executive Boulevard, Suite 506 Rockville, MD 20852. (301) 984-1441 Fax (301) 984-4737 aaoptom@aol.com. <http://www.opt.org>.

American Optometric Association. 2420 North Lindbergh Boulevard, St. Louis, MO 63141. (800) 365-2219. <http://www.aoanet.org/>.

Council on Optometric Practitioner Education 4401 East West Highway, Suite 205 Bethesda, MD 20814-4521. (800) 758-COPE (2673) (301) 913-0641 Fax (301) 913-2034. COPE@copeonline.org. <http://www.copeopt.org>.

National Board of Examiners in Optometry. 4340 East West Highway, Suite 1010, Bethesda, MD 20814. (301)652-5192. nbeo@optometry.org. <http://www.optometry.org>.

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Mary Bekker

Optometry assisting

Definition

Optometric assistants aide the optometrist (O.D.) and medical team in a variety of daily duties, including gathering patient history and performing ocular tests.

Description

With the advent of managed care into medicine, O.D.s examine more patients than ever. They are also required to see more patients to keep up with managed care demands and to boost their sagging bottom lines caused by decreased insurance payments. To keep up with the increased office traffic, more O.D.s are turning to their office staff to perform duties only they had handled previously.

An optometric assistant is the first medical staff member the patient meets. Assistants play a critical role in determining the patient's medical problem through recording a detailed patient history and a patient lifestyle questionnaire. During this interview, the assistant will discuss the reason the patient is being examined and any visual difficulties. The assistant makes detailed notes to pass on to the O.D. to help in the diagnosis.

More skilled assistants, called technicians or paraoptometric, perform testing and other procedures. These include retinal photography, **blood pressure** readings, automated lensometry, automated perimetry, acuities, and corneal topography. High-tech equipment now allows technicians to perform refractions, although these measurements are usually checked by the physician. The technician also may perform pre-testing for **contact lenses**, although with the advances in this technology, many physicians are turning to highly trained contact lens technicians to perform these duties.

Assistants take part in the medical aspects of the practice, but they also handle other duties as well. Assistants perform such tasks as maintaining **medical records**, keeping medical transcriptions, answering tele-

phones, patient recall, and tracking insurance payments. Larger practices may have specific employees for these duties. In smaller practices, assistants are more likely to handle many duties simultaneously.

Work settings

Optometrists either work alone in private practices or in group private practice with other O.D.s. Assistants may be required to handle the responsibilities for more than one physician. O.D. offices are located in office buildings, medical parks, storefronts, and shopping malls. O.D.s who work in chain stores usually do not have assistants, but employees from the parent company. Assistants may also work in hospital settings or clinics.

Optometric assistants may work long hours to meet the needs of patients. Doctors now regularly keep evening and weekend hours. Optometric assistants should also be capable of handling **stress** and many tasks at once. Direct contact with patients, scheduling, and collecting payments require a certain tact.

Education and training

Many assistants receive on-the-job training from other employees or the optometrist. There are certifications available, and a registered optometric assistant is designated by Opt. A., R. The American Optometric Association (AOA) paraoptometric section provides training to optometric assistants. The AOA began certifying paraoptometrics with a new program that instructs assistants on basic optometric terminology, optometric practice operation, anatomy of the eye, and optometric examinations and treatments. Applicants must have a minimum of a high school diploma or equivalent and must be able to verify a minimum of six months employment in the eye care field.

Paraoptometric assistant training certification programs are also available through some universities and community colleges. While these training sessions help develop skills, many optometrists hire assistants with no formal training. More highly trained assistants command higher salaries.

Advanced education and training

Optometric assistants may seek more formal training and become certified ophthalmic medical assistants, technicians or technologists. The Joint Commission on Allied Health Personnel in Ophthalmology (JCAHPO) offers certification that enable assistants to perform everything from clinical optics to assisting an ophthalmologist in the operating room. These positions demand

KEY TERMS

Ophthalmology—A medical doctor specializing in diseases of the eye and eye surgery.

Optometry—The profession of examining the eye for defects, diseases, or faults of refraction, and prescribing pharmaceuticals, corrective lenses, or exercises to treat these conditions. Optometrists (O.D.s) are trained and licensed to detect and treat ocular symptoms and diseases.

Polycarbonate—A very strong type of plastic often used in safety glasses, sport glasses, and children's eyeglasses. Polycarbonate lenses have approximately 50 times the impact resistance of glass lenses.

much more medical knowledge than optometric assisting. Technicians require a one-year course and technologists must complete a two-year course before being certified.

Future outlook

Optometric assistants will be more in demand as optometrists seek employees that can perform a number of tasks skillfully in their busy offices. This need will become greater as optometrists continue to add patients to their practices because of managed care. They will require more support personnel to perform testing and run their practices efficiently. The number of open positions for optometric assistants is expected to grow at a fast rate in the coming years. Even more importantly, as the population ages the need for qualified eye care professionals will rise to meet their needs.

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<<http://www.aama.ntl.org>>.

American Optometric Association Paraoptometric Section. 243 N. Lindbergh Blvd., St. Louis, MO 63141. (800) 365-2219.

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Mary Bekker

Oral cancer

Definition

Oral **cancer** refers to malignancies in the oral cavity (mouth) and the oropharynx. The oral cavity includes the lips, buccal mucosa (lining of the lips and cheeks), the hard palate, floor of the mouth, teeth, front two-thirds of the tongue, and gingiva (gums). The oropharynx includes the tonsils, soft palate, back third of the tongue, and the back of the throat.

Description

In the United States, oral cancer is diagnosed in approximately 30,000 patients each year and is responsible for about 8,000 deaths. Oral cancer is the sixth most frequently occurring cancer, and the most common sites of oral cavity cancers are the floor of the mouth and the tongue. In the oropharynx the most common sites of cancerous tumors are the tonsils and base of the tongue.

The economic and social impact of this disease is great. Oral cancer may result in serious long-term disabilities such as loss of speech, **hearing**, salivary, and chewing functions, as well as **pain** and disfigurement resulting from head and neck surgery.

Causes and symptoms

Nearly three-quarters of all oral cancers are related to tobacco use—either cigarette, pipe, or cigar smoking, or the use of smokeless tobacco products such as snuff. Tobacco-specific nitrosamines are the carcinogens (cancer-causing substances) implicated in the development of oral cancers. Chronic alcohol consumption is linked to oral cancers, and the use of alcohol and tobacco together poses a greater risk than using either one alone.

Exposure to asbestos or radiation increases the risk of developing oral cancers, and exposure to sunlight is a risk factor for cancer of the lips. A high-fat diet that is also low in fruits, vegetables, and other sources of **vitamins** A and C has been linked to development of oral cancers.

Age, gender, and race affect the risk of developing oral cancers. Oral cancer usually occurs among older adults because they have longer exposure to lifestyle and environmental risk factors. Oral cancer occurs 2.5 times more often in males than females, and blacks are affected more often than whites. The higher rate of oral cancer among black men is attributed to lifestyle, such as nutritional status, tobacco, and alcohol use, rather than genetic differences. Recent research on tobacco and alcohol use, however, has demonstrated comparable rates of oral cancer among blacks and whites.

The signs and symptoms of oral cancer depend upon the site of the tumor. Certain types of lesions in the oral cavity have the potential to become cancerous. Leukoplakias (white lesions) and erythroplakia (red lesions) that do not resolve within two weeks should be evaluated by a healthcare professional. Other possible signs or symptoms include:

- sore throat, hoarseness, or sensation that something is caught in the throat
- lump or thickening in the oral cavity
- difficulty chewing, eating, or swallowing
- difficulty moving the tongue or jaw
- numbness, weakness, or altered sensation in the mouth or tongue
- swelling of the jaw, mouth, or tongue
- changes in hearing, **smell**, or taste
- changes in the fit or feel of dentures or dental appliances
- abnormal odor or discharge from nose, ears, or mouth
- lesions, sores, or thickened patches that do not readily heal or resolve

Diagnosis

An examination to screen for oral cancer may be made by a physician, dentist, or dental hygienist. Though regular self-examination—with attention to inspection for lumps, thickenings, whitish patches, or sores—may detect some oral cancers, it is not a substitute for a thorough professional examination. An oral examination, performed by a physician or dentist using a mirror and lights, identifies abnormalities in the oral cavity. The physician will also palpate the throat, neck, and head for lumps or thickenings. X rays of the mouth, performed by a radiological technologist, may be used to examine suspicious areas.

When an abnormal area is detected in the oral cavity, the definitive diagnostic technique is biopsy—removal of all or part of the suspicious area for examination under the **microscope** by a pathologist. Biopsy is usually performed by an oral surgeon or an ear, nose, and throat specialist, also known as an otolaryngologist. Since squamous cells line the oral cavity, nearly all oral cancers are squamous cell carcinomas.

Staging

Staging refers to the process of determining the extent to which the cancer has metastasized (spread). Since treatment depends upon the stage of the oral cancer, additional diagnostic tests may be performed. These include imaging studies such as **dental x rays** and **CT scans**, and lymph node biopsy. Cancers of the oral cavity are identified as Stages I through IV and recurrent. Stage I cancers are less than three-quarters of an inch (2 centimeters) in size and have not spread to local lymph nodes. Stage II cancers are between three-quarters and one and one-half inches (2-4 centimeters) and have not metastasized to local lymph nodes. Stage III cancers are larger than one and one-half inches (4 centimeters), or are cancers of any size that have spread to a single lymph node on the same side of the neck as the cancer. Stage IV cancers have one or more of the following characteristics:

- spread to surrounding oral cavity tissue
- metastasized to more than one lymph node on the same side of the neck as the cancer
- metastasized to lymph nodes on both sides of the neck
- widespread metastasis throughout the body

Recurrent oral cancers are those that have returned following treatment. Recurrences may present in the oral cavity or elsewhere on the body.



A specimen of a squamous cell carcinoma of the tongue and jaw. (Custom Medical Stock Photo. Reproduced by permission.)

Treatment

Treatment depends upon the location and stage of the cancer, as well as the age and overall health of the patient. It generally consists of a combination of surgery to remove as much of the cancer as possible and radiation and/or adjuvant **chemotherapy (anticancer drugs)** to kill any remaining cancer cells. Drugs called radiosensitizers are sometimes used to render cancer cells more sensitive to radiation. Most oral cancers are treated with surgery and fractionated (small, measured doses) radiation therapy. Another treatment that is presently being tested is hyperthermia. Since cancer cells are more sensitive to heat than normal cells, hyperthermia treatment involves heating the body in order to kill cancer cells.

Surgical treatment and radiation of the lips and oral cavity may produce disfigurement and difficulty with activities such as eating and talking. Patients recovering from treatment may benefit from rehabilitation with a

KEY TERMS

Adjuvant therapy—Treatment involving radiation, chemotherapy (anticancer drug treatment), or a combination of both.

Biopsy—Surgical removal and microscopic examination of living tissue for diagnostic purposes.

Carcinogen—Any substance or agent capable of causing cancer.

Chemotherapy—Systemic treatment of cancer with synthetic drugs that destroy the tumor either by inhibiting the growth of cancerous cells or by killing them.

Malignant—Cancerous.

Metastasize—The spread of cancer cells from a primary site to distant parts of the body.

Oncologist—A physician who specializes in cancer medicine.

Pathologist—A person who specializes in the diagnosis of disease by studying cells and tissues under a microscope.

Radiation therapy—Treatment using high energy radiation from X-ray machines, cobalt, radium, or other sources.

Stage—A term used to describe the size and extent of spread of cancer.

speech therapist and support from social workers or other mental health professionals.

Prognosis

The prognosis for patients with oral cancer depends, again, upon the location and stage of the cancer, as well as the patient's age, overall health and effectiveness of treatment. Generally, oral cancers detected early, such as Stage I cancers, have the best prognoses. Patients who have had oral cancers are at increased risk for developing another cancer of the mouth, head, or neck; for this reason, all patients require vigilant, regular follow up. Patients who stop smoking or using tobacco products and alcohol also have better outlooks than those who do not.

Health care team roles

Patients with oral cancers may be cared for by oral surgeons, otolaryngologists, oncologists, surgical and oncology nurses, laboratory and radiological technolo-

gists, speech therapists, and mental health professionals. Health educators and behavior modification specialists may be involved in assisting patients with smoking cessation or recovery from alcohol dependency.

Patient education

The objectives of education are to prevent patients from smoking or using tobacco products, and to encourage smokers to quit. Participation in smoking cessation programs should be encouraged, and patients should be informed about the health risks of excessive alcohol consumption. Patient teaching also should describe the role of environmental carcinogens such as asbestos, radiation, and sun exposure in the development of oral cancers.

Prevention

Since tobacco products and alcohol abuse are associated with more than 75% of oral cancers, health education efforts to prevent their use could sharply reduce the incidence of oral cancers. Regular examinations by a dentist or physician are vital for early detection of oral cancers.

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ORGANIZATIONS

- American Cancer Society. (800) ACS-2345.
<<http://www.cancer.org>>.
- Cancer Care, Inc. (800) 813-HOPE.
<<http://www.cancercareinc.org>>.
- Cancer Information Service of the NCI. (800) 4-CANCER.
<<http://wwwicic.nci.nih.gov>>.
- Cancer Research Institute. 681 Fifth Avenue, New York, NY 10022. (800) 992-2623.
- Centers for Disease Control. <<http://www.cdc.gov>>.

National Cancer Institute (National Institutes of Health). 9000 Rockville Pike, Bethesda, MD 20892. (800) 422-6237 <<http://www.nci.nih.gov>>.

National Coalition for Cancer Survivorship. 1010 Wayne Ave., 5th Floor, Silver Spring, MD 20910 (301) 650-8868.

Barbara Wexler

Oral cholecystography *see* **Gallbladder x rays**

Oral contraceptives *see* **Contraception**

Oral debridement *see* **Nonsurgical periodontal therapy**

Oral herpes *see* **Cold sore**

Oral hygiene

Definition

Oral hygiene is the practice of keeping the mouth clean and healthy by brushing, flossing, and using appropriate therapeutic aids to prevent caries (tooth decay) and periodontal disease.

Purpose

The goal of proper oral hygiene is to control plaque, the sticky bacterial film that continually forms on teeth. Plaque adheres to the crevices and fissures of teeth and, when not removed on a regular basis, generates acids that can decay the enamel surface of teeth. Plaque is also a physical and a chemical irritant to the periodontium, the tissues investing and supporting the teeth.

Toothbrushing and flossing remove plaque from teeth, and antiseptic mouthwashes kill some of the **bacteria** in plaque. Fluoride—in toothpaste, drinking water, or dental treatments—also protects teeth by binding with enamel to make it stronger. Despite a patient's best efforts, plaque formation can lead to calculus formation. Calculus, also called tartar, is an adherent, calcified deposit made up of dead bacterial cells from plaque. Calculus does not cause tooth decay, but is a primary cause of periodontal disease. Calculus can only be removed by a dental professional, therefore regular dental visits are essential to good oral hygiene.

Precautions

Brushing should be performed thoroughly and gently with the correct brush, refraining from “scrubbing” at

the teeth with too much force. Brushing that is unnecessarily vigorous can cause gum irritation, gum recession, and abrasion of tooth structure. Flossing can also be performed too vigorously. A patient who inserts floss between teeth, then “saws” back and forth with downward force can create fissures in gum tissue that destroy the attachment of gum to tooth.

As deciduous (primary) teeth erupt, caregivers should develop the habit of brushing children's teeth after every meal. Since excess ingested fluoride can cause dental **fluorosis**, a mottled discoloration of tooth enamel, care should be taken that the child does not swallow any toothpaste. A pea-size amount of fluoridated toothpaste is all that is necessary to clean a child's teeth. Fluoride-free toothpaste for children is available.

Patients with full or partial prostheses are not exempt from the need for good oral hygiene. Dentures should be removed daily, cleaned with a brush and rinsed or soaked in a denture cleansing bath. Gum tissue should be brushed and rinsed to remove food particles and bacteria. If possible, dentures should be left out at night to allow the tissues to breathe without pressure from the prosthesis. When not in use, dentures should be covered with water or a denture cleaning solution to prevent drying. Dentures should be adjusted, relined, and replaced when necessary by a dentist.

Fixed prostheses such as bridges and implants require special cleaning tools for proper maintenance and to prevent failure of the prosthesis.

Description

Using a toothbrush

Ideally, patients should brush after every meal and snack with a fluoride toothpaste. Following a set routine ensures that no teeth are missed. A recommended sequence is to start on the upper right outside surfaces, continue to the upper left, switch to the inside left surfaces and return to the inside right. Then brush the occlusal (chewing) surfaces of the back teeth, move to the bottom and repeat the same sequence. The tongue should also be brushed to remove odor-causing bacteria. A thorough tooth brushing should take two to three minutes.

The American Dental Hygienists' Association recommends the following technique:

- Place toothbrush bristles along the gumline at a 45-degree angle. Bristles should contact both the tooth surface and the gum.



Dental floss helps remove food particles from between the teeth and gums. (Photograph by Andrew McClenaghan. *Science Source/Photo Researchers. Reproduced by permission.*)

- Gently brush the surfaces of two or three teeth using a vibrating, back and forth rolling motion. Lift the brush, move it to the next group of two or three teeth, and repeat.
- Behind anterior teeth, tilt the brush vertically. Make several up and down strokes using the front half of the brush.
- Place the brush against the occlusal (chewing) surface of the teeth and use a gentle back and forth scrubbing motion.

Consumers should look for a toothbrush with soft, nylon, end-rounded bristles in a size and shape that allows them to reach all tooth surfaces easily. Power toothbrushes are available in various styles, and have been proven to be as effective as manual toothbrushes. Research has found no significant differences in plaque reduction between manual and powered tooth brushing.

For those with limited use of their hands, toothbrush handles can be inserted in a small ball, bicycle grip, or sponge hair curler for easier gripping. Children's toothbrushes typically have larger handles, and may be appropriate for adults with less flexibility.

Toothbrushes should be replaced every three to four months, since bristles lose their integrity and don't clean as well after a period of time. In addition, toothbrush bristles and handles collect microbes that can cause colds, the flu, herpes, and periodontal infections. Some brushes have colored bristles that lose their coloration gradually, prompting a patient to replace it when the color is gone.

Using floss

Using dental floss daily to clean between teeth has many benefits. Interproximal (between adjacent teeth) decay is prevented because plaque is removed; interproximal restorations are maintained in healthy condition; and the sulcus surrounding each tooth is kept free from plaque and associated pathogens, ensuring periodontal health. Floss comes in many varieties (waxed, unwaxed, flavored, tape), and may be chosen by personal preference. As with brushing, flossing is easier for a caregiver when he or she is positioned behind the patient.

To begin, one end of an 18-inch piece of floss is wrapped around the middle finger of one hand. Most of the rest of the floss is wrapped around the middle finger

of the opposite hand, leaving a one- to two-inch center section that is grasped between the thumb and forefinger of each hand. The floss is eased between two teeth with a gentle back-and-forth motion, then pressed in a c-shape against one tooth, covering as much tooth surface as possible. The floss is worked gently up and down, back and forth, in and out to clean and scrape plaque from the side surface of the tooth, both above and below the gumline. The floss is then lifted over the papilla (raised gum tissue between teeth), and the process is repeated on the opposite tooth. As floss becomes soiled, fresh floss can be released from one hand, and used floss taken up by the other hand.

Using therapeutic aids

Toothpicks, both wooden and plastic, can be used as interdental cleaners. Small interdental brushes are also useful for cleaning wide spaces between teeth and under bridgework. Flossing can be made easier with floss holders. For flossing under fixed bridgework and around implants, floss threaders can be used, or floss with a stiff leader attached to one end.

Complications

Gingivitis is the immediate consequence of poor oral hygiene. An early form of periodontal disease, gingivitis is characterized by inflammation of the gums with painless bleeding during brushing and flossing. This condition is reversible with proper dental care, but if left untreated will progress to **periodontitis**. A professional cleaning by a hygienist or dentist is indicated, followed by home care instruction.

Periodontitis is a disease of the support structures of teeth, the gums, ligaments, and bone. Without support, teeth will loosen and may fall out or have to be extracted. To diagnose periodontitis, a dental professional looks for gums that are red, swollen, bleeding, and shrinking away from the teeth, leaving widening spaces between the teeth and exposed root surfaces vulnerable to decay. Measurements are taken in the sulcus—the space between tooth and gum—to determine the level of attachment of tooth to gum and bone. Studies may be undertaken to measure bacterial load in the sulcus. A general dentist is qualified to treat periodontitis. Some choose to specialize in this area, and are called periodontists. Treatment for periodontitis may include detailed home care instruction, specialized prophylaxis, antibiotic therapy, surgery, or a combination of the above.

Caries, or tooth decay, is a common consequence of poor oral hygiene when acid from bacterial plaque is allowed to form. A dentist will remove the decay, prep the clean cavity, and fill it with an amalgam or resin

KEY TERMS

Calculus—An adherent, calcified deposit of bacteria, fungi, desquamated epithelial cells and food debris, formed on the surface of teeth. Also known as tartar.

Caries—Tooth decay.

Fluorosis—Mottled discoloration of tooth enamel, caused by excess systemic intake of fluoride.

Gingivitis—Swollen, bleeding gums, usually not painful.

Periodontitis—A gum disease that destroys the structures supporting the teeth, including gums, ligaments, and bone.

Plaque—A thin, sticky, colorless film of bacteria that forms on teeth.

Sulcus—Pocket space between tooth and gum.

restoration. Left untreated, decay can expand, destroying the entire tooth and causing significant **pain**.

Results

With proper home care, oral hygiene may be maintained and oral health problems may be avoided. Older adults no longer assume they will lose all their teeth in their lifetime. Regular oral care preserves appearance, speech, and eating functions, thus prolonging the quality of life. Without proper home care, the patient runs a significant risk of losing teeth prematurely from decay or periodontal disease.

Health care team roles

Dental professionals monitor their patients' oral hygiene practices, making recommendations and providing instruction when necessary. During routine recall visits, a hygienist will typically review home care and make suggestions.

Caregivers such as nurse's aides are critical team members when it comes to oral hygiene. A patient who cannot brush and floss for himself or herself may compromise overall health by exposure to decay or periodontal disease.

Patient education

Patients receive oral hygiene training throughout life, first from parents or caregivers, then from educators,

then from dental professionals. A child may be taught to brush by his or her mother, then have that training reinforced by a school health educator. As children begin to visit the dentist regularly, they receive further training at routine visits. Flossing instruction is usually given at the dental office or in school, once permanent teeth have erupted and the child has enough manual dexterity to learn this skill. As the child becomes an adult, the hygienist or dentist can reinforce prior training and make any adjustments necessary.

Training

Health educators and caregivers can receive training from dental professionals to help their students and patients achieve good oral health. In-service programs are available from dental associations and boards, state health boards, and sometimes from local dental offices.

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<<http://www.ada.org>>.

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Oral hygiene aids

Definition

Oral hygiene aids are the tools used in the mouth to remove food residue and plaque, a bacterial film that causes tooth decay (**dental caries**), periodontal disease, and halitosis (bad breath).

Bacterial plaque must be removed daily. The toothbrush and dental floss are the primary oral hygiene aids for this process. The toothbrush is a brush used to clean the teeth by removing plaque from the teeth and stimulating the gums. Dental floss is thin, thread-like material used to clean the areas between teeth and under the gum line. A dental toothpick may be used to clean between teeth.

Also used in conjunction with mouth care are toothpaste and mouthwash. Toothpaste is a preparation used on the toothbrush to clean teeth. Some of the ingredients of toothpaste are as follows:

- polishing agents that aid in cleaning
- fluoride, to prevent dental caries
- antitartar agents, to prevent buildup of calculus
- antiplaque/antigingivitis agents, to control plaque and **gingivitis**
- whiteners, to remove dental stains
- sensitivity agents, to decrease sensitivity to heat, cold, and sweets

Mouthwash is a liquid product that patients gargle or use as a rinse to fight **bacteria**. It is used to control:

- halitosis
- plaque
- gingivitis
- tartar and calculus

Most mouthwashes contain fluoride, which helps to control caries.

Purpose

Oral hygiene aids such as the toothbrush, dental floss, mouthwash, and toothpicks are used in the daily battle against germs that live in the mouth. Plaque is formed when bacteria in the mouth feed on the food residue—particularly sugar residue—and dead epithelial cells (the covering of internal and external body surfaces). Depending on the bacterial pathogen present in the plaque, plaque can cause tooth decay or periodontal disease. When periodontal disease is not treated, it can lead to the loss of teeth when the supporting tissue that keeps teeth in the jaw is destroyed.

Although oral hygiene aids date back thousands of years, many people don't correctly use preventive tools like toothbrushes and interdental aids. In the United States, one-third of people in all age groups have untreated tooth decay, according to *Oral Health 2000*, the United States Surgeon General's report from May 2000. By age 17, 78% of youths have a cavity and 7% have lost

at least one tooth, according to the report by Surgeon General David Satcher, M.D.. His report also stated that 48% of adults between the age of 35 and 44 suffer from gingivitis.

Oral hygiene's long history

People have been concerned about oral health for thousands of years. Ancient civilizations used urine as a mouthwash. The earliest record of this usage dates back to China 5,000 years ago when the rinse was used for toothaches and bleeding gums. Although this form of mouth rinse seems disgusting, urine is sterile in a healthy person. Furthermore, historians believe that the urine rinse may have aided in preventing tooth decay.

Ancient civilizations used the toothpick to clean the teeth. The Roman poet, Pliny, wrote in the first century about cleaning the gums with a toothpick made from the bones of puffin fish. Other toothpick materials included gold, ivory, and bronze.

Toothbrushes were in use by the 18th century. While some people cleaned their teeth with small sponges, others used brushes made from the root of a marshmallow. People also brushed their teeth with horsehair bristles.

Contemporary oral hygiene

In modern times, the toothbrush and dental floss are the most important oral cleaning aids. The American Dental Association (ADA) calls brushing and flossing the “dental care twins,” the activities crucial to a healthy mouth. The dental toothpick and interdental brush may sometimes be utilized in place of floss, and the household toothpick can be used to remove food from the teeth.

The ADA Seal of Acceptance on products indicates that they were tested for safety and effectiveness.

Contemporary oral hygiene aids are used to remove food residue that can create plaque and cause tooth decay. The residue, especially that from sugar, provide nutrients for germs.

BRUSHING AND INTERDENTAL CLEANING. The toothbrush and dental floss are used to remove plaque. The toothbrush is used to remove plaque from the teeth and stimulates the gums. Dental floss or a dental toothpick is used to remove plaque and food from the areas between teeth. Plaque is a waste product that causes tooth decay. If not removed, it calcifies (hardens) and forms tartar (calculus). This hard, calcified substance must be removed by a dentist or dental hygienist.

MOUTHWASH AND TOOTHPASTE. The ADA recommends that people use mouthwash and toothpaste that contain fluoride, a mineral that helps fight tooth decay. Toothpaste is used on the brush to clean teeth.

Mouthwash is used as a rinse. While a fluoridated toothpaste is essential for daily oral health care, mouthwash can supplement a mouth care regimen and is best recommended on a patient-need basis.

Oral hygiene in the 21st century

In June 2000, the ADA announced that research was under way on new oral hygiene aids, such as chewing gums and mouthwashes that would reverse early tooth decay. In 2000, scientists at the American Dental Association Health Foundation's Paffenbarger Research Center were investigating **calcium** phosphate-based technologies to remineralize hard tooth tissue or possibly slow down caries-producing demineralization. Center director, Frederick Eichmiller, D.D.S., announced in 2000 that other research included the study of toothpaste that strengthened and restored tooth **minerals**.

Description

Within the general categories of toothbrush, interdental aids and mouthwash, the choices can be overwhelming. Because of the vast number of products available, it is important for the dentist and the dental hygienist to advise patients about what type of products to purchase, based on individual needs. Along with that advice, the patient must be reminded to brush and clean interdental areas properly.

Both child and adult patients should use toothpaste and mouthwash containing fluoride, the mineral used to fight tooth decay. Fluoride helps strengthen the tooth's outer surface, and it can stop small areas of decay from spreading.

Proper use of oral hygiene aids will remove plaque, the film of bacteria that forms on teeth. The bacteria creates toxins that irritate the gums and demineralize tooth structure. If left untreated, plaque can initiate damage to the gums and bones supporting the teeth.

Manual toothbrushes

The toothbrush is the oral hygiene aid used to clean teeth. A manual toothbrush is activated by hand and not powered by electricity or batteries. The ADA recommends that people use a toothbrush with soft, rounded filaments (bristles). These brushes are better than those with hard filaments for removing plaque.

A toothbrush with soft bristles is recommended because tooth enamel could be worn away by intense scrubbing. When enamel is worn away, it can promote tooth decay, hypersensitivity, and gum recession. The size of the toothbrush and design of the head are less



It is important for dentists and dental hygienists to instruct patients in the correct way to brush and floss their teeth.

(P. Stocklein/Custom Medical Stock Photo. Reproduced by permission.)

important than the patient's commitment to using it properly.

Powered toothbrushes

Powered toothbrushes are operated by batteries or electricity. Powered toothbrushes have heads that move in a counter-rotational, rotary, or up-and-down manner; they work at a speed of 4,200 times per minute. Powered and manual toothbrushes are equally effective in removing plaque if used properly. On the other hand, studies have shown that people with poor oral hygiene or limited dexterity may benefit from using a powered toothbrush. Other studies have shown that some powered brushes are more effective in controlling stain and tartar. For children, this type of brush can be fun to use. For adults, the purchase of a powered-toothbrush could represent a commitment to improving oral hygiene habits.

No matter what type of toothbrush is used, the ADA recommends that patients use a toothpaste containing fluoride.

Toothpaste

Toothpaste is a preparation used to clean the tooth surface and remove plaque. Toothpaste flavor is a matter of consumer preference, and dental professionals advocate any flavor that stimulates people to brush at least twice a day. The ADA and the surgeon general recommend the use of a toothpaste containing fluoride to prevent tooth decay. Other effective ingredients of toothpaste are detergents and abrasives that help to remove plaque when teeth are brushed. Toothpastes that have the ADA Seal of Acceptance have a mild abrasive that is useful for plaque removal.

Tartar-control toothpaste that bear the ADA Seal of Acceptance can reduce tartar formation above the gum line. However, as of spring 2001, these products were not shown to have a "therapeutic effect on periodontal disease."

For people with receding gums and sensitive teeth, the ADA recommends brushing with a toothpaste that includes a desensitizing ingredient. These toothpastes reduce the painful effects of thermal, chemical, and mechanical stimuli on people with dental hypersensitivity.

Dental floss and picks

Dental floss is a thin, thread-like oral hygiene aid used to clean between teeth and under the gum line. Both waxed and unwaxed flosses are effective at fighting plaque. The important criteria when using floss is that it does not shred. Some patients prefer waxed floss, dental tape, or durable diameter floss, believing that they are gentler and easier to manipulate between teeth. For those who find shredding a problem, there are nonshred flosses.

Floss also varies in flavor. Some people find mint-flavored floss refreshing; others say that cinnamon is invigorating. Furthermore, floss widths vary. People with plaque problems may be advised to use the wider "tape" type of dental floss.

Wide spaces between teeth can also be cleaned with dental toothpicks, small pieces of material like soft orangewood, or interdental brushes. In fact, the American Academy of Periodontology recommends the interdental brush when space between the teeth exists.

Mouthwash

A fluoride mouthwash can be used in conjunction with brushing and flossing to help fight tooth decay. A

patient may be advised by the dentist to use an antimicrobial mouthwash to control buildup and gingivitis.

Mouthwashes that promise fresher breath provide temporary relief of a condition that may be socially uncomfortable. However, unless these products contain fluoride, these rinses are not effective oral hygiene aids.

Furthermore, the dentist and dental hygienist know that bad breath can be a symptom of gum (periodontal) disease. The odor can be caused by the bacteria created when food particles are not removed from teeth.

Operation

The habit of brushing and flossing is more important than whether a manual or an electric toothbrush, or waxed or unwaxed floss, is used. In addition, many people do not know how to brush or floss correctly, so the dentist and dental hygienist play important roles in preventive patient care. The proper use of oral hygiene aids can be demonstrated and effective products can be recommended by either of these professionals.

Brushing the teeth

Teeth should be brushed at least twice daily, ideally after eating. The dentist and dental hygienist should advise patients to use toothpaste containing fluoride and to spend two minutes brushing their teeth.

BRUSHING THE TEETH MANUALLY. When brushing the teeth, people should use gentle circular motions to massage and scrub the tooth and gums. It is best to have a systematic approach to ensure all teeth are brushed.

The toothbrush is angled 45 degrees so that the bristles touch the teeth and gums. The person moves the brush back and forth with small strokes. Only a few teeth are brushed in this way, and the person brushes several times in one spot until moving on to the next set of teeth. This is done until all teeth are brushed. Then the tongue should be brushed to remove plaque and dead epithelial cells. The next step is to floss the teeth or use the interdental cleaner appropriate for the client.

BRUSHING WITH A POWER TOOTHBRUSH. The power toothbrush, also known as the electric toothbrush, moves the brush with faster strokes than a person can when brushing by hand. However, that speed doesn't contribute to mouth health. The person must brush for two minutes. That is the same amount of time required when brushing manually. However, some power toothbrushes come with two-minute timers, so that people can be aware of how long brushing is needed.

Using oral hygiene aids

Problem	Device/method
Debris removal	Water irrigation Toothbrush
Edentulous (toothless) gingiva under removable denture	Toothbrush (soft nylon) (manual or power assisted)
Exposed furcation maxillary first premolar	Interdental brush and rubber tip
Exposed furcation molars	Floss/yarn in threader Interdental brush and rubber tip
Exposed root surfaces	Fluoride dentifrice Dentifrice containing desensitizing agent
Fixed partial denture	Toothbrush (soft nylon) Floss threader with floss/yarn
Proximal surfaces open contacts	Gauze strip Yarn
Proximal surfaces plaque removal	Floss, or floss with threader Yarn with floss and/or threader Interdental brush or single-tuft brush
Removable denture	Denture brush Clasp brush Chemical cleanser for immersion
Sulcular brushing	Toothbrush with soft end-rounded filaments
Tongue cleaning	Toothbrush (soft nylon)

SOURCE: Alvarez, K.H. *Williams & Wilkins' Dental Hygiene Handbook*. Baltimore: Williams & Wilkins, 1998.

Flossing

Flossing may be done prior to or after brushing. In the dental office, a teeth cleaning appointment may end with the dental hygienist flossing the patient's teeth to remove particles of tartar and abrasive agents that might be left behind by the hygienist. Since flossing is a crucial part of dental health, the hygienist will generally describe this process so that the patient knows how to floss correctly.

DENTAL FLOSS. To clean between teeth with dental floss, the person takes an 18-in (46-cm) length of dental floss and wraps an end around the index or middle finger of each hand. The person inserts the floss in the gap between two teeth and gently moves it back and forth. The floss should rub against the front and back surfaces of each tooth. In addition, the floss up should be worked up and under the gum line to remove food and plaque. When the floss is moved to another area of the tooth, it should be adjusted, so that a clean area of the floss is used. When flossing for the first time, there may be slight gum bleeding. If bleeding persists, the patient should consult a dentist.

TOOTHPICKS. Toothpicks should be regarded as temporary oral hygiene aids. Household toothpicks can be used to remove food from teeth. Dental toothpicks made

KEY TERMS

Calculus—Calcified bacterial plaque.

Caries, dental—The decalcification and destruction of the tooth by microorganisms. Also known as tooth decay.

Cavity—A hole in the tooth.

Fluoride—A mineral that helps fight tooth decay.

Gingivitis—The inflammation of the gingiva (gums).

Periodontitis—The inflammation of the area surrounding the teeth. These areas include the gingiva (gums), the periodontal ligaments that attach teeth to sockets and the alveolar bone, the part of the jaw bone that holds the roots of teeth.

Plaque—A transparent material in the mouth that contains bacteria and causes tooth decay.

Tartar—Plaque that has calcified and hardened on the teeth. Also known as calculus.

of material, such as soft orangewood, can be used to stimulate gums or to reach plaque in the wide spaces between teeth. They can be an effective cleaning device in people with wide spaces between their teeth. However, toothpicks should not be used in place of flossing with dental floss in people with a normal interdental anatomy. Furthermore, patients should be cautioned by dentists and dental hygienists not to chew on toothpicks, as they can damage teeth.

Mouthwash

A fluoride mouthwash used in the morning and evening can help to fight plaque. Patients should be advised to look for products bearing the ADA Seal of Acceptance.

Mouthwash is taken full strength and used as a rinse. The person follows directions on the product. For one ADA-approved rinse, the person measures out 4 tsp (20 ml) of mouthwash and places it in the mouth. The rinse is swirled around for 30 seconds in the mouth and then expelled.

Oral hygiene aids for children

An oral hygiene program should begin when a baby gets his or her first tooth, according to the ADA. At this time, the infant's baby or primary teeth start to surface. Newly erupting teeth can be cared for by the parents,

using an infant toothbrush or a clean washcloth to scrub away any plaque. The ADA recommends that the child's first appointment with the dentist be scheduled by the time the baby is one year old. At this time, the dentist or dental hygienist can provide guidance about proper brushing and flossing.

At age three, most children have 20 primary teeth. By the time children are six years old, their jaws are growing to accommodate permanent or "adult" teeth. Those teeth will grow within the next six years and replace the primary or baby teeth.

TOOTHBRUSHING. For an infant, a parent can use a baby toothbrush or a soft cloth.

Children age six and younger should be supervised brushing their teeth. The parent should place a pea-sized amount of toothpaste on the toothbrush. This small amount helps to minimize the risk of swallowing toothpaste. The parent should still clean the child's mouth once a day to ensure proper cleaning.

When a child is seven and permanent teeth are growing, the ADA advises that children can brush their own teeth. However, an adult should supervise this process. And the dentist or hygienist may recommend that parents set the example by brushing along with the child

FLOSSING. The ADA recommends that children's teeth should be flossed when any two teeth are touching. By age eight, most children are old enough to floss on their own. Children with **orthodontic appliances** may not be able to floss in those areas.

MAKING ORAL HYGIENE EASIER. A disability, an injury, or illness can make it difficult for a person to brush or floss. Patients experiencing difficulty can get recommendations from their dentists or dental hygienists regarding commercial products and self-designed modifications that make the process easier.

When a patient has trouble brushing, the dentist or dental hygienist may advise the patient to purchase a powered toothbrush. If the patient's preference is to brush manually, the ADA recommends self-designed modifications and adaptations; for example, the patient can attach the toothbrush to the hand with an elastic band, using a sponge or rubber ball to widen the handle, and lengthening the handle by attaching a ruler or tongue depressor to it.

If the patient has difficulty flossing due to bridge-work, a commercial floss holder or threader can be used to pull floss between teeth. In addition, tiny interdental brushes can be used to clean the area between teeth.

Maintenance

Maintenance is relatively simple for the oral hygiene products used for mouth care.

Toothbrushes

After use, a toothbrush should be allowed to dry in the air. It should not touch other toothbrushes, and people should not share toothbrushes because diseases can be transmitted. For occasional cleaning, the toothbrush can be soaked in a household bleach solution for about 10 minutes and rinsed thoroughly, or can be washed in dishwasher.

The toothbrush should be replaced after three or four months. Since many people do not remember when they bought a toothbrush, they can be told by dentists and dental hygienists to replace the toothbrush when the bristles are worn, bent or at the first sign of wear.

Furthermore, patients should also be advised to dispose of the toothbrush after an illness to prevent the spread of germs. The same procedures should be followed for the brushes used in a powered toothbrush. The brush should be replaced after three or four months. Other maintenance will be based on the manufacturer's specifications.

Other hygiene aids

Products such as floss and toothpicks should be disposed of after usage. Toothpaste and mouthwash can be expelled from the mouth after the person rinses or brushes.

Health care team roles

Although oral hygiene aids like the toothbrush, dental floss, mouthwash, and toothpicks are household items, they are not used to fight plaque effectively. As a result, patients may be given instruction about the correct use of these aids by members of the dental team, such as the dentist or dental hygienist. Most dental offices and clinics maintain an inventory of sample products that can be used for demonstration.

A new toothbrush may be used by the dentist to demonstrate effective brushing techniques, such as how to angle the brush. Upon conclusion of the cleaning appointment, the teeth are usually flossed by the dental hygienist to remove particles of tartar and abrasive agents that may be left behind. This process may be described by the hygienist during the flossing.

It is also helpful to give the patient a mirror so that the person can see areas which should be flossed. Another option is to stand in front of the patient and demonstrate the technique for proper flossing or brush-

ing. It is always best to use the patient's own mouth as a model.

The dental professional may then have the patient angle the brush or floss several teeth. The dentist or hygienist then gives the toothbrush or a sample package of floss to the patient. The same process is effective with aids such as floss holders or toothpicks.

Most dental patients rinse their mouths during an appointment. However, the dentist or dental hygienist may need to explain about the types of mouthwash, as well as the amount of time needed for rinsing at home.

Training

Training is required to use oral hygiene aids such as the toothbrush, dental floss, mouthwash, or toothpicks effectively. Since improper use of oral hygiene aid products can lead to tooth decay and gum disease, it is important for the dentist and dental hygienist to provide patients with instructions about the most effective use of these products, their purposes, and techniques for use.

Furthermore, continuing education courses allow dentists, dental hygienists, dental assistants, and others in the dental office to keep informed about advances in dental care, oral hygiene, and new products.

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ORGANIZATIONS

American Dental Association. 211 E. Chicago Ave., Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org>>.

American Dental Hygienists' Association. 444 N. Michigan Ave., Suite 3400, Chicago, IL 60622. (312) 440-8900. <<http://www.adha.org>>.

Centers for Disease Control and Prevention. National Center for Chronic Disease Prevention and Health Promotion. Division of Oral Health, MS F-10. 4770 Buford Highway, NE. Atlanta, GA 30341. 1-(888)-CDC-2306. <<http://www.cdc.gov>>.

International Federation of Dental Hygienists. 55 Kemble Road, Forest Hill, London, SE23 2DH, UK. Tel.: +44 208-699-3531. <<http://www.ifdh.org>>.

National Institute of Dental & Craniofacial Research. National Institutes of Health. Building 45, Room 4AS-18. 45 Center Drive MSC 6400, Bethesda, MD 2089-6400. <<http://www.nidr.nih.gov/>>.

Liz Swain

Oral hygiene index see **Dental indices**

Oral hypoglycemics see **Antidiabetic drugs**

Oral medication administration

Definition

Oral medication administration is the process by which drugs are delivered by mouth through the alimentary tract.

Purpose

Drugs are taken by this route because of convenience, absorption of the drug, ease of use, and cost containment. It is, therefore, the most common method used.

Precautions

Other routes are used when a person cannot take anything by mouth, or the drug is poorly absorbed by the gastrointestinal tract. The nurse should check whether the patient has any known **allergies**. It is useful to remember the following checks when administering any medication: the right patient, the right medicine, the right route, the right dose, the right site, and the right time.

Description

Oral drugs can be prescribed to be taken at different intervals, either before or after food. They can be in either liquid or solid form. Questions about the frequency with which drugs should be taken should be addressed to the primary health care provider.

Preparation

Wash the hands. The patient's order sheet should be checked to ensure that the dose has not already been given. Once that is confirmed, the correct drug and dose should be selected. The appropriate number of pills should be shaken onto the lid of their container and dropped into a small measuring cup to hand to the patient. This should be done immediately prior to giving the drug and not done in advance.

If the medication is liquid, the bottle should be shaken, the cap removed, and the bottle held at eye level with the label turned upwards, to prevent staining. The correct dose should be poured into a measuring cup.

The patient should be informed that his or her doctor has prescribed some medicine for him or her. The nurse should check the drug and dose against the patient's prescription chart again, then confirm the patient's name on his or her wristband. The drug can then be handed to the patient, who should also be offered a drink of water to aid in swallowing pills.

Liquid medicines containing **iron** should be taken through a straw to minimize staining of the teeth.

After ensuring that the drug has been taken, the nurse should record the time and the dose that has been given.

Aftercare

The nurse should monitor the patient's reaction and provide reassurance, if required.

Complications

Possible complications include:

- The drug may interact with other drugs the patient is taking and alter the desired effect.
- The patient may refuse the drug.
- There may be difficulty in swallowing.
- The drug may irritate the gastrointestinal tract.
- The drug may pass quickly through the body, and the benefits of the drug may be lost.

KEY TERMS

Alimentary—Relating to the system of nutrition.

Alimentary tract—The alimentary tract and the other organs involved in digestion and absorption.

Gastro—Referring to the stomach.

Gastrointestinal tract—The stomach and intestinal tracts involved in digestion and the elimination of waste products.

Intestinal—Referring to the intestine.

Results

Administration of oral medication should result in the patient receiving the proper dose of drug safely, and with no complications. Oral drugs can also interact with other medications that the patient is taking, such as injections. The nurse should check for any adverse reactions if the drug is being administered for the first time.

Health care team roles

The staff should establish whether a patient is taking any drugs prior to being given any additional medication. It is important that a nurse understand the actions, side effects, and incompatibility of drugs, recognize normal doses, and be knowledgeable about any reactions that a patient may experience. The nurse should report any unusual effects to the medical staff and record any side effects or negative reactions to the drug that has been given.

If the medication is to be prescribed regularly for a specific disease, the patient can be directed to a self-help group in which members have the same medical condition. The patient should be helped to feel confident that his or her privacy is ensured.

If the labels on liquid medicine bottles are stained and illegible, the medicine should not be used.

Resources

BOOKS

Denville, N.J. *The Self Help Source Book*. American Self Help Clearinghouse, 1998.

ORGANIZATIONS

American Academy of Nurse Practitioners. AANP, PO Box 12846, Austin, Texas, 78711. (512) 442-4262. admin@aanp.org.

American Nurses Association, 600 Maryland Avenue, SW, Suite 100 West, Washington, DC 20024. (202) 651-7000.

National Association of Clinical Nurse Specialists, 3969 Green Street, Harrisburg, PA, 17110. (717) 234-6799. info@nacns.org.

National League for Nursing, 61 Broadway, 33rd Floor, New York, NY 10006. (212) 363-5555 or (800) 669-1656.

OTHER

“How to Administer Medications.” <<http://nursing.about.com>>.

Margaret A. Stockley, RGN

Orgasmic disorders see **Sexual dysfunction**

Orthodontic appliances

Definition

Orthodontic appliances are corrective and supportive braces, designed and prescribed by an orthodontist. The appliances treat malocclusions, including crooked, crowded, and protruding teeth that do not fit properly together.

Purpose

In a controlled manner, dental appliances gently force teeth to move through the supporting bone to a desired position. The purpose of the appliances is to correct tooth crowding, overjet or protruding upper teeth, deep overbite, spacing problems, crossbite and underbite, or lower jaw protrusion.

Precautions

Orthodontists applying orthodontic appliances should make sure that a patient's bones, gums and tooth roots are in a healthy condition. They should also prepare the patient emotionally for the experience of wearing orthodontic appliances. The cooperation of the patient is important in achieving a successful result. Patients with emotional or self-image problems can be difficult to treat.

Description

Orthodontic appliances are custom-made appliances, or braces, which are designed by orthodontists to fix bite problems, or malocclusions. There are two large classifications of these appliances: fixed (cemented and/or bonded to teeth) and removable. Appliances can be active or passive—some actively move the teeth, while others, such as retainers, are designed to keep the teeth where



An orthodontist fits a twelve-year-old boy for braces.
(Richard Hutchings Photo. Photo Researchers, Inc. Reproduced by permission.)

they are. Orthodontic appliances, or braces, can be made of metal, ceramic, or plastic. In recent years, there have been advances in the materials used to make braces. The wires used on today's braces are stainless steel, alloys of nickel, titanium, **copper**, and cobalt, and some are heat-activated. They are designed to exert pressure so that results are faster and more comfortable for patients. Clear orthodontic wires are being studied for application in the general population of orthodontic patients. New braces are smaller and more efficient. The wires cause teeth to continue to move during some treatment phases, which can result in a patient having to make fewer appointments for wire adjustments.

Specific examples of orthodontic appliances include headgear, the bionator, Herbst, the Frankel and maxillary expansion appliances. These are orthodontic appliances designed to actively guide the growth and development of the jaw. Headgear or the Herbst appliance can, over the course of treatment, make the lengths of the upper and lower jaw compatible. An upper jaw expansion appliance can significantly widen a narrow upper jaw. One of the newer orthodontic appliances is a plastic aligner, used to move teeth around without requiring brackets. Orthodontists have a wide range of options in selecting an orthodontic appliance for a particular application.

Another advance in the area of orthodontic appliances is that modern braces are less noticeable than those in which a metal band and bracket were placed around

each tooth. In many cases, patients have brackets bonded directly to the front teeth, minimizing the "tinsel tooth" appearance. Patients can choose between clear, metal, or colored brackets. Some braces are bonded behind the teeth.

Preparation

Orthodontists have patients undergo diagnostic testing, prior to applying braces, to help plan the best course of treatment. Diagnostic records usually include a medical and dental history, clinical examination, plaster study models of the teeth, photos of the patient's face and teeth, a panoramic or other type of x ray of the teeth, a facial profile x ray, and other x rays. The cephalometric film, or profile x ray, shows the patient's facial form, growth pattern, and front teeth positions. Other x rays, including panoramic x rays, reveal impacted teeth, missing teeth, and shortened or damaged tooth roots.

Aftercare

Patients who have dental appliances have to take special care of their teeth. They must be careful to avoid hard or sticky foods, which can loosen their appliances and therefore diminish the effect. Orthodontic patients must not chew on hard things, such as pencils or nails, because these can damage the appliances. Cleanings must be more thorough than ever. Teeth should be brushed immediately after eating sweet foods. Special floss threaders are available to make flossing easier.

Complications

Successful orthodontic treatment with appliances requires a consistent, cooperative effort by the orthodontist and the patient. A patient's failure to clean his or her teeth, or to wear rubber bands, headgear, or other prescribed appliances, can result in failure of the teeth to move to their desired positions, and can even prolong treatment.

Ankylosis is a condition that in many cases cannot be controlled or detected by the orthodontist. It occurs when the tooth and underlying bone fuse together and become one. Should a patient have this condition, the braces will not be able to move the fused tooth or teeth.

Results

Orthodontic treatment with orthodontic appliances results in improved aesthetics and better function of the teeth and jaws. Left untreated, crooked or crowded teeth can become worse, sometimes requiring costly treatment to address serious problems that can develop over time.

KEY TERMS

Ankylosis—A condition where the tooth fuses to bone.

Bionator—An orthodontic appliance that actively guides the growth and development of the jaw.

Bracket—The braces part that holds the wire.

Crossbite—The condition in which the upper teeth bite inside the lower teeth.

Deep overbite—The condition in which the lower front teeth bite too closely or into the gum tissue behind the upper teeth.

Headgear—An orthodontic appliance, which actively guides the growth and development of the jaw.

Herbst appliance—An orthodontic appliance that actively guides the growth and development of the jaw.

Malocclusion—Misaligned bite.

Maxillary expansion appliances—An orthodontic appliance used to widen a narrow upper jaw.

Overjet—The condition in which the upper front teeth extend beyond normal contact with lower front teeth.

Retainer—A passive orthodontic appliance designed to keep teeth in place.

Orthodontic problems can contribute to conditions that cause tooth decay and gum disease. They also can help to cause abnormal wear of tooth surfaces, inefficient chewing function, excessive stress on gum tissue and supporting bone, as well as jaw misalignment, resulting in headaches and face or neck **pain**.

Health care team roles

The general dentist can identify a **malocclusion** and refer patients to specialists, such as orthodontists. Dental hygienists may help to identify malocclusions during routine **dental hygiene** appointments. Together with dentists, hygienists watch the development of pediatric dental patients. They look at how teeth mesh together, examine the patient's profile, and identify instances of crowding or too much space between teeth. Hygienists in the general or pediatric dental office help patients to maintain healthy teeth and gums while the braces are on, by in-office cleanings and education about proper home-care techniques (brushing, soaking, and removal of

removable appliances) to maintain overall oral health. Dental assistants are ancillary personnel in dentists' or orthodontists' offices who assist in recording data, taking study models, and performing procedures.

Resources

ORGANIZATIONS

Academy of General Dentistry. 211 East Chicago Ave., Chicago, IL 600611. (312) 440-4800. <<http://www.agd.org>>.

American Association of Orthodontists. 401 N. Lindbergh Blvd. St. Louis, MO 63141-7816. 314-993-1700. <www.aaortho.org>.

American Dental Hygienists' Association. 444 North Michigan Avenue, Suite 3400, Chicago, IL 60611.(312)440-8900. <<http://adha.org>>.

OTHER

Callahan Barnard, Susan. American Dental Hygienists' Association. Interview with Lisette Hilton, conducted April 16, 2001.

Preis, Frederick (president). American Association of Orthodontists. Interview with Lisette Hilton, conducted April 16, 2001.

Lisette Hilton

Orthopedic tests

Definition

Orthopedic tests are designed to evaluate individuals for musculoskeletal impairment. Orthopedic tests enable the clinician, such as a physician or physical therapist, to identify a specific area of injury and aid in the diagnosis and treatment plan of the injured individual. There is a general plan for physical assessment that includes taking a patient's history; examining how the patient moves and how individual joints move; evaluating sensation and **reflexes**; and, if necessary, administering diagnostic tests to aid in the diagnosis. These are specific orthopedic tests for the upper and lower extremities as well as the spine. The orthopedic tests, or "special tests," help the clinician in the differential diagnosis of the patient.

Purpose

A medical or **health history** taken by the clinician is extremely important in evaluating and diagnosing the patient. A patient's description of the **pain**, weakness, or both will guide the clinician as to what structures to evaluate and which orthopedic tests, if necessary, to com-

plete. After the history has been taken, the clinician may focus on sensory and reflex testing to evaluate the integrity of the nervous system. Depending on where the injury or impairment is on the body, the clinician may opt to evaluate range of motion of the joint(s) of the area of injury or near the injury. For example, if a patient has knee pain, the clinician will more than likely assess how far the patient can bend the knee and straighten the knee. The clinician will compare this movement to the uninjured side or “good leg.” Thus, the clinician has a baseline for the individual and the “good leg” serves as a reference point or goal. It is usually advisable that the “good side” always be evaluated first, so that a true comparison can be made to the affected side. Obviously, if there is bilateral involvement the clinician must use his/her experience with other patients to evaluate and set a plan of care. Also included in an assessment is the evaluation of muscle strength.

Precautions

Most orthopedic tests stress areas to be evaluated in an effort to evaluate pain, joint play, and muscle extensibility. Because of the stress involved during some orthopedic tests, care must be taken to avoid further injury. Before doing any orthopedic tests, an area must be free from fracture or neoplasm (an abnormal growth). Furthermore, any patient with characteristics such as severe spasm, pain with unknown etiology, or pain that awakens the patient at night, should not be evaluated with orthopedic tests until a full medical evaluation can be completed to address these unexplained symptoms.

Description

There are numerous orthopedic tests that help the clinician diagnose impairment. It should be pointed out that these tests alone do not confirm a diagnosis. As stated previously, the medical history and other evaluative tools need to be completed so as to get a total representation of the patient’s health and the nature of injury or problem. Furthermore, a positive test does not necessarily indicate a specific problem, and a negative test does not necessarily rule out the problem. Some tests that are frequently used by clinicians to evaluate the spine and extremities will be described below.

Cervical spine

One possible problem associated with the cervical spine could be narrowing of the space occupied by the nerve root. This could be due to many causes, two of which could be injury or **osteoarthritis**. It is possible that as the space occupied by the nerve root closes, there

may be impingement on the nerve root. If this occurs there could be pain, changes in sensation, and weakness in the neck, shoulder, and possibly down the arm. Two tests that may help diagnose an individual with this pathology are the distraction and compression tests. The distraction test for the cervical spine is performed by the clinician to assess if there is pressure on the nerve roots. In a positive test, symptoms will decrease or disappear. The compression test is also performed by the clinician to evaluate if there is pressure on the nerve root. If symptoms are provoked down either arm during the test, it would indicate pressure on the nerve root and thus, a positive test.

Shoulder

In the shoulder there are many muscles that act to stabilize and control the humeral head in the glenoid (shoulder socket). Injury can occur to any of these muscles and cause pain in and around the shoulder. The biceps muscle flexes the elbow but has a tendinous attachment that crosses the shoulder. It is commonly involved in overuse injuries. Yergason’s test evaluates muscle tendon pathology of the biceps tendon. In this test, a positive result is evidenced by tenderness or pain over the bicipital groove of the shoulder indicating a possible bicipital tendinitis (inflammation of the biceps tendon). Another common test is the Neer impingement test, which evaluates the integrity of the subacromial space (below the highest point of the shoulder blade) as it relates to the supraspinatus muscle (a muscle in the shoulder area). A positive sign is when pain is elicited in the superior shoulder and is usually an indication of some type of injury to the supraspinatus tendon, that is tendinitis. The cause of tendinitis is usually overuse.

Elbow

Tennis elbow test or Cozen’s test is used to assess if there is an injury to the lateral epicondyle of the humerus (a bony prominence at the elbow end of the bone). A positive test is indicated by the patient having increased symptoms over the area of the lateral epicondyle. Pain usually indicates involvement of the wrist extensors at their origin. Pain is usually due to inflammation secondary to overuse. Golfer’s elbow test or the medial epicondylitis test assesses the integrity of the medial epicondyle and the muscular attachments. A positive sign is pain over the area of the medial epicondyle and is usually indicative of tendinitis of the wrist flexors, also at their origin.

Wrist and hand

A common problem associated with repetitive strain is that of typists who spend hours at a time with the wrist slightly bent in the upward position. Constant stress on the wrist can eventually lead to pain and abnormal sensations, often tingling, of the wrist and hand. The common term is **carpal tunnel syndrome**. Phalen's test is a good test to evaluate the presence of pressure on the median nerve, which is the cause of pain. A positive test occurs when tingling is present in the fingers and is usually indicative of carpal tunnel syndrome. Another common test is the Finkelstein test. It is a test to evaluate the presence of tenosynovitis (inflammation of the tendon sheath) in the thumb. A positive sign is pain across the top and base of the thumb.

Hip

Sometimes individuals who are in sitting positions for extended periods of time, such as being in a wheelchair, may present with tightness of the muscles around the hip. There are three tests that are good tools to evaluate muscle flexibility around the hip. The Thomas test assesses flexibility of the hip flexors. It is a good test to evaluate tightness of the muscles that cross the front of the hip. The Ober test is another common flexibility test to assess the tightness of the tensor fasciae latae (connective tissue that covers the muscle and directs its tightening) and the iliotibial band (connects the pelvis to the leg bone). Ely's test is another test for assessing muscle tightness. It is used for evaluating the tightness of the rectus femoris, which crosses the front of the hip joint.

Knee

The knee is a common area that is frequently involved in pathology. One common problem, especially in the athletic population, is the disruption or tearing of the anterior cruciate ligament (ACL) of the knee. A Lachman test is probably the best orthopedic manual test to evaluate the integrity of the ACL. Other tests that assess the stability of the ligaments and the joint capsule are the Slocum test, lateral pivot shift test, and Hughston's test. The tests mentioned here are termed stress tests, and they assess laxity, or the amount of movement, at the knee joint.

Foot and ankle

The foot and ankle is a complex area that allows for both mobility and stability. There are many flexibility and ligamentous stress tests to evaluate the foot and ankle. Some common tests are the Talar tilt test, Thompson's test, and a test to assess **blood** supply to the lower extremity called Buerger's test.

KEY TERMS

Anatomy—The study of the structural makeup of the human body.

Anterior cruciate ligament—A ligament that attaches the surfaces of the tibia and femur, thus stabilizing the knee joint. This structure prevents anterior translation of the tibia with respect to the femur.

Biomechanics—The study of mechanics pertaining to the human body.

Etiology—The causes of a disease or abnormal condition.

Iliotibial band—A fascial sheath that extends from the upper thigh and traverses down the side of the femur, attaching around the area of the knee joint.

Kinesiology—The study of the principles of biomechanics as it pertains to human movement.

Physiology—The study of the physical and chemical processes as it relates to an organism, i.e. human body.

Rectus femoris—An anterior muscle that, when contracting, can initiate hip flexion, knee extension, or both at the same time.

Spasm—An involuntary and abnormal muscular contraction.

Tensor fasciae latae—A single muscle on the side of the thigh covering the hip joint that, when contracting, aids other muscles in moving the leg away from midline and out to the side.

Preparation

There are many orthopedic tests designed to aid the clinician in better evaluating the patient who has musculoskeletal impairment. Before doing these tests, clinicians must have knowledge of anatomy, biomechanics, kinesiology, and physiology. Furthermore, most of these tests are performed by licensed and experienced clinicians such as physicians, chiropractors, and physical therapists. Before doing these tests, it is important to point out that most of these tests can cause pain and produce symptoms. In fact, some of these tests are termed provocation tests, because they produce or "provoke" onset of symptoms.

Aftercare

Clinicians will focus on specific tests that can best evaluate the joint, limb, or spine. The goal is not to com-

plete as many tests as possible, but to isolate tests that are joint or pathology specific. Clinicians should refrain from over-testing. It is not uncommon that after extensibility tests or stress tests to a joint, the patient may require heat to relax tight tissues or ice to minimize pain and/or inflammation.

Complications

Orthopedic tests are designed to aid the clinician in the determination of a diagnosis. When used sparingly and appropriately, these “special tests” can provide valuable information about the impairment. However, these tests require clinical competencies, and problems can arise when clinicians are not properly trained in certain techniques.

Results

Orthopedic tests will give the clinician some insight into the nature of the patient’s complaints, although they may not directly correlate to a specific diagnosis. Imaging studies, such as x rays or an MRI scan, may be done to aid in diagnosis. Once the source of the pain has been determined, a course of treatment will be set. Treatment may include icing and resting the injury and prescribing pain relievers. Surgery is sometimes necessary. **Physical therapy** is often begun as soon as the patient’s level of pain permits.

Health care team roles

It is important for the clinician to utilize as many sources as possible when evaluating an individual who presents with musculoskeletal involvement. For example, a physical therapist doing an evaluation needs to take a sound medical history followed by a complete assessment of all systems, i.e. muscular, skeletal, nervous. Furthermore, the physical therapist must be in complete contact with the referring physician and the nursing staff regarding medication, protocols, and diagnostic tests. Other therapies, such as speech, occupational, and respiratory may also be part of the evaluation. If the patient is in a rehabilitation hospital or nursing home, the nursing staff can provide an up-to-date status on the patient. It is quite clear that the evaluation of a patient requires input from the entire healthcare team, including the patient.

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Mark Damian Rossi, Ph.D., P.T.

Orthopedic x rays see **Bone x rays**

Osteoarthritis

Definition

Osteoarthritis (OA) is a progressive disorder of the joints caused by gradual loss of cartilage that may result in the development of bony spurs and cysts at the margins of the joints. The name osteoarthritis comes from three Greek words meaning bone, joint, and inflammation.

Description

OA is one of the most common causes of disability due to limitations of joint movement, particularly in people over the age of 50. It is estimated that 2% of the United States population under the age of 45 also suffers from osteoarthritis; this figure rises to 30% in persons between the ages of 45 and 64, and 63–80% in those over age 70. Approximately 90% of the American population will have some features of OA in their weight-bearing joints by age 40. Men tend to develop OA at earlier ages than women.

OA typically develops gradually, over a period of years. Patients with OA may have joint **pain** on only one side of the body. It primarily affects the knees, hands, hips, feet, and spine.

Causes and symptoms

Osteoarthritis results from deterioration or destruction of the cartilage that normally acts as a protective cushion between bones, particularly in weight-bearing joints such as the knees and hips. As the cartilage is worn away, the bones may form spurs, areas of abnormal hardening, and fluid-filled pockets in the marrow. These are known as subchondral cysts. As the disorder progresses, pain results from deformation of the bones and fluid accumulation in the joints. Pain may be relieved by rest, but worsened by placing weight on, or moving, the joint.

In the early stages of OA, the pain is minor and may take the form of mild stiffness in the morning. In the later stages of OA, inflammation develops; the patient may experience pain even when the joint is not being used; and he or she may suffer permanent loss of the normal range of motion in that joint.

Osteoarthritis typically has been considered by laypeople as an inevitable part of aging caused by simple wear and tear on the joints. This view has been replaced by recent research into cartilage formation and preservation. Osteoarthritis is now considered to be the end result of several different factors that can contribute to cartilage damage, and is classified as either primary or secondary.

Primary osteoarthritis

Primary OA results from abnormal stress on weight-bearing joints, or normal stress affecting weakened joints. Primary OA most frequently affects the finger joints, the hips and knees, the cervical and lumbar spine, and the big toe. Some gene mutations appear to be associated with OA. **Obesity** also increases the pressure on the weight-bearing joints of the body. Finally, as the body ages, there is a reduction in the ability of cartilage to repair itself. In addition to these factors, some researchers have theorized that primary OA may be triggered by enzyme disturbances, bone disease, or **liver** dysfunction.

Secondary osteoarthritis

Secondary OA results from chronic or sudden injury to a joint. It can occur in any joint. Secondary OA is associated with the following factors:

- trauma to the body, including sports injuries
- repetitive stress injuries associated with certain occupations (i.e., the performing arts, construction or assembly line work, computer keyboard operation, etc.)
- repeated episodes of **gout** or septic arthritis
- poor posture or bone alignment caused by developmental abnormalities
- metabolic disorders

Diagnosis

The two most important diagnostic clues in the patient's history are the pattern of joint involvement and the presence or absence of **fever**, rash, or other symptoms outside the joints.

History and physical examination

When taking **vital signs** (i.e., **blood pressure**, weight, temperature), the patient's gait and arm and hand

movement should be observed by the nursing staff or physician assistants; if pain is the chief complaint, the affected joint should be examined. After a brief examination, the nurse, nurse practitioner, or physician assistant should ask the length of time the pain has affected the patient and if there have been any limitations in his or her work or home life. The practitioner should record abnormal symptoms on the intake sheet for review by the physician. As part of the **physical examination**, the physician will evaluate swelling, limitations on the range of motion, pain on movement, and crepitus (i.e., cracking or grinding sound heard during joint movement). Osteoarthritis is often similar in presentation to rheumatoid arthritis, but lacks the presence of inflammation (until its very late stages) found in rheumatoid arthritis.

Diagnostic imaging

There is no laboratory test specific to the diagnosis of OA. Laboratory tests are important, however, in ruling out other diseases that may be responsible for the symptoms the patient is presenting. Treatment is usually based on the results of diagnostic imaging, which is conducted by a radiologic technician or radiologist. The features of the disease are a loss of joint space, the presence of subchondral cysts, and evidence of new bone formation (i.e., bone spurs). The patient's symptoms, however, do not always correlate with x-ray findings. **Magnetic resonance imaging** (MRI) and computed tomography (CT), or computed axial tomography (CAT) scans can be used to more precisely determine the location and extent of cartilage damage.

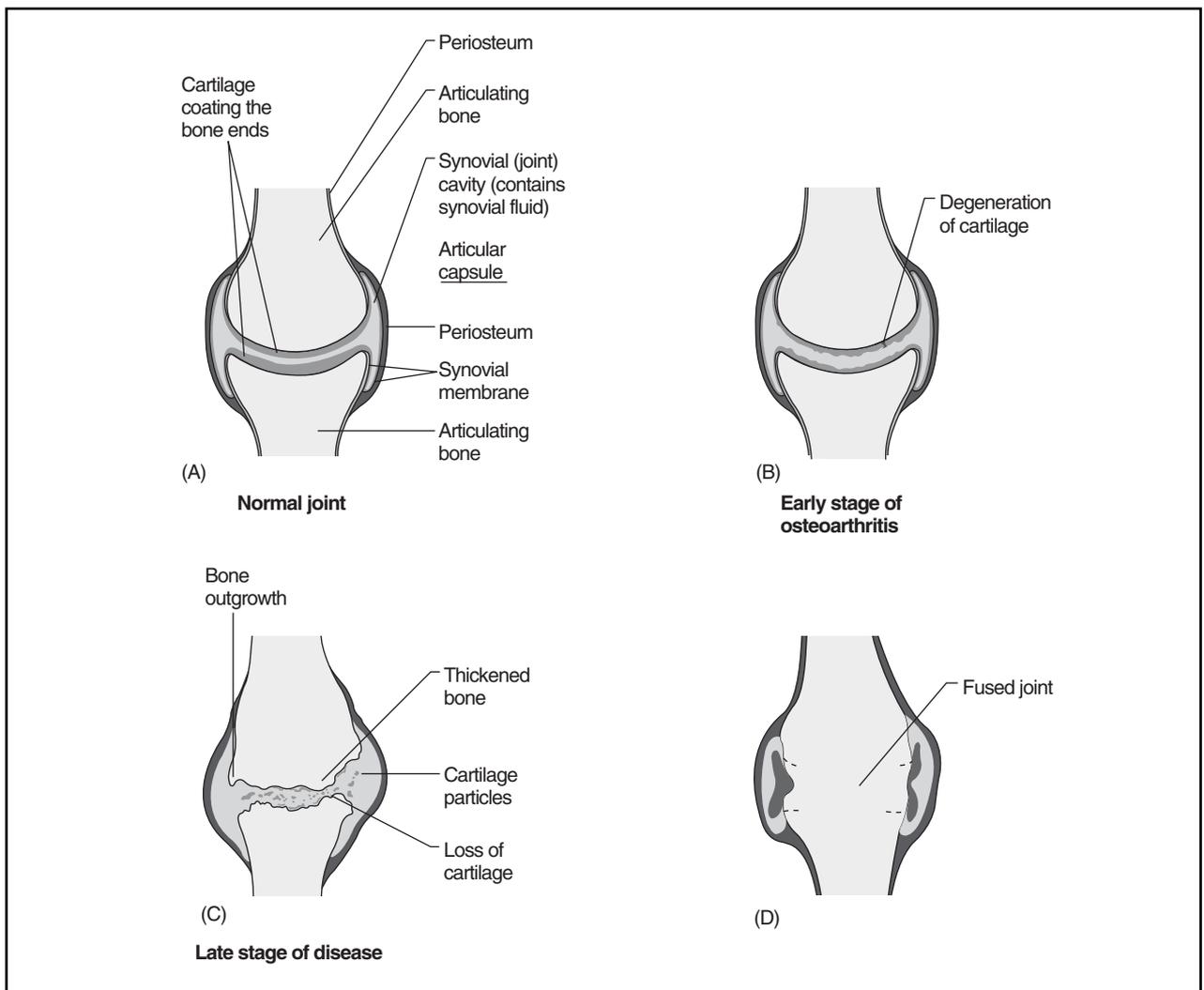
Prognosis

Osteoarthritis is a progressive disorder without a permanent cure. In some patients, the rate of progression can be slowed by weight loss, appropriate **exercise**, surgical treatment, and the use of alternative therapies.

Health care team roles

Early detection and diagnosis are key factors that affect the outcome of the progression of OA. Patients may present with vague symptoms of joint pain and stiffness, which should be noted when taking the patient history. The patient should be asked when these symptoms began. Co-morbid conditions such as **heart** disease, **hypertension**, or other disease should be considered. After ongoing observation and consultation with the patient, a more complete diagnosis can be made.

As with other painful conditions, understanding of the patient's lifestyle changes and physical condition is of the highest priority. **Patient education** and follow-up



The progression of osteoarthritis. (Illustration by Hans & Cassidy.)

support can assist with the mental health treatment, if necessary. Health care staff should counsel the patient on the basic facts of OA, make themselves available for follow-up phone consultation, and track the patient's visits to other health care providers. If the patient seems especially distressed about the condition, staff may recommend to the physician that the patient seek mental health support.

Should a rheumatologist or other subspecialist be consulted by the patient, members of the health care team should coordinate and monitor the treatment prescribed outside of the team's environment.

Patient contact has been shown to be a valuable aspect of the management of OA. Optimal follow-up consists of staff members (i.e., nurses, nurse practitioners, physicians assistants) making phone calls to patients and recording changes in symptoms, compliance with treatment regimen,

and any decline of condition. Nursing parameters can include pain control, assessment of medication efficacy, exercise, diet, means of joint protection, and awareness of psychosocial factors of depression/anxiety.

Knowledge of over-the-counter medications for OA can assist the patient in avoiding **drug interactions** or undue financial burden. Patients with limited range of motion may require special accommodations in waiting and treatment rooms; they may need an entrance to the building or a bathroom that is specially made to accommodate the handicapped, or a modified examination table.

Treatment

Treatment of patients with OA is tailored to the needs of each individual. Patient's symptoms vary widely due to the location of the joints involved, the rate of

progression, the severity of symptoms, the degree of disability, and individual response to specific forms of treatment. Most treatment programs include several forms of therapy and include the participation of the entire health care team.

Patient education and psychotherapy

Patient education is an important part of OA treatment because of the highly individual nature of the disorder and its potential impact on the patient's life. Patients who are depressed because of changes in employment or recreation usually benefit from participation in self-help groups, or counseling. The patient's family or friends should be involved in discussions of coping, household reorganization, and other aspects of the patient's disease and treatment regimen.

Medications

Patients with mild OA may be treated only with pain relievers such as acetaminophen (i.e., Tylenol). Most patients with OA, however, are given **nonsteroidal anti-inflammatory drugs** (NSAIDs). These include compounds such as ibuprofen (e.g., Motrin, Advil), ketoprofen (e.g., Orudis), and naproxen (e.g., Naprosyn). NSAIDs have the advantage of relieving slight inflammation as well as pain. Patients taking NSAIDs, however, may experience side effects, including **stomach** ulcers, sensitivity to sun exposure, kidney disturbances, and nervousness/anxiety or depression. Topical capsaicin cream (e.g., AthriCare) may provide relief when applied to affected areas.

Some OA patients are treated with **corticosteroids**, which are injected directly into the joints to reduce inflammation. As of 2001, studies were being conducted regarding the use of hyaluronic acid, which is more commonly injected into the knee. Because the joint naturally contains some hyaluronic acid (for joint lubrication), the addition of extra hyaluronic acid can protect the joint, in some cases, for six months to one year.

Physical therapy

Patients with OA are encouraged to exercise as a way of keeping joint cartilage lubricated and mobile. Consultation with a physical therapist is highly recommended, as it can ensure patient compliance and safety while exercising. Low-impact exercises to increase balance, flexibility, and range of motion are also recommended. These exercises may include walking, swimming or other water activities, **yoga**, and other stretching exercises, or isometric exercises (i.e., a program of exercises in which a muscle group is tensed against another

muscle group or an immovable object so that the muscles may contract without shortening).

Physical therapy may also include massage, the application of moist hot packs, or soaks in a hot tub. Prescriptions may be written for protective devices. Instructions for their use would be given to patients by physical therapy staff.

Surgery

Surgical treatment of OA may include the replacement of a damaged joint with an artificial part or application, surgical fusion of spinal bones, scraping or removal of damaged bone from the joint, or the removal of a piece of bone in order to realign the bone.

Protective measures

Support staff will be required to educate the patient on the correct use of any protective measure, the length of time it will be needed, and counsel on the correct way to bend, lift or move the affected joint. The consequences of not using protective measures should be outlined (i.e., exacerbation of symptoms, additional muscle strain, undue pain from noncompliance). Depending on the location of the affected joint, patients with OA may be advised to use neck braces or collars, crutches, canes, hip braces, knee supports, bed boards, or elevating chairs and toilet seats. Patients would also be advised to avoid unnecessary bending, stair climbing, or lifting of heavy objects.

Potential treatments

Several methods of treatment for OA are being investigated. They include:

- Disease-modifying drugs. These compounds may be useful in assisting the body to form new cartilage or improve its repair of existing cartilage.
- Hyaluronic acid. This treatment is well supported in theory.
- Electromagnetic therapy. This treatment is viewed with skepticism by mainstream medicine.
- Gene therapy. This is a promising area of treatment, although it may not be available for several years.

Alternative treatment

DIET. Food intolerance can be a contributing factor to OA, although this is more significant in rheumatoid arthritis. Dietary suggestions that may be helpful for people with OA include emphasizing high-fiber, complex-carbohydrate foods, while minimizing **fats**.

KEY TERMS

Bouchard's nodes—Swelling of the middle joint of the finger.

Cartilage—Elastic connective tissue that covers and protects the ends of bones.

Primary osteoarthritis—OA that results from hereditary factors or stresses on weight-bearing joints.

Secondary osteoarthritis—OA that develops following joint surgery, trauma, or repetitive joint injury.

Subchondral cysts—Fluid-filled sacs that form inside the marrow at the ends of bones as part of the development of OA.

NUTRITIONAL SUPPLEMENTS In recent years, a combination of glucosamine and chondroitin sulfate has been studied as a dietary supplement to help the body maintain and repair cartilage. These substances are nontoxic and do not require prescriptions, but studies continue to be conducted to evaluate their effectiveness. Other supplements that may be helpful in the treatment of OA include the antioxidant **vitamins A, C, and E**, and **minerals selenium and zinc**.

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Michele R. Webb

Osteogenic sarcoma see **Sarcomas**

Osteoporosis

Definition

The word osteoporosis literally means "porous bones." It occurs when bones lose an excessive amount of their protein and mineral content, particularly **calcium**. Over time, bone mass, and therefore bone strength, is decreased. As a result, bones become fragile and break easily. Even a sneeze or a sudden movement may be enough to break a bone in someone with severe osteoporosis.

Description

Osteoporosis is a serious **public health** problem. Some 28 million people in the United States are affected by this potentially debilitating disease, which is responsible for 1.5 million **fractures** (broken bones) annually. These fractures, which are often the first sign of the disease, can affect any bone, but the most common locations are the hip, spine, and wrist. Breaks in the hip and spine are of special concern because they almost always require hospitalization and major surgery, and may lead to other serious consequences, including permanent disability and even death.

To understand osteoporosis, it is helpful to understand the basics of bone formation. Bone is living tissue that is constantly being renewed in a two-stage process (resorption and formation) that occurs throughout life. In the resorption stage, old bone is broken down and removed by cells called osteoclasts. In the formation stage, cells called osteoblasts build new bone to replace the old. During childhood and early adulthood, more bone is produced than removed, reaching its maximum mass and strength by the mid-30s. After that, bone is lost at a faster pace than it is formed, so the amount of bone in the skeleton begins to slowly decline. Most cases of osteoporosis occur as an acceleration of this normal aging process—a form referred to as primary osteoporosis. The condition can also be caused by other disease processes or prolonged use of certain medications that result in bone loss—a form called secondary osteoporosis.

Osteoporosis occurs most often in older people and in women after **menopause**. It affects nearly half of all men and women over the age of 75. Women, however, are five times more likely than men to develop the disease. They have smaller, thinner bones than men to begin with, and they lose bone mass more rapidly after menopause (usually around age 50), when they stop producing a bone-protecting hormone called estrogen. In the five to seven years following menopause, women can lose about 20% of their bone mass. By age 65 or 70,

though, men and women lose bone mass at the same rate. As an increasing number of men reach an older age, they are becoming more aware that osteoporosis is an important health issue for them as well.

Causes and symptoms

A number of factors increase the risk of developing osteoporosis. They include:

- **Age.** Osteoporosis is more likely as people grow older and their bones lose tissue.
- **Gender.** Women are more likely to have osteoporosis because they are smaller and so start out with less bone. They also lose bone tissue more rapidly as they age. While women commonly lose 30–50% of their bone mass over their lifetimes, men lose only 20–33% of theirs.
- **Race.** Caucasian and Asian women are at higher risk for the disease than women of African or Hispanic ethnicities.
- **Figure type.** Women with small bones and those who are thin are more liable to have osteoporosis.
- **Early menopause.** Women who stop menstruating early because of heredity, surgery or a lot of physical **exercise** may lose large amounts of bone tissue early in life. Conditions such as anorexia and bulimia may also lead to early menopause and osteoporosis.
- **Lifestyle.** People who smoke or drink too much, or do not get enough exercise have an increased chance of getting osteoporosis.
- **Diet.** Those who do not get enough calcium or protein may be more likely to have osteoporosis. People who constantly diet are more prone to the disease. It has been shown that adolescent girls (but not boys) have insufficient calcium intake levels in the diet. This calcium deficiency occurs during a period of rapid bone growth, stunting the peak bone mass ultimately achieved; thus, these individuals are at greater risk of developing osteoporosis.
- **Genetics.** People with a family history of osteoporosis are more likely to contract the disease.
- **Chronic use of medication.** Certain types of medication, such as steroids, interfere with the body's ability to absorb calcium or accelerate calcium depletion, damaging bone density.

Osteoporosis is often called the “silent” disease, because bone loss occurs without symptoms. People often do not know they have the disease until a bone breaks, frequently in a minor fall that would not normally cause a fracture. A common occurrence is compression

fractures of the spine. These can happen even after a seemingly normal activity, such as bending or twisting to pick up a light object. The fractures can cause severe back **pain**, but sometimes they go unnoticed—either way, the vertebrae collapse down on themselves, and the person actually loses height. The hunchback appearance of many elderly women, sometimes called “dowager’s hump” or “widow’s hump,” is due to this effect of osteoporosis on the vertebrae.

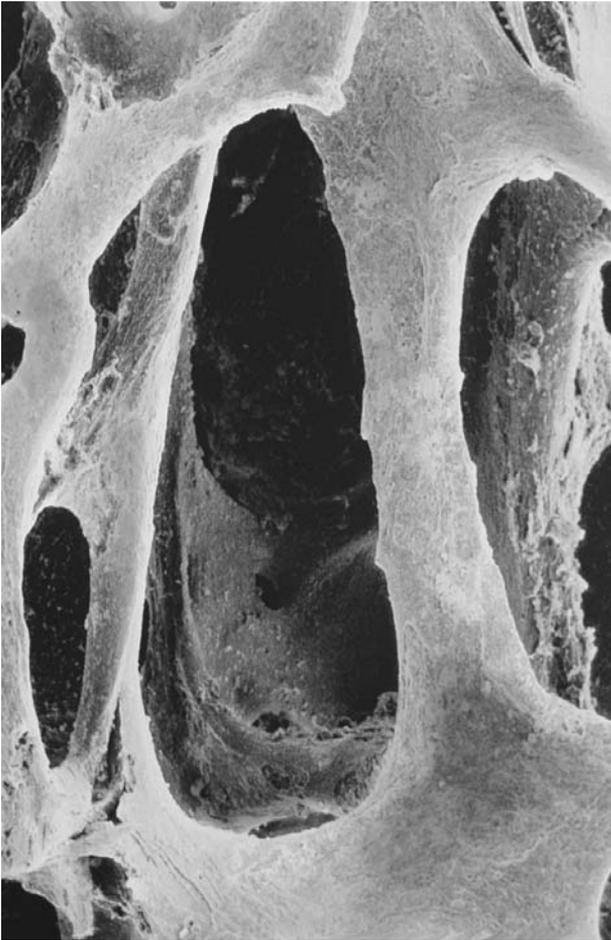
Diagnosis

Certain types of doctors may have more training and experience than others in diagnosing and treating people with osteoporosis. These include geriatricians, who specialize in treating the aged; endocrinologists, who specialize in treating diseases of the body’s **endocrine system** (glands and hormones); and orthopedic surgeons, who treat fractures, such as those caused by osteoporosis.

Before making a diagnosis of osteoporosis, the doctor usually takes a complete medical history, conducts a physical exam, and orders x-rays, as well as **blood** and urine tests, to rule out other diseases that cause loss of bone mass. The doctor may also recommend a bone density test. This is the only way to determine if osteoporosis is present. It can also show how far the disease has progressed.

Several diagnostic tools are available to measure the density of a bone. The most accurate and advanced of the densitometers uses a technique called DEXA (dual energy x-ray absorptiometry). With the DEXA scan, a double x-ray beam takes pictures of the spine, hip, or entire body. It takes about 20 minutes to do, is painless, and exposes the patient to only a small amount of radiation—about one-fiftieth that of a **chest x ray**. The ordinary x ray is one, though it is the least accurate for early detection of osteoporosis, because it does not reveal bone loss until the disease is advanced and most of the damage has already been done. Other tools that are more likely to catch osteoporosis at an early stage are computed tomography scans (**CT scans**) and machines called densitometers, which are designed specifically to measure bone density. The CT scan, which takes a large number of x rays of the same spot from different angles, is an accurate test, but uses higher levels of radiation than other methods.

People should talk to their doctors about their risk factors for osteoporosis and if, and when, they should get the test. A woman should have bone density measured at menopause, and periodically afterward, depending on the condition of their bones. Men should be tested around age 65. Men and women with additional risk factors, such as those who take certain medications, may need to be tested earlier.



A scanning electron micrograph (SEM) of cancellous (spongy) bone from an osteoporosis patient. Osteoporosis is characterized by increased brittleness of the bones and a greater risk of fractures. This is reflected here in the thin appearance of the bony network of the cancellous bone that forms the core of the body's long bones (Photograph by Professor P. Motta, Photo Researchers, Inc. Reproduced by permission.)

Treatment

There are a number of good treatments for primary osteoporosis, most of them medications. In addition, calcium (0.5 to 2 g/day) and **vitamin D** (400 to 800 IU/day) supplementation can reduce the rate of bone loss in women who are more than five years postmenopausal. Fracture reduction efficacy of calcium and vitamin D supplementation, administered independently, has been demonstrated in women older than 75 years of age.

For people with secondary osteoporosis, treatment may focus on curing the underlying disease.

Drugs

For most women who have gone through menopause, the best treatment for osteoporosis is hor-

mone replacement therapy (HRT). Many women participate in HRT when they undergo menopause, to alleviate symptoms such as hot flashes, but hormones have other important roles as well. They protect women against **heart** disease, the number one killer of women in the United States, and they help to relieve and prevent osteoporosis. HRT increases a woman's supply of estrogen, which helps build new bone, while preventing further bone loss.

Some women, however, do not want to take or are not candidates for hormones, because some studies show they are linked to an increased risk of **breast cancer** or uterine **cancer**. Other studies reveal that risk is due to increasing age. (Breast cancer tends to occur more often as women age.) Whether or not a woman takes hormones is a decision she should make carefully with her doctor. Women should talk to their doctors about personal risks for osteoporosis, as well as their risks for heart disease and breast cancer.

Novel delivery systems of HRT have been developed. For example, Vivelle is a estradiol transdermal system that is used for prevention of osteoporosis. It uses a "patch" to continuously deliver the hormone estradiol through the skin.

Studies have shown women who started taking HRT within five years of menopause show significantly reduced rates of hip fractures than women who began HRT more than five years postmenopausal. However, even while taking HRT, 10 to 20% of women continue to lose bone density and therefore may require additional intervention.

For people who cannot or will not take estrogen, other agents can be good choices. These include:

- bisphosphonates
- calcitonin
- selective estrogen receptor modulators
- sodium fluoride
- androgens

Although there are a number of bisphosphonates used for the treatment of various forms of osteoporosis and resorptive bone diseases, alendronate (sold under the brand name Fosamax), etidronate (sold under the brand name Didronel), and risedronate (sold under the brand name Actonel) are some of the agents most commonly used for therapeutic treatment of postmenopausal osteoporosis. Bisphosphonates act by decreasing bone resorption or breakdown. For example, alendronate attaches itself to bone that has been targeted by bone-eating osteoclasts. It protects the bone from these cells. Osteoclasts help the body break down old bone tissue.

Alendronate has shown to be an effective agent in preventing bone loss and building bone in recently postmenopausal women and is especially useful in women who have contraindications for HRT. It has been licensed for the treatment and prevention of vertebral and nonvertebral postmenopausal osteoporosis. Alendronate has proven safe in very large, multi-year studies, but not much is known about the effects of its long-term use. Side effects are generally minimal with abdominal pain, nausea, dyspepsia, constipation and **diarrhea** occurring in 3% to 7% of patients treated with alendronate. It can be taken daily, and now a new formulation has been developed that can be taken weekly.

Etidronate has been shown to reduce the rate of new vertebral and nonvertebral fractures. It appears to be well tolerated in clinical studies.

Calcitonin is a hormone that has been used as an injection for many years. It is also marketed as a nasal spray. It also slows down bone-eating osteoclasts. Side effects are minimal, but calcitonin builds bone by only 1.5% a year, which may not be enough for some women to recover the bone they lose.

Selective estrogen receptor modulators (SERMs) such as raloxifene, droloxifene, idoxifene, and tamoxifen are used as alternatives to hormone replacement therapy (HRT) which commonly use estrogen. SERMs have been shown to protect against postmenopausal bone loss without the estrogenic side effects. Raloxifene was the first SERM to be approved in the osteoporosis market for prevention and treatment of osteoporosis. Raloxifene binds to estrogen receptors and mimics estrogen's action on bone by preventing bone loss, and improving cholesterol **metabolism**, therefore acting as an agonist. It also acts as an estrogen antagonist in the uterus and the breasts, by not imitating the action of estrogen. These drugs may thus improve blood lipid profiles and protect against breast cancer. There is an enhanced risk of venous thromboembolic events during raloxifene therapy, especially during the first four months of therapy. It also has a propensity to induce hot flashes, and leg pain.

Sodium fluoride has been used as an anabolic agent to stimulate bone formation. However, a high incidence of side effects, mainly gastrointestinal symptoms and lower extremity pain syndrome have occurred in clinical trials.

Androgens have been used for reducing bone loss. Androgens are classified as anabolic steroids, which include nandrolone, stanozolol and testosterone, are used as antiresorptive agents. Androgens are important for postmenopausal women as they serve as a substrate for the peripheral production of estrogens.

The treatments currently available are antiresorptive, which limits the ability to increase bone mass. Other bone-building agents are under investigation including parathyroid hormone which has been clinically evaluated but is still awaiting FDA approval as of March 2001. The biphosphonates have demonstrated the most dramatic reduction in fracture rates and may be the best choice for women with severe osteoporosis. Estrogen's effect may be similar, but has not been established in large randomized trials. Raloxifene may be particularly useful in women who wish to benefit from a breast cancer risk reduction. Calcitonin may be the least potent but may be useful in women who cannot tolerate other therapies.

Surgery

Unfortunately, treatment for osteoporosis is usually tied to fractures that result from advanced stages of the disease. For complicated fractures, such as broken hips, hospitalization and a surgical procedure are required. In hip replacement surgery, the broken hip is removed and replaced with a new hip made of plastic, or metal and plastic. Though the surgery itself is usually successful, complications of the hip fracture can be serious. Those individuals have a 5%–20% greater risk of dying within the first year following that injury than do others in their age group. A large percentage of those who survive are unable to return to their previous level of activity, and many end up moving from self-care to a supervised living situation or nursing home. Getting early treatment and taking steps to reduce bone loss are vital.

Alternative treatment

Alternative treatments for osteoporosis focus on maintaining or building strong bones. A healthy diet low in **fats** and animal products and containing whole grains, fresh fruits and vegetables, and calcium-rich foods (such as dairy products, dark-green leafy vegetables, sardines, salmon, and almonds), along with nutritional supplements (such as calcium, magnesium, and vitamin D), and weight-bearing exercises are important components of both conventional prevention and treatment strategies and alternative approaches to the disease. In addition, alternative practitioners recommend a variety of botanical medicines or herbal supplements. Herbal supplements designed to help slow bone loss emphasize the use of calcium-containing plants, such as horsetail (*Equisetum arvense*), oat straw (*Avena sativa*), alfalfa (*Medicago sativa*), licorice (*Glycyrrhiza galbra*), marshmallow (*Althaea officinalis*), and yellow dock (*Rumex crispus*). Homeopathic remedies focus on treatments believed to help the body absorb calcium. These remedies are likely to include such substances as *Calcarea carbonica* (calcium carbonate) or silica. In traditional Chinese medicine,

KEY TERMS

Alendronate—A nonhormonal drug used to treat osteoporosis in postmenopausal women.

Anticonvulsants—Drugs used to control seizures, such as in epilepsy.

Biphosphonates—Compounds (like alendronate) that slow bone loss and increase bone density.

Calcitonin—A hormonal drug used to treat postmenopausal osteoporosis.

Estrogen—A female hormone that also keeps bones strong. After menopause, a woman may take hormonal drugs with estrogen to prevent bone loss.

Glucocorticoids—Any of a group of hormones (like cortisone) that influence many body functions and are widely used in medicine, such as for treatment of rheumatoid arthritis inflammation.

Hormone replacement therapy (HRT)—Also called estrogen replacement therapy, this controversial treatment is used to relieve the discomforts of menopause. Estrogen and another female hormone, progesterone, are usually taken together to replace the estrogen no longer made by the body. It has the added effect of stopping bone loss that occurs at menopause.

Menopause—The ending of a woman's menstrual cycle, when production of bone-protecting estrogen decreases.

Osteoblasts—Cells in the body that build new bone tissue.

Osteoclasts—Cells that break down and remove old bone tissue.

Selective estrogen receptor modulator—A hormonal preparation that offers the beneficial effects of hormone replacement therapy without the increased risk of breast and uterine cancer associated with HRT.

practitioners recommend herbs thought to slow or prevent bone loss, including dong quai (*Angelica sinensis*) and Asian ginseng (*Panax ginseng*). Natural hormone therapy, using plant estrogens (from soybeans) or progesterone (from wild yams), may be recommended for women who cannot or choose not to take synthetic hormones.

It should be noted, however, that very few clinical trials are conducted on alternate therapies and therefore efficacy cannot be established.

Prognosis

There is no cure for osteoporosis, but it can be controlled. Most people who have osteoporosis fare well once they get treatment. The medicines available now build bone, protect against bone loss, and halt the progress of this disease.

Health care team roles

Doctors, nurses, physical therapists, radiation technologists, and dietitians all play roles in the process of controlling osteoporosis. Because osteoporosis is treatable but not curable, the main responsibility for controlling the progress of the disease rests with the patient. All of these team members play an important role in identifying risk of osteoporosis before it strikes and in convincing the patient to take appropriate steps (including lifestyle modification) to minimize the dangers of fracturing major bones.

Prevention

Building strong bones, especially before the age of 35, and maintaining a healthy lifestyle are the best ways of preventing osteoporosis. To build as much bone mass as early as possible in life, and to help slow the rate of bone loss later in life:

Get calcium in foods

Experts recommend 1,500 milligrams (mg) of calcium per day for adolescents, pregnant or breast-feeding women, older adults (over 65), and postmenopausal women not using hormone replacement therapy. All others should get 1,000 mg per day. Foods are the best source for this important mineral. Milk, cheese, and yogurt have the highest amounts. Other foods that are high in calcium are green leafy vegetables, tofu, shellfish, Brazil nuts, sardines, and almonds.

Take calcium supplements

Many people, especially those who do not like or cannot eat dairy foods, do not get enough calcium in their diets and may need to take a calcium supplement. Supplements vary in the amount of calcium they contain. Those with calcium carbonate have the most amount of useful calcium. Supplements should be taken with meals and accompanied by six to eight glasses of water a day. Calcium supplements and **antacids** interfere with absorption of alendronate and should be taken at least one half hour later.

Get vitamin D

Vitamin D helps the body absorb calcium. People can get vitamin D from sunshine with a quick (15–20 minutes) walk each day or from foods such as **liver**, fish oil, and vitamin-D fortified milk. During the winter months it may be necessary to take supplements (400–800 IU/day).

Avoid smoking and alcohol

Smoking reduces bone mass, as does heavy drinking. To reduce risk, do not smoke and limit alcoholic drinks to no more than two per day. An alcoholic drink is 1.5 oz (44 mL) of hard liquor, 12 oz (355 mL) of beer, or 5 oz (148 mL) of wine.

Exercise

Exercising regularly builds and strengthens bones. Weight-bearing exercises—where bones and muscles work against gravity—are best. These include aerobics, dancing, jogging, stair climbing, tennis, walking, and lifting weights. People who have osteoporosis may want to attempt gentle exercise, such as walking, rather than jogging or fast-paced aerobics, which increase the chance of falling. Try to exercise three to four times per week for 20–30 minutes each time. As physical activity improves muscle strength and coordination it may also aid in reducing the risk of fall-related fractures.

Those at risk should avoid medications known to compromise bone density, such as glucocorticoids, thyroid hormones and chronic heparin therapy.

Resources

BOOKS

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PERIODICALS

- Feder, G., et al. “Guidelines for the Prevention of Falls in People over 65.” *British Medical Journal* 321 (2000): 1007-1011.
- McClung, Michael R., et al. “Effect of Risedronate on the Risk of Hip Fracture in Elderly Women.” *The New England Journal of Medicine* 344, no. 5 (2001): 333-40.

ORGANIZATIONS

- Arthritis Foundation, 1330 W. Peachtree St., PO Box 7669, Atlanta, GA 30357-0669. (800) 283-7800. <<http://www.arthritis.org>>.
- National Center for Complementary and Alternative Medicine (NCCAM), 31 Center Dr., Room #5B-58, Bethesda, MD 20892-2182. (800) NIH-NCAM. Fax: (301) 495-4957. <<http://nccam.nih.gov>>.
- National Osteoporosis Foundation, 1150 17th Street, Suite 500 NW, Washington, DC 20036-4603. (800) 223-9994. <<http://www.nof.org>>.
- Osteoporosis and Related Bone Diseases-National Resource Center. 1150 17th St., NW, Ste. 500, Washington, DC 20036-4603. (800) 624-BONE. <<http://www.osteoporosis.gov>>.

Crystal Kaczkowski, MSC

Otoscope

Definition

An otoscope is a hand-held device for visual examination of the auditory canal, inner ear, and tympanic membrane.

Purpose

An otoscope is designed to enable the health care professional to view the auditory canal, inner ear, and tympanic membrane as part of a normal **physical examination**. It is also used if **infection** of the auditory canal is suspected, if there is a blockage due to the presence of a foreign object or build up of wax, and to inspect the tympanic membrane for signs of rupture, puncture, or **hearing loss**.

Description

An otoscope consists of a handle with power source, an optical head with fiberoptic strands, a lens, specula, a small light bulb, a polished reflector, and may have pneumoscopy bellows as an option. The unit is designed to be operated by one hand, enabling the other hand to manipulate the patient’s ear.



An otoscope shines light into the ear and allows a health care practitioner to view the inside of the ear through an opening in the otoscope. (Photograph by Wolfgang Weinhäupl. Science Source/Photo Researchers. Reproduced by permission.)

Batteries, either disposable or rechargeable, can power the unit and are often stored in the handle of the otoscope. Alternatively, the unit can be recharged using a transformer to enable it to be used from a 110V power supply mounted on a wall. Some units have other options available for the power source, including a clip-on battery unit with a two-pronged cord that can be attached to a pocket or table, and a cord with batteries that is attached to the otoscope and hangs around the health care professional's neck.

An optical head is attached to the handle and contains fiberoptic strands, a bulb, a swivel-headed magnifying lens, and the reflector, allowing the health care professional to view the patient's auditory canal via an attached speculum. The lens is constructed of scratch-resistant optical glass. Specula may be disposable or autoclavable and can range in size from 2.5–8mm. This enables the appropriate-sized speculum to be selected for the patient's ear offering comfort for the patient during the otoscopy procedure, while providing a positive ear seal for pneumoscopy. An otoscope bulb provides light that shines through the tip of the speculum while a reflector increases the amount of forward light given off by the device. The bulb is usually halogen to give off a clear light that will not affect the color of the ear canal, potentially altering the diagnosis. The illuminated canal is viewed through the magnifying lens.

Pneumoscopia bellows are made of plastic or rubber and are attached to the otoscope via a thin plastic tube. When the bellows are squeezed, a small puff of air is forced through the tubing, striking the tympanic membrane. The action of the air striking the membrane is

viewed through the otoscope. Signs of oscillation are normal.

Each otoscope has different features depending on the manufacturer and the cost of each unit.

Operation

The patient will be asked to sit with the head tipped slightly toward the shoulder so that the ear to be examined is pointing up. After selecting the appropriate sized speculum for the patient's ear, the speculum is attached to the optical head of the otoscope and gently inserted into the patient's ear. The doctor or nurse may hold the ear lobe as the speculum of the otoscope is inserted into the ear. Both ears are usually examined, even if there seems to be a problem with just one ear, and the procedure takes no more than a few minutes to perform.

Maintenance

The otoscope should be maintained by ensuring the bulb light is bright and extends from the tip of the speculum to the eardrum. Bulbs should be replaced every six months, and rechargeable batteries changed every two years. The fiberoptic strands in the optical head may crack over prolonged use, and if the light remains dim, the unit should be repaired. The device should be checked for air leaks that prevent an adequate seal to be formed around the ear or permit air to escape from around the lens or where attachments fit the unit. A poor seal will also allow moisture to enter behind the lens and fogging will occur.

Health care team roles

The otoscope enables the professional to detect signs of infection, obstruction, and injury in the ear canal and eardrum. It is most often used by physicians and **advanced practice nurses**.

Training

The person using the scope should know how to recognize signs of inflammation and disease, including pressure behind the eardrum and be thoroughly familiar with the normal appearance and anatomy of the ear. Training hospitals may offer otoscopy programs.

Resources

OTHER

"Hotchkiss Otoscope." <<http://www.preferredproduct.com>>. Schwartz, Richard H. "The Maintenance of the Office Otoscope." *Slack Incorporated Newspaper*. Apr. 2001. <<http://www.slackinc.com>>.

KEY TERMS

Auditory canal—The ear canal.

Ear speculum—A cone or funnel-shaped attachment for an otoscope that is inserted into the ear canal to examine the eardrum.

Otoscope—A hand-held instrument with a tiny light and a funnel-shaped attachment called an ear speculum, which is used to examine the ear canal and eardrum.

Pneumoscapy—An examination using air.

Tympanic membrane—The ear drum.

“Welch Allyn 3.5v Diagnostic with Convertible Handle.”
<<http://www.nurses.com>>.

Margaret A Stockley, RGN

Otoscope examination

Definition

An otoscopic examination is the visual examination of the auditory canal and tympanic membrane using an **otoscope**.

Purpose

An otoscopic examination is a procedure that examines the auditory canal and tympanic membrane for **infection** or blockage due to the presence of a foreign object or build up of wax, the tympanic membrane for signs of rupture, puncture, or **hearing loss**, and the canal for any variations from normal. Some otoscopes can deliver a small puff of air to the eardrum to determine if the eardrum will vibrate (which is normal). An otoscopic examinations is also part of a normal **physical examination**.

Precautions

No special precautions are required. However, if an ear infection is present, an ear examination may cause some discomfort or **pain**.

Description

An otoscopy is an ear examination with an otoscope, a handheld instrument with a tiny light and a cone-shaped

attachment called an ear speculum. A physician or nurse usually performs an otoscopic examination as part of a complete physical examination. The ears may also be examined if an ear infection is suspected, or if the patient has a **fever**, ear pain, or **hearing loss**. The patient will be asked to sit with the head tipped slightly toward the shoulder so the ear to be examined is pointing up. The doctor or nurse may hold the ear lobe as the speculum of the otoscope is inserted into the ear. Both ears are usually examined, even if the problem seems to affect just one ear, and the procedure takes no more than a few minutes to perform.

Preparation

No special preparation is required prior to an ear examination with an otoscope. The ear speculum, which is inserted into the ear, is cleaned and sanitized before it is used. Specula come in various sizes, and the doctor or nurse will select the size that will be most comfortable for the patient’s ear.

Aftercare

If an ear infection is diagnosed, the patient may require treatment with **antibiotics**. If there is a buildup of wax in the ear canal, it might be rinsed or scraped out.

Complications

This type of ear examination is simple and generally harmless. Caution should always be used any time an object is inserted into the ear. This process could irritate an infected external ear canal and could rupture an eardrum if performed improperly or if the patient moves.

Results

The ear canal is typically skin-colored and covered with tiny hairs. It is normal for the ear canal to have some yellowish-brown earwax. The eardrum is typically thin, shiny, and pearly-white to light gray in color. The tiny bones in the middle ear can be seen pushing on the eardrum membrane like tent poles. The light from the otoscope will reflect off of the surface of the eardrum. Abnormal results such as a red or swollen ear canal may indicate an ear infection is present. In cases where the eardrum has ruptured, there may be fluid draining from the middle ear. A doctor may also see scarring, retraction of the eardrum, or bulging of the eardrum.

Health care team roles

The health care team should be aware of the physiology of the auditory canal to detect any deviations

KEY TERMS

Auditory canal—Ear canal.

Ear speculum—A cone- or funnel-shaped attachment for an otoscope that is inserted into the ear canal to examine the canal and the eardrum.

Otoscope—A handheld instrument with a tiny light and a funnel-shaped attachment called an ear speculum.

Tympanic membrane—Ear drum.

from normal. A knowledge of the function and care of the otoscope is important to ensure the light is bright, there are no loose parts, and if disposable speculums are not used, the speculums are sterilized between patients. Hospitals may offer training programs in the use of otoscopes and their detection of abnormalities of the auditory canal.

Resources

ORGANIZATIONS

American Academy of Otolaryngology—Head and Neck Surgery. One Prince Street, Alexandria, VA 22314. (703) 836-4444.

Ear Foundation. 2000 Church Street, Box 111, Nashville, TN 37236. (615) 329-7807. (800) 545-HEAR.

National Institute on Deafness and Other Communication Disorders. 1 Communication Avenue, Bethesda, MD 20892-3456. Voice: (301) 496-7243. TTY: (301) 402-0252.

OTHER

“Ear Test.” <<http://www.healthanswers.com>>.

Hearing Health Information. <<http://www.hei.org>>.

Schwartz, Richard H. “The Maintenance of the Office Otoscope.” *Slack Incorporated Newspaper* April 2001. <<http://www.slackinc.com>>.

Margaret A. Stockley

Outlays see **Dental crowns, inlays, and bridges**

Ova & parasites collection see **Stool O & P test**

Overdose

Definition

An overdose is the accidental or intentional use of a drug or medicine in an amount that is higher than normally used or prescribed.

Description

All drugs have the potential to be misused, whether legally prescribed by a doctor, purchased over the counter at the local drug store, or bought illegally on the street. Taken in combination with other drugs or with alcohol, even drugs normally considered safe do cause death or serious long-term consequences. Children are particularly at risk for accidental overdose, accounting for more than one million poisonings each year from drugs, alcohol, and other chemicals and toxic substances. People who suffer from depression and who have suicidal thoughts are also at high risk for drug overdose.

Causes and symptoms

Accidental drug overdose may be the result of the misuse of prescription medicines or commonly used medications such as **pain** relievers and cold remedies. Symptoms differ depending on the drug taken. Some of the drugs commonly involved in overdoses are listed below along with symptoms and outcomes.

Acetaminophen is the generic name for the commonly used pain reliever Tylenol. An overdose of this drug can cause **liver** damage with symptoms that include loss of appetite, tiredness, nausea and vomiting, paleness, and sweating. The next stage of symptoms indicates liver failure and includes abdominal pain and tenderness, swelling of the liver, and abnormal **blood** tests for liver enzymes. In the last stage of this **poisoning**, liver failure advances and patients become jaundiced, with yellowing of the skin and whites of the eyes. They may also experience kidney failure, **bleeding disorders**, and encephalopathy (swelling of the **brain**).

Salicylates are found in aspirin and some creams or ointments used for muscle and joint pain such as Ben-Gay and for psoriasis, a skin condition. Initial symptoms are gastrointestinal irritation, **fever**, and vomiting, possibly with blood in the vomit. An overdose of salicylates will cause metabolic acidosis and respiratory alkalosis, conditions in which the body's pH (acid/base balance) malfunctions. Symptoms include rapid **heart** beat and fast breathing. Nervous system symptoms include confusion, hallucinations, tiredness, and ringing in the ears. An increased tendency to bleed is also common. Serious

complications include acute renal failure, **coma**, and **heart failure**. Acute salicylate poisoning can lead to death.

Anticholinergic drugs that block the action of acetylcholine, a neurotransmitter include atropine, scopolamine, belladonna, **antihistamines**, and antipsychotic agents. They cause the skin and moist tissues such as in the mouth and nose to become dry and flushed. Dilated pupils, an inability to urinate, and mental disturbances are also symptoms. Severe toxicity can lead to seizures, abnormal heart rhythms, extremely high **blood pressure**, and coma.

Cholinergic drugs that stimulate the parasympathetic nervous system, such as carbamate and pilocarpine, cause nausea, **diarrhea**, increased secretion of body fluids such as sweat, tears, saliva, and urine, fatigue, and muscle weakness. Convulsions are possible. Death can occur due to **respiratory failure** and heart failure.

Antidepressant drugs such as amitriptyline, desipramine, and nortriptyline can cause irregular heart rate, vomiting, low blood pressure (hypotension), confusion, and seizures. An overdose of antidepressants also causes symptoms similar to those seen with anticholinergic drug overdoses.

Depressant drugs such as tranquilizers, **antianxiety drugs**, and sleeping pills cause sleepiness, slowed or slurred speech, difficulty walking or standing, blurred **vision**, impaired ability to think, disorientation, and mood changes. Overdose symptoms can include slowed breathing, very low blood pressure, stupor, coma, **shock**, and death.

Cocaine and crack cocaine overdoses cause seizures, high blood pressure, increased heart rate, paranoia, and other changes in behavior. Heart attack or stroke are serious risks within three days after cocaine overdose.

Heroin, morphine, and codeine are narcotic or opiate drugs. Clonidine and diphenoxylate (Lomotil) are also in this category. Overdose with opiate drugs causes sedation (sleepiness), low blood pressure, slowed heart rate, and slowed breathing. Pinpoint pupils, where the black centers of the eyes become smaller than normal, are common in opiate overdose. However, if other drugs are taken at the same time as the opiates, they may counteract this effect on the pupils. A serious risk is that the patient will stop breathing (respiratory arrest).

Digoxin, a drug used to regulate the heart, can cause irregular heartbeats, nausea, confusion, loss of appetite, and blurred vision.

Diagnosis

Diagnosis of a drug overdose may be based on the symptoms that develop; however, the drug may do extensive damage to the body before significant symptoms develop. If the patient is conscious, the physician may be able to find out what drugs were taken and in what amounts. The patient's recent medical and social history may also help in a diagnosis. Information such as a list of medications that the patient takes, whether or not alcohol was consumed recently, or whether the patient had eaten in the last few hours can be valuable in determining how fast the overdosed drug will be absorbed into the system.

Different drugs have varying effects on the body's pH and on certain elements in the blood such as potassium and **calcium**. Blood tests can be used to detect changes in body chemistry that may give as clues to what drugs were taken. Blood can also be screened for various drugs in the system. Once the overdose drug is identified, blood tests can be used to monitor how fast the drug is being cleared out of the body. Urine tests are another way to screen for some drugs and to detect changes in the body's chemistry. Blood and urine tests may show if there is damage to the liver or **kidneys** as a result of the overdose.

Treatment

Immediate care

If a drug overdose is discovered or suspected, and the person is unconscious, having convulsions, or not breathing, emergency help must be called immediately. If the person who took the drug is not having symptoms, it is recommended not to wait to see if symptoms develop, but to call a poison control center immediately. Providing as much information as possible to the poison control center can help determine what the next course of action should be.

The poison control center, paramedics, and emergency room staff will want to know the following:

- what drug(s) were taken
- how much of the drug was taken
- when was the drug taken
- if the drug was taken with alcohol or any other drugs or chemicals
- what the age of the patient is
- what symptoms the patient is experiencing
- if the patient is conscious
- if the patient is breathing

KEY TERMS

Gastric lavage—The inside of the stomach is rinsed with a saline (salt water) solution or regular tap water; also called a stomach pump.

Hypotension—Having a low blood pressure: less than 90/60 mmHg.

Intubation—A procedure in which a tube is inserted through the mouth or nose and into the trachea to keep the airway open and to help the patient breathe.

The poison control center may recommend a liquid called **ipecac** syrup, which is used to induce vomiting. Ipecac syrup is an over-the-counter medication available from pharmacies, and no prescription is required. Pediatricians may advise families to keep ipecac syrup on hand in households with children. This medication should be used only on the advice of a medical professional. An important caveat is that vomiting should not be induced if the patient is unconscious as there is serious risk of choking.

Emergency care

Emergency medical treatment may include:

- Assessment of the patient's airway and breathing to make sure that the trachea, the passage to the **lungs**, is not blocked. If needed, a tube may be inserted through the mouth or nose and into the trachea to help the patient breathe. This procedure is called endotracheal (in the trachea) intubation.
- Assessment of the patient's **vital signs**, including heart rate, blood pressure, body temperature, respiratory rate, and other physical signs that might indicate the effects of the drug.
- Blood and urine samples may be collected to test for the presence of the suspected overdose drug, and other drugs or alcohol that might be present.
- Attempt to eliminate the whatever of the drug that has not yet been absorbed. Vomiting may be induced using ipecac syrup or other drugs that cause vomiting. Ipecac syrup should not be given to patients who overdosed with tricyclic antidepressants, theophylline, or any drug that causes a significant change in mental status.
- Gastric lavage, also known as pumping the **stomach**, may be attempted. For this procedure, a large flexible tube is inserted through the nose or mouth, down the throat, and into the stomach. The contents of the stom-

ach are then suctioned out through the tube. A solution of saline (salt water) or regular tap water is pushed down into the tube to rinse out the stomach. The saline solution or water is then suctioned out. This process is repeated several times until the suctioned fluid is clear.

- Activated charcoal to absorb the drug is sometimes given through a stomach tube or by having the patient swallow it.
- Medication to stimulate urination or defecation may be given to try to flush the excess drug out of the body faster.
- Intravenous (IV) fluids may be given. An intravenous line, a needle inserted into a vein, may be put into the arm or back of the hand. Fluids, either sterile saline (salt water solution) or dextrose (sugar water solution), can be administered through this line. Increasing fluids can help to flush the drug out of the system and to reestablish balance of fluids and **minerals** in the body. The pH of the body may need to be corrected by administering electrolytes such as sodium, potassium, and bicarbonate through the IV line. If drugs need to be administered quickly, they can also be injected directly into the IV line.
- Hemodialysis is a procedure in which blood is circulated out of the body, pumped through a dialysis machine, then reintroduced back into the body. This process can be used to filter some drugs out of the blood and can clean the blood. It may also be used temporarily or long term if the kidneys are damaged due to the overdose.
- Antidotes that are available for some drug overdoses may be administered. An antidote is another drug that counteracts or blocks the overdose drug.
- Psychiatric evaluation is performed if the drug overdose was taken deliberately. If the overdose is determined to be a deliberate act, further psychiatric care is provided while the patient is hospitalized.

Prognosis

While many victims of drug overdose recover without long-term effects, there can be serious consequences. Some drug overdoses cause the failure of major organs like the kidneys or liver, or failure of whole systems like the respiratory or circulatory systems. Patients who survive drug overdose may need **kidney dialysis**, kidney or liver transplant, or ongoing care as a result of heart failure, stroke, or coma. Death can occur in almost any drug overdose situation, especially if treatment is not started immediately.

Health care team roles

Nurses play a vital role in helping victims of drug overdoses. The emergency room nurses perform the gastric lavage procedure on the patient who has overdosed, as well as administering antidotes or other medications ordered by the doctor. Nurses are responsible for monitoring the patient and recording important assessment findings. Nurses should be cognizant of the importance of careful monitoring of drug levels.

Another important assessment done by the nurse, either in the emergency room or on the psychiatric unit, is the evaluation of patient support systems. A deliberate overdose can be a devastating event for the entire family, and the nurse can help foster communication between the patient and family members. When a family tries to minimize the intentional overdose, the nurse must strongly emphasize that any suicidal threat or act ought to be regarded as critical.

Prevention

To protect children from accidental drug overdose, all medications should be stored in containers with child-resistant caps. All drugs should be out of sight and out of reach of children, preferably in a locked cabinet. The person to whom medication is prescribed should take it according to the directions. Threats of suicide need to be taken seriously, and appropriate help sought for people with depression or other mental illness that may lead to suicide.

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Lori Beck

Oxygen chamber therapy see **Ventilation assistance**

Oxygen mask application see **Nasal cannula/face mask application**

Oxygen therapy

Definition

Oxygen may be classified as an element, a gas, and a drug. Oxygen therapy is the administration of oxygen at concentrations greater than that in room air to treat or prevent hypoxia. Oxygen delivery systems are classified as stationary, portable, or ambulatory, and oxygen can be administered by mask, nasal cannula, and tent. Hyperbaric oxygen therapy involves placing the patient in an airtight chamber with oxygen under pressure.

Purpose

The body is constantly taking in oxygen and releasing carbon dioxide. If this process is inadequate, oxygen levels in the **blood** decrease, and the patient may need supplemental oxygen. Oxygen therapy is a key treatment in respiratory care. The purpose is to increase oxygen saturation in tissues where the saturation levels are too low due to illness or injury. Oxygen therapy is frequently ordered in the **home care** setting, as well as in acute care.

Some of the conditions that oxygen therapy is used for include:

- documented hypoxemia
- severe respiratory distress (e.g., acute **asthma** or **pneumonia**)
- severe trauma
- acute **myocardial infarction**
- short-term therapy, such as post-anesthesia recovery

Hyperbaric oxygen therapy is used in the following conditions:



A doctor communicates with a patient lying in a pressure chamber and undergoing hyperbaric oxygen therapy.

(James King-Holmes/Science Photo Library. Photo Researchers, Inc.)

- gas gangrene
- decompression sickness
- air embolism
- smoke inhalation
- carbon monoxide poisoning
- cerebral hypoxic event

Precautions

Oxygen supports combustion, therefore no open flame or products that are combustible should be permitted when oxygen is in use. These include petroleum jelly, oils, and aerosol sprays. A spark from a cigarette, electric razor, or other electrical device could easily ignite oxygen-saturated hair or bedclothes around the patient. Explosion-proof plugs should be used for vaporizers and humidifier attachments.

Care must be taken with oxygen equipment used in the home or hospital. Cylinders should be kept in carts, or have collars for safe storage. If not stored in a cart, smaller canisters may be lain on the floor. Knocking cylinders together can cause sparks, so bumping them

should be avoided. In the home, the oxygen source must be placed at least 6 ft (1.8 m) away from flames or other sources of ignition, such as a lit cigarette. Oxygen tanks should be kept in a well-ventilated area. Oxygen tanks should not be kept in the trunk of a car. Use “No Smoking—Oxygen in Use” signs to warn visitors not to smoke near the patient.

Special care must be given when administering oxygen to **premature infants**, because of the danger of high oxygen levels causing retinopathy of prematurity or contributing to the construction of ductus arteriosus. PaO₂ (partial pressure of oxygen) levels greater than 80 mm Hg should be avoided.

Patients who are undergoing a laser **bronchoscopy** should have concurrent administration of supplemental oxygen to avoid **burns** to the trachea.

Description

The procedure discussed is the administration of oxygen therapy other than with mechanical **ventilators** and hyperbaric chambers.

In the hospital, oxygen is supplied to each patient room and is available via an outlet in the wall. Oxygen is delivered from a central source through a pipeline in the facility. A flow meter attaches to the wall outlet to access the oxygen. A valve regulates the oxygen flow and attachments may be connected to moisturize the oxygen flow. In the home, the oxygen source is usually an oxygen canister or an air compressor. Whether in home or hospital, plastic tubing connects the oxygen source to the patient. Oxygen is most commonly delivered to the patient via a nasal cannula or mask attached to the tubing. Another delivery option is transtracheal oxygen therapy, which involves a small flexible catheter inserted in the trachea or windpipe through a tracheostomy tube. In this method, the oxygen bypasses the mouth, nose, and throat, and a humidifier is required at flow rates of 2.1 pt (1 l) per minute and above. Other oxygen delivery methods include tents and specialized infant oxygen delivery systems.

Preparation

A physician’s order is required for oxygen therapy except in emergency use. The need for supplemental oxygen is determined by inadequate oxygen saturation, as determined by blood gas measurements, pulse oximetry, or clinical indications. No special preparation of the patient is required to administer oxygen therapy.

Aftercare

Once oxygen therapy is initiated, periodic assessment and documentation of oxygen saturation levels is required. If the patient is using a mask or a cannula, gauze can be tucked under the tubing to prevent irritation of the cheeks or the skin behind the ears. Water-based lubricants can be used to relieve dryness of the lips and nostrils.

Complications

Complications from oxygen therapy used in appropriate situations are infrequent. Respiratory depression, oxygen toxicity, and absorption atelectasis are the most serious complications with overuse of oxygen.

Delivery equipment may present other problems. Perforation of the nasal septum as a result of using a nasal cannula and non-humidified oxygen has been reported. In addition, bacterial contamination of nebulizer and humidification systems can occur, potentially leading to the spread of pneumonia. High-flow systems that employ heated humidifiers and aerosol generators, especially when used by patients with artificial airways, also pose a risk of **infection**.

Results

The patient demonstrates adequate oxygenation through pulse oximetry, **blood gases**, and clinical observation. Signs and symptoms of inadequate oxygenation include **cyanosis**, drowsiness, confusion, restlessness, **anxiety**, or slow, shallow, difficult, or irregular breathing. Patients with obstructive airway disease may exhibit “aerophagia” or “air hunger,” as they work to pull air into the **lungs**. In cases of carbon monoxide inhalation, the oxygen saturation can be falsely elevated.

Health care team roles

Team members include the physician, nurse, and respiratory therapist. **Respiratory therapy** technicians and nursing assistants who are adequately trained may check and document that oxygen therapy is being used appropriately and the oxygen flow is as ordered.

- Physicians are responsible for ordering oxygen therapy. The prescription must include the flow rate and when the patient will need to use the oxygen.
- Nurses are responsible for assessing patients, ensuring that oxygen therapy is initiated as prescribed, monitoring oxygen delivery systems, and recommending changes in therapy.

KEY TERMS

Combustion—Burning or fire. Objects that are combustible ignite easily.

Cyanosis—Blue, gray, or dark purple discoloration of the skin caused by a deficiency of oxygen.

Flow meter—Device for measuring the rate of a gas, especially oxygen, or liquid.

Hypoxic—Oxygen deficient.

Oxygen—A non-metallic element occurring free in the atmosphere as a colorless, odorless, tasteless gas.

Oxygenation—Saturation with oxygen.

- Respiratory therapists may assess patients, initiate and monitor oxygen delivery systems, and recommend changes in therapy.

Patient education

Patient education involves instructing patients regarding the safe use of oxygen. Patients must be advised not to change the flow rate of oxygen unless directed to do so by the physician. Patients in the home setting are directed to notify the suppliers when replacement oxygen supplies are needed.

A physician should be notified and emergency services may be required if the following develop:

- frequent headaches
- anxiety
- cyanotic (blue) lips or fingernails
- drowsiness
- confusion
- restlessness
- slow, shallow, difficult, or irregular breathing

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American Lung Association 1740 Broadway, New York, NY 10019-4374. (800) LUNG-USA. <<http://www.lungusa.org>>.

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Oxytocin see **Uterine stimulants**

P

Pacemakers

Definition

A pacemaker is an implantable electronic device that delivers electrical stimulation to the **heart** to help regulate its beat.

Purpose

Pacemakers are used to correct abnormal rhythms of the heart, most notably, brachycardia, an abnormally slow heartbeat. Normal heartbeat is 60 to 100 beats per minute (bpm) and brachycardia occurs anywhere below 60. One cause of brachycardia is when the natural pacemaker of the heart, the sinoatrial (SA) node, does not function. Known as sick sinus syndrome, signals from the node are always slow or do not accelerate to accommodate **exercise** or **stress**. Considered a part of the normal aging process, this syndrome results in a heartbeat that is too slow to circulate enough **blood** to meet the needs of the body. Symptoms include fatigue, activity intolerance, or even unconsciousness (also known as **syncope**). Pacemakers cure this condition by providing the needed electrical stimulus when the SA node does not work.

Pacemakers can also be used to treat a condition known as heart block. This problem occurs when the electrical connection between the upper chambers of the heart (atria) and lower chambers of the heart (ventricles) either fails or is significantly slowed. The area of the heart where this signal travels is called the atrio-ventricular (AV) node. The ventricles, without other stimulus, will produce their own beat of about 20 to 40 bpm, which is insufficient to support the body. Accordingly, patients with this problem feel tired and can lose consciousness. A pacemaker can treat this condition by keeping the heart rate within the normal range.

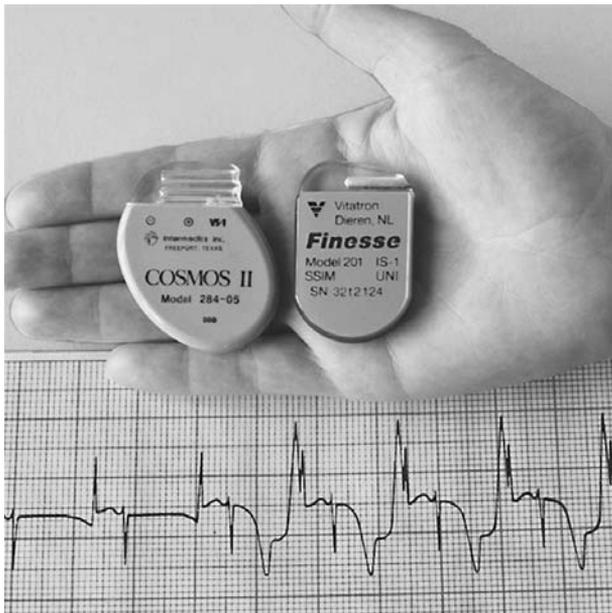
Patients that have brachycardia or heart block are at high risk for developing a tendency to have very fast,

very inefficient contractions of the atria known as atrial fibrillation. A pacemaker that senses this abnormal rhythm and can switch to a mode of firing that brings it under control has been developed. Once the defibrillation has stopped, the pacemaker automatically switches back to its usual mode of function.

Description

The two main parts of a pacemaker are the pulse generator and the leads. The pulse generator is made of a computer chip, other electronic circuitry, and a lithium battery, all enclosed in a titanium case about the size of three to four stacked fifty-cent pieces. There can be one or two leads that carry the electrical impulse produced by the generator to the heart. The generator works by sensing whether the heart is firing at the right rate and supplying the electrical signal needed to start the heartbeat if it is not. The leads are flexible, double insulated wires that are placed within the heart chambers so that the needed signal is supplied to the area of the heart as needed. The leads can be unipolar, where the implanted tip is the negative pole (the positive is the pacemaker case) or bipolar where both the negative and positive poles are in the tip. Because the electrical signal has to travel across the chest with unipolar leads, pacemakers with leads of this type are more susceptible to outside interference.

If the pacemaker has one lead, it is known as a single chamber pacemaker. The lead can be placed in either the right atrium or the right ventricle. This type of device can be used only if the signal from the SA node or the AV node is the problem, and all other electrical conduction in the patient's heart is working correctly. Patients with this type of pacemaker can sometimes feel an uncomfortable neck throbbing, chest fullness or faintness when the device fires, known as pacemaker syndrome. Because of this problem, and the general ability to pump a greater volume of blood, some patients are treated with a dual chamber system.



Two types of pacemakers. (Photograph by Eamonn McNulty. National Audubon Society Collection/Photo Researchers, Inc. Reproduced by permission.)

The dual chamber pacemaker has two leads, one that is implanted in the right atrium, and one in the right ventricle. These pacemakers are also called sequentially pacing because the electrical signal is produced in a sequence—first to the atrium, then to the ventricle. The signal generators in dual chamber systems evaluate the heart's own electrical production in both chambers and produce their own signal when either or both become inadequate.

A third type of pacemaker is a rate-responsive system. These devices have the ability to sense physical activity and alter the heart rate to accommodate it. The responsiveness of this system results from one or more types of sensors. Some conditions that are sensed include motion, depth and rate of breathing, and blood temperature. As any of these conditions increase, the pacemaker speeds the rate of firing. Rate-responsive pacemakers most closely mimic the way the heart works naturally.

To help treat patients who have atrial fibrillation, pacemakers have been developed that can switch how they work to treat the rapid abnormal heart beat, then return to the normal function.

Operation

Installing a pacemaker is a relatively minor surgical procedure that generally takes about an hour. It is often performed by an electrophysiologist, a specialized cardiologist, or surgeon. Under **local anesthesia**, a small inci-

sion is made under the collarbone, then the lead or leads are threaded through the subclavian vein into the heart's right side. Fluoroscopy, a type of x ray that involves projecting an image on a fluorescent screen, is used to guide the process and requires the wearing of a lead apron during operation. Often, right-handed patients have their pacemaker put in their left side and vice versa to speed return to normal activities.

Once the leads are in place, tests are performed to make sure the placement provides the needed connection for pacing. If the signals from the leads on the heart are too weak, the tip may have been placed in dead heart tissue and may need to be repositioned. The connection can be attached to the surface of the heart by a small corkscrew, known as active fixation, or a tined tip, known as passive fixation. With either passive or active fixation, a layer of fibrin (a blood protein) matures the lead connection within six weeks of the installation.

Next, the pulse generator is embedded into a pocket under the skin of the chest and the leads are connected. At this point the pulse generator has to be checked to make sure it is functioning correctly using a pacemaker system analyzer (PSA), a computer which checks the device is working correctly. If all checks out, the skin is sutured in place and a dressing placed over the wound.

Fine tuning of the pacemaker settings will occur in the recovery room using a programmer, a special computer equipped with a wand that is placed on the patient's chest over the pacemaker. The programmer and the pacemaker communicate in a method similar to a television remote control. Two important variables in this programming are the pacemaker's capture and sensing. Capture refers to the voltage and pulse width of the electrical signal the device will deliver. The programming is set to ensure that the capture is set high enough that two to three times the threshold (minimum) voltage necessary is delivered, called the margin of safety. However, the capture should not be so high as to unnecessarily drain the battery and require earlier replacement of the device.

Sensing involves the ability of the pacemaker to detect signals coming from the patient's heart and to shut itself off until a predetermined interval passes without a signal. Pacemakers see the heart signals much like an implanted **electrocardiography unit**. Poor sensing is what causes the pacemaker syndrome often seen with single chamber pacemakers. For proper sensing, the leads need to be adjusted so that the intra-cardial signals are seen at the highest voltage possible. This allows the sensitivity of the pacemaker to be set at a lower level. If the sensitivity has to be turned up too much, chest muscle activity could interfere with the heart signal.

Most patients stay in the hospital for one to two days after implantation, but some can leave the same day.

Safety

Once the pacemaker is installed environmental conditions can affect the functioning of the unit. These include:

- strong electromagnetic fields, such as those used in arc-welding
- contact sports
- shooting a rifle from that shoulder
- cell phones used on that side of the body
- some medical tests such as **magnetic resonance imaging (MRI)**

Environmental conditions often erroneously thought to affect pacemakers include:

- microwave ovens (the waves only affect old, unshielded pacemakers)
- airport security (although metal detector alarms could be set off—patients should carry a card stating they have a pacemaker implanted)

Maintenance

In general, if the condition of the patient's heart, drug intake, and metabolic condition remain the same, the pacemaker requires only periodic checking every two months or so for battery strength and function. This is done by placing a special device over the pacemaker that allows signals to be sent over the telephone to the doctor, a process called trans-telephonic monitoring.

If changes in medications or physical condition occur, the doctor can adjust the pacemaker settings using a programmer, which involves placing the wand above the pacemaker and remotely changing the internal settings.

Drugs taken by the patient and metabolic conditions affect both capture and sensing thresholds. For example, drugs such as ephedrine or glucocosteroids cause lower thresholds, while some anti-arrhythmics cause higher thresholds. Hyperoxia (an excess of oxygen in the system) and hypocapnia (a deficiency of carbon dioxide) are two metabolic conditions that can lower thresholds and acidosis (an accumulation of acid in the body) or alkalosis (an accumulation of base in the body) can cause higher thresholds. Reprogramming of the pacemaker can accommodate the new capture and sensing values needed.

When the periodic testing indicates that the battery is getting low, an elective pacemaker replacement operation is scheduled. The entire signal generator is replaced because the batteries are sealed within the case. The leads

KEY TERMS

Atrial fibrillation—An abnormal rhythm of the heart characterized by rapid, nonproductive contractions of the atria.

Brachycardia—A diseased condition of the heart characterized by an abnormally slow heartbeat.

Dual chamber—A type of pacemaker having two leads that are placed in the right atria and the right ventricle.

Electrophysiologist—A specially trained physician or cardiologist specializing in the treatment and study of disorders of the heart's electrical conduction system.

Fluoroscopy—A special type of x ray where images are projected on a fluorescent screen. Used to guide lead placement in pacemaker installations.

Single chamber—A type of pacemaker having one lead that is placed either in the right atria or the right ventricle.

Subclavian vein—The large vein in the chest that pacemaker leads are threaded through to be implanted in the right atria or ventricle.

Trans-telephonic monitoring—A method of checking on the function and battery strength of a pacemaker involving a special device that allows signals from an implanted pacemaker to be communicated to health care personnel using the telephone lines.

can often be left in place and reattached to the new generator. Batteries usually last about six to eight years.

Health care team roles

Electrophysiologists are specially trained cardiologists who study and treat problems with the heart conduction system. They are often the type of physician that will implant the pacemaker system and oversee the programming or reprogramming of the device. They are assisted in the operating room by specially trained nurses, who can help with the testing of the pacemaker, and the anesthesiologist, who is responsible for numbing the area of the incision and keeping the patient comfortable. Pacemaker manufacturers often send representatives to be present for the implantation and initial programming.

The maintenance of the pacemaker can be overseen by the electrophysiologist or cardiologist and their staff,

which can include specially trained cardiac medical assistants as well as nurses.

Training

The training for pacemakers and their use occurs during medical training (medical or nursing school) and on the job. Physicians, nurses, and other allied health professionals can also receive training in pacemakers as part of their continuing education courses. Such training often focuses on a particular aspect of pacemaker use, such as diagnosing problems in persons having pacemakers implanted, the installation of transient pacing, or the treatment of fibrillation or **heart failure** with pacemakers.

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Michelle L. Johnson, M.S., J.D.

Packed cell volume see **Hematocrit**

Packed red blood cell volume see **Hematocrit**

Pain

Definition

Pain, medically termed "nociception," is a response to noxious stimuli that is conveyed to the **brain** by sensory **neurons**. The discomfort signals actual or impending injury to the body. However, pain is more than a sensation, or the physical awareness of pain; it also includes

perception, the subjective interpretation of the discomfort. Perception gives information on the pain's location, intensity, and something about its nature. The various conscious and unconscious responses to both sensation and perception, including the emotional response, add further definition to the overall concept of pain.

Description

Pain arises from any number of situations. Injury is a major cause, but pain may also arise from an illness. It may accompany a psychological condition, such as depression, or may even occur in the absence of a recognizable trigger.

Acute pain

Acute pain often results from tissue damage, such as a skin burn or broken bone, but it may also be a warning of impending damage, such as angina or the pain associated with **appendicitis** or the body's attempt to pass a kidney stone. Acute pain is also associated with severe headaches (such as migraines) or muscle cramps. This latter pain usually goes away as the injury heals or the cause of the pain (stimulus) is removed.

To understand acute pain, it is necessary to understand the nerves that support it. Nerve cells, or neurons, perform many functions in the body. Although their general purpose—to provide an interface between the brain and the body—remains constant, their capabilities vary widely. Certain types of neurons are capable of transmitting a pain signal to the brain.

As a group, these pain-sensing neurons are called nociceptors, and virtually every surface and organ of the body is wired with them. The central part of these cells is located in the spine, and they send threadlike projections to every part of the body. Nociceptors are classified according to the stimulus that prompts them to transmit a pain signal. Thermoreceptive nociceptors are stimulated by temperatures that are potentially tissue damaging. Mechanoreceptive nociceptors respond to a pressure stimulus that may cause injury. Polymodal nociceptors are the most sensitive and can respond to temperature and pressure. Polymodal nociceptors also respond to chemicals released by the cells in the area from which the pain originates.

Nerve-cell endings, or receptors, are at the front end of pain sensation. A stimulus at this part of the nociceptor unleashes a cascade of neurotransmitters (chemicals that transmit information within the nervous system) in the spine. Each neurotransmitter has a purpose. For example, substance P relays the pain message to nerves leading to the **spinal cord** and brain. These neurotrans-

mitters may also stimulate nerves leading back to the site of the injury. This response prompts cells in the injured area to release chemicals that not only trigger an **immune response**, but also influence the intensity and duration of the pain.

Chronic and other types of pain

Chronic pain refers to pain that persists after an injury is apparently healed, **cancer** pain, pain related to a persistent or degenerative disease, and long-term pain from an unidentifiable cause. It is estimated that one in three people in the United States will experience chronic pain at some point in their lives. Of these people, approximately 50 million are either partially or completely disabled by the pain and its cause.

Chronic pain may be caused by the body's response to acute pain. In the presence of continued stimulation of nociceptors, changes occur within the nervous system. Changes at the molecular level are dramatic and may include alterations in genetic transcription of neurotransmitters and receptors. These molecular or cellular changes may also occur in the absence of an identifiable cause; one of the frustrating aspects of chronic pain is that the stimulus may be unknown. For example, the stimulus cannot be identified in as many as 85% of individuals suffering lower-back pain.

Other types of pain include allodynia, hyperalgesia, and phantom-limb pain. These pain categories are neuropathic, indicating damage to the nervous system. Allodynia is a feeling of pain in response to a normally harmless stimulus. For example, some individuals who have suffered nerve damage as a result of viral **infection** (like herpes zoster) experience unbearable pain from just the light weight of their clothing. Hyperalgesia is somewhat related to allodynia in that the response to a painful stimulus is extreme. In this case, a mild pain stimulus, such as a pin prick, causes a maximum pain response. Phantom-limb pain occurs after a limb has been amputated; although an individual is missing the limb, the nerve pathways may still perceive pain as originating from the absent extremity, on an intermittent basis.

Causes and symptoms

Pain is the most common symptom of injury and disease, and descriptions can range in intensity from a dull ache to sharp, knifelike or burning pain. Nociceptors have the ability to convey information to the brain that indicates the location, nature, and intensity of the pain. For example, stepping on a nail sends an information-packed message to the brain; the foot has experienced a puncture wound that hurts a lot, at which point (almost simultaneously) the message goes back to the foot and

leg to move or change placement immediately, to get away from the stimulus (nail). This has been termed a “knee-jerk reaction.”

Pain perception also varies depending on the location of the pain. The kinds of stimuli that cause a pain response on the skin include pricking, cutting, crushing, burning, scraping (skin layers removed), and freezing. These same stimuli would not generate much of a response in the intestine. Intestinal pain arises from stimuli such as swelling, inflammation, distension, and diminished **blood** supply (tissue hypoxia).

Diagnosis

The assessment of pain is subjective and is weighed in relation to other symptoms and individual experiences when trying to determine the source of the pain. An observable injury, such as a broken bone, may be a clear indicator of the type of pain a person is suffering. Determining the specific cause of internal pain is more difficult. Other symptoms, such as **fever** or nausea, help to refine and focus attention to more specific possibilities. In some cases, such as lower-back pain, a specific cause may not be identifiable without image assessment, such as by x ray or CT scan. Diagnosis of the disease or disorder causing a specific pain is further complicated by the fact that pain can be referred, manifesting farther along the pathway than the origin might suggest. For example, pain arising from fluid accumulating at the base of the lung may be referred, with the patient experiencing pain in the shoulder area. In addition, there is the pain (usually muscular) that results from “guarding” against the original pain source. For instance, a rotator-cuff shoulder injury causes acute pain, but it may be associated with muscular pain of the neck and upper back, the result of the body's attempt to either protect itself or get away from sharp pain.

Since pain is a subjective experience, it may be very difficult for the patient to communicate its exact quality and intensity to the nurse or doctor. There are no diagnostic tests that can determine the quality or intensity of an individual's pain. Therefore, a medical examination will include many questions about where the pain is located, its intensity, and its nature (type of pain). Questions are also directed to determining the things that increase or relieve the pain, how long the pain has lasted, and whether there are any variations in it. An individual may be asked to use a pain scale to describe the pain. One such scale assigns a number to the pain intensity; for example, 0 may indicate no pain, and 10 may indicate the worst pain the person has ever experienced. Scales are modified by using faces for infants and children to accommodate their level of comprehension.

Treatment

There are many drugs aimed at preventing or treating pain. Nonopioid **analgesics**, narcotic analgesics, anticonvulsant drugs, and tricyclic antidepressants work by blocking the production, release, or uptake of selected neurotransmitters. Drugs from different classifications may be combined to alleviate specific types of pain.

Nonopioid analgesics include common over-the-counter medications such as aspirin, acetaminophen (Tylenol), and ibuprofen (Advil). These are most often used for minor pain, but there are some prescription-strength medications in this classification. These drugs are called **nonsteroidal anti-inflammatory drugs** (NSAIDs) and relieve pain by reducing inflammation.

Narcotic analgesics are available legally only with a prescription and are used for the relief of severe pain, such as postoperative pain from major surgery, or cancer pain. These drugs include codeine, morphine, meperidine, and methadone. Contrary to earlier beliefs, addiction to these medications is not common; people who genuinely need these drugs for pain control typically do not become addicted, because the drugs are usually given for only a short period of time, with the exception of cancer-pain relief.

Anticonvulsants as well as **antidepressant drugs** were initially developed to treat seizures and depression, respectively. However, it was discovered that these drugs also have pain-killing applications. Furthermore, in cases of chronic or extreme pain, it is not unusual for an individual to suffer some degree of depression; therefore, antidepressants may serve a dual role. Commonly prescribed anticonvulsants for pain include phenytoin, carbamazepine, and clonazepam. Tricyclic antidepressants include doxepin, amitriptyline, and imipramine.

Intractable (unrelenting) pain may be treated by injections directly into or near the main nerve supply that is transmitting the pain signal. One class of medications used in this way is **corticosteroids**. These are powerful anti-inflammatory agents. Pain decreases when the inflammation subsides. In other cases, local anesthetics, such as lidocaine, are used to create a neuromuscular blockade. However, these blockades are for short-term relief only, lasting a few hours, but the result is a break in the pain-response cycle that may have been self-perpetuating. These root blocks may also be useful in determining the site of pain generation. As the underlying mechanisms of pain transmission and perception are uncovered, other pain medications are being developed.

Drugs are not always effective in controlling pain. Surgical methods are used as a last resort if analgesics and local anesthetics fail. The least destructive surgical

procedure involves implanting a device that emits low-level electrical signals. These signals disrupt the nerve and prevent it from transmitting the pain message. However, this method may not completely control pain and is not used frequently. Other surgical techniques involve destroying or severing the nerve (a procedure called a rhizotomy), but the use of this technique is limited by side effects, including residual numbness that may pose a risk for future injury.

Alternative treatment

Both physical and psychological aspects of pain can be dealt with through alternative treatment. Some of the most popular treatment options are **acupressure** and acupuncture, massage, chiropractic adjustments, and **relaxation** techniques such as **yoga**, hypnosis, and **meditation**. Herbal therapies are gaining increased recognition as viable options. For example, capsaicin, the component that makes cayenne peppers spicy, is used in ointments associated with arthritis; it serves as a counteractive or contradictory pain site—the mind focuses on it, rather than on the joint pain. Contrast **hydrotherapy** can also be very beneficial for pain relief.

Behavioral modification to incorporate a healthier diet and regular **exercise** may be of help. Aside from relieving **stress**, regular exercise has been shown to increase endorphins, pain alleviators that are naturally produced in the body.

Health care team roles

As members of the health care team, **advanced practice nurses** (A.P.N.s), registered nurses (R.N.s), and licensed practical nurses (L.P.N.s) are responsible for assessing the pain response that patients demonstrate, implementing proper pain-medication therapy, assessing the outcomes of pain therapy, documenting the patient's perception of pain severity using a pain scale, as well as describing other pain characteristics and teaching patients pain-management techniques.

Joint Commission on Accreditation of Healthcare Organizations standards

The Joint Commission on Accreditation of Healthcare Organizations (JCAHO), which is the accrediting body for all health care facilities, is focusing on auditing health care organizations on their appropriate pain-assessment and pain-management techniques by way of newly published pain standards. Health care institutions are being held accountable for outcomes of **pain management** according to the standards, and A.P.N.s, R.N.s, and L.P.N.s must be aware of these standards in

order to modify practices to meet the new regulations. The 2001 JCAHO standards are:

- to acknowledge that every patient has a right to pain evaluation and pain management
- to evaluate pain in every patient
- to do a thorough examination when the presence of pain has been identified
- to document the examination in a specific format that supports standard reexamination and review
- to establish a customary protocol for observation and management of pain
- to teach practitioners and guarantee health care team proficiency on pain-management standards
- to create guidelines that incorporate adequate dispensing of appropriate medication for pain control
- to create and implement educational materials for pain control to give to patients and families
- to address pain-control measures upon the patient's release from the facility
- to establish tools to evaluate the success of pain management

Assessing characteristics of pain

The health care team must be able to describe the characteristics of pain when identified by the patient. Subjective data should be collected. Information on the following eight variables is essential to get a clear picture of the patient's experience of pain:

- Describe the pain (sharp, dull, aching, stabbing).
- How often (constant or transient—comes and goes).
- Where (point to the exact location, does the pain radiate, or spread)?
- Intensity: Assign a number from 0 (no pain) to 10 (the worst pain you have ever had).
- How long: all the time, or episodes of seconds, minutes, hours?
- Does anything help to relieve the pain (a certain position, medication, ice, or warm compresses)?
- Does anything make it worse (a certain position, exercise)?
- Have you ever experienced this type of pain before?

Importance of pain reassessment

As the R.N. or L.P.N., assessing the outcomes of pain-management therapies is an important part of the health care role. Intravenous medications should provide relief within 10 minutes, intramuscular medications are

active within 30 to 40 minutes, and oral medication takes effect within one hour or less. Pain reassessment takes these times into consideration. Reassessment in these time frames allows accurate outcomes evaluation for pain management.

Patient education

Teaching appropriate pain-medication administration as well as informing the patient of ancillary pain-management techniques are important in **patient education**. A person in pain should understand that various medications take time to be absorbed and start working. Also, teaching relaxation techniques, such as meditation, imagery, and aromatherapy, offers measures that complement pain-medication effectiveness and may even reduce the need for medication. Many patients are afraid to take some pain medications, for fear of becoming addicted. Explaining that the appropriate use of the medication, in the dose prescribed and in direct proportion to the level of pain, will avoid the potential for addiction. Health care team members are patient advocates, and they should not allow their patient to suffer.

Prognosis

Successful pain management is dependent on successful identification of the pain's cause. Acute pain will stop when an injury heals or when an underlying condition is treated successfully. Chronic pain is more difficult to treat, and it may take longer to achieve a successful outcome. Some pain is intractable and will require extreme measures for relief.

Prevention

Pain is generally preventable only to the degree that the cause of the pain is preventable; diseases and injuries may be unavoidable. Some injuries, or reinjury, can be avoided. For example, proper muscle use and positioning when lifting heavy objects will prevent back injury. Increased pain, pain from surgery and other medical procedures, and continuing pain may be preventable through appropriate treatments and therapies.

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KEY TERMS

Acute pain—Pain in response to injury or another stimulus that resolves when the injury heals or the stimulus is removed.

Chronic pain—Pain that lasts beyond the term of an injury or painful stimulus. The term may also refer to cancer pain, pain from a chronic or degenerative disease, and pain from an unidentified cause.

Neuron—A nerve cell.

Neurotransmitters—Chemicals within the nervous system that transmit information from or between nerve cells.

Nociceptor—A neuron that is capable of sensing pain.

Referred pain—Pain felt at a site different from the location of the injured or diseased part of the body. Referred pain is due to the fact that nerve signals from several areas of the body may “feed” the same nerve pathway leading to the spinal cord and brain.

Stimulus—A factor capable of eliciting a response in a nerve.

Transient—Staying in one place only for a brief amount of time.

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Lori Beck

Paillae see **Dental anatomy**

Pain disorder see **Somatoform disorders**

Pain management

Definition

If **pain** can be defined as a highly unpleasant, individualized experience of one of the body’s defense mechanisms indicating an injury or problem, pain management encompasses all interventions used to understand and ease pain, and, if possible, to alleviate the cause of the pain.

Purpose

Pain serves to alert us to potential or actual damage to the body. The definition for damage is quite broad; pain can arise from injury as well as disease. After the message is received and interpreted, further pain can be counter-productive. Pain can have a negative impact on a person’s quality of life and impede recovery from illness or injury, thus contributing to escalating health care costs. Unrelieved pain can become a syndrome in its own right and cause a downward spiral in a person’s health and outlook. Managing pain properly facilitates recovery, prevents additional health complications, and improves an individual’s quality of life.

Yet the experiencing of pain is a completely unique occurrence for each person, a complex combination of several factors other than the pain itself. It is influenced by:

- Ethnic and cultural values. In some cultures tolerating pain is related to showing strength and endurance. In others, it is considered punishment for misdeeds.
- Age. The concept that grownups don’t cry.
- Anxiety and **stress** related to being in a strange, fearful place such as a hospital, fear of the unknown consequences of the pain and the condition causing it can all make pain feel more severe.
- Fatigue and depression. It is known that pain in itself can actually cause depression. Fatigue from lack of sleep or the illness itself also contribute to depressed feelings.

Precautions

As noted, the perception of pain is an individual experience. Health care providers play an important role in understanding their patients' pain. All too often, both physicians and nurses have been found to incorrectly assess the severity of pain. A study reported in the *Journal of Advanced Nursing* evaluated nurses' perceptions of a select group of American-born and Mexican-American women patients' pain following **gallbladder** surgery. Objective assessments of each patient's pain showed little difference between the severity for each group. Yet nurses involved in the study consistently rated all patients' pain as less than the patients reported, and with equal consistency, believed that better-educated women born in the United States were suffering more than less educated, Mexican-American women. Nurses from a Northern European background were more apt to minimize the severity of pain than nurses from Eastern and Southern Europe or Africa. Health care staff, and especially nursing staff, need to be aware of how their own background and experience contributes to how they perceive a person's pain.

Description

Before considering pain management, a review of pain definitions and mechanisms may be useful. Pain is the means by which the peripheral nervous system (PNS) warns the **central nervous system** (CNS) of injury or potential injury to the body. The CNS comprises the **brain** and **spinal cord**, and the PNS is composed of the nerves that stem from and lead into the CNS. PNS includes all nerves throughout the body except the brain and spinal cord. Pain is sometimes categorized by its site of origin, either cutaneous (originating in the skin of subcutaneous tissue, such as a shaving nick or paper cut), deep somatic pain (arising from bone, ligaments and tendons, nerves, or veins and arteries), or visceral (appearing as a result of stimulation of pain receptor nerves around organs such as the brain, **lungs**, or those in the abdomen).

A pain message is transmitted to the CNS by special PNS nerve cells called nociceptors. Nociceptors are distributed throughout the body and respond to different stimuli depending on their location. For example, nociceptors that extend from the skin are stimulated by sensations such as pressure, temperature, and chemical changes.

When a nociceptor is stimulated, neurotransmitters are released within the cell. Neurotransmitters are chemicals found within the nervous system that facilitate nerve cell communication. The nociceptor transmits its signal to nerve cells within the spinal cord, which con-

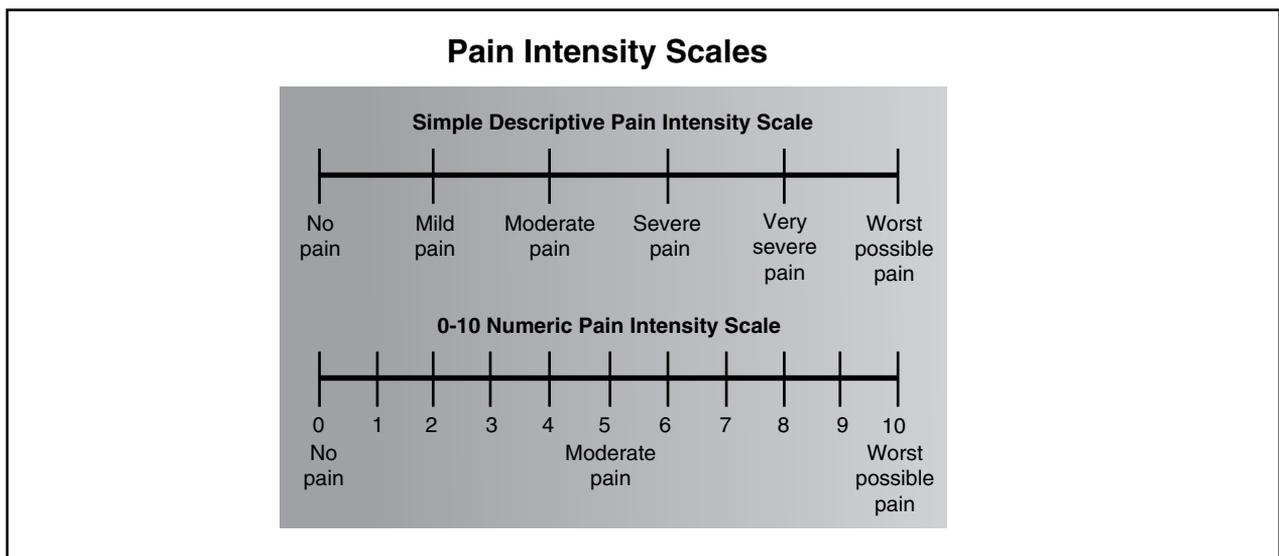
veys the pain message to the thalamus, a specific region in the brain.

Once the brain has received and processed the pain message and coordinated an appropriate response, pain has served its purpose. The body uses natural painkillers, called endorphins, to derail further pain messages from the same source. However, these natural painkillers may not adequately dampen a continuing pain message. Also, depending on how the brain has processed the pain information, certain hormones, such as prostaglandins, may be released. These hormones enhance the pain message and play a role in **immune system** responses to injury, such as inflammation. Certain neurotransmitters, especially substance P and calcitonin gene-related peptide, actively enhance the pain message at the injury site and within the spinal cord.

Pain is generally divided into two additional categories, acute and chronic. Nociceptive pain, or the pain that is transmitted by nociceptors, is typically called acute pain. This kind of pain is associated with injury, headaches, disease, and many other conditions. Response to acute pain is made by the sympathetic nervous system (the nerves responsible for the fight or flight response of the body). It normally resolves once the condition that precipitated it is resolved.

Following some disorders, pain does not resolve. Even after healing or a cure has been achieved, the brain continues to perceive pain. In this situation, the pain may be considered chronic. Chronic pain is within the province of the parasympathetic nervous system, and the changeover occurs as the body attempts to adapt to the pain. The time limit used to define chronic pain typically ranges from three to six months, although some health-care professionals prefer a more flexible definition, and consider chronic pain as pain that endures beyond a normal healing time. The pain associated with **cancer**, persistent and degenerative conditions, and neuropathy, or nerve damage, is included in the chronic category. Also, unremitting pain that lacks an identifiable physical cause, such as the majority of cases of low back pain, may be considered chronic. The underlying biochemistry of chronic pain appears to be different from regular nociceptive pain.

It has been hypothesized that uninterrupted and unrelenting pain can induce changes in the spinal cord. In the past, severing a nerve's connection to the CNS has treated intractable pain. However, the lack of any sensory information being relayed by that nerve can cause pain transmission in the spinal cord to go into overdrive, as evidenced by the phantom limb pain experienced by amputees. Evidence is accumulating that unrelenting pain or the complete lack of nerve signals increases the



Pain intensity scales. (Public domain.)

number of pain receptors in the spinal cord. Nerve cells in the spinal cord may also begin secreting pain-amplifying neurotransmitters independent of actual pain signals from the body. Immune chemicals, primarily cytokines, may play a prominent role in such changes.

Managing pain

Considering the different causes and types of pain, as well as its nature and intensity, management can require an interdisciplinary approach. The elements of this approach include treating the underlying cause of pain, pharmacological and nonpharmacological therapies, and some invasive (surgical) procedures.

Treating the cause of pain underpins the idea of managing it. Injuries are repaired, diseases are diagnosed, and certain encounters with pain can be anticipated and treated prophylactically (by prevention). However, there are no guarantees of immediate relief from pain. Recovery can be impeded by pain and quality of life can be damaged. Therefore, pharmacological and other therapies have developed over time to address these aspects of disease and injury.

PHARMACOLOGICAL OPTIONS. General guidelines developed by the World Health Organization (WHO) have been developed for pain management. These guidelines operate upon a three-step ladder approach:

- Mild pain is alleviated with acetaminophen or a nonsteroidal anti-inflammatory drug (NSAID). NSAIDs and acetaminophen are available as over-the-counter and prescription medications, and are frequently the initial pharmacological treatment for pain. These drugs can

also be used as adjuncts to the other drug therapies that might require a doctor's prescription. NSAIDs include aspirin, ibuprofen (Motrin, Advil, Nuprin), naproxen sodium (Aleve), and ketoprofen (Orudis KT). These drugs are used to treat pain from inflammation and work by blocking production of pain-enhancing neurotransmitters, such as prostaglandins. Acetaminophen is also effective against pain, but its ability to reduce inflammation is limited. NSAIDs and acetaminophen are effective for most forms of acute (sharp, but of a short course) pain.

- Mild to moderate pain is eased with a milder opioid medication plus acetaminophen or NSAIDs. Opioids are both actual opiate drugs such as morphine and codeine, and synthetic drugs based on the structure of opium. This drug class includes drugs such as oxycodone, methadone, and meperidine (Demerol). They provide pain relief by binding to specific opioid receptors in the brain and spinal cord.
- Moderate to severe pain is treated with stronger opioid drugs plus acetaminophen or NSAIDs. Morphine is sometimes referred to as the gold standard of palliative care as it is not expensive, can be given starting with smaller doses and gradually increased, and is highly effective over a long period of time. It can also be given by a number of different routes, including by mouth, rectally, or by injection.

Although **antidepressant drugs** were developed to treat depression, it has been discovered that they are also effective in combating chronic headaches, cancer pain, and pain associated with nerve damage. Antidepressants that have been shown to have analgesic (pain-reducing)

properties include amitriptyline (Elavil), trazodone (Desyrel), and imipramine (Tofranil). Anticonvulsant drugs share a similar background with antidepressants. Developed to treat epilepsy, anticonvulsants were found to relieve pain as well. Drugs such as phenytoin (Dilantin) and carbamazepine (Tegretol) are prescribed to treat the pain associated with nerve damage.

Close monitoring of the effects of pain medications is required in order to assure that adequate amounts of medication are given to produce the desired pain relief. When a person is comfortable with a certain dosage of medication, oncologists typically convert to a long-acting version of that medication. Transdermal fentanyl patches (Duragesic) are a common example of a long-acting opioid drug often used for cancer pain management. A patch containing the drug is applied to the skin and continues to deliver the drug to the person for typically three days. Pumps are also available that provide an opioid medication upon demand when the person is experiencing pain. By pressing a button, they can release a set dose of medication into an intravenous solution or an implanted catheter. Another mode of administration involves implanted catheters that deliver pain medication directly to the spinal cord. Delivering drugs in this way can reduce side effects and increase the effectiveness of the drug. Research is underway to develop toxic substances that act selectively on nerve cells that carry pain messages to the brain, killing these selected cells and thus stopping transmission of the pain message.

NONPHARMACOLOGICAL OPTIONS. Pain treatment options that do not use drugs are often used as adjuncts to, rather than replacements for, drug therapy. One of the benefits of non-drug therapies is that an individual can take a more active stance against pain. **Relaxation** techniques, such as **yoga** and **meditation**, are used to focus the brain elsewhere than on the pain, decrease muscle tension and reduce stress. Tension and stress can also be reduced through biofeedback, in which an individual consciously attempts to modify skin temperature, muscle tension, **blood pressure**, and **heart rate**.

Participating in normal activities and exercising can also help control pain levels. Through **physical therapy**, an individual learns beneficial exercises for reducing stress, strengthening muscles, and staying fit. Regular **exercise** has been linked to production of endorphins, the body's natural pain killers.

Acupuncture involves the insertion of small needles into the skin at key points. **Acupressure** uses these same key points, but involves applying pressure rather than inserting needles. Both of these methods may work by prompting the body to release endorphins. Applying heat or being massaged are very relaxing and help reduce

stress. Transcutaneous electrical nerve stimulation (TENS) applies a small electric current to certain parts of nerves, potentially interrupting pain signals and inducing release of endorphins. To be effective, use of TENS should be medically supervised.

INVASIVE PROCEDURES. There are three types of invasive procedures that may be used to manage or treat pain: anatomic, augmentative, and ablative. These procedures involve surgery, and certain guidelines should be followed before carrying out a procedure with permanent effects. First, the cause of the pain must be clearly identified. Next, surgery should be done only if noninvasive procedures are ineffective. Third, any psychological issues should be addressed. Finally, there should be a reasonable expectation of success.

Anatomic procedures involve correcting the injury or removing the cause of pain. Relatively common anatomic procedures are decompression surgeries, such as repairing a **herniated disk** in the lower back or relieving the nerve compression related to **carpal tunnel syndrome**. Another anatomic procedure is neurolysis, also called a nerve block, which involves destroying a portion of a peripheral nerve.

Augmentative procedures include electrical stimulation or direct application of drugs to the nerves that are transmitting the pain signals. Electrical stimulation works on the same principle as TENS. In this procedure, instead of applying the current across the skin, electrodes are implanted to stimulate peripheral nerves or nerves in the spinal cord. Augmentative procedures also include implanted drug-delivery systems. In these systems, catheters are implanted in the spine to allow direct delivery of drugs to the CNS.

Ablative procedures are characterized by severing a nerve and disconnecting it from the CNS. However, this method may not address potential alterations within the spinal cord. These changes perpetuate pain messages and do not cease even when the connection between the sensory nerve and the CNS is severed. With growing understanding of neuropathic pain and development of less invasive procedures, ablative procedures are used less frequently. However, they do have applications in select cases of peripheral neuropathy, cancer pain, and other disorders.

Preparation

Prior to beginning management, pain is thoroughly evaluated. Pain scales or questionnaires are used to attach an objective measure to a subjective experience. Objective measurements allow health care workers a better understanding of the pain being suffered by the patient.

KEY TERMS

Acute—Referring to pain in response to injury or other stimulus that resolves when the injury heals or the stimulus is removed.

Chronic—Referring to pain that endures beyond the term of an injury or painful stimulus. Can also refer to cancer pain, pain from a chronic or degenerative disease, and pain from an unidentified cause.

CNS or central nervous system—The part of the nervous system that includes the brain and the spinal cord.

Iatrogenic—Resulting from the activity of the physician.

Neuropathy—Nerve damage.

Neurotransmitter—Chemicals within the nervous system that transmit information from or between nerve cells.

Nociceptor—A nerve cell that is capable of sensing pain and transmitting a pain signal.

Nonpharmacological—Referring to therapy that does not involve drugs.

Parasympathetic nervous system—Pertaining to that part of the autonomic nervous system consisting of nerves that arise from the cranial and sacral regions and which oppose the action of the sympathetic nervous system.

Pharmacological—Referring to therapy that relies on drugs.

PNS or peripheral nervous system—Nerves that are outside of the brain and spinal cord.

Stimulus—A factor capable of eliciting a response in a nerve.

Sympathetic nervous system—The portion of the autonomic nervous system consisting of nerves that originate in the thoracic and lumbar spinal cord and that function in opposition to the parasympathetic nervous system.

Evaluation also includes physical examinations and diagnostic tests to determine underlying causes. Some evaluations require assessments from several viewpoints, including neurology, psychiatry and psychology, and physical therapy. If pain is due to a medical procedure, management consists of anticipating the type and intensity of associated pain and managing it preemptively.

Nurses or physicians often take what is called a *pain history*. This will help to provide important information that can help health care providers to better manage the patient's pain. A typical pain history includes the following questions:

- Where is the pain located?
- On a scale of 1 to 10, with 1 meaning the least pain, how would the person rate the pain they are experiencing?
- Describe what the pain feels like.
- When did (or does) the pain start?
- How long has the person had it?
- Is the person sometimes free of pain?
- Does the person know of anything that triggers the pain, or makes it worse?
- Does the person have other symptoms (nausea, dizziness, blurred **vision**, etc.) during or after the pain?
- What pain medications or other measures has the person found to help in easing the pain?
- How does the pain affect the person's ability to carry on normal activities?
- What does it mean to the person that they are experiencing pain?

Aftercare

An assessment by nursing staff as well as other health care providers should be made to determine the effectiveness of the pain management interventions employed. There are objective, measurable signs and symptoms of pain that can be looked for. The goal of good pain management is the absence of these signs:

Signs of acute pain:

- rise in pulse and **blood** pressure
- more rapid breathing
- perspiring profusely, clammy skin
- taut muscles
- more tense appearance, fast speech, very alert
- unusually pale skin
- pupils of the eye are dilated

Signs of chronic pain:

- lower pulse and blood pressure
- changeable breathing pattern
- skin is warm and dry
- nausea and vomiting
- slow speech in monotone

- inability, or difficulty in getting out of bed and doing activities
- pupils of the eye are constricted

When these signs are absent and the patient appears to be comfortable, health care providers can consider their interventions to have been successful. It is also important to document interventions used, and what ones were successful.

Complications

Owing to toxicity over the long term, some drugs can only be used for acute pain or as adjuncts in chronic pain management. NSAIDs have the well-known side effect of causing gastrointestinal bleeding, and long-term use of acetaminophen has been linked to kidney and **liver** damage. Other drugs, especially narcotics, have serious side effects, such as constipation, drowsiness, and nausea. Serious side effects can also accompany pharmacological therapies; mood swings, confusion, bone thinning, cataract formation, increased blood pressure, and other problems may discourage or prevent use of some **analgesics**.

Nonpharmacological therapies carry little or no risks. However, it is advised that individuals recovering from serious illness or injury consult with their health care providers or physical therapists before making use of adjunct therapies. Invasive procedures carry risks similar to other surgical procedures, such as **infection**, reaction to anesthesia, iatrogenic (injury as a result of treatment) injury, and failure.

A traditional concern about narcotics use has been the risk of promoting addiction. As narcotic use continues over time, the body becomes accustomed to the drug and adjusts normal functions to accommodate to its presence. Therefore, to elicit the same level of action, it is necessary to increase dosage over time. As dosage increases, an individual may become physically dependent on narcotic drugs.

However, physical dependence is different from psychological addiction. Physical dependence is characterized by discomfort if drug administration suddenly stops, while psychological addiction is characterized by an overpowering craving for the drug for reasons other than pain relief. Psychological addiction is a very real and necessary concern in some instances, but it should not interfere with a genuine need for narcotic pain relief. However, caution must be taken with people with a history of addictive behavior.

Results

Effective application of pain management techniques reduces or eliminates acute or chronic pain. This treatment can improve an individual's quality of life and aid in recovery from injury and disease.

Health care team roles

Physicians, both primary care physicians (PCPs) and surgeons, treat both the conditions causing the pain, and the pain itself. The physician's role as teacher is an important one, alleviating fears about both the patient's condition and the possibility of addiction to narcotics, which is often a fear among patients on narcotic medication. Some physicians specialize in the treatment of pain, and work out of pain clinics.

Registered nurses (RNs) are the professional staff member that will likely spend the most time with the patient, whether the patient is in the hospital or other health care facility, or at home. Gathering the necessary information regarding the person's pain through a pain history, and careful observation and listening can help tremendously in the provision of pain relief. RNs also administer the medications at times, and provide information to the patient about the various medications that may be used, and allay concerns about the use of them.

Licensed practical nurses (LPNs) also spend considerable time with the patient in a health care facility or at home. Like RNs, LPNs administer medications as necessary, and provide information to patients.

Pain clinic staff may be any of the above, or psychologists, social workers, occupational or recreational therapists, or other people with specific training in group therapy, yoga, meditation, or other non-pharmacological means of relieving pain.

Pharmacists fill prescriptions for pain-relieving medications, monitor the use of narcotic medications, and provide information regarding the uses and side-effects of the medications.

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American Pain Society. 4700 West Lake Ave., Glenview, IL 60025. (847) 375-4715. <<http://www.ampainsoc.org>>.

National Chronic Pain Outreach Association, Inc. P.O. Box 274, Millboro, VA 24460-9606. (540) 597-5004.

OTHER

What We Know About Pain. National Institute of Dental Research, National Institute of Health, Bethesda, MD 20892. (301) 496-4261.

Joan M. Schonbeck

Pain relievers see **Analgesics**

Pancreas

Definition

The pancreas is an organ important in digestion and **blood** sugar regulation. It is considered to be part of the gastrointestinal system. The pancreas produces digestive enzymes to be released into the **small intestine** to aid in reducing food particles to basic elements that can be absorbed by the intestine and used by the body. It has another very different function in that it forms insulin, glucagon and other hormones to be sent into the bloodstream to regulate blood sugar levels and other activities throughout the body.

Description

The pancreas is a pear-shaped organ about 6 in (15 cm) long located in the middle and back portion of the abdomen. It is connected to the first part of the small intestine, the duodenum, and lies behind the **stomach**. The pancreas is made up of glandular tissue, or cells that form substances to be secreted outside of the organ. Glandular tissues can be categorized as endocrine (secreting directly into the bloodstream or lymph) or exocrine (secreting into another organ). The pancreas is both an exocrine and an endocrine organ.

Function

Exocrine secretions

The digestive juices produced by the pancreas are secreted into the duodenum via a Y-shaped duct, at the point where the common bile duct from the **liver** and the

pancreatic duct join just before entering the duodenum. In this way, a variety of digestive enzymes (trypsin, chymotrypsin, lipase, and amylase, among others) are delivered into the small intestine to aid in the digestion of **proteins, fats, and carbohydrates**. The enzymes are delivered in an inactive form called zymogens. The zymogens are activated by the chemical substances in the small intestine. The digestive enzymes carried into the duodenum are representative of the exocrine function of the pancreas, in which specific substances are made to be passed directly into another organ.

Endocrine secretions

The pancreas is unusual among the body's glands in that it also has a very important endocrine function. Small groups of special cells called islet cells throughout the organ make such hormones as insulin and glucagon, which are critical in regulating blood sugar levels; and vasoactive intestinal peptide, which influences gastrointestinal activity. These hormones are secreted directly into the bloodstream to affect organs all over the body. No organ except the pancreas makes significant amounts of insulin or glucagon, but other tissues do produce vasoactive intestinal peptide. Insulin acts to lower blood sugar levels by allowing the sugar to flow into cells. Glucagon acts to raise blood sugar levels by causing glucose to be released into the circulation from its storage sites. Insulin and glucagon act in an opposite but balanced fashion to keep blood sugar levels stable.

Role in human health

A normal pancreas is important for maintaining good health, preventing malnutrition, and maintaining normal levels of blood sugar. The digestive tract needs the help of the enzymes produced by the pancreas to reduce food particles to their simplest elements, or the nutrients cannot be absorbed. Carbohydrates must be broken down into individual sugar molecules. Proteins must be reduced to simple amino acids. Fats must be broken down into fatty acids. The pancreatic enzymes are important in all these transformations. The basic particles can then easily be transported into the cells that line the intestine, and from there they can be further altered and transported to different tissues in the body as fuel sources and construction materials.

Similarly, the body cannot maintain normal blood sugar levels without the balanced action of insulin and glucagon. Both hypoglycemia (low blood sugar) and hyperglycemia (high blood sugar) cause symptoms and serious health problems.

Common diseases and disorders

Diabetes

Glucose is a simple sugar molecule, but one that is necessary to every type of cell as a major source of energy. Insulin made in the pancreas has a critical role in permitting glucose to enter cells. Without insulin, the cells of the body literally “starve in the midst of plenty,” and are unable to make use of sugar in the blood even if blood sugar levels are very high. This condition is called **diabetes mellitus**. Diabetes actually represents a collection of disorders resulting in high blood sugars related to abnormal insulin levels, or abnormalities of the receptor that binds the insulin to allow glucose to enter the cell. Diabetes is quite common in the United States, affecting 1–2% of the general population.

Type I diabetes, which is sometimes called insulin-dependent diabetes, is a disease in which a patient must use insulin regularly to avoid serious problems with cells starving for glucose and acidic waste products accumulating in the blood. In this form of diabetes, the pancreas is essentially not producing insulin. Pancreas transplantation is a method of treating type I diabetes that has achieved success rates of 80–85% in the past decade, success being defined as the organ recipient’s remaining insulin-independent. In type II diabetes, or non-insulin-dependent diabetes, blood sugar levels can often be controlled with diet, **exercise**, and medications taken by mouth. In some forms of type II diabetes the pancreas is not producing enough insulin; in other cases the receptor that binds insulin is no longer sensitive to it, or too few receptors are made by the cells that need glucose. Sometimes a combination of these problems is present. **Gestational diabetes mellitus (GDM)** is a third type of diabetes, which is a temporary problem with blood sugar levels that exists only during **pregnancy**. Women with GDM, however, need to know they are at increased risk for developing type II diabetes.

Pancreatitis

Pancreatitis is a relatively common condition that affects the pancreas. It can occur as an acute (sudden onset) problem or chronic (slow, ongoing) disorder. The common element in both types is inflammation caused by the normal digestive enzymes of the pancreas. In pancreatitis, these secretions act abnormally and start to digest the pancreas itself. Between 50,000 and 80,000 people in the United States develop acute pancreatitis every year, usually related to gallstones or alcohol abuse. Most patients recover within a week, but the most severe forms of pancreatitis have a mortality rate of 10%. Chronic pancreatitis is slow and insidious in onset, and



Posterior view of the pancreas. (Custom Medical Stock Photo, Inc. Reproduced by permission.)

so harder to diagnose. Alcohol use is the most common cause of deterioration in pancreatic function over time. Without adequate levels of enzymes and hormones produced by the pancreas, such diseases as diabetes mellitus and malabsorption syndromes will develop. A **malabsorption syndrome** is a condition in which the body is not able to absorb the nutrients it needs from the food it attempts to digest. Vitamin deficiencies, protein malnutrition, and problems with frequent, greasy stools may occur.

Complications of pancreatitis include pancreatic necrosis (the death of a significant portion of the cells in the pancreas, putting the patient at risk of bleeding, **infection**, **shock**, and failure of many major organs); pancreatic **abscess** (an infection with a wall of scar tissue around it); and pancreatic pseudocyst (a pocket full of fluid and pancreatic enzymes that may shrink, expand, or rupture). Patients with chronic pancreatitis are also at increased risk of developing **cancer** of the pancreas.

KEY TERMS

Amino acids—The category of molecules used to build proteins.

Diabetes mellitus—A chronic form of diabetes in which insulin does not effectively transport glucose from the bloodstream.

Duodenum—The portion of the small intestine that lies between the stomach and the jejunum. The pancreas empties some of its secretions into the duodenum via a Y-shaped duct.

Endocrine—A type of gland that secretes hormones directly into the blood or lymph.

Enzymes—Complex protein molecules that speed up chemical reactions, or make reactions happen under conditions where they normally would not occur.

Exocrine—A type of gland that secretes its products to an epithelial surface.

Glucagon—A hormone secreted by the pancreas that opposes insulin in the regulation of blood sugar levels.

Insulin—A hormone produced in the islet cells of the pancreas that regulates the metabolism of glucose and other nutrients.

Islet cells—Endocrine cells in the pancreas that are specialized to secrete glucagon or insulin.

Jaundice—A condition in which the skin and whites of the eyes are yellow because of bile products retained in the bloodstream.

Pancreatitis—Inflammation of the pancreas.

Zymogens—Enzyme precursor molecules that may change into enzymes as a result of catalytic change.

Cancer of the pancreas

Pancreatic cancer is a major cause of death from cancer around the world. Tumors of the pancreas may arise from either endocrine or exocrine cells. Some rare types of pancreatic tumors hypersecrete either glucagon (glucagonomas) or insulin (insulinomas). Cancer of the pancreas is difficult to diagnose in its early stages; about 90% of patients present with **pain, diarrhea**, blood clots, weight loss, or **jaundice** when the cancer has already spread outside the pancreas. As of 2001, about 25,000 people die every year with this disease, and there are few medical interventions to help these patients. Under cer-

tain circumstances, **chemotherapy** or surgery to remove part of the pancreas may be attempted. Only 2–5% of patients are alive five years after being diagnosed.

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Erika J. Norris

Pancreatitis

Definition

Pancreatitis is an inflammation of the **pancreas**, an organ that is important in digestion. In pancreatitis, normal digestive enzymes act abnormally to break down the pancreas itself.

Description

The pancreas is a complex organ with many critical functions for normal digestion and regulation of **blood sugar**. When inflamed, as in pancreatitis, several potent enzymes are inappropriately activated within the organ itself. In acute pancreatitis, inflammation is sudden and causes symptoms. In almost 90% of acute cases, the symptoms disappear within one week after treatment, and the pancreas returns to its normal function. With chronic pancreatitis, damage to the pancreas occurs over longer periods of time. Symptoms may be persistent or sporadic, as the pancreas is slowly but permanently impaired. More than 90% of pancreatic tissue will be destroyed before serious symptoms begin. Late signs of

chronic pancreatitis include **diabetes mellitus** and malabsorption syndromes in which nutrients are poorly absorbed from the digestive tract.

Causes and symptoms

There are a number of causes of acute pancreatitis, the most common of which are gallstones and **alcoholism**. These two diseases are responsible for more than 80% of all hospitalizations for acute pancreatitis. Gallstones may obstruct normal drainage from the pancreas into the **small intestine**, resulting in a backup of normal pancreatic secretions and inflammation of the pancreas until the obstruction is relieved.

The mechanism by which alcohol inflames the pancreas is not so well understood. It is thought that alcohol causes **proteins** to collect and result in obstruction and calcification of the pancreas.

Other factors in the development of acute pancreatitis include:

- certain drugs, including estrogens, sulfonamides, and diuretics
- infections
- structural problems of the pancreatic duct and common bile duct
- injury to the abdomen
- abnormally high levels of circulating **fats** in the bloodstream
- high blood levels of **calcium**
- complications from kidney failure or transplant
- a hereditary tendency toward pancreatitis
- various forms of vasculitis (inflamed **blood vessels**)

In pancreatitis, enzymes become prematurely activated so that they actually begin their digestive functions within the pancreas. The pancreas, in essence, begins digesting itself. Digestion of the blood vessels in the pancreas results in bleeding. Other active pancreatic chemicals cause blood vessels to become leaky, and fluid begins seeping into the abdominal cavity. The activated enzymes also gain access to the bloodstream through leaky, eroded blood vessels, and begin circulating throughout the body.

Pain is a major symptom in acute pancreatitis, and it is usually quite intense and steady, located in the upper abdomen, and radiating to the patient's back. Nausea and vomiting and abdominal swelling are also common symptoms. A patient will often have a slight **fever**, with an increased **heart rate** and low **blood pressure**.

Patients with acute pancreatitis are at risk of complications related to **shock**, a very serious syndrome that occurs when the blood pressure is too low to get adequate circulation to critical organs. Without adequate blood pressure, organs are deprived of oxygen, nutrients, and waste removal and may not function well. Kidney, respiratory, and **heart failure** are serious possible outcomes of shock.

Even if shock does not occur, circulating pancreatic enzymes and related toxins can cause damage to the heart, **lungs, kidneys**, lining of the gastrointestinal tract, **liver**, eyes, bones, and skin. As the pancreatic enzymes affect blood vessels, the risk of blood clots increases. When blood flow is blocked by clotting, the supply of oxygen is further decreased to various organs and additional damage done.

Other serious complications of acute pancreatitis include pancreatic necrosis, abscess, and pseudocyst formation. Pancreatic necrosis occurs when a significant portion of the pancreas is permanently damaged during an acute attack. Pancreatic necrosis has an increased risk of death and an increased chance of pancreatic **infection**. A pancreatic **abscess** is a local collection of pus that may develop several weeks after the illness subsides. Another late complication of pancreatitis, occurring several weeks after the illness begins, is called a pancreatic pseudocyst, which occurs when dead pancreatic tissue, blood, white blood cells, enzymes, and fluid leaked from the circulatory system accumulate. Pseudocysts cause recurrent abdominal pain and also press on other nearby structures in the gastrointestinal tract, causing disruption of function. Pseudocysts are life threatening when they become infected (abscess) and rupture. Simple rupture of a pseudocyst causes death 14% of the time, but rupture complicated by bleeding causes death 60% of the time.

In very severe cases of pancreatitis, called necrotizing pancreatitis, the pancreatic tissue begins to die, and bleeding increases. Due to the bleeding into the abdomen, two distinctive signs may be noted in patients with necrotizing pancreatitis. Turner's sign is a reddish-purple or greenish-brown color to the area between the ribs and the hip (flank). Cullen's sign is a bluish color around the navel.

Alcohol abuse is the cause of tissue damage in 80% of cases of chronic pancreatitis. Tissue damage occurs more slowly, and many digestive functions become disturbed. The quantity of hormones and enzymes normally produced by the pancreas begins to decrease, resulting in the inability to appropriately digest food. Fat digestion, in particular, is impaired. A patient's stools become greasy as fats are passed out of the body. The inability to digest and use proteins results in smaller muscles (wast-

KEY TERMS

Abscess—A pocket of infection; pus.

Acute—Of short and sharp course; illnesses that appear quickly and can be serious or life-threatening.

Chronic—Of long duration and slow progression; illnesses that develop slowly over time, and do not end.

Diabetes—A disease characterized by an inability to regulate blood sugar levels in the blood.

Endocrine—A system of organs that produces chemicals that go into the bloodstream to affect the function of other organs from a distance.

Enzyme—A chemical that speeds up or makes a particular chemical reaction more efficient.

Exocrine—A system of organs that produces chemicals that go through a duct (or tube) to affect the functioning of other organs.

Gland—A collection of tissue that produces chemicals needed for use outside of the gland itself.

Hormone—A chemical produced in one part of the body that travels to another part of the body in order to exert an effect.

ing) and weakness. The inability to digest and use the nutrients in food leads to malnutrition, vitamin deficiencies, and a generally weakened condition. As the disease progresses, permanent injury to the pancreas can lead to diabetes.

Diagnosis

Diagnosis of pancreatitis, whether acute or chronic, is not simple. History and physical exam are very important, as well as imaging studies and laboratory tests. Levels of amylase and lipase that are three times above the upper limit of normal are very predictive of acute pancreatitis. Other abnormalities in the blood may also point to pancreatitis, including increased white blood cells, changes due to **dehydration** from fluid loss, and abnormalities in the blood concentration of calcium, magnesium, sodium, potassium, bicarbonate, and glucose.

X rays or ultrasound examination of the abdomen may reveal gallstones, possibly responsible for blocking the pancreatic duct. The gastrointestinal tract will show signs of inactivity (ileus) due to the presence of pancre-

atitis. Chest x rays may reveal abnormalities due to shallow breathing or due to lung complications from the circulating pancreatic enzyme irritants. Computed tomography (CT) scans of the abdomen may reveal the inflammation and fluid accumulation of pancreatitis.

In the case of chronic pancreatitis, lipase and amylase levels will no longer be elevated. However, blood tests will reveal the loss of pancreatic function that occurs over time. Blood sugar (glucose) levels will rise, eventually reaching the levels consistent with diabetes. The levels of various pancreatic enzymes will fall, as the organ is increasingly destroyed and replaced by non-functioning scar tissue. Calcification of the pancreas can also be seen on x rays. Endoscopic retrograde cholangiopancreatography (ERCP) may be used to diagnose chronic pancreatitis in unclear cases. In this procedure, the physician uses a medical instrument fitted with a fiber-optic camera to inspect the pancreas.

Treatment

Treatment of acute pancreatitis involves replacing lost fluids intravenously (in a vein). These IV solutions need to contain appropriate amounts of salts, sugars, and sometimes even proteins, in order to correct the patient's disturbances in blood chemistry. Pain is treated with a variety of medications, chiefly meperidine. To decrease pancreatic function, the patient is not allowed to eat. A thin, flexible tube (nasogastric tube) may be inserted through the patient's nose and down into the **stomach**. The nasogastric tube can empty the stomach of fluid and air that may accumulate due to the inactivity of the gastrointestinal tract.

The patient will need careful monitoring in order to identify complications that may develop. Infections will require **antibiotics** through the IV. Severe necrotizing pancreatitis may require surgery to remove part of the dying pancreas, especially if infection has begun. A pancreatic abscess can be drained by a needle inserted through the abdomen and into the collection of pus (percutaneous needle aspiration). An abscess may also require surgical removal. In 25–40% of cases, pancreatic pseudocysts may shrink on their own or continue to expand, requiring needle aspiration or surgery. Surgery may be necessary for the removal of gallstones.

Because chronic pancreatitis often includes repeated flares of acute pancreatitis, the same kinds of basic treatment are necessary. Treatment of chronic pancreatitis caused by alcohol consumption requires that the patient stop drinking alcohol entirely. A low-protein and low-fat diet is prescribed. As chronic pancreatitis continues and insulin levels drop, a patient may require insulin injections to be able to process sugars in the diet. Pancreatic

enzymes can be replaced with oral medications. As the pancreas is progressively destroyed, some patients stop feeling the abdominal pain that was initially so severe. Others continue to have constant abdominal pain, and may require a surgical procedure for relief.

Prognosis

When necrosis and bleeding are present, as many as 50% of patients with pancreatitis may die.

Ranson's criteria can help determine the severity of the disease. The first five categories are evaluated when the patient is admitted to the hospital, including:

- age over 55 years
- blood sugar level over 200 mg/dl
- serum lactic dehydrogenase over 350 IU/L
- AST over 250 μ (a measure of liver function, as well as a gauge of damage to the heart, muscle, **brain**, and kidney)
- white blood count over 16,000 μ L

The following six of Ranson's criteria are reviewed 48 hours after the patient's admission to the hospital, including:

- greater than 10% decrease in **hematocrit** (a measure of red blood cell volume)
- increase in BUN (blood urea nitrogen, an indicator of kidney function) greater than 5 mg/dL
- blood calcium less than 8 mg/dL
- PaO₂ (a measure of oxygen in the blood) less than 60 mm Hg
- base deficit greater than 4 mEq/L (a measure of change in the normal acidity of the blood)
- fluid sequestration greater than 13 pt (6 l) (an estimation of the quantity of fluid that has leaked out of the blood circulation and into other body spaces)

Once it is determined how many of Ranson's signs are present in the patient, the physician can better predict the risk of death. A patient with less than three positive Ranson's signs has less than a 5% chance of dying. A patient with three to four positive Ranson's signs has a 15–20% chance of death.

The results of a CT scan can also be used to predict the severity of pancreatitis. Slight swelling of the pancreas indicates mild illness. Significant swelling, especially with evidence of destruction of the pancreas and/or fluid build-up in the abdominal cavity, indicates more severe illness and a worse prognosis.

Health care team roles

The physician will make a full **physical examination** of the patient to determine which tests are necessary. Radiation technologists will perform imaging studies and clinical laboratory technicians will perform the laboratory tests. Nurses have an active supportive role throughout the patient's illness.

Prevention

Alcoholism is essentially the only preventable cause of pancreatitis. Patients with chronic pancreatitis must stop drinking alcohol entirely. The drugs that may cause pancreatitis should also be avoided when possible.

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Erika J. Norris

Pap test

Definition

The Pap test (Pap smear) is the microscopic examination of cells scraped from the both the outer cervix (ectocervix) and the cervical canal (endocervix). It is called the "Pap" test after its developer, Dr. George N. Papanicolaou, who described a procedure for staining vaginal and cervical cells that gives clearly defined detail to the nuclear chromatin. Using the Papanicolaou stain,

he developed a classification system for abnormal cervical cells. Before the application of the Pap test in the 1940s, cervical **cancer** caused approximately 26,000 deaths in the United States each year. The death rate from cervical cancer since the use of the Pap test has become widely accepted has been reduced by 70%.

Purpose

The Pap test is a screening test used to detect abnormal growth of cervical cells at an early stage, so that if necessary, treatment can be started before the cells become cancerous and invasive. The test helps physicians identify women who are at increased risk of cervical dysplasia (abnormal cells) or cervical cancer. Only an examination of the cervix, and samples of cervical tissue (biopsies) can diagnose precancerous and cancerous changes in the cells that line the uterus, called squamous epithelium.

This microscopic analysis of cells can detect cervical cancer, precancerous changes, inflammation (called vaginitis), infections, and some sexually transmitted diseases (STDs). The Pap test can sometimes detect endometrial (uterine) cancer or ovarian cancer, although it was not designed for this purpose.

Women should begin to have Pap tests at the age of 18 years or whenever they start having sex. Young people are more likely to have multiple sex partners, which increases their risk of certain diseases that can cause cancer, such as human papillomavirus (HPV). The American Cancer Society recommends that a Pap test be done annually for two consecutive negative examinations, then repeated once every three years until age 65 for women without symptoms of gynecologic problems. Many other doctors, however, recommend annual Pap tests for all their patients.

Women with certain risk factors should always have yearly tests. Those at highest risk for cervical cancer are women who started having sex before age 18; those with many sex partners (especially if they did not use condoms, which protect against STDs); those who have had STDs such as **genital herpes** or genital warts; and those who smoke. Women older than 40 also should have the test yearly, especially in the event of bleeding after **menopause**. Women over age 60 account for 25% of new cases of cervical cancer and 40% of deaths from this disease. Women who have had a hysterectomy (removal of the uterus) may need to have Pap tests, if the surgery was for cancer, or if the cervix was left in place. Pregnant women should have a Pap test as part of their first prenatal examination.

Women who have a positive test result should be retested more frequently. If atypical squamous cells or low-grade lesions are found they should be tested every four to six months until they have three consecutive normal results. The test should be repeated within two to three months if severe inflammation, **infection**, or postmenopausal atrophy is found. If atypical cells or low-grade lesions persist, or high-grade lesions are found, **colposcopy** (examination of the cervix with a magnifying lens) should be performed, and treatment initiated as indicated.

Precautions

The Pap smear is a microscopic evaluation of individual cells, a process that requires interpretation. Differentiation of inflammatory, reactive, and atrophied cells from atypical cells is difficult and cannot always be performed with complete certainty. The test is not 100% sensitive and between 5–10% of cervical abnormalities may be missed. Most false negatives result from poor sample collection (insufficient cervical cells) or poor smear preparation. The finding of abnormal cells on a Pap smear does not mean that the cells were present on previous exams.

The Pap test should be performed in the middle of the menstrual cycle to prevent interference from **blood**. Sexual intercourse, douching, or the use of vaginal suppositories may affect results. Other factors that can affect test results include: water or lubricant on the specimen from the speculum; blood, mucus, or pus on the slide that obstructs the view of epithelial cells; cell damage during collection; and improper slide fixation. An acceptable smear is one that is correctly labeled with the patient's name, age, and last menstrual period; contains squamous cells covering at least 10% of the slide; and demonstrates the presence of cells from the endocervix and transformation zone. The transformation zone is the area where the squamous epithelium of the ectocervix meets the glandular epithelium of the endocervix.

Description

The Pap test is an extremely cost-effective and beneficial test able to detect about 95% of cervical cancer. According to a report published May 16, 2000 in the *Annals of Internal Medicine*, the widespread use of this diagnostic procedure decreased the number of cervical cancers in the United States from 14.2 per 100,000 in 1973, to 7.8 per 100,000 in 1994. However, the disease still ranks as the ninth-leading cause of cancer deaths in U.S. women.

During the pelvic examination, an instrument called a speculum is inserted into the vagina to open it. A spatula, (Ayre spatula) that is flat at one end and curved at the other so that its contour complements the ectocervix is used to collect the sample. The spatula is firmly rotated using a circular motion to scrape the cells off the ectocervix. The flat end can be used to pick up cells which have exfoliated from the rear of the vagina. This procedure, called vaginal pool sampling, is recommended for women in menopause and if signs of inflammation are seen. A tiny brush, pointed spatula, or cotton-tipped swab is used to collect cells from the endocervix. These samples can be mixed and spread evenly on a single glass slide, or a slide or slide section can be used for each. The slide should be dipped in 95% alcohol or sprayed with fixative immediately. Though some women find the procedure uncomfortable, it is usually painless and only takes five to 10 minutes.

A new technique called the Thin Prep is being used by some physicians because it is purported to reduce the false negative rate caused by inadequate smear preparation. For the Thin Prep, the sample is placed in a vial containing a preservative solution. The vial is labeled and sent to the laboratory where a processing instrument disrupts the blood cells and mucus and spreads the decontaminated sample in a thin layer over the slide. Unlike the classical procedure, cells are not left on the collection device. This results in a greater yield of epithelial cells to examine. The staining detail is easier to evaluate because the epithelial cells are not obscured by blood cells or mucus.

Smears are stained with the Papanicolaou stain when they reach the lab. The Pap stain begins with rehydrating the cells in water. The cells are stained with Gill hematoxylin, then dehydrated with 95% ethanol. They are stained with OG-6 followed by EA-65, then fully dehydrated with absolute ethanol. In the last step, they are cleared with xylol, and a coverglass is applied. The entire smear is examined under a **microscope**. In addition to detecting and classifying abnormalities within the squamous epithelium and glandular epithelium, the smears are also examined for the presence of inflammatory cells (polymorphonuclear white cells, lymphocytes, histiocytes), normal vaginal flora (Lactobacilli), coccobacilli (indicative of vaginal infection), trichomonads (vaginal parasites), yeast, and cytopathic effects of **viruses** in the epithelial cells.

Squamous epithelial cells from the cervix are evaluated for abnormal intracellular changes that indicate a risk of cancerous transformation. Two systems of classification are widely employed, the CIN (Richart) and Bethesda systems. Both describe a progression of cells from normal to low risk, then to high risk, then to malig-

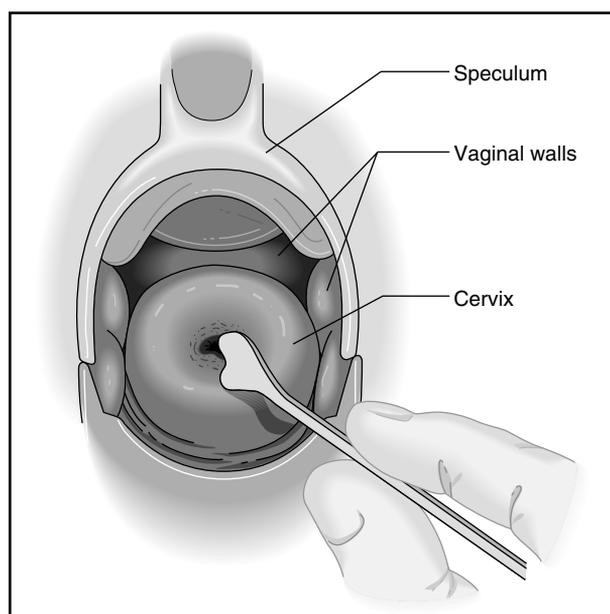
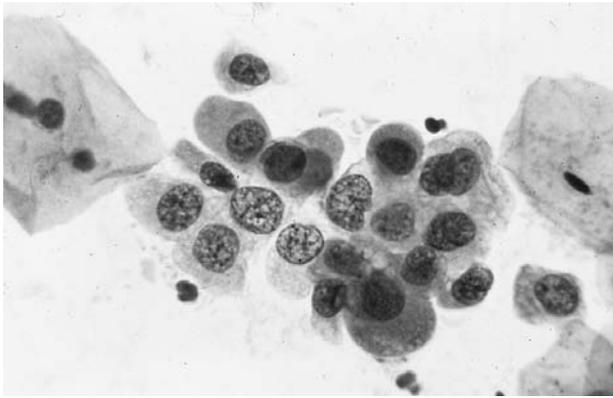


Illustration of the vaginal area during a PAP smear. (Delmar Publishers, Inc. Reproduced by permission.)

nant cells. The CIN system uses the term, cervical intraepithelial neoplasia (CIN) to describe premalignant cells. CIN-I is characterized by mild cellular abnormalities (mild dysplasia), CIN-II moderate dysplasia, and CIN-III severe dysplasia. CIN-III includes the presence of immature cells with cancerous features that have not yet invaded the surrounding connective tissue. This is called carcinoma *in situ*. When such cells are found beyond the transformation zone (within the underlying stroma), the lesion is classified as invasive cancer (squamous carcinoma). The CIN classification system classifies cells that are most likely benign (called squamous atypica) and low-risk precancerous cells in the category of CIN-I. In 1989, the Bethesda system was introduced in order to more clearly define the difference between mild dysplasia that is likely to be benign and that which is precancerous. The former comprise a group called ASCUS which stands for atypical squamous cells of undetermined significance. This distinguishes cells that are often reactive from those of the next group, low-grade intraepithelial neoplasia (LSIL) that show precancerous changes, but are at a low risk of transforming into cancerous cells. ASCUS is reserved for cells that cannot be conclusively called benign. Classification of a smear as ASCUS is based upon judgement and depends upon the quality of the smear and the numbers and appearance of atypical cells present. A pap test in which ASCUS is found should be repeated in three to four months, and if ASCUS is detected the second time, the patient should be evaluated by colposcopy and biopsy. Between 19% and 57% of these patients will be reclassified as SIL on the



These cells were taken from a woman's cervix during a PAP test. (Photograph by Parviz M. Pour, Photo Researchers, Inc. Reproduced by permission.)

basis of biopsy. The LSIL category is the counterpart of the CIN-I category. The final category of the Bethesda system is high-grade intraepithelial neoplasia (HSIL) which comprises both CIN-II and CIN-III groups including carcinoma *in situ*. Beyond HSIL, the lesion is classified as an invasive squamous cell carcinoma.

In general, cervical cells are classified as ASCUS if the nuclear enlargement is no greater than three-fold the size of the nucleus of a normal intermediate squamous cell, or there is mild hyperchromasia (increased chromatin staining). LSIL cells are superficial or intermediate squamous cells that display a nucleus that is at least three-fold larger than the normal intermediate squamous cell. There is moderate variation in the size and shape of the nucleus. Nuclear hyperchromasia is present either as uniformly granular or smudged chromatin staining. In addition, cells that are associated with infection by HPV have a cytoplasm with hollowed-out cavities. About 80% of cervical cancers are associated with HPV infection. Therefore, these cells, called koilocytes, are classified as LSIL provided that some nuclear abnormality or binucleation is present. HSIL cells are immature squamous cells (smaller cells) with a three-fold or greater nuclear enlargement, an increased nuclear to cytoplasm ratio, severe hyperchromasia with irregular chromatin and nuclear membrane contour. They are usually seen in streaming rows or groups of attached cells.

Preparation

While most women are not routinely advised to make any special preparations for a Pap test, some simple preparations may help to ensure that the results are reliable. Among the measures that may help increase test reliability are:

- abstaining from sexual intercourse 24 hours prior to the test
- not douching 18–72 hours before the test
- avoiding vaginal creams or medications one week before the test

If possible, women may want to ensure that their test is performed by an experienced gynecologist and sent to a certified laboratory. Certification requires successful participation in a proficiency testing program approved by the U.S. Department of Health and Human Services. In such a program every cytotechnologist reading pap smears is tested at least once per year and is required to meet specific performance criteria.

Before the exam, the physician will take a complete sexual history to determine a woman's risk status for cervical cancer. Questions may include date and results of the last Pap test, any history of abnormal Pap tests, date of last menstrual period and any irregularity, use of hormones and birth control, family history of gynecologic disorders, and any vaginal symptoms. These topics are relevant to the interpretation of the Pap test, especially if any abnormalities are detected. Immediately before the Pap test, the woman should empty her bladder to avoid discomfort during the procedure.

Aftercare

Harmless cervical bleeding is possible immediately after the test; women may need to use a sanitary napkin. They should also be sure to comply with their doctor's orders for follow-up visits.

Complications

No appreciable health risks are associated with the Pap test. However, abnormal results (whether valid or due to technical error) can cause significant **anxiety**. Women may wish to have their sample retested, either by the same laboratory or via computer-assisted screening. Two re-screening programs approved by the Food and Drug Administration are called Papnet and AutoPap QC.

Results

Normal (negative) results from the laboratory exam mean that no atypical cells were detected, and the cervix is normal. It is important to remember that an abnormal (positive) result does not necessarily indicate cancer. Fully 60–70% of abnormal results resolve by themselves, and only 1% of mild abnormalities ever develop into cancer. Between 19% and 57% of patients with ASCUS will be reclassified as having SIL (mostly LSIL) following biopsy. Approximately 57% of LSIL lesions regress on

their own (i.e., return to normal); 32% remain LSIL on retesting, 11% progress to HSIL, and 1% may progress to invasive carcinoma. Approximately 43% of HSIL (CIN-II) lesions regress, 35% remain HSIL on retesting, and 22% progress to CIN-III. Approximately 5% of HSIL (CIN-II) lesions progress to invasive cancer. Approximately 32% of HSIL (CIN-III) lesions regress, up to 55% persist on repeat exam, and more than 12% progress to invasive carcinoma.

Treatment

CHANGES OF UNKNOWN CAUSE (ASCUS OR SQUAMOUS ATYPICA). The most common abnormality (found in 50–60% of abnormal tests) is ASCUS. If squamous atypica is thought to be inflammatory or reactive, this will be noted on the report as well as any evidence of infection (e.g., coccobacilli, yeast, white blood cells) seen on the microscopic exam. These women may be treated for infection and then undergo repeat Pap testing in two to three months. If ASCUS is present without signs of inflammation, re-testing is performed every four to six months for two years or until three consecutive tests are negative. If the lesion persists, or ASCUS is seen twice within a two-year period, colposcopy is recommended.

DYSPLASIA. Typically, dysplasia causes no symptoms, although women may experience abnormal vaginal bleeding. Because dysplasia can be precancerous, it should be treated if it is moderate or severe. Treatment of dysplasia depends on the degree of abnormality. In women with no other risk factors for cervical cancer, mild dysplasia may be simply observed over time with repeat testing, every four to six months as described above. If the lesion persists, colposcopy with biopsy and scraping of the endocervix are often recommended.

The second most common finding (about 30–40% of abnormal tests) is LSIL, which includes mild dysplasia or CIN I and changes caused by HPV. Unlike cancer cells, these cells do not invade normal tissues. Women are most susceptible to mild dysplasia at ages 25–35 years. HSIL (found in 5–10% of abnormal Pap tests) includes moderate to severe dysplasia or carcinoma *in situ* (CIN II or III). The frequency of HSIL is highest at ages 30–40. In women with HSIL lesions, colposcopy, biopsy, and treatment (excision or destruction of the lesion) are performed. In addition to surgical resection (removal), several outpatient techniques are available: conization (removal of a cone-shaped piece of tissue), **laser surgery**, cryotherapy (freezing), electrosurgical cauterization, and radiation. Cure rates are nearly 100% after prompt and appropriate treatment of carcinoma *in situ*. Of course, frequent checkups are then necessary.

KEY TERMS

Carcinoma *in situ*—Precancerous cells that are present only in the ectocervix (i.e., do not extend beyond the basement membrane). The abnormal cells do not extend beyond the transformation zone.

Cervical intraepithelial neoplasia (CIN)—A term used to categorize degrees of dysplasia arising in the cervical epithelium (outer cervix).

Cervix—The opening between the vagina and the uterus, or womb.

Cytology—The study of cells, their origin, structure, function, and pathology.

Dysplasia—Abnormal changes in cells.

Human papilloma virus (HPV)—The leading STD in the United States. Various types of HPV are known to cause cancer.

Neoplasia—Abnormal growth of cells, which may lead to a neoplasm, or tumor.

Squamous intraepithelial lesion (SIL)—A term used to categorize the severity of abnormal changes arising in the squamous cells of the cervix.

In addition to abnormal squamous epithelium, abnormal glandular cells from the endocervix may be found. Atypical glandular cells of undetermined significance (AGUS) is used to designate cells that cannot be classified with certainty as benign, precancerous, or cancerous. AGUS should be investigated further to determine the risk of endometrial carcinoma. Malignant glandular cells may also be found on the Pap smear and may result from cervical or vaginal adenocarcinoma. This cancer is uncommon in women under 40, and most common in women over 50 who have postmenopausal bleeding. Malignant glandular cells are more often recovered from vaginal pool sampling or aspiration than from cervical scraping, and therefore, vaginal cell smears should be made along with cervical smears for women in menopause. Hysterectomy is recommended for confirmed cases of endometrial adenocarcinoma.

CANCER. Human papilloma virus (HPV), the most common STD in the United States, may be responsible for many cervical cancers. Cancer may be manifested by unusual vaginal bleeding or discharge, bowel and bladder problems, and **pain**. The peak ages for cervical cancer are between 45 and 55 years. Biopsy is indicated when

any abnormal growth is found on the cervix, even if the Pap test is negative.

Invasive cervical cancer is usually treated with surgery or radiation, or both. Most cases of invasive cervical cancer are treated with radical hysterectomy. **Chemotherapy** may be used if the cancer has spread to lymph nodes or other organs. Survival rates at five years after treatment of early invasive cancer are about 90%; rates are below 60% for more severe invasive cancer. That is why prevention, risk reduction, and frequent Pap tests are the best defense for a woman's gynecologic health.

Health care team roles

The slides are prepared by a gynecologist. Cytotechnologists, laboratory professionals who specialize in the study of cells, read the Pap smears looking for abnormal cells. Abnormal findings may be reviewed by the laboratory's pathologist.

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ORGANIZATIONS

American College of Obstetricians and Gynecologists. 409 12th St. SW, PO Box 96920, Washington, DC 20090-6920. (202) 638-5577. <<http://www.acog.com>>.

National Cancer Institute, National Institutes of Health, U.S. Department of Health and Human Services. 9000 Rockville Pike, Bethesda, MD 20892. (301) 496-0265. <<http://cancernet.nci.nih.gov/>>.

Victoria E. DeMoranville

Papanicolaou test see **PAP test**

Paracentesis

Definition

Paracentesis is a procedure in which excess fluid in the abdomen is sampled by aspiration through a needle. The fluid may be called ascites fluid, abdominal fluid, or peritoneal fluid.

Purpose

Paracentesis is commonly performed to identify the cause of newly diagnosed ascites (excess fluid in the abdominal cavity); to diagnose changes in the condition of a patient already known to have ascites; and to relieve pressure from severe distention due to increased fluid in the abdomen. A sample of the fluid withdrawn from the abdominal cavity is nearly always sent for laboratory analysis to determine the presence or absence of **infection**, and/or to learn more about the cause of ascites if necessary. Ascites forms for a variety of reasons, including infection, diseases of various organs, and conditions which result in abnormal **blood** flow. The most common cause in the United States is alcoholic cirrhosis.

Precautions

Ascites is difficult to diagnose by physical exam, although with experience health care practitioners can note "shifting dullness" by percussion. Generally at least 17 oz (500 mL) of fluid must accumulate before the effusion is detected by x ray, and 3.2 pt (1500 mL) before ascites is easily detected on physical exam. Ultrasound may be necessary to differentiate ascites from **obesity** and other reasons for abdominal distention. Ultrasound may even be used to guide the needle for paracentesis. When performing this procedure, the physician should observe **universal precautions** for the prevention of transmission of bloodborne pathogens.

Description

Consent should be obtained for the procedure after discussion of the possible complications (discussed below). The area beneath the umbilicus is cleansed with betadine or other antibacterial solution, and local anesthetic administered. A long thin needle or trochar with a stylet is inserted about 2 in (5 cm) below the umbilicus, and the appropriate amount of fluid withdrawn. Usually a syringe is used, but for very large amounts of ascites, polyethylene tubing may be attached to vacuum bottles and the excess fluid aspirated. A minimum of 1 oz (30 mL) of fluid should be collected by sterile technique in two or three sterile syringes. One portion should be trans-

ferred to a tube containing EDTA for cell counts and the last syringe should be used to inoculate **blood culture** media. These samples and the remaining fluid should be sent to the laboratory for analysis. If cytologic exam is requested, 3.4 oz (100 mL) of fluid should be submitted to the laboratory.

Cirrhosis of the **liver** and malignant abdominal masses are the two most common causes of ascites. Cirrhosis is usually associated with a transudative fluid, a fluid of low cellularity and protein, while malignancy causes an exudative (inflammatory) fluid of high cellularity and protein. Transudative fluids result from changes in blood flow, and are typically seen in persons with cirrhosis, congestive **heart failure**, and a few other conditions that disrupt normal hemodynamics. An explanation of ascites formation in cirrhosis serves well to explain some principles common to transudative fluid formation. Blood entering the portal vein from the intestines passes through the liver on its way back to the **heart**. When progressive disease such as alcohol damage or hepatitis destroys enough liver tissue, the scarring which results compresses the hepatic sinusoids and vessels and restricts the blood flow. The blood bypasses the liver and enters the splenic, gastric, and esophageal veins causing very high hydrostatic pressure. This pressure causes fluid to escape the vessels and enter the abdominal cavity. Slowly the fluid accumulates in the areas with the lowest pressure and the greatest capacity. The free space around abdominal organs receives most of it. This space is called the peritoneal space because it is enclosed by a thin membrane called the peritoneum. The peritoneum wraps around nearly every organ in the abdomen, and lines the entire abdominal cavity, providing many folds and spaces in which fluid can gather. Normally, only 1–1.7 oz (30–50 mL) of fluid is found in the peritoneal cavity. The fluid itself is essentially an ultrafiltrate of plasma. Any condition that causes an increase in peritoneal fluid is called an effusion or ascites. Kidney disease can contribute to this process, since the **kidneys** have a critical role in **fluid balance**. Nephrotic syndrome in particular is associated with ascites formation. In this condition the kidneys lose large amounts of protein into the urine causing a drop in plasma oncotic pressure. Since **proteins** hold fluid in the vascular bed, loss of protein (albumin) causes fluid to enter the tissue spaces. Heart failure also can cause ascites, because decreased cardiac output causes blood to accumulate in the return circulation. The increased venous pressure results in fluid leaking from the circulatory system. First **edema** is noticed in the legs, due to the effect of gravity, then in ascites formation in the abdomen.

Malignancy, infection, **pancreatitis**, bowel obstruction, and several other conditions produce an exudative

effusion. These conditions cause inflammation that results in increased blood vessel permeability. The fluid that accumulates typically contains white blood cells and if **cancer** is the cause, malignant cells from the tissue of origin. Malignancy may result from cancerous transformation of the cells that line the peritoneum, called mesothelial cells. Mesotheliomas may difficult to distinguish from reactive mesothelial cells that occur whenever the lining of the abdomen is traumatized. The two most common metastatic cancers invading the abdomen are ovarian and **breast cancer**, but lymphoma, leukemia, lung, and many other cancers can also infiltrate the abdomen. Bacterial peritonitis is an infection of the peritoneum, and is a life-threatening cause of exudative ascites. It can result from intestinal perforation, leakage through a diseased bowel wall, ruptured appendix or gall bladder, or septicemia (infection in the blood). Inflammation of the abdominal wall can also result from blunt trauma, pancreatitis, intestinal obstruction, and other conditions.

Physical characteristics of ascites fluid

Normal ascites fluid is clear and straw colored. Turbid fluid occurs in bacterial peritonitis, malignancy, and pancreatitis. Green fluid occurs when bile is present. This can be caused by a ruptured bowel or perforated bile duct. Bloody fluid occurs in trauma, malignancy, and pancreatitis. Milky fluid contains chyle from the intestinal lymphatics and occurs when lymphatic vessels rupture.

Microscopic analysis

The WBC count is performed using a hemacytometer. Normal fluid has a very low WBC count (less than 300 per microliter) and does not have to be diluted. Counts above 1000 indicate an exudative process. The differential is performed on a cytocentrifuged sample to concentrate the cells. Macrophages predominate in normal fluid and together with mesothelial cells account for about 70% of the nucleated cell population. Lymphocytes are normally less than 20% and neutrophils less than 10% of nucleated cells. Neutrophils accounting for 50% or 500 per microliter are most often associated with bacterial peritonitis. Lymphocytes will predominate in lymphoma, nephrotic syndrome, and congestive heart failure and may be abundant along with macrophages in **tuberculosis**. Red cell counts are also performed manually. Red cells often enter the fluid during sample collection, a process referred to as a traumatic tap. In this case, the red count will be low, the supernatant fluid will be pale yellow (normal), and the fluid will clear as more is collected. In the absence of a traumatic tap, red blood cells are most often encountered in malignancy and trauma. It is especially important to examine the fluid for the presence

KEY TERMS

Ascites—Abnormal quantity of peritoneal fluid, which is basically an ultrafiltrate of plasma.

Edema—Fluids that have shifted outside of the circulatory system and are temporarily trapped in soft tissues.

Gram stain—A common laboratory test in which a specimen on a glass slide is subjected to a series of stains and rinses to visualize micro-organisms.

Lymphocyte—A specific type of white blood cell (leukocyte) involved in fighting atypical, fungal and viral infections.

Neutrophil—A specific type of white blood cell (leukocyte) involved in fighting bacterial infections. Also called a polymorphonuclear leukocyte.

of malignant cells. As mentioned, metastatic cancer cells from ovarian and breast cancer are the most commonly seen infiltrates. Malignant mesothelial cells are difficult to distinguish from reactive mesothelial cells. Cytology should be evaluated with both Wright and Papanicolaou stains. Cytochemical tests and flow cytometry may be needed to identify malignant mesothelial cells, leukemic blasts (immature white cells), and lymphoma cells.

Biochemical tests

Chemical tests are performed on ascites fluid by the same methods used for plasma. Total protein, lactate dehydrogenase (LD), and glucose levels should be measured and compared to blood levels. Fluid to serum total protein and LD ratios are used to help distinguish exudative from transudative fluids. The serum albumin minus the fluid albumin is now considered the most sensitive single test to distinguish cirrhosis from malignancy as causes of ascites. Most transudative fluids are associated with cirrhosis and have a difference above 1.1. Most exudative fluids result from malignancy and have a difference less than 1.1. The fluid glucose is normally the same as the plasma glucose. Distinctly lower levels are seen in bacterial peritonitis, peritoneal tuberculosis, and malignancy. Lactate dehydrogenase is increased in bacterial peritonitis and malignant diseases. A fluid:serum ratio of 0.6 or higher has a sensitivity of about 80% in identifying exudative fluids. Amylase is very useful in diagnosing exudates caused by pancreatitis. Levels are usually in excess of three times the upper limit of normal. Fluid amylase testing can detect pancreatitis in approximately 90% of cases, and is also positive in the majority

of persons with bowel obstruction, proliferation and intestinal cancer. Alkaline phosphatase is elevated in exudates associated with bowel injury, obstruction, and some malignancies such as hepatoma.

Tumor markers may be useful to help distinguish the tissue of origin and to increase the sensitivity of cancer detection. Both carcinoembryonic antigen levels and CA125 levels in abdominal fluid have been found elevated in some persons with malignant infiltration of the abdomen but negative initial cytology. Creatinine may be measured when it is suspected that inadvertent puncture of the urinary bladder occurred during paracentesis. Creatinine in urine is about 100 times higher than in ascites fluid.

Microbiology

Bacterial cultures are usually performed on ascites fluid, but recovery of organisms is low when the fluid is frankly transudative. **Gram stain** detects about 25% of cases of bacterial peritonitis. The sensitivity can be increased by fluorescent microscopy using acridine orange stain. Cultures are positive in about 75% of cases that are eventually documented as infections. Detection of bacterial peritonitis is more sensitive when blood culture bottles containing tryptic soy broth are inoculated immediately after collection of the fluid rather than plating the fluid after transport to the lab. Regardless of the media used, cultures should be performed under both aerobic and anaerobic conditions. Spontaneous bacterial peritonitis which usually occurs in cirrhosis following sepsis typically grows a single organism, usually *E. coli* or *Streptococcus pneumoniae*. Peritonitis resulting from bowel sources usually grows several different intestinal organisms.

Preparation

A **hematocrit**, prothrombin time, and platelet count should be obtained within 48 hours of paracentesis. This will identify which patients may be at risk for bleeding complications, and provide a baseline hematocrit to estimate blood loss should bleeding occur. In addition, blood should be collected for glucose, total protein, lactate dehydrogenase, and albumin at the time of paracentesis. These results are compared to those of ascites fluid as a diagnostic aid. Abdominal girth and **vital signs** should be documented. The patient should be asked to empty his or her bladder, and should be warned about very brief discomfort as the needle goes through the peritoneum, in spite of **local anesthesia**. If very large amounts of peritoneal fluid are to be removed, it may need to be done very slowly to avoid large fluid shifts and a rapid fall in **blood pressure**. In extreme cases, a central venous pres-

sure (CVP) line may need to be placed in order to monitor the patient's fluid status.

Aftercare

Vital signs are documented several times, perhaps even hourly for several hours if a large volume has been removed. The site of needle puncture is covered with a simple sterile dressing, or closed with a stitch if a trochar was used, and the dressing observed for possible continued leakage or bleeding.

Complications

Serious intra-abdominal bleeding is possible, although not very frequent. Puncture of the bladder or bowel are also possible. If good sterile technique is not used, infection could be introduced into the abdomen, resulting in peritonitis.

Results

Results of laboratory tests on ascites fluid are dependent upon the method of analysis used. Most studies of normal persons are performed with very small sample sizes, and cell counts are performed manually. This results in greater interlaboratory variation in normal ranges than usually is seen for measurements performed on blood. Representative values for commonly measured analytes are shown below:

- Volume: 1–1.7 oz (30–50 mL).
- Color: pale yellow.
- Transparency: clear.
- WBC count: < 200 per microliter.
- Total protein: < 3.0 g/dL.
- Amylase: 0–130 U/L (similar to plasma for the method used).
- Serum to ascites albumin gradient (serum minus fluid albumin): greater than 1.1 g/dL.
- Fluid: serum LD ratio < 0.6.
- Lactic acid: < 40 mg/dL.
- Bilirubin: < 6.0 mg/dL and serum fluid ratio below 1.0.

Health care team roles

A physician collects the ascites fluid using sterile technique. The physician is usually assisted by a nurse. Nursing staff are responsible for documenting the patient's status before and after the procedure; educating and preparing the patient for the procedure; and observing for complications. Samples must be clearly labeled

and sent to the laboratory. Clinical laboratory scientists/medical technologists perform blood counts, biochemical, and microbiological tests. A histologic technician prepares and stains slides for cytological review by a pathologist.

Resources

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Erika J. Norris

Paralysis

Definition

Paralysis is defined as complete loss of strength in an affected limb or muscle group.

Description

The chain of nerve cells that runs from the **brain** through the **spinal cord** out to the muscle is called the motor pathway. Normal muscle function requires intact connections all along this motor pathway. Damage at any point reduces the nervous system's ability to control voluntary movements. Incomplete damage may cause weakness, also called paresis. Complete loss of communication prevents any willed movement at all. This lack of control is called paralysis. Certain inherited abnormalities in muscle cause periodic paralysis, in which the weakness comes and goes.

The line between weakness and paralysis is not absolute. A condition causing weakness may progress to paralysis. On the other hand, strength may be restored to a paralyzed limb. Nerve regeneration or regrowth is one way that strength can return to a paralyzed muscle. Paralysis almost always causes a change in muscle tone. Paralyzed muscle may be flaccid, flabby, and without appreciable tone, or it may be spastic, tight, and with

abnormally high tone that increases when the muscle is moved.

Paralysis may affect an individual muscle, but usually affects an entire body region. The distribution of weakness is an important clue to the location of the nerve damage that is causing the paralysis. Words describing the distribution of paralysis use the suffix *-plegia*, from the Greek word for “stroke.” The types of paralysis are classified by region:

- **Monoplegia:** affecting only one limb.
- **Diplegia:** affecting the same body region on both sides of the body (for example, both arms or both sides of the face).
- **Hemiplegia:** affecting one side of the body.
- **Paraplegia:** affecting both legs and the trunk
- **Quadriplegia:** affecting all four limbs and the trunk.

Causes and symptoms

Causes

The nerve damage that causes paralysis may be in the brain or spinal cord (the **central nervous system**), or it may be in the nerves outside the spinal cord (the peripheral nervous system). The most common causes of damage to the brain are:

- stroke
- tumor
- trauma (caused by a fall or a blow)
- **multiple sclerosis** (a disease of that destroys the protective sheath that covers nerve cells)
- **cerebral palsy** (a condition caused by a defect or injury to the brain that occurs at or shortly after birth)
- metabolic disorder (a disorder that interferes with the body’s ability to maintain itself)

Damage to the spinal cord is most often caused by trauma, such as a fall or a car crash. Other conditions that may damage nerves within or immediately adjacent to the spine include:

- tumor
- herniated disk (also called a ruptured or slipped disk)
- spondylosis (a disease that causes stiffness in the joints of the spine)
- rheumatoid arthritis of the spine
- neurodegenerative disease (a disease that damages nerve cells)
- multiple sclerosis

Damage to peripheral nerves may be caused by:

- trauma
- compression or entrapment (such as carpal tunnel syndrome)
- Guillain-Barré syndrome (a disease of the nerves that sometimes follows **fever** caused by a viral **infection** or immunization)
- chronic inflammatory demyelinating polyradiculoneuropathy (CIDP) (a condition that causes **pain** and swelling in the protective sheath that covers nerve cells)
- radiation
- inherited demyelinating disease (a condition that destroys the protective sheath around the nerve cell)
- toxins or poisons

Symptoms

The distribution of paralysis offers important clues to the site of nerve damage. Hemiplegia is almost always caused by brain damage on the side opposite the paralysis, often from a stroke. Paraplegia occurs after injury to the lower spinal cord, and quadriplegia occurs after damage to the upper spinal cord at the level of the shoulders or higher (the nerves controlling the arms leave the spine at that level). Diplegia usually indicates brain damage, most often from cerebral palsy. Monoplegia may be caused by isolated damage to either the central or the peripheral nervous system. Weakness or paralysis that occurs only in the arms and legs may indicate demyelinating disease. Fluctuating symptoms in different parts of the body may be caused by multiple sclerosis.

Sudden paralysis is most often caused by injury or stroke. Spreading paralysis may indicate degenerative disease, inflammatory disease such as Guillain-Barré syndrome or CIDP, metabolic disorders, or inherited demyelinating disease.

Other symptoms often accompany paralysis from any cause. These symptoms may include numbness and tingling, pain, changes in **vision**, difficulties with speech, or problems with balance. **Spinal cord injury** often causes loss of function in the bladder, bowel, and sexual organs. High spinal cord injuries may cause difficulties in breathing.

Diagnosis

Careful attention should be paid to any events in the patient’s history that might reveal the cause of the paralysis. The examiner should look for incidents such as **falls** or other traumas, exposure to toxins, recent infections or surgery, unexplained headache, preexisting metabolic disease, and family history of weakness or other neuro-

logic conditions. A neurologic examination tests strength, **reflexes**, and sensation in the affected and unaffected areas.

Imaging studies, including computed tomography scans (**CT scans**), **magnetic resonance imaging (MRI)** scans, or **myelography**, may reveal the site of the injury. **Electromyography** and nerve conduction velocity tests are performed to test the function of the muscles and peripheral nerves.

Treatment

The only treatment for paralysis is to treat its underlying cause. The loss of function caused by long-term paralysis can be treated through a comprehensive rehabilitation program. Rehabilitation includes:

- **Physical therapy.** The physical therapist focuses on mobility. Physical therapy helps develop strategies to compensate for paralysis by using those muscles that still have normal function, helps maintain and build any strength and control that remain in the affected muscles, and helps maintain range of motion in the affected limbs to prevent muscles from shortening (contracture) and becoming deformed. If nerve regrowth is expected, physical therapy is used to retrain affected limbs during recovery. A physical therapist also suggests adaptive equipment such as braces, canes, or wheelchairs.
- **Occupational therapy.** The occupational therapist focuses on daily activities such as eating and bathing. Occupational therapy develops special tools and techniques that permit self-care and suggests ways to modify the home and workplace so that a patient with an impairment may live a normal life.
- **Other specialties.** The nature of the impairment may mean that the patient needs the services of a respiratory therapist, vocational rehabilitation counselor, social worker, speech-language pathologist, nutritionist, special education teacher, recreation therapist, or clinical psychologist.

Prognosis

The likelihood of recovery from paralysis depends on the cause and how much damage has been done to the nervous system.

Health care team roles

A team of therapists and other health care specialists may be involved in the care of a person with paralysis. A person with paralysis may have difficulty expressing his or her needs. Health care workers should pay partic-

KEY TERMS

Computed tomography (CT)—An imaging technique in which cross-sectional x rays of the body are compiled to create a three-dimensional image of the body's internal structures.

Electromyography—A test that uses electrodes to record the electrical activity of muscle. The information gathered is used to diagnose neuromuscular disorders.

Magnetic resonance imaging (MRI)—An imaging technique that uses a large circular magnet and radio waves to generate signals from atoms in the body. These signals are used to construct images of internal structures.

Myelin—The insulation covering nerve cells. Demyelinating disease causes a breakdown of myelin.

Myelography—An x-ray process that uses a dye or contrast medium injected into the space around the spine.

Nerve conduction velocity test—A test that measures the time it takes a nerve impulse to travel a specific distance over the nerve after electronic stimulation.

ular attention to the individual's emotional and psychological well-being, as well as physical. Particular attention should be paid to providing ongoing **patient education**.

Prevention

Prevention of paralysis depends on prevention of the underlying causes. Risk of stroke can be reduced by controlling high **blood pressure** and cholesterol levels. Seatbelts, air bags, and helmets reduce the risk of injury from motor vehicle accidents and falls. Good **prenatal care** can help prevent premature birth, which is a common cause of cerebral palsy.

Resources

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ORGANIZATIONS

Christopher Reeve Paralysis Foundation. 500 Morris Avenue, Springfield, NJ 07081. (800) 225-0292. <<http://paralysis.apacure.org>>.

National Institute of Neurological Disorders and Stroke. NIH Neurological Institute, P.O. Box 5801, Bethesda, MD 20824. (800) 352-9424. <<http://www.ninds.nih.gov>>.

Jennifer F. Wilson

Paralysis agitans *see* **Parkinson's disease**

Paramedics *see* **Emergency medical technicians**

Paraplegia *see* **Paralysis**

Parasomnia *see* **Sleep disorders**

Parathyroid glands

Definition

The four parathyroid glands are small, light-colored lumps protruding from the surface of the **thyroid gland**. They secrete parathyroid hormone, the most important regulator of **calcium** and **phosphorus** amounts in the body.

Description

The parathyroid glands are located on the thyroid gland, a butterfly-shaped gland found in the neck on both sides of the windpipe. There are then two parathyroid glands on each side of the neck for a total of four. Parathyroid tissue consists of two major cell types: oxyphil cells, whose function is unknown, and chief cells, which produce parathyroid hormone. The structure of a parathyroid gland is very different from that of a thyroid gland. The chief cells that produce parathyroid hormone are arranged in tightly-packed nests around small **blood vessels**, quite unlike the thyroid cells that produce thyroid hormones, which are arranged in spheres (thyroid follicles).

The parathyroid glands secrete parathyroid hormone (PTH), a polypeptide consisting of 84 amino acid residues. A hormone is a chemical messenger of the body, produced and secreted by special glands called exocrine glands. It is released directly into the bloodstream and

travels to its target cells, often distant, where it binds to a structure called a receptor, that is found either inside or on the surface of the target cells. Receptors bind a specific hormone and the result is a specific physiologic response, meaning a normal response of the body. The activity of all the hormones or growth factors secreted by endocrine glands and circulating in **blood** is controlled by the exocrine system of the body. PTH finds its major target cells in bone, **kidneys**, and the gastrointestinal system.

Function

The function of the parathyroid glands is to secrete parathyroid hormone, which causes the release of the calcium present in bone to extracellular fluid (ECF). The ECF is the fluid found outside cells in all body tissues. PTH does this by activating the production of osteoblasts, special cells of the body involved in the production of bone and slowing down osteoclasts, other specialized cells involved in the removal of bone.

Calcitonin, a hormone produced by the thyroid gland that also regulates ECF calcium levels and serves to counteract the calcium-producing effects of PTH. The adult body contains as much as 1 kg of calcium. Most of this calcium is found in bone and teeth, and less than 1 g is found in the ECF, with 50% in the form of ionized calcium (Ca^{2+}). Both calcitonin and PTH respond to the circulating levels of Ca^{2+} . An increased amount of ECF Ca^{2+} leads to an increased release of calcitonin and a decreased PTH release; similarly, a decreased amount of ECF Ca^{2+} results in a decreased release of calcitonin and an increased PTH release. Overall, calcitonin acts quickly to reduce ECF Ca^{2+} levels, while PTH works more slowly to ensure that adequate Ca^{2+} ECF levels are maintained. PTH action is thus opposed to that of calcitonin.

Three major calcium regulatory processes are affected by PTH:

- Release of calcium from bone: Although the mechanisms remain unclear, it is known that PTH stimulates bone tissue to release calcium into blood.
- Increased calcium absorption in the intestine: Facilitating calcium absorption from the **small intestine** increases calcium amounts in the blood. PTH also stimulates this process, but indirectly, meaning that it stimulates production of **vitamin D** in the kidney. Vitamin D in turn facilitates the production of a protein in intestinal cells that binds calcium for its efficient absorption into the blood.
- Suppression of calcium loss in urine: Additionally, PTH slows down the elimination of calcium in urine, thus maintaining calcium levels in blood.

KEY TERMS

Amino acid—A class of organic molecules containing mostly the elements carbon, nitrogen, and oxygen, and that combine in linear chains to form polypeptides and proteins. There are 20 naturally-occurring amino acids: alanine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, and valine.

Antagonist—A substance that cancels or counteracts the action of another.

Bone—The hard tissue of the skeleton. Bones mostly consist of calcium carbonate, calcium phosphate, and gelatine.

Bone mineral density—Proper degree of hardness in bones. It is regulated by remodeling, a process that occurs 24 hours a day, seven days a week and involves the continuous breakdown and re-formation of bone.

Calcitonin—A polypeptide hormone produced by the thyroid gland that causes a reduction of calcium levels in the blood. Counteracts PTH.

Endocrine glands—Glands that secrete substances that are released directly into the blood stream and that regulate metabolism and other body functions.

Endocrine system—The system of glands in the body that secrete their hormones directly into the circulatory system.

Extracellular fluid (ECF)—The fluid found outside of the cells and between the cells in body tissues.

Hormone—A naturally occurring substance secreted by specialized cells that affects the metabolism or behavior of other cells possessing receptors for the hormone. Thus, hormones acts like chemical messengers and bind to receptors on target cells.

Metabolism—The sum of all the physical and chemical reactions required to maintain the function of body systems and organs.

Osteoblasts—Cells that are associated with the production of bone as they mature.

Osteoclasts—A large cell with many nuclei associated with the absorption and removal of bone.

Parathyroid hormone (PTH)—Polypeptide hormone consisting of 84 amino acid residues that is secreted by the parathyroid glands. PTH is involved in regulating bone metabolism by controlling calcium and phosphorus levels in the body. Counteracts calcitonin.

Physiologic response—Characteristic of, or conforming to the normal functioning of the body or a tissue or organ.

Receptor—A cell structure, inside or on the surface of cells, that binds a specific hormone and starts a specific physiologic response.

Thyroid gland—A butterfly-shaped endocrine gland located in the neck on both sides of the windpipe. It secretes the hormone thyroxine which controls the rate of metabolism.

Role in human health

The regulation of ECF calcium levels by PTH is the key for essential body functions such as the transmission of impulses across nerve junctions (synapses), **muscle contraction**, and **blood coagulation**, processes that all require calcium. Calcium imbalance will therefore result in serious adverse health effects.

Another major effect of the calcium regulatory activity of PTH is to play a significant role in bone formation and bone maintenance. Bones are hard because they contain calcium compounds, such as calcium carbonate and calcium phosphate. Thus, they provide a frame to the body for physical support as well as for protection. They also store calcium and phosphorus reserves, the chemicals required for bone growth. Bone formation, or the

development of bone mineral density is usually complete around 25–28 years of age. Since bone is a live tissue, just like the other organs of the body, such as the **heart** and kidneys, it maintains its optimal degree of hardness by a very active process, called remodeling. Remodeling occurs 24 hours a day, seven days a week. It involves the continuous breakdown and re-formation of bone to repair any damage that may occur, such as **fractures**, and to maintain the proper levels of calcium in the bone cells.

When the amount of calcium in the ECF falls below normal as a result of the bone remodeling process absorbing it inside the bone cells, the release of PTH then brings it back within the normal range. As calcium amounts increase, the amount of phosphate in blood is also reduced.

Common diseases and disorders

- Primary hyperparathyroidism. The most common disease of parathyroid glands is overactivity, meaning that too much PTH is being produced. Hyperparathyroidism is the result of parathyroid gland disease, which then secretes the hormone in abnormally high amounts. Common symptoms of this disorder are chronic increases of calcium amounts in the blood (hypercalcemia), **kidney stones**, and decalcification of bone. The major symptom of this condition is decalcification of bone, leading to brittle bones that fracture easily (rubber bones).
- Secondary hyperparathyroidism. In this form of hyperparathyroidism, the condition is due to a disease not directly affecting the parathyroid glands that leads to high levels of PTH. Kidney disease is often associated with this disorder because it reduces the renal excretion of phosphate, causing increased phosphate levels in the blood which then decrease the level of free ionized calcium. In addition, most of the calcium in extracellular fluid is not in the ionized form. Rather, at least 50% of the extracellular fluid calcium is in the non-ionized form bound to **proteins** and phosphate. Secondary hyperparathyroidism is also due to a poor diet, deficient in calcium or vitamin D, or which is high in phosphorus (found in meat).
- Hypoparathyroidism. Hypoparathyroidism results from inadequate PTH production. It is a rare condition, most commonly caused by damage or removal of the parathyroid glands at the time of parathyroid or thyroid surgery. Typically, it results in decreased concentrations of calcium and increased concentrations of phosphorus in blood. The resulting hypocalcemia often leads to convulsions, and can be life-threatening.
- Parathyroid adenoma. Parathyroid adenoma commonly occurs on only one of the four parathyroids. The condition accounts for 87–93% of all patients diagnosed with primary hyperparathyroidism. The enlarged parathyroid that has the tumor usually secretes all the PTH with the other three glands responding to the high calcium levels caused by the overactive one by becoming dormant. Parathyroid adenoma is very rarely cancerous (less than one in 500), but it slowly damages the body by causing abnormally high level of calcium in the blood.
- Secondary **osteoporosis**. This bone disorder results from a slight excess of bone removal over bone formation, often the result of prolonged hyperthyroidism.
- Congenital hypoparathyroidism. Individuals with this condition are born without parathyroid tissues. It is due to a genetic disorder resulting in abnormal genes that

either encode for abnormal forms of PTH or its receptor, or prevent normal parathyroid gland development before birth.

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Monique Laberge, Ph.D.

Parathyroid hormone test

Definition

The parathyroid hormone (PTH) test is a **blood** test performed to determine the serum levels of a hormone secreted by the parathyroid gland. The **parathyroid glands** are small paired glands located near the **thyroid gland** at the base of the neck. Most people have four glands, two on each side of the neck. PTH regulates **cal-**

cium and **phosphorus** levels in the body. It is secreted in response to low blood ionized calcium levels, causing bone to release calcium into the blood stream. In addition, it promotes the renal reabsorption of calcium and excretion of phosphorus.

Purpose

The PTH level is measured to evaluate the cause of an abnormal serum or plasma calcium. It is routinely monitored in patients with a kidney disorder called chronic renal failure (CRF). These patients lose calcium via the **kidneys** which stimulates release of PTH. This can lead to bone demineralization. The PTH test is also used to distinguish between primary hyperthyroidism and malignancies that result in high ionized calcium via secretion of a protein called parathyroid hormone-related protein. This stimulates the PTH receptor of bone causing increased plasma ionized calcium. PTH is also used to distinguish between hypoparathyroidism and a condition called pseudohypoparathyroidism, which results from a poor renal response to the hormone. Persons with primary hypoparathyroidism have a low ionized calcium because the parathyroid glands fail to produce enough PTH. Persons with pseudohypoparathyroidism have a low ionized calcium but have a normal or elevated level of PTH.

Description

Measurement of PTH is used for the differential diagnosis of hyperparathyroidism. Primary hyperparathyroidism is most often caused by a benign tumor (adenoma) in one or more of the parathyroid glands. It is rarely caused by parathyroid malignancy. Patients with this condition have high plasma PTH and ionized calcium levels and low plasma inorganic phosphorus. Primary hyperparathyroidism is treated by surgical removal of the tumor(s). The PTH test is used to measure the plasma hormone level during surgery. Complete removal of the tumor is signaled by a return to normal plasma PTH levels.

Secondary hyperparathyroidism is often seen in patients with chronic renal failure (CRF). The kidneys fail to excrete sufficient phosphate and do not reabsorb calcium. The parathyroid gland secretes PTH in an effort to raise the plasma ionized calcium level. Because of the constant stimulation of the parathyroid, CRF patients have high PTH and normal or slightly low calcium levels.

Tertiary hyperparathyroidism occurs when CRF causes proliferation of the parathyroids that does not respond to normal suppression by ionized calcium. Patients with this condition have high plasma PTH and calcium levels and low plasma inorganic phosphorus.

Specific PTH assays

Some PTH is split into peptide fragments by enzymes in the parathyroid gland prior to being released into the blood. Therefore, in addition to intact PTH, three smaller fragments are also present, an amino or N-terminal fragment, a midregion fragment, and a carboxy or C-terminal fragment. Only the intact hormone and fragments containing the amino terminal end of the molecule are physiologically active. A two-site enzyme immunoassay was recently developed to measure PTH. This method measures only the intact PTH and active fragments and is preferred over other assays that detect the inactive fragments.

Precautions

Drug interactions

Some prescription drugs affect the results of PTH tests. Drugs that *increase* PTH levels include phosphates, anticonvulsants, steroids, isoniazid, lithium, and rifampin. Drugs that *decrease* PTH include cimetidine and propranolol.

Timing

PTH levels are subject to diurnal variation. The plasma level peaks at around 2:00 A.M. and is lowest around 2:00 P.M. Specimens are usually drawn at 8:00 A.M. The laboratory should be notified if the patient works the night shift so that this difference in biological rhythm can be taken into account.

Related blood tests

Due to the relationship between PTH and calcium, ionized calcium and inorganic phosphorus levels should be tested at the same time as PTH. In addition, creatinine and other tests of renal function are helpful in identifying those patients who have secondary hyperparathyroidism caused by renal loss of calcium.

Preparation

The PTH test is performed on a sample of the patient's blood, withdrawn from a vein. The procedure, which is called a venipuncture, takes about five minutes. When performing this procedure, the nurse or phlebotomist should follow **universal precautions** for the prevention of transmission of bloodborne pathogens. The patient should have nothing to eat or drink starting at midnight of the day of the test.

KEY TERMS

Assay—An analysis of the chemical composition or strength of a substance.

Hypercalcemia—Abnormally high levels of blood calcium.

Hyperparathyroidism—Overactivity of the parathyroid glands. Symptoms include generalized aches and pains, depression, and abdominal pain.

Hypoparathyroidism—Insufficient production of parathyroid hormone, which results in low levels of blood calcium.

Complications

Risks for this test are minimal, but may include slight bleeding from the puncture site, a small bruise or swelling in the area, or fainting or feeling lightheaded.

Results

Reference ranges for PTH tests vary somewhat depending on the specificity of the antibodies used in the assay to detect the hormone. Results should always be interpreted in association with calcium results. The following ranges are typical:

- intact PTH: 10–65 pg/mL
- PTH N-terminal (includes intact PTH): 8–24 pg/mL
- PTH C-terminal (includes C-terminal, intact PTH, and midmolecule): 50–330 pg/mL

Abnormally high PTH values may indicate primary, secondary, or tertiary hyperparathyroidism. Causes of secondary hyperparathyroidism include chronic renal failure, **malabsorption syndrome**, and **vitamin D** deficiency. Abnormally low PTH levels indicate primary hypoparathyroidism or hypercalcemia. Primary hypoparathyroidism is less common than hyperthyroidism and may result from surgical removal of the glands (during thyroidectomy) or chronic inflammatory (autoimmune) disease. Malignancies producing parathyroid hormone-related protein are common causes of low PTH induced by high ionized calcium.

Health care team roles

This test is ordered by a physician. The blood sample is collected by a nurse or phlebotomist. PTH levels are usually analyzed by clinical laboratory scientists/medical technologists. If abnormal results occur, the

patient is usually referred to an endocrinologist for further evaluation and treatment.

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Parathyroid scan

Definition

A parathyroid scan is sometimes called a parathyroid localization scan or parathyroid scintigraphy. This scan uses radioactive pharmaceuticals that are readily taken up by specific cells in the **parathyroid glands** to obtain an image of the glands. The test is done primarily to detect tumors.

Purpose

The parathyroid glands, embedded in the **thyroid gland** in the neck, but separate from the thyroid in function, control **calcium metabolism** in the body. The parathyroid glands produce parathyroid hormone (PTH). PTH regulates the level of calcium in the **blood**.

Calcium is critical to cellular metabolism, as well as being the main component of bones. If too much PTH is secreted, the bones release calcium into the bloodstream. Over time, the bones become brittle and more likely to break. A person with levels of calcium in the blood that are too high feels tired, run down, irritable, and has difficulty sleeping. Additional signs of too much calcium in the blood are nausea and vomiting, frequent urination, **kidney stones**, and bone **pain**. A parathyroid scan is administered when the parathyroid appears to be overactive and a tumor is suspected.

Precautions

A radioactive material is used to obtain the images of the parathyroid glands, therefore patients who are pregnant are cautioned against having this test unless the benefits outweigh the risks. Women who are breast feeding will need to stop for a specified period of time depending on the particular radiopharmaceutical used. People who

have had other recent nuclear medicine procedures or an x ray consisting of administration of an intravenous contrast material may need to wait until the earlier radioactive tracers or contrast media have been eliminated from their system in order to obtain accurate results from the parathyroid scan.

Description

Parathyroid scans are typically performed in either in a hospital nuclear medicine department or out-patient radiology facility.

A parathyroid scan can be performed using various methods, but are most commonly performed using one of two basic methods. One method uses only one radionuclide whereas the other procedure uses two radionuclides. In either procedure, the patient is injected intravenously with a radiopharmaceutical that accumulates in certain cells within the parathyroid glands. Initial images are obtained approximately 15 minutes after the injection, and then later, at about three hours. For the procedure using two radiopharmaceuticals, separate images can be obtained simultaneously because the gamma camera has the capability to detect more than one radionuclide at a time. The equipment also has the processing capabilities to subtract one image from another, thus revealing two different sets of images used for comparison.

Patients are positioned supine (lying down) under the gamma camera. The camera does not touch, but comes very close to the patient. Each set of pictures takes approximately 30 to 45 minutes.

Preparation

No special preparation is necessary for this test. There is no need to fast or maintain a special diet. The patient should wear comfortable clothing with no metal jewelry around the neck.

Aftercare

The patient should not feel any adverse effects of the test and can resume normal activities immediately.

Complications

There are no known complications associated with this test.

Results

Normal results will show no unusual activity in the parathyroid glands. An increased concentration of

radioactive materials in the parathyroid glands suggests excessive activity and the presence of a tumor. False positive results sometimes result from the presence of multinodular goiter, neoplasm, or cysts. False positive tests are tests that interpret the results as abnormal when this is not true. Parathyroid scans are often paired with other imaging studies such as MRI and ultrasound to confirm a diagnosis.

Health care team roles

A parathyroid scan is performed by a nuclear medicine technologist. The technologist is trained to handle radioactive materials, administer the injections, operate the equipment, and process the data. The technologist will obtain any pertinent medical history and explain the test to the patient. The test is interpreted by a doctor who is a radiologist or nuclear medicine specialist. The patient receives the results of the test from their personal physician or the doctor who ordered the test.

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Parentage testing

Definition

In parentage testing, an individual's DNA is used to prove or disprove his or her relatedness to a particular child.

Purpose

Parentage, or paternity, testing may be sought solely for the sake of curiosity, but is most often used to prove or disprove paternity for legal purposes. Legally motivat-

ed reasons to seek parentage testing can include contested child support, custody, or visitation rights, immigration status, adoption, and insurance or inheritance claims.

Historically, paternity testing was based on examination of the **blood** groups of the child and putative father, and the test could only exclude the possibility of relatedness when blood groups did not match; matching blood groups could not prove parentage, but only the possibility thereof. Modern testing, based on the examination of DNA, can prove with virtually 100% certainty exclusion of paternity or the probability to a certainty of 99.9% that a given person is the parent of a particular child.

Parentage testing is recommended in adoption cases, as identifying both biological parents can help the adoptive parents judge the possibility that the adopted child will develop certain inheritable medical conditions such as **cystic fibrosis**, or Tay Sachs disease. Further, as the adopted child grows to adulthood, a genetic medical history can prove useful in diagnosis of other conditions such as breast or colon **cancer** or **heart** disease. Also, paternity testing ensures that the true biological father relinquishes parental rights and negates the possibility that the adoption will be contested later.

In the infrequent but dramatic cases of babies being switched at birth, parentage testing allows unequivocal identification of parents. In surrogacy cases, DNA testing can confirm the success of the implantation procedure by verifying the identity of the biological parents.

Precautions

Currently, the vast majority of DNA testing for parentage determination is performed by commercial laboratories that are not associated with a hospital, blood bank, or medical laboratory. The focus of such facilities is often legal rather than medical. Persons seeking testing should be aware that psychological support and **genetic counseling** may be needed following parentage testing to help them deal with the implications of the results.

Many laboratories advertising paternity testing services lack any accreditation. Individuals seeking paternity testing should choose a laboratory that is accredited by the American Association of Blood Banks (AABB), which performs on site laboratory inspections to ensure that the techniques and equipment being used are acceptable and that the methods followed are consistent with the strict national standards established for paternity/parentage testing.

When blood or other body fluid is collected for DNA analysis, **universal precautions** should be observed for the prevention of transmission of bloodborne pathogens.

It is important that the parties seeking parentage testing clearly understand their own motivation for testing. Testing that includes “chain of custody” of the samples to be analyzed—notarized proof of identity of all parties being tested and traceable transport of samples from collection to the testing laboratory—is admissible as evidence in the courtroom, but costlier than testing without chain of custody. However, testing on self-collected samples for curiosity purposes, in which chain of custody protocols are not strictly followed, has no legal standing.

The DNA restriction fragment length polymorphisms (RFLPs) and short tandem repeat (STR) loci that commonly serve as identity markers are noncoding regions (i.e., DNA that is not transcribed into RNA and does not code for **proteins**). As such, the mutation rate in these sections of DNA tends to be higher than in normal genes. Also, the polymerase chain reaction (PCR) used to amplify the STRs is subject to introduction of mutations. These mutation events can complicate the interpretation of results.

Interpretation of parentage testing results are generally based on the assumption that the alleged father is not related to the actual father, which may not be true. Also, extra care is required in the interpretation of results in the case where the mother’s DNA is not available for testing.

Description

Modern parentage (paternity) testing is also known as DNA testing, profiling, or fingerprinting. The dramatic evolution of DNA profiling techniques has been in the field of forensic identification, and since 1985, the technologically advanced DNA-based methodology has essentially completely displaced blood-antigen-based paternity investigation.

Restriction fragment length polymorphisms (RFLPs)

One approach to DNA fingerprinting is based on analysis of slight differences between individuals in the sequence of nucleotides, called sequence polymorphisms, in the chromosomal DNA. A sequence change can cause restriction endonucleases, enzymes used to cut the DNA into pieces small enough to analyze, to make fewer cuts in the DNA, leading to DNA fragments of different sizes called restriction fragment length polymorphisms (RFLPs). These RFLPs are well cataloged, and every person will display a given set of them upon analysis. Clusters of RFLPs tend to be consistent within ethnic groups. A greater number of matches between individuals indicates a greater probability of relatedness. Each person has RFLPs inherited from both parents, and thus has a unique RFLP “fingerprint.”

In a RFLP DNA analysis, 1–5 ml of blood is drawn from which about 100 ng DNA is extracted and treated with a restriction endonuclease. The DNA fragments are separated by electrophoresis on an agar or polyacrylamide gel, denatured and transferred to nitrocellulose paper, and incubated with pieces of radioactively labeled DNA probes complimentary for the RFLPs. The RFLPs that are present in a sample show up as dark bands on X-ray film exposed to the nitrocellulose sheet.

Short tandem repeats (STRs)

The current state-of-the-art approach to DNA profiling is the investigation of short tandem repeat (STR) loci—short sequences of DNA, normally two to six base pairs that are repeated head to tail numerous times. STRs, also known as microsatellite DNA, are, like RFLPs, well characterized, and each individual carries a distinct set inherited from both parents. STRs are the result of length polymorphisms (inherited differences in the number of these short sequences) as opposed to sequence polymorphisms (inherited differences in the order of bases). The extracted DNA is subjected to amplification in the polymerase chain reaction (PCR), in which fluorescently labeled primer pieces of DNA specific for known STR sequences are incubated with appropriate enzymes and nucleotide building blocks to amplify synthesis of the STR regions of the sample DNA; only the STRs that are present in the sample DNA become amplified. The fluorescently labeled amplified STRs are then separated by gel or capillary electrophoresis, and read by a fluorescence detector. DNA fingerprinting based on STRs has the advantage of being more sensitive than tests based on RFLPs, that is, requiring only 1–5 ng of DNA extracted from a few drops of blood, or from buccal cells collected with a swab from the inside of the cheek. Further, the PCR technique, capillary electrophoresis separation, and fluorescence detection are amenable to automation, leading to faster throughput and less human error.

In 1997, the FBI announced the selection of 13 STR loci to constitute the core of a national DNA profiling database known as CODIS, which has been widely adopted by forensic DNA analysts worldwide. All CODIS STRs are discrete tetrameric repeat sequences that behave according to known principles of population genetics and can be rapidly analyzed with commercially available kits. The CODIS STR set of loci is rapidly becoming the industry standard in paternity testing. A kit that tests the 13 CODIS plus three more STR sites has recently become commercially available.

Testing procedure

The laboratories that perform parentage testing are generally commercial facilities engaged in only parentage testing. The person seeking parentage testing contacts such a laboratory to receive instructions. Generally, the appointment for sample collection is scheduled at a local medical laboratory or clinic contracted by the testing laboratory. At the time of scheduling, the names, addresses, and telephone numbers of all persons to be tested, the date of birth or approximate age of the child(ren) to be tested, the preferred day and time for the sample collection, and the name and contact information of any attorney(s) involved is recorded. It is possible to schedule collections for different people in different locations at different times. The samples are all shipped to the testing laboratory to be analyzed simultaneously.

For testing with chain of custody, it is extremely important that everyone being tested is positively identified. For every adult person being tested, the social security number and a picture ID, such as a driver's license, passport, or state identification card is required, and for each child a birth certificate must be provided. Photographs and fingerprints of all persons may be taken at the time of sample collection. Strict chain of custody procedures must be followed, and all information and results are kept strictly confidential and are not released without proper prior authorization.

A small blood sample, usually from a finger prick, is collected from the mother, the child(ren), and alleged father(s). For newborns, the blood sample can be obtained from the umbilical cord at birth, or from a heel prick. Alternatively, cells from the inside of the mouth are collected with a buccal swab. It is also possible to arrange for prenatal testing to be performed on chorionic villi or precultured amniotic fluid cells.

Buccal swabs have become the specimen collection method of choice for DNA testing. The specimen is collected by gently stroking the inner facial cheek with the swab for 30 seconds. It is not necessary to fast before specimen collection, since buccal swab specimens are unaffected by foods, toothpaste, cigarettes, chewing tobacco, lipstick, or bacterial DNA. The collected buccal cells are still usable after years of storage. Buccal samples do not need to be refrigerated nor is immediate shipping to the laboratory required.

To extract DNA from the swab, the head of the swab is transferred to a small plastic tube containing a small amount (0.6 ml) of dilute sodium hydroxide solution (50 mM), and the stick is cut off to allow the tube to be closed (special buccal swabs with ejectable heads have recently become available). The tube is mixed and incubated for 5 min in boiling water, after which the swab

KEY TERMS

Amniotic fluid—The watery fluid in the amnion, in which the embryo is suspended; the fluid contains cells of fetal origin.

Buccal—Pertaining to the cheek.

Capillary electrophoresis—A technique for separating biomolecules such as DNA in a fluid-filled thin glass tube on the basis of size and rate of migration in an electric field.

Chorionic villi—Branching outgrowths of the chorion that form the placenta in combination with maternal tissue.

DNA—Deoxyribonucleic acid, a long polymeric biomolecule composed of two self-complementary deoxyribonucleotide strands that adopt a double helical structure and become tightly coiled together with proteins to form chromosomes; DNA is the molecule that stores and transfers the genetic information in virtually all life forms.

Electrophoresis—A technique for separating biomolecules such as DNA in a gel medium on the basis of size and rate of migration in an electric field.

Nucleotide—A biomolecule composed of one of the organic nitrogen-containing bases (adenine, cytosine, guanine, or thymine), a phosphate group, and a pentose sugar that serve as the building blocks of DNA and RNA (in RNA, the thymine base is replaced by uracil).

Polymerase chain reaction (PCR)—A method used in DNA analysis whereby a specific region(s) of the DNA sequence is amplified, allowing rapid DNA analysis.

Polymorphism—The presence of two or more distinct phenotypes in a population due to the expression of different alleles of a given gene.

Restriction endonuclease—Any of a group of enzymes that catalyze the cleavage of DNA molecules at specific sites, used in recombinant DNA technology.

Short tandem repeat—A defined region of DNA, also called microsatellite DNA, containing multiple copies of short sequences of bases repeated a number of times.

head is removed, and a few drops of a buffer (0.06 ml Tris-HCL, pH 8) are added.

For curiosity testing without chain of custody, kits can be obtained for home collection of cheek cells with buccal swabs. The samples are then sent by courier to the testing laboratory.

The fee for testing, with chain of custody, one alleged father and one child, usually with or without the mother, is \$400–500, and about \$150 is charged for each additional person tested. The level of the fee may also depend on the number of DNA loci or systems probed; generally six to 16 loci are analyzed. Most parentage testing firms require payment of a nonrefundable deposit of \$100–150 to initiate the scheduling process; this deposit is applied toward the total fee. Payment may be made by major credit card, certified check, or money order, and is unlikely to be covered by medical insurance. In most cases, the local collection facility additionally charges a specimen collection fee, typically \$15–40 per person. The fee for prenatal testing can be substantially higher. Testing without chain of custody can cost \$280–400, depending on whether samples are collected at home or by a clinic. Curiosity testing may be performed on samples other than collected blood or buccal cells, such as cigarette butts, chewed gum, bloodstained or semen-stained clothing, used condoms, plucked hair or electric razor debris, or Q-tips containing earwax; additional fees may apply for non-standard samples.

Preparation

No physical preparation is required. For chain of custody testing, identification documents for every person to be tested must be provided at the time of sample collection.

Aftercare

None.

Complications

None.

Results

Results are returned generally after one to two weeks, and are usually not released until all fees have been collected. Many facilities offer express service with shorter turn-around times, but with correspondingly larger fees, for example, up to about \$1,500 for results returned within one working day.

The sample from the child(ren) will give rise to banding patterns on the gel or in the electropherogram reflecting bands inherited from each parent. On the basis

of the banding pattern, inclusion or exclusion of parentage is decided.

The commercial parentage testing laboratories typically guarantee over 99.9% exclusion and over 99.0% inclusion of paternity. The actual numbers for the state-of-the-art testing protocols are 100% exclusion and 99.99% inclusion of parentage. For analyses in which the mother's DNA is not available for testing, the rates of inclusion can drop dramatically to 80–99% depending on the number of gene loci examined.

Health care team roles

Initial consultations and scheduling of sample collection appointments is carried out by a representative of the commercial parentage testing facility, often by telephone. A nurse, phlebotomist, or laboratory technician collects the samples and verifies documents at the locally contracted clinic or laboratory, and arranges for transport of the samples to the testing facility. At most accredited parentage testing laboratories, the sample analysis is performed by Ph.D. scientists.

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- DNA Diagnostics Center. 205 Corporate Court, Fairfield, OH 45014. 1 (800) 613-5768. <<http://www.dnacenter.com/about.html>>.
- DNA Testing Centre, Inc. 1201 W. Airport Fwy. STE 255, Euless, TX 76040. <<http://www.homedna-test.com>>.
- Genetic Profiles Corporation. 6122 Nancy Ridge Drive, San Diego, CA 92121. 1-800-551-7763. <<http://www.geneticprofiles.com>>.
- GeneTree Inc. 3150 Almaden Expressway #203 San Jose, CA 95118-1253. 1 (408) 723-2670. <<http://www.genetree.com>>.

The National HLA Fund, Inc. 909 Oradell Avenue, Oradell, NJ 07649-1924. <<http://www.nationalhlafund.org>>.

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Patricia L. Bounds, Ph.D.

Parenteral nutrition

Definition

When patients cannot use their gastrointestinal tracts for **nutrition**, parenteral nutrition may be used to maintain or improve the patient's nutritional status. This form of intravenous treatment provides all the nutrients that are delivered to the patient. This treatment may be temporary or long-term.

Purpose

The harmful effects of malnutrition on the overall health of a patient are well documented. Poor nutrition is associated with slowed or impaired recovery from illness and surgery. For wound healing, tissue maintenance, and faster recovery, patients need optimal nutritional intake. When a patient is unable to take in enough food on his own, there are two options. Enteral feeding is preferred because it is less invasive, has a lower risk for **infection**, and is safer than the parenteral method. Though enteral feeding is the preferred route of nutritional intake, parenteral nutrition plays an important role in many clinical situations. Patients who cannot consume enough nutrients on their own, or who cannot eat at all because of an illness, surgery, or an accident, may be fed through an intravenous line.

Precautions

Patients receiving parenteral nutrition need to be monitored closely to ensure that the therapy is providing adequate amounts of fluids, **minerals**, and other nutrients that are needed. Laboratory testing will take place on a regular basis to monitor the patient's status.

Description

Parenteral nutrition, also known as hyperalimentation, is subdivided into two categories: partial parenteral

KEY TERMS

Enteral nutrition—Nutrition provided by introducing nutritional substances into the intestines.

Hyperosmolarity—An increased concentration of osmotically active particles in solution.

nutrition and total parenteral nutrition. These categories differ by the makeup of the solutions and the site of administration.

Partial parenteral nutrition (PPN) is normally prescribed for patients who can tolerate some oral feedings but cannot ingest adequate amounts of food to meet their nutritional needs. It is usually administered through a peripheral intravenous catheter. Two types of solutions are commonly used in a number of combinations for PPN: lipid emulsions and amino acid-dextrose solutions.

Total parenteral nutrition (TPN) is given when a patient requires an extended period of intensive nutritional support. It is usually administered through a central venous catheter. TPN solutions contain high concentrations of **proteins** and dextrose. Various components like electrolytes, minerals, trace elements, and insulin are added based on the needs of the patient. Total parenteral nutrition provides the calories a patient requires and keeps the body from using protein for energy. TPN is given using an infusion pump.

Both of these types of nutrition may be administered either in a medical facility or in the patient's home. Home parenteral nutrition normally requires a central venous catheter, which must first be inserted in a fully equipped medical facility. After it is inserted, therapy can continue at home.

Preparation

The physician orders the particular PPN or TPN solution as well as any additional nutrients or drugs that should be added. The doctor also specifies the rate at which the solution will be infused. The IV (intravenous) solutions are prepared under the supervision of a doctor, pharmacist, or nurse, using techniques to prevent bacterial contamination.

In the case of home parenteral nutrition, the solution is delivered to the patient's home on a regular basis and should be kept refrigerated. The solution should be allowed to come to room temperature before it is connected to the patient.

Aftercare

Patients who have been receiving parenteral nutrition for more than a few days, and have been given permission to start eating again, should reintroduce foods gradually. This will give the digestive tract time to start functioning again.

Complications

Patients receiving PPN or TPN are at risk for a number of very serious complications. These complications may result from the IV solutions or from the central venous catheter.

Fluid imbalances may occur in patients receiving parenteral nutrition. The extreme hyperosmolarity of the solutions may cause fluid shifts in the body. This hyperosmolarity is caused by the concentrations of dextrose and amino acids. The increased levels of dextrose may cause hyperglycemia, which may in turn cause the dextrose to move into the interstitial spaces into the plasma. This can cause a series of events that may lead to **dehydration** and hypovolemic **shock**. If the patient's **heart** or **kidneys** function poorly, the situation may develop into congestive **heart failure** and pulmonary **edema**. The patient should be monitored closely for signs of these complications. Accurate records of intake and output should be maintained, and daily weights recorded. Serum electrolytes and glucose are also monitored.

Another possible complication for those receiving parenteral nutrition is a variety of electrolyte imbalances. Daily serum electrolyte levels are normally ordered to find imbalances. Sodium and potassium imbalances are seen frequently among patients receiving PPN and TPN, especially when insulin is part of the intravenous solution. Hypercalcemia may also occur, although it may be more closely associated with the hazards of immobility than the parenteral therapy itself.

Another complication associated with parenteral nutrition is infection at the site of the central venous catheter. For patients receiving long-term therapy, the risk of infections spreading to the entire body (sepsis) is fairly high. Measures should be taken to prevent infections at the catheter site. This includes regular sterile dressing changes, and prompt reporting of any signs of redness, swelling, or drainage.

Results

For those on short-term parenteral therapy, the goal is to provide adequate nutritional supplementation until the patient can transition back to solid foods. Patients receiving long-term therapy should have their nutritional needs met, with a goal of avoiding potential complications.

Health care team roles

A variety of members of the health care team may be involved in the decisions to order parenteral nutrition and in the care required to administer it. These include:

- physicians
- pharmacists
- dietitians
- nurses

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Parkinsonism see **Parkinson's disease**

Parkinson's disease

Definition

Parkinson's disease (PD) is a progressive movement disorder marked by tremors, rigidity, slow movements (bradykinesia), and postural instability. It occurs when, for unknown reasons, cells in one of the movement-control centers of the **brain** begin to die.

Description

Usually beginning in a person's late 50s or early 60s, PD causes a progressive decline in movement control, affecting the ability to control initiation, speed, and smoothness of motion. Symptoms of PD are seen in up to 15% of those between the ages 65–74, and almost 30% of those between the ages 75–84.

Genetic profile

Most cases of PD are sporadic. This means that there is a spontaneous and permanent change in nucleotide sequences (the building blocks of genes). Sporadic mutations also involve unknown environmental factors in

combination with genetic defects. The abnormal gene (mutated gene) will form an altered end-product or protein. This will cause abnormalities in specific areas of the body where the protein is used. Some evidence suggests that the disease is transmitted by autosomal dominant inheritance. This implies that an affected parent has a 50% chance of transmitting the disease to any child. This type of inheritance is not commonly observed. The most recent evidence links PD with a gene that codes for a protein called alpha-synuclein. Further research is attempting to fully understand the relationship with this protein and nerve cell degeneration.

Demographics

PD affects approximately 500,000 people in the United States, both men and women, with as many as 50,000 new cases being diagnosed each year.

Causes and symptoms

Causes

The immediate cause of PD is degeneration of brain cells in the area known as the substantia nigra, one of the movement control centers of the brain. Damage to this area leads to the cluster of symptoms known as parkinsonism. In PD, degenerating brain cells contain Lewy bodies, which help identify the disease. The cell death leading to parkinsonism may be caused by a number of conditions, including **infection**, trauma, and **poisoning**. Some drugs given for psychosis, such as haloperidol (Haldol) or chlorpromazine (Thorazine), may cause parkinsonism. When no cause for nigral cell degeneration can be found, the disorder is called idiopathic parkinsonism, or Parkinson's disease. Parkinsonism may be seen in other degenerative conditions, known as the parkinsonism plus syndromes, such as progressive supranuclear palsy.

The substantia nigra, or black substance, is one of the principal movement control centers in the brain. By releasing the neurotransmitter known as dopamine, it helps to refine movement patterns throughout the body. The dopamine released by nerve cells of the substantia nigra stimulates another brain region, the corpus striatum. Without enough dopamine, the corpus striatum cannot control its target muscles. Ultimately, the movement patterns of walking, writing, reaching for objects, and other basic programs cannot operate properly, and the symptoms of parkinsonism are the result.

There are some known toxins that can cause parkinsonism, most notoriously a chemical called MPTP, found as an impurity in some illegal drugs. Parkinsonian symptoms appear within hours of ingestion and are permanent. MPTP may exert its effects through generation of toxic

molecular fragments called free radicals. Reducing free radicals has been a target of several experimental treatments for PD using antioxidants.

It is possible that early exposure to some as-yet-unidentified environmental toxin or virus leads to undetected nigral cell death, and that PD then becomes manifest as normal age-related decline brings the number of functioning nigral cells below the threshold needed for normal movement. It is also possible that, for genetic reasons, some people are simply born with fewer cells in their substantia nigra than others, and develop PD again as a consequence of normal decline.

Symptoms

The identifying symptoms of PD include:

- Tremors, usually beginning in the hands, often occurring on one side before the other. The classic tremor of PD is called a pill-rolling tremor, because the movement resembles rolling a pill between the thumb and forefinger. This tremor occurs at a frequency of about three per second.
- Slow movements (bradykinesia) occur, which may involve slowing down or stopping in the middle of familiar tasks such as walking, eating, or shaving. This may include freezing in place during movements (akinesia).
- Muscle rigidity or stiffness, occurring with jerky movements replacing smooth motion.
- Postural instability or balance difficulty occurs. This may lead to a rapid, shuffling gait (festination) to prevent falling.
- In most cases, there is a typical facial expression called masked face, characterized by little facial expression and decreased eye-blinking.

In addition, a wide range of other symptoms may often be seen, some beginning earlier than others:

- depression
- speech changes, including rapid speech without inflection changes
- problems with sleep, including restlessness and nightmares
- emotional changes, including fear, irritability, and insecurity
- incontinence
- constipation
- handwriting changes, with letters becoming smaller across the page (micrographia)

- progressive problems with intellectual function (**dementia**)

Diagnosis

The diagnosis of Parkinson disease involves a careful medical history and a neurological exam to look for characteristic symptoms. There are no definitive tests for PD, although a variety of lab tests may be done to rule out other causes of symptoms, especially if only some of the identifying symptoms are present. Tests for other causes of parkinsonism may include brain scans, **blood** tests, lumbar puncture, and x rays.

Treatment

There is no cure for Parkinson disease. Most drugs treat only the symptoms of the disease, although one drug, selegiline (Eldepryl), may slow degeneration of the substantia nigra.

Exercise, nutrition, and physical therapy

Regular, moderate **exercise** has been shown to improve motor function without an increase in medication for a person with PD. Exercise helps maintain range of motion in stiff muscles, improve circulation, and stimulate appetite. An exercise program designed by a physical therapist has the best chance of meeting the specific needs of a person with PD. A physical therapist may also suggest strategies for balance compensation and techniques to stimulate movement during slowdowns or freezes.

Good **nutrition** is important to maintenance of general health. A person with PD may lose some interest in food, especially if depressed, and may have nausea from the disease or from medications, especially those known as dopamine agonists. Slow movements may make it difficult to eat quickly, and delayed gastric emptying may lead to a feeling of fullness without having eaten much. Increasing fiber in the diet can improve constipation, soft foods can reduce the amount of needed chewing, and a prokinetic drug such as cisapride (Propulsid) can increase the movement of food through the **digestive system**.

People with PD may need to limit the amount of protein in their diets. The main drug used to treat PD, L-dopa, is an amino acid, and is absorbed by the digestive system by the same transporters that pick up other amino acids broken down from **proteins** in the diet. Limiting protein, under the direction of a physician or nutritionist, can improve the absorption of L-dopa.

No evidence indicates that vitamin or mineral supplements can have any effect on the disease other than in their improvement of general health. No antioxidants used to date have shown promise as a treatment except for selegiline, an MAO-B inhibitor. A large, carefully controlled study of **vitamin E** demonstrated that it could not halt disease progression.

Drugs

The pharmacological treatment of Parkinson disease is complex. While there are a large number of drugs that can be effective, their effectiveness varies among individuals, disease progression, and the length of time the drug has been used. Dose-related side effects may preclude the use of the most effective dose, or require the introduction of a new drug to counteract them. There are five classes of drugs currently used to treat PD.

DRUGS THAT REPLACE DOPAMINE. One drug that helps replace dopamine, levodopa (L-dopa), is the single most effective treatment for the symptoms of PD. L-dopa is a derivative of dopamine, and is converted into dopamine by the brain. It may be started when symptoms begin, or when they become serious enough to interfere with work or daily living.

L-dopa therapy usually remains effective for five years or longer. Following this, many persons develop motor fluctuations, including peak-dose dyskinesias (abnormal movements such as tics, twisting, or restlessness); rapid loss of response after dosing (known as the on-off phenomenon); and unpredictable drug response. Higher doses are usually tried, but may lead to an increase in dyskinesias. In addition, side effects of L-dopa include nausea and vomiting, and low **blood pressure** upon standing (orthostatic hypotension), which can cause dizziness. These effects usually lessen after several weeks of therapy.

ENZYME INHIBITORS. Dopamine is broken down by several enzyme systems in the brain and elsewhere in the body, and blocking these enzymes is a key strategy to prolonging the effect of a dose of dopamine. The two most commonly prescribed forms of L-dopa contain a drug to inhibit the amino acid decarboxylase (an AADC inhibitor), one type of enzyme that breaks down dopamine. These combination drugs are Sinemet (L-dopa plus carbidopa) and Madopar (L-dopa plus benzaseride). Controlled-release formulations also aid in prolonging the effective interval of an L-dopa dose.

The enzyme monoamine oxidase B (MAO-B) inhibitor selegiline may be given as add-on therapy for L-dopa. Research indicates selegiline may have a neuroprotective effect, sparing nigral cells from damage by free radicals. Because of this, and the fact that it has few side

KEY TERMS

AADC inhibitors—Drugs that block the amino acid decarboxylase; one type of enzyme that breaks down dopamine. Also called DC inhibitors, they include carbidopa and benserazide.

Akinesia—A loss of the ability to move; freezing in place.

Bradykinesia—Extremely slow movement.

COMT inhibitors—Drugs that block catechol-O-methyltransferase, an enzyme that breaks down dopamine. COMT inhibitors include entacapone and tolcapone.

Dopamine—A chemical in the brain (neurotransmitter) that helps send signals that control movement.

Dyskinesia—An abnormal involuntary movement. Dyskinesias are common late in PD as L-dopa therapy becomes less effective.

MAO-B inhibitors—Inhibitors of the enzyme monoamine oxidase B. MAO-B helps break down dopamine; inhibiting it prolongs the action of dopamine in the brain. Selegiline is an MAO-B inhibitor.

Orthostatic hypotension—A sudden decrease in blood pressure upon sitting up or standing. May be a side effect of several types of drugs.

Substantia nigra—One of the movement control centers of the brain.

effects, it is also frequently prescribed early in the disease before L-dopa is begun. Entacapone (Comtan) and tolcapone (Tasmar), two inhibitors of another enzyme system called catechol-O-methyltransferase (COMT), have recently been approved for use and marketed. They effectively treat PD symptoms with fewer motor fluctuations and decreased daily L-dopa requirements.

DOPAMINE AGONISTS. Dopamine works by stimulating receptors on the surface of corpus striatum cells. Drugs that also stimulate these cells are called dopamine agonists, or DAs. DAs may be used before L-dopa therapy, or added on to avoid requirements for higher L-dopa doses late in the disease. DAs available in the United States as of 2001, include bromocriptine (Permax, Parlodel), pergolide (Permax), pramipexole (Mirapex), cabergoline (Dostinex), and ropinirole (Requip). Other dopamine agonists in use elsewhere include lisuride

(Dopergine) and apomorphine. Side effects of all the DAs are similar to those of dopamine, plus confusion and hallucinations at higher doses.

ANTICHOLINERGIC DRUGS. Anticholinergics maintain dopamine balance as levels decrease. However, the side effects of anticholinergics (dry mouth, constipation, confusion, and blurred **vision**) are usually too severe in older individuals or in persons with dementia. In addition, anticholinergics rarely work for very long. They are often prescribed for younger people who have predominant shaking. Trihexyphenidyl (Artane) is the most commonly prescribed drug.

DRUGS WHOSE MODE OF ACTION IS UNCERTAIN. Amantadine (Symmetrel) is sometimes used as an early therapy before L-dopa is begun, and as an add-on later in the disease. Its anti-parkinsonian effects are mild, and are not seen in many persons. Clozapine (Clozaril) is effective, especially against psychiatric symptoms of late PD, including psychosis and hallucinations.

Surgery

Two surgical procedures are used for treatment of PD that cannot be controlled adequately with drug therapy. In PD, a brain structure called the globus pallidus (GPi) receives excess stimulation from the corpus striatum. In a pallidotomy, the GPi is destroyed by heat that is delivered by long thin needles inserted under anesthesia. Electrical stimulation of the GPi is another way to reduce its action. In this procedure, fine electrodes are inserted to deliver the stimulation, which may be adjusted or turned off as the response dictates. Other regions of the brain may also be stimulated by electrodes inserted elsewhere. In most persons, these procedures lead to significant improvement for some motor symptoms, including peak-dose dyskinesias. This allows a person to receive more L-dopa, since these dyskinesias are usually responsible for any upper limit on the L-dopa dose.

A third procedure, transplant of fetal nigral cells, is still highly experimental. Its benefits to date have been modest, although improvements in technique and surgical candidate selection are likely to increase successful outcomes.

Alternative treatment

Currently, the best treatments for PD involve the use of conventional drugs such as levodopa. Alternative therapies, including acupuncture, massage, and **yoga**, can help relieve some symptoms of the disease and loosen tight muscles. Alternative practitioners have also applied herbal and dietary therapies, including amino acid supplementation, antioxidant (**vitamins** A, C, E, selenium, and **zinc**) therapy, B vitamin supplementation, and **cal-**

cium and magnesium supplementation to the treatment of PD. Persons using these therapies in conjunction with conventional drugs should check with their doctor to avoid the possibility of adverse interactions. For example, vitamin B₆ (either as a supplement or from foods such as whole grains, bananas, beef, fish, liver, and potatoes) can interfere with the action of L-dopa when the drug is taken without carbidopa.

Prognosis

Despite medical treatment, the symptoms of Parkinson's disease worsen over time, and become less responsive to drug therapy. Late-stage psychiatric symptoms are disease often the most troubling. These include difficulty sleeping, nightmares, intellectual impairment (dementia), hallucinations, and loss of contact with reality (psychosis).

Health care team roles

A physician usually makes an initial diagnosis of Parkinson's disease. Treatment is often managed by a family physician or internist. Neurologists may be asked for consultations. Occasionally, neurosurgeons perform surgery in the treatment of parkinsonism. Clinical nutritionists and physical therapists may assist in managing persons with PD. Nurses provide bedside care in the hospital, and administer the frequent patient neurologic evaluations. They also provide patient and family education about the diagnosis and home management.

Prevention

There is no known way to prevent Parkinson's disease.

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ORGANIZATIONS

- American Academy of Neurology. 1080 Montreal Avenue, St. Paul, MN 55116. (651) 695-1940. <<http://www.aan.com>>.
- American College of Physicians. 190 N. Independence Mall West, Philadelphia, PA 19106-1572. (800) 523-1546. <<http://www.acponline.org>>.
- American Parkinson Disease Association. Inc., 1250 Hylan Boulevard, Suite 4B, Staten Island, NY 10305-1946. (800) 223-2732. <<http://www.apdaparkinson.com>>.
- Parkinson's Disease Foundation. 710 West 168th Street, New York, NY 10032-9982. (800) 457-6676. <<http://www.pdf.org>>.
- Parkinson's Disease Society (UK). 215 Vauxhall Bridge Road, London SW1V 1EJ. (020) 7931-8080. <<http://www.parkinsons.org.uk>>.

OTHER

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Parotid gland scan see **Salivary gland scan**

Partial thromboplastin time see

Coagulation tests

Paternity testing see **Parentage testing**

Patient-controlled analgesia

Definition

Patient-controlled analgesia (PCA) is a system of providing **pain** medication that allows the patient to self-administer synthetic, opium-like pain-relievers (opioids) on an "as-needed" basis, but only within the limit of a maximum dose every eight (or 12) hours. A pump-type device delivers the medicine into the veins (intravenously, the commonest of the three methods), under the skin (subcutaneously), or between the dura mater and the **skull** (epidurally). A health care provider programs the device both with the specific dosage to deliver at each request made by the patient and with the total permitted during the time for which the device is set (commonly eight hours, sometimes 12, especially if the health-care providers are working 12-hour shifts). Some of these devices are very sophisticated and even monitor themselves and ring an alarm-bell if there is an indication that they might be malfunctioning.

Purpose

The purpose of PCA is improved pain control. PCA allows for immediate delivery of pain medication without the delay that would occur if a nurse, busy with many other patients on the floor, must answer the patient's buzzer or other signal. (It is not as needed if the patient has a full-time, private-duty nurse in the room every minute.) PCA also allows more frequent but smaller doses and thus a more even level of the pain-killer in the patient's body. The busy nurse must administer large-

er doses at one time. Unfortunately, these larger doses peak shortly after administration, often causing undesirable side-effects such as nausea and difficulty in breathing. Their effect often wears off before the next dose is scheduled.

Precautions

Using such a pump requires an understanding of how to work it and the physical strength to do so (usually by pressing a button). Therefore, PCA should not be offered to patients who are confused, unresponsive, or paralyzed. Patients with neurologic disease or head injuries in whom narcotics would mask neurologic changes are not eligible for PCA. Patients with poor kidney or lung function are usually not good candidates for PCA, unless they are monitored very closely.

PCA may be used by children as young as seven years old. It has proven safe and successful in such children in the control of postoperative pain, sickle-cell pain, and pain associated with bone-marrow transplantation.

Whenever opium-like pain-killers are administered to the elderly patient, the health care professional must keep several things in mind: older adults may be more susceptible to side effects of narcotics because their **heart, liver, and kidneys** work less well than when they were younger. The elderly may also clear the narcotic out of their system more slowly. If the pump's timing device is calibrated for the typical younger person's rate of eliminating the drug, the elderly patient, who still has much of an earlier dose in the bloodstream, could accidentally receive an **overdose**. The health care provider should calculate the doses more conservatively for such elderly patients.

Description

PCA uses a computerized pump that delivers a drug in small doses controlled by the patient. The same pump may also be programmed to deliver a large initial dose, or a steady, even flow of pain medications. The large initial dose or the steady flow is, of course, not patient-controlled analgesic at all, but the same pump can deliver the drug in these two ways when it is not advisable for the patient to control the medication.

The patient presses a button when medication is desired. When this button is pressed, some sound (usually a beep) is heard, indicating that the pump is working properly and that the button was pressed correctly. The nurse should instruct the patient to call a health care provider if the pump doesn't beep (or if its alarm sounds). The pain-killers most commonly used in PCA pumps are

morphine and meperidine (Demerol). The pump delivers the medication through a plastic tube (the line) and a needle.

The pump may be set to deliver a larger initial dose of the drug (for example, 2 mg of morphine delivered one time only). The health care provider sets the pump to deliver a specified dose on demand with a lock-out time (for example, 1 mg of morphine on demand, but not more frequently than one dose every six minutes). If the patient presses the button before six minutes have elapsed, the pump will not administer the medication. It also generates a record which the health personnel can read to discover that the patient has indeed been pushing the button more frequently than every six minutes. An around-the-clock, even dose may also be set. The practitioner sets an total limit for an hour (or other period) that takes into account the initial dose, the demand doses, and the around-the-clock doses. The pump's computerized controls calculate all these amounts nicely, make a record of the requests it received, of the requests it refused, and even keep inventory and warn the staff when the supply of the drug is getting low.

Here is an example of how a nurse might program the pump. A patient has a prescription for a maximum of 11 mg of morphine an hour. The nurse sets the machine to deliver 1 mg at the beginning of the hour, and 1 mg on demand with a six-minute lock-out. There are 10 six-minute periods in an hour, so the patient could request and receive 10 mg. If he or she pressed the button every three minutes for a total of 20 times, the machine would deliver the same 1 mg every six minutes for the same total of 10 mg as if the patient had conscientiously cooperated with the prescription. The patient who pushed the button only three times for a total of 3 mg would probably be congratulated by the health professionals for being well on the way to recovery and therefore not needing as much pain medication. The nurse might program the machine to give an initial 2 mg, to give 3 additional mg at a steady rate throughout the hour (one twentieth of a mg every minute). That would use up 5 of the patient's 11 mg. That in turn leaves 6 mg on demand throughout the hour. There are six 10-minute periods in one hour, so the lock-out time would be 10 minutes.

Preparation

When preparing to initiate PCA, the nurse must assess the patient to determine that PCA is indeed applicable in this case. and must then set the total dose and the timings as prescribed by the physician. The small amount of drug prescribed (3,000 doses of 10 mg each weigh less than 1 oz total) would not be sufficient to keep the plastic tube (the line) and the needle through which the drug

moves from the pump into patient from clogging and the contents from coagulating. Therefore, the drug must be administered in a solution that will flush out the tube and needle (a flush solution), keep them open, and permit rapid administration. The flush solution may also be used if the patient has a reaction to the opioid, to keep the line open for administration of other medication. For example, a patient may have a bad reaction to the pain-killing drug and thus need counteractive medication in a great hurry. The flush solution can also help keep the patient from becoming dehydrated. Likewise, many pain-killers prescribed (such as morphine sulfate) are solid crystals at room temperature, and hence would have to be dissolved in some fluid in any event.

When entering the settings into the system, the nurse must pay close attention to the physician's orders to ensure that the correct medication is used (there are different pain-killing drugs), that the concentration of the drug in the flushing solution is correct, that the dose of the drug itself is correct, that lock-out time is appropriate, and that the total hourly limit is properly entered into the pump's computerized controls. To eliminate the risk of incorrect programming, many institutions have adopted policies that require verification by an RN witness for all programming. That is, everything must be checked by a second nurse, and both must sign the written record.

Another important aspect of PCA is **patient education**. The settings on the PCA pump must be explained to patients so that they understand how and when medications will be available. The nurse should observe the patients as they first start using the button, should ensure that the equipment is functioning properly, and that the patients understand their role in the process and are carrying it out correctly.

Aftercare

While using PCA, patients should be assessed frequently to ensure that they are not being excessively sedated, that they are breathing enough, that the control of their pain remains effective, and that no dangerous side-effects to the medication arise. The nurse must also check regularly to see that the line and needle delivering the drug in the flush solution remain open and thus to ensure that the medication is really getting into the patients, not merely into the line, as programmed.

Complications

Problems that may occur with PCA include allergic reactions to the medications and adverse side-effects such as nausea, a dangerous drop in the rate and effectiveness of breathing, and excessive sedation. The device

KEY TERMS

Analgesia—A medicine that relieves pain.

Basal infusion—An around-the-clock, or continuous, even dose of a medication. It is one possible setting on a PCA pump.

Bolus—A large, one-time-only initial dose of medication. A bolus is usually given only when PCA is initiated, but it may also be given if pain is uncontrolled with the basal and on-demand settings.

Demand dose—A dose of pain-killer that is given when the patient requests it by pressing a button which activates a pump.

Lock-out time—The minimum amount of time (usually expressed in minutes) after one dose of pain-medication on demand is given before the patient is allowed to receive the next dose on demand.

Opiate—A drug which contains opium or an alkaloid derived from opium.

Opioid—A synthetic drug resembling opium or alkaloids of opium.

Respiratory depression—Decreased rate (number of breaths per minute) and depth (how much air is inhaled with each breath) of breathing. It is an undesired side-effect of many opioids. It leads to insufficient oxygen in the body. It can be very severe, even leading to death.

Sedation—A side-effect of many opioids that can range from a feeling of slight tiredness to semi-consciousness.

must be monitored frequently to prevent tampering by the patient or family. Many patients would love to change that 10-mg-an-hour maximum to 100. Even sophisticated devices that monitor themselves and sound an alarm when there are indications of something wrong should be checked, since no such machine is perfect. Ineffective pain control must be assessed to determine whether the problem stems from inadequate dosage or from inability, or unwillingness, of the patient to obey the rules.

Results

The goal of patient-controlled analgesia is pain control enhanced by a more stable and constant level of the pain-killer in the patient's body than the peaks and valleys often found in the presence of the drug in the body when a nurse administers, for example, only one dose in

one hour. PCA also gives the patient some control in an unfamiliar and uncomfortable situation where so much else depends on the actions of others. When administered properly, and with watchful assessment by health care providers, PCA can be a safe alternative to traditional methods of relieving pain.

Interestingly enough, studies have shown that when patients control their pain-killing medication, most of them use less pain medication overall than similar patients who have nurse-administered pain-killers.

Health care team roles

The nurse has a great responsibility with PCA, first of all to ensure that the pump is set and filled correctly and that the tube or line delivering the medication remains open. While PCA is in use, the nurse has an ongoing responsibility to assess the patient's level of pain, to monitor the patient's **vital signs**, and to check for any indications that the system is not working properly, or that the dose and settings may be inappropriate for the patient.

Patient education

Patient education is an extremely important part of PCA. The patient must be taught about the different settings on the PCA pump. Most pumps lock so that patients and family members cannot tamper with them. However, patients may need to be reminded that the settings programmed have been determined by their physician to be safe for them and that altering those settings may result in complications. A large, unauthorized overdose could result in death. On the other hand, patients who fear that the pump may give them an overdose should be reassured by information about the lock-out and hour limit settings.

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American Association of Nurse Anesthetists/AANA. 222 South Prospect Avenue, Park Ridge, IL 60068-4001. (847) 692-7050. Fax: (847) 692-6968. <info@aana.com>. <http://www.aana.com>.

American Society of Anesthesiologists/ASA. 520 North Northwest Highway, Park Ridge, IL 60068-2573. (847) 825-5586. Fax: (847) 825-1692. <mail@asahq.org>.

American Society of PeriAnesthesia Nurses/ASPAN. 10 Melrose Avenue, Suite 110, Cherry Hill, NJ 08003-3696. (877) 737-9696 (toll-free). Fax: (856) 616-9601. <aspan@aspan.org>. <http://www.aspan.org>.

The National Hospice and Palliative Care Organization/NHPCO. 1700 Diagonal Road, Suite 300, Alexandria, VA 22314. (703) 837-1500. <Info@nhpco.org>.

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Patient charts see **Medical charts**

Patient confidentiality

Definition

Confidentiality is the right of an individual patient to have personal, identifiable medical information kept private; such information should be available only to the physician of record and other health care and insurance personnel as necessary.

Description

Patient confidentiality means that personal and/or medical information given to a health care provider will not be disclosed to others unless the patient has given **informed consent**. This is becoming extremely difficult to ensure in an age of electronic **medical records** and third-party insurance payers.

Viewpoints

Because the disclosure of personal information could cause professional or personal problems, patients rely on physicians to keep their medical information private. It is rare for medical records to remain completely sealed, however. The most benign breach of confidentiality takes place when clinicians share medical information as case studies. When this data is published in professional journals the identity of the patient is never divulged, and all identifying data is either eliminated or

changed. If this confidentiality is breached in any way, patients may have the right to sue.

The greatest threat to medical privacy, however, occurs because most medical bills are paid by some form of health insurance, either private or public. This makes it difficult, if not impossible, to keep information truly confidential. Health records are routinely viewed not only by physicians and their staffs, but by insurance companies, **medical laboratories**, **public health** departments, researchers, and many others. If health insurance is provided by an employer, they too may have access to their employees files.

Professional implications

The American Medical Association (AMA) encourages doctors to guard their patients' privacy despite the widespread use electronic health records. The organization advises its members to get patient consent for any and all releases of medical information, and recommends that all office personnel and consultants be aware of the paramount importance of maintaining confidentiality. Such policies must be in place, especially in care institutions, in order to maintain Joint Commission on Accreditation of Healthcare Organizations (JCAHO) accreditation. Most confidentiality releases identify the types of information that can be released, the people and/or groups that have been permitted access to the information, and limit the length of time for which the release is valid.

Despite these safeguards, unfortunately, patient confidentiality has eroded with the almost-complete dominance of health-maintenance organizations and other types of third-party payers. In light of this, the medical profession must remain constantly vigilant that their patients' right to privacy is upheld. Confidentiality is essential for a good relationship between patient and practitioner, whose duty to keep information private dates from the Hippocratic Oath. If personal information is disseminated without the patient's permission, it can erode confidence in the medical profession and expose health care professionals to legal action.

Physicians are increasingly being sued by patients whose information has been released without their permission, as the following legal cases show. Even though the plaintiffs do not always prevail, the costs of legal action are burdensome to both sides:

- *Estate of Behringer v. Princeton Medical Center*, 592 A.2d 1251 (N.J. Super. Ct. Law Div. 1991). The late Behringer, a surgeon who worked at Princeton Medical Center, was diagnosed with and treated for **AIDS** at the same hospital. Behringer's chart, which included sever-

al references to his diagnosis, was kept at the nurses' station on his floor with no special protection. His condition became widely known as a result, and the hospital began requiring his patients to sign a form acknowledging the risk to their health. Ultimately, the doctor's surgical privileges were suspended. Behringer's estate sued the hospital for its failure to take reasonable steps to protect his privacy. The hospital was found to have breached confidentiality by leaving the chart out in the open, but the court said they did not discriminate against Dr. Behringer by requiring his patients' informed consent.

- *Velazquez v. St. Clare's Hospital*, (Kings County Supreme Court, New York, 1994). Nydia Velazquez was admitted to St. Clare's Hospital in 1991 after attempting suicide. In 1992, while she was running for election to U.S. House of Representatives, copies of her medical records were faxed anonymously to several newspapers, which ran them in front-page stories. It was never determined whether hospital personnel were responsible for the disclosure. Regardless, Velazquez sued the hospital for breach of contractual and fiduciary duties of confidentiality, for wrongful disclosure, and for negligence in maintenance of the security of her medical records. She won both the seat in Congress and the lawsuit.
- *Doe v. Methodist Hospital*, 690 N.E.2d 681 (26 Med. L. Rptr. 1289 (1997)), Hancock County Superior Court, Indiana. According to the filed complaint, Doe, a postal worker who was HIV positive, disclosed his HIV status to paramedics when he was taken to the hospital after a **heart** attack. The paramedics noted his status on their report, which became part of Doe's medical file. Several coworkers eventually learned of his condition and discussed his HIV status. They were sued, along with the hospital and some of its employees, for invasion of privacy and other wrongful conduct. The court found that Doe's privacy had not been invaded, nor had he been slandered or libeled.

Legal framework

Each state, and the federal government, has enacted laws to protect the confidentiality of health care information generally, with particular attention paid to information about communicable diseases and mental health. For example, through the 1960s substance and alcohol abuse were treated as mental illnesses, with patient confidentiality determined by the laws in each state, since at the time the state was responsible for mental health care and treatment.

In the early 1970s, however, the rising numbers of those needing substance abuse treatment came to the

KEY TERMS

Joint Commission on Accreditation of Healthcare Organizations (JCAHO)—The accrediting organization that evaluates nearly 20,000 United States health care organizations and programs. Accreditation is maintained with onsite surveys every three years; laboratories are surveyed every two years.

attention of the federal government, because drug-related activity, including the treatment for substance abuse, could be the basis for criminal prosecution on a federal level. Congress concluded that this might stop many who needed treatment from seeking it. They enacted a strict confidentiality law to limit disclosure of information that could reveal a patient's identity.

Confusion ensued when practitioners who were treating substance abusers were required to follow two practices for patient confidentiality—one mandated by the state, the other dictated by the federal government. With the varying degrees of protection provided by state mental health laws, the confusion grew further still. While all states specify exceptions to confidentiality, few have spelled out the necessary elements of valid consent for disclosure of mental health information. Some states allow disclosure of the following types of mental health information without client consent:

- disclosures to other treatment providers
- disclosures to health care services payers or other sources of financial assistance to the patient
- disclosures to third parties that the mental health professional feels might be endangered by the patient
- disclosures to researchers
- disclosures to agencies charged with oversight of the health care system or the system's practitioners
- disclosures to families under certain circumstances
- disclosures to law enforcement officials under certain circumstances
- disclosures to public health officials

Providers are increasingly concerned that these exceptions are not addressed uniformly, particularly when providers and payers do business across state lines. This results in open-ended disclosures that specify neither the parties to whom disclosure is to be made nor the specific information allowed to be revealed.

The critical nature of confidentiality

Both the ethical and the legal principles of confidentiality are rooted in a set of values regarding the relationship between caregiver and patient. It is essential that a patient trust a caregiver so that a warm and accepting relationship may develop; this is particularly true in a mental health treatment.

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Patient education

Definition

Patient education involves helping patients become better informed about their condition, medical procedures, and choices they have regarding treatment. Nurses typically have opportunities to educate patients during bedside conversations or by providing prepared pamphlets or handouts. Patient education is important to enable individuals to better care for themselves and make informed decisions regarding medical care.

Description

Patients acquire information about their condition in a variety of ways: by discussing their condition with health professionals; by reading written materials or

watching films made available in hospitals or doctors' offices; through specific health care organizations, such as the American **Cancer** Association; and through drug advertisements on television and in popular magazines. With the explosion of information on the World Wide Web, patients can access a wide range of medical information, from professional medical journals to on-line support and chat groups with a health focus.

Viewpoints

Being informed about one's health care options is essential to a patient's health and well-being. Especially with the increase in managed care, in which economics and efficiency is sometimes paramount, patients may be able to obtain better health care if they are knowledgeable and assertive about their needs and wishes. Informed patients may benefit, for example, by realizing they have a choice of different medications, different treatments, or what lifestyle patterns may affect their condition.

Professional implications

Professional health care givers have traditionally borne the responsibility for patient education. In recent years, however, patients independently have easy access to a wide range of health information. However, many patients cannot easily obtain information, especially if they are not well educated or are not fluent in English. In addition, many patients may not understand enough about their condition to ask relevant questions. Finally, a significant amount of popular information is inaccurate or publicized for a profit motive rather than for education purposes. Patients may not be able to sort out what is true or what is relevant to their own condition.

Another relatively recent aspect of patient education centers around legal ramifications. When a patient is fully informed about the risks and benefits of a particular procedure or therapeutic approach, the likelihood of a lawsuit resulting from a complication is sharply reduced. A patient must be made aware of risks before accepting treatment.

Nurses play an important role in providing health education. They are often the best sources of information regarding caring for patients, such as learning to breast feed, soothing fussy babies, or staying comfortable in the hospital. They may be more accessible than doctors, both because they may spend more time with patients, and because patients may feel less intimidated by nurses and more comfortable asking questions and sharing fears. It is important that nurses do not provide information they are unsure about, or falsely reassure patients about their condition.

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Patient rights

Definition

Patient rights encompass legal and ethical issues in the provider-patient relationship, including the patient's right to privacy, the right to quality medical care without prejudice, the right to make informed decisions about care and treatment options, and the right to refuse treatment.

Description

Many issues comprise the rights of patients in the medical system, including a patient's ability to sue a health plan provider; access to emergency and specialty care, diagnostic testing and prescription medication without prejudice; confidentiality and protection of patient medical information; and continuity of care.

Health care reform brought an emergence of Health Maintenance Organizations (HMOs) and other managed health care plans. The rapid change in medical care moved considerable health care decision making from medical professionals to business entities. Many feel that the change has been detrimental to the health care industry in general. Establishing a patient's bill of rights has been the response to this issue. As of mid 2001, the Bipartisan Patient Protection Act of 2001 was up for debate in the U.S. Senate. It is certain that patient rights are a growing concern for the public at large, a fact that cannot be ignored for long by legislators.

At issue, besides basic rights of care and privacy, is education of patients concerning what to expect of their health care facility and its providers. These rights include the right to participate in the development and implementation in the plan of care; the right to be treated with respect and dignity; the right to be informed about condition, treatment options, and the possible results and side effects of treatment; the right to refuse treatment in

accordance with the law, and information about the consequences of refusal; the right to quality health care without discrimination because of race, creed, gender, religion, national origin, or source of payment; the right to privacy and confidentiality, which includes access to **medical records** upon request; the right to personal safety; the right to know the identity of the person treating the patient, as well as any relationship between professionals and agencies involved in the treatment; the right of **informed consent** for all procedures; the right to information, including the medical records by the patient or by the patient's legally authorized representative and hospital charges except for **Medicaid** and general assistance; the right to consultation and communication; the right to complain or compliment without the fear of retaliation or compromise of access or quality of care.

The patient is also expected to meet a fair share of responsibility. The patient is to follow the plan of care, provide complete and accurate health information, and communicate comprehension of instructions on procedures and treatment. The patient is further responsible for consequences of refusal of treatment, following rules and regulations of a hospital, and to be considerate of others' rights. The patient is also responsible for providing assurance that financial obligations of care are met.

The American Hospital Association provides an informal bill of rights for patients who are hospitalized. In it, the hospital informs patients that they have the right to refuse any procedure or medication that is prescribed, stating that full information should be provided by the attending physician if the patient has doubt or concerns.

Persons United Limiting Substandards and Errors in Health Care (PULSE), a non-profit organization concerned with **patient education** and improving communication within the health care system, encourages the partnership of health care professionals and patients. A patient who is educated about his or her own medical condition can work together with health care providers regarding treatment decisions.

New federal privacy rules, beyond the proposed Patient Bill of Rights, give patients additional control over private medical information. Patients have the right to examine their own medical records and to amend them if necessary. In practice, medical personnel have often been reluctant to part with patient records, even to the patients themselves. While health care providers and patients assume that medical records are private, the widespread use of computer transmissions opens the potential for seriously compromising **patient confidentiality**. Regulations recently imposed by the federal government are aimed at protecting patient records by creat-

ing limits on the methods in which medical information is shared. Direct authorization from a patient must be gained before information may be released. Criminal and civil penalties may be imposed for a privacy violation. Intentional disclosure of private information can bring a \$50,000 fine and one-year prison term. Penalties for selling medical information are higher. Following a two-year implementation period, the rules will become enforceable in February 2003.

Viewpoints

Not all agree with the new regulations. Some complain that they are too restrictive, while others maintain that they are not restrictive enough. The Joint Commission on Accreditation of Health care Organizations (JCAHO) cites complexity and cost factors as major problems, and that the full extent of the impact caused by the ruling was not adequately considered when it passed. Government estimates are that it will cost taxpayers \$17.6 billion over 10 years to comply with the privacy regulations. Critics of the regulations imply that the cost will be more than triple, and that billable hours for attorneys specializing in the complexities of the regulations will skyrocket, thus resulting in even higher costs of patient care.

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National Patient Advocate Foundation. 753 Thimble Shoals Blvd, Suite A, Newport News, VA 23606. 800-532-5274. Fax: 757-873-8999. <<http://www.npaf.org>>. action@npaf.org.

Persons United Limiting Substandards and Errors in Health Care (P.U.L.S.E.). <<http://www.pulseamerica.org>>.

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PCV see **Hematocrit**

Peak acid output see **Gastric analysis**

Pediatric assessment tests see **Development assessment**

Pediatric nutrition

Definition

Pediatric **nutrition** considers the dietary needs of infants to support growth and development, including changes in organ function and body composition.

Purpose

Decisions parents make about nutrition and feeding their infants have short- and long-term effects on the babies' subsequent growth and development. Infectious disease and chronic digestive disease can be reduced with good nutrition choices such as breastfeeding. Breastfed infants have better overall health, so choices about pediatric nutrition are important considerations.

Precautions

Infants consume small amounts of food at a time, but they should not be fed directly from the jar because **bacteria** is introduced into a jar from the babies' mouth. If uneaten food is then put into the refrigerator, bacteria will likely grow and may cause **diarrhea**, vomiting, or other signs of food-borne illness. In order to prevent food sensitivities, some foods such as wheat, eggs, and chocolate should be avoided until the child is one year of age.

Ensuring adequate water intake, which can be derived solely through milk, is critical to maintain **electrolyte balance** and therefore the overall health of infants and young children.

Description

Breastfeeding for optimum health

There are several advantages that breastfeeding provides compared to bottle-feeding. Breast milk imparts superior nutritional, immunological, and psychological benefits to infants. Breastfeeding is also much more economical, and no preparation is required. The American Dietetic Association advocates breastfeeding exclusively for four to six months, and breastfeeding with weaning foods for at least 12 months. The American Academy of Pediatrics also advocates breastfeeding, stating, "Exclusive breastfeeding is ideal nutrition and sufficient to support optimal growth and development for approximately the first six months after birth...It is recommended that breastfeeding continue for at least 12 months, and thereafter for as long as mutually desired."

Breast milk's nutritional advantages are:

- It provides infants with most of the nutrients they need for growth and is a readily available energy source.
- It contains large amounts of **vitamin E**, which may help prevent anemia. Additionally, vitamin E is an important antioxidant.
- It is compatible with infants' enzymes.
- Unlike cow's milk, it has an optimum **calcium to phosphorus** ratio of 2:1.
- Breastfeeding transfers antibodies from mothers to infants.
- All infectious diseases occur less frequently in infants who are breastfed rather than bottle fed.
- It favorably changes the pH of stools and the intestinal flora, thus protecting against bacterial diarrheas.

Formula feeding

There are a number of commercially prepared infant formulas on the market available in powder, concentrated liquid, and pre-diluted liquid forms. The American Academy of Pediatrics advises that whole cow's milk should not be given to a child during the first year of life. It also recommends iron-fortified formula for all infants on formula. Infant formula has more protein and more **iron** than human milk, but lacks antibodies.

Introduction of solid foods

The age to start solid foods depends on infants' needs and readiness, but they do not need solid food before six months of age, particularly breastfed infants. Tongue and mouth movement is usually adequate by four months. If infants are force-fed early, some will rebel and develop feeding problems. Weaning of a breastfed infant depends on the preferences and needs of the mother and infant. Weaning gradually over weeks or months is easiest. When the infant is about seven months old, breastfeeding once a day should be replaced by a bottle or cup of modified formula or fruit juice. By 10 months, the infant may be weaned to a cup. Thereafter, one or two feedings daily can be continued until age 18 to 24 months. A full diet of solid foods and fluids by cup should be given to infants who are nursed even longer.

To determine an infant's tolerance, solid foods should be offered by spoon and introduced one flavor at a time. Many commercial baby foods (desserts and soup mixtures, in particular) are high in starch, calories, have no or little vitamin or mineral value, and are high in cellulose, which is poorly digested by infants. Commercial baby foods with high sodium content, more than 200 mg/jar, should be avoided. The daily sodium requirement is 17.6 mg/kilogram. Pureed home foods will suffice.

KEY TERMS

Anemia—A decrease in the number of red blood cells in the bloodstream, characterized by pallor, loss of energy, and generalized weakness.

Cystic fibrosis—A hereditary genetic disorder that occurs most often in Caucasians. Thick, sticky secretions from mucus-producing glands cause blockages in the pancreatic ducts and the airways.

Dietary reference intakes (DRI)—This standard recommends the daily amounts of energy, protein, minerals, and fat-soluble and water-soluble vitamins needed by healthy males and females, from infancy to old age.

Electrolytes—Any of the various ions such as sodium, potassium, or chloride required by cells to regulate the electric charge and flow of water molecules across the cell membrane.

Gluten enteropathy—A hereditary malabsorption disorder caused by sensitivity to gluten, a protein found in wheat, rye, barley, and oats. Also called non-tropical sprue or celiac disease.

Recommended dietary allowance (RDA)—The recommended dietary allowances are the quantities of nutrients in the diet that are needed for good health.

Meat should be preferentially introduced to high-carbohydrate foods; however, because infants often reject meat, it must be introduced patiently and carefully.

To ensure infants eat enough fat when weaning from breast milk or formula, choose whole milk up to two years of age. Two good sources of protein and fat that infants enjoy are peanut butter and cheese. If there are concerns about **obesity**, lean protein choices provide the fat and protein. Adequate intakes of grains, fruits, and vegetables will ensure that infants receive all the necessary **vitamins** and **minerals**.

Preparation

In order to make appropriate choices about pediatric nutrition, it is important to be aware of the nutritional needs of infants. The following are the recommended vitamin and mineral intakes for infants and young children:

- Vitamin A for infants 0–6 months: 400 micrograms/day (mcg/d); 7–12 months: 500 mcg/d; children 1–3 years: 300 mcg/d.
- Thiamine (vitamin B₁) for infants 0–6 months: 0.2 milligrams/day (mg/d); 7–12 months: 0.3 mg/d; children 1–3 years: 0.5 mg/d.
- Riboflavin (vitamin B₂) for infants 0–6 months: 0.3 mg/d; 7–12 months: 0.4 mg/d; children 1–3 years: 0.5 mg/d.
- Niacin for infants 0–6 months: 2 mg/d; 7–12 months: 4 mg/d; children 1–3 years: 6 mg/d.
- Vitamin B₆ for infants 0–6 months: 0.1 mg/d; 7–12 months: 0.3 mg/d; children 1–3 years: 0.5 mg/d.
- Vitamin B₁₂ for infants 0–6 months: 0.4 mcg/d; 7–12 months: 0.5 mcg/d; children 1–3 years: 0.9 mcg/d.
- Pantothenic acid for infants 0–6 months: 1.7 mg/d; 7–12 months: 1.8 mg/d; children 1–3 years: 2.0 mg/d.
- Biotin for infants 0–6 months: 5 mcg/d; 7–12 months: 6 mcg/d; children 1–3 years: 8 mcg/d.
- Folate for infants 0–6 months: 65 mcg/d; 7–12 months: 80 mcg/d; children 1–3 years: 150 mcg/d.
- Vitamin C (ascorbic acid) for infants 0–6 months: 40 mg/d; 7–12 months: 50 mg/d; children 1–3 years: 15 mg/d.
- **Vitamin D** (in the absence of adequate sunlight) for infants 0–6 months: 5 mg/d; 7–12 months: 5 mg/d; children 1–3 years: 5 mg/d.
- Vitamin E for infants 0–6 months: 4 mg/d; 7–12 months: 5 mg/d; children 1–3 years: 6 mg/d.
- Vitamin K for infants 0–6 months: 2.0 mcg/d; 7–12 months: 2.5 mcg/d; children 1–3 years: 30 mcg/d.
- Calcium for infants 0–6 months: 210 mg/d; 7–12 months: 270 mg/d; children 1–3 years: 500 mg/d.
- Phosphorus for infants 0–6 months: 100 mg/d; 7–12 months: 275 mg/d; children 1–3 years: 460 mg/d.
- Magnesium for infants 0–6 months: 30 mg/d; 7–12 months: 75 mg/d; children 1–3 years: 80 mg/d.
- Selenium for infants 0–6 months: 15 mcg/d; 7–12 months: 20 mcg/d; children 1–3 years: 20 mcg/d.
- Zinc for infants 0–6 months: 2 mg/d; 7–12 months: 3 mg/d; children 1–3 years: 3 mg/d.
- Iron for infants 0–6 months: 0.27 mg/d; 7–12 months: 11 mg/d; children 1–3 years: 7 mg/d.

The following is the recommended dietary allowance for energy and protein intakes for infants and young children:

- Energy (calories) for infants 0–6 months, with a weight of approximately 6 kg (13 lb): 650 kilocalories per day (kcal/d); 6–12 months with a weight of approximately

9 kg (20 lb): 850 kcal/d; children 1–3 years with a weight of approximately 13 kg (28 lb): 1300 kcal/d.

- Protein for infants 0–6 months: 13 grams per day (g/d); 6–12 months: 14 g/d; children 1–3 years: 16 g/d.

Breastfed infants need 400 international units (IU) of vitamin D and 0.25 mg of fluoride daily.

Breastfeeding does not require any preparation, but bottle feeding requires some preparation such as ensuring the milk is the right temperature and the nipples are sterilized, if sterilized disposable nipples are not used.

Complications

Obesity may start with excessive eating in infancy. If an infant has two obese parents, it is particularly important to monitor and control weight gain. With two obese parents, an infant has an 80% chance of becoming obese.

Diarrhea may be caused by conditions such as celiac disease (gluten enteropathy), **cystic fibrosis**, and sugar (lactose) intolerance.

Results

Infants should be closely monitored for proper weight gain to ensure they are receiving adequate nutrition. Resources such as the National Center for Health Statistics growth charts can be used as a guide.

Health care team roles

Breastfeeding education efforts are important steps for health care teams. They should encourage a longer duration of breastfeeding to achieve maximum nutritional benefits for infants. A dietitian can assist in providing advice regarding pediatric nutrition feeding decisions.

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- American Dietetic Association. 216 W. Jackson Blvd., Chicago, IL 60606-6995. (312) 899-0040. <<http://www.eatright.org/>>.
- Food and Nutrition Information Center Agricultural Research Service, USDA. National Agricultural Library, Room 304, 10301 Baltimore Avenue, Beltsville, MD 20705-2351. (301) 504-5719. (301) 504-6409. <<http://www.nal.usda.gov/fnic/>>. fnic@nal.usda.gov.
- Food and Nutrition Professionals Network.* <<http://nutrition.cos.com/>>.
- La Leche League International. 1400 N. Meacham Road, Schaumburg, IL 60168-4079. (847) 519-7730. <<http://www.lalecheleague.org/>>.

OTHER

- Women, Infants, and Children. The Food and Nutrition Service Headquarters. 3101 Park Center Drive, Alexandria, VA 22302. (703) 305-2746.

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Pediatric physical therapy

Definition

Pediatric **physical therapy** is concerned with the examination, evaluation, diagnosis, prognosis, and intervention of children, aged birth through adolescence, who are experiencing functional limitations or disability due to trauma, a disorder, or disease process.

Purpose

Pediatric physical therapy is indicated when a child has a pathology or suffers a trauma which results in an impairment leading to the loss of function and/or societal disability. Pathologies may include non-progressive neurological disorders such as **cerebral palsy**, which results from trauma to the **brain** during or shortly after birth. Children born with genetic syndromes, **heart** and/or lung defects, hydrocephalus, spina bifida, **fetal alcohol syn-**

drome, or drug addiction may also be seen by physical therapists. Pathologies resulting in musculoskeletal impairments include, but are not limited to: juvenile rheumatoid arthritis, **hemophilia**, **scoliosis**, peripheral nerve injury, arthrogyriposis, osteogenesis imperfecta, and **muscular dystrophy**. Acquired pathologies that may require physical therapy include traumatic brain injury, **spinal cord injury**, and **cancer**.

Pediatric physical therapists are employed in several different settings, including hospitals, outpatient clinics, and school systems. In the hospital, a pediatric physical therapist may work with patients such as those recovering from heart or lung conditions or surgery, burn trauma, orthopedic surgeries, or any number of other conditions. In addition, many neonatal intensive care units (NICUs) also employ physical therapists to evaluate and treat high-risk or **premature infants**. In an outpatient setting, the same children may be seen further along in their recovery. Children with lifelong conditions may be referred to outpatient clinics upon manifestation of secondary impairments. School physical therapists are employed to insure that children with disabilities or developmental difficulties are functioning adequately in their least restrictive environment.

In any case, the goal of treatment is to diminish impairments and functional limitations to prevent or decrease disability. Treatment may be focused on improving developmental tasks, motor planning, manipulation skills, balance, and/or coordination. The affected child may present with difficulties with ambulation, positioning, communication, attention, cognition, and/or motor function. All of these problems need to be addressed, as they can result in the inability to keep up with peers or perform work at school.

Precautions

Upon patient examination, a physical therapist collects the patient's history and does a systems review. The review includes assessment of the cardiovascular, respiratory, integumentary, musculoskeletal, and neuromuscular systems, including cognition. Physical therapists are educated in differential diagnosis for the purpose of identifying problems that are beyond the scope of physical therapy practice or require the attention of another health care professional.

Description

Examination

Determining a child's need for physical therapy requires both qualitative and quantitative measures to gather information. Observation in natural settings, per-

sonal and family history, and subjective information from teachers or caregivers are all valuable pieces of the puzzle. A systems review should be performed, as discussed above. Through observation and measurement, active and passive range of motion and strength should be assessed. In addition, equilibrium and righting reactions and persistent abnormal **reflexes** should be noted. Posture and gait observation and assessment are essential for providing recommendations regarding exercises, seating, orthotics, and assistive devices.

Assessment of functional motor ability is often performed using a standardized test. In infants, tests often used include, but are not limited to: Movement Assessment of Infants, Peabody Developmental Motor Scales (PDMS), Test of Infant Motor Performance, Alberta Infant Motor Scale, and Bayley Scales of Infant Development II. Tests for children include the PDMS, Bruininks-Oseretsky Test of Motor Proficiency, and Gross Motor Function Measure. These tests look at the ability to perform tasks such as maintaining a prone position or rolling in infants, to walking a balance beam or throwing a ball in children.

Evaluation, diagnosis, and prognosis

Although a child may have been given a medical diagnosis, the therapist should formulate a physical therapy diagnosis upon evaluation of the examination findings. The physical therapy diagnosis focuses not on the pathology (e.g., hydrocephalus), but rather on the dysfunction(s) toward which the therapist will direct intervention (e.g., decreased balance).

The prognosis encompasses a prediction of the level of function realistically attainable and the time period in which it will be accomplished. The prognosis includes the plan of care, which outlines treatment procedures and frequency, in addition to specifying long-term and short-term goals. In a rehabilitation or outpatient clinic setting, goal-setting may be more short-term than in an educational setting, where the tendency is to set yearly goals related to school function.

While goals often encompass the reduction of impairment to prevent functional limitations, reductions of primary impairment can help to prevent secondary impairment as well. For example, a goal focused on reduction of spasticity through proper positioning can help to prevent or diminish the occurrence of muscle shortening and joint contractures.

Intervention

Intervention involves the interaction between therapist and patient. It also includes communication with the family and other professionals as needed, including physi-

cians, nurses, psychologists, occupational therapists, speech and language pathologists, physical therapist assistants, and social workers. In the educational setting, interactions also take place with classroom and physical education teachers, along with paraprofessionals.

Intervention encompasses the coordination and documentation of care, specific treatment procedures, and patient/family education. Physical therapists also must be skilled in recognizing the need to refer a patient back to a physician or recommend the services of other professionals as necessary. The physical therapist usually plays a key role in making recommendations or sometimes participating in the fabrication and fitting of orthoses, walking aids, and wheelchairs. In addition, the physical therapist is instrumental in choosing appropriate adaptive equipment, such as seating devices or standing frames, for the classroom or home.

Specific treatment procedures are numerous, falling into several categories: functional training for activities of daily living; **therapeutic exercise**; manual techniques such as mobilization and stretching; and therapeutic modalities. In 2001, evidence-based practice would require the use of recent motor control, motor development and motor learning theories as an umbrella over these treatment procedures. Motor control, development, and learning theories focus on the idea that several factors contribute to emergence of motor behavior. These factors include not only the **central nervous system (CNS)** as the driving force, but also biomechanical, psychological, social, and environmental components. Teaching and practice of skills under these theories is task-oriented and intermittent versus rote and repetitive. Higher-level learning takes place through problem-solving by the child rather than by the therapist's hands-on facilitation. Emphasis has also been placed on the importance of family-centered care, transdisciplinary service, and treatment in natural environments.

Treatment sessions may take place as frequently as once or twice a day in a rehabilitation setting, to once or twice a month in a school setting. Sessions may last 20 minutes to a full hour. Consultation with other professionals also takes place frequently during a patient's length of stay or a student's education.

Re-examination

A physical therapist is continually assessing a child's abilities and adjusting treatment appropriately. Some or all of the same tests and measures used during initial examination may be again used in order to evaluate progress and determine the need to modify, redirect or discontinue treatment.



A physical therapist works with a baby to strengthen problem muscles. (Photograph by Andy Levin. Science Source/Photo Researchers. Reproduced by permission.)

Aftercare

Aftercare depends upon the setting in which the child has been treated. After a stay in a hospital, a child may be discharged with the recommendation to continue outpatient or school-based physical therapy. Upon discharge in any case, a physical therapist should provide recommendations for exercises or adaptations, if any, which should be continued at school or at home. In addition, a therapist may make suggestions regarding participation in programs such as adaptive sports leagues, therapeutic horseback riding, camps, etc.

Results

Although pediatric physical therapy addresses problems related to a wide variety of pathologies, the common goal usually is that functional activity increases and that disability decreases. In the case of non-progressive disorders, long-term retention of learned skills and the

KEY TERMS

Motor control—The control of movement and posture.

Motor learning—A set of processes related to practice or experience that results in relatively permanent changes in the ability to produce a skilled action.

Motor planning—The ability to execute skilled nonhabitual tasks.

Neuromuscular re-education—The training of an individual to recover or develop effective sensory and motor strategies for task demands.

ability to transfer skills to different environments and situations are results of effective physical therapy intervention. In the case of progressive disorders such as muscular dystrophy, maintenance of capabilities and/or slowing of functional losses may be the goal.

Health care team roles

The physical therapist and the physical therapist assistant, under the supervision of the physical therapist, are the direct providers of pediatric physical therapy. There are, however, many other key players. Although many states allow direct access to physical therapy, many require a referral from a physician. The physician usually provides the therapist with a prescription for physical therapy that outlines the medical diagnosis, and sometimes, precautions and recommendations. The child's physician and nurses also may provide valuable information regarding past medical history, surgical procedures, and medications.

Occupational therapists, speech and language pathologists, social workers, and psychologists also play important roles in the transdisciplinary provision of services. Physical therapists may work closely with these professionals to combine efforts toward fulfilling a child's maximum potential.

To summarize the various roles of a therapist in pediatric physical therapy, it is necessary to recognize that in addition to the description outlined above, he or she is responsible for consultation, education, critical inquiry, administration, and supervision.

Consultation

There are many facets to the role of consultation. Physical therapists may be called upon to assist other

health care professionals in determining whether or not physical therapy services are required for a specific patient, and which types of service are required. In addition, physical therapists may be asked to perform activities such as: assessing an environment or program for accessibility; providing opinions or recommendations on adaptations in the classroom, home or recreational arena; and making recommendations for compliance with the Individuals with Disabilities Education Act or the Americans with Disabilities Act.

Education

Physical therapists are responsible for educating patients and families, as discussed earlier. This education may include: general information about a disease and course of physical therapy treatment; teaching of home exercises and adaptations; instruction on prevention of secondary impairments; and suggestions for long-term wellness. In addition, pediatric physical therapists may be asked to provide information about disabilities to teachers or students in a school, or provide in-services to physical education teachers about adaptive sports. Pediatric physical therapists also are responsible for furthering their own education, mentoring future physical therapists and PT assistants, and increasing public awareness of areas in which physical therapists have expertise. The American Physical Therapy Association (APTA) offers a program for specialized certification, which is governed by the American Board of Physical Therapy Specialties (ABPTS) to facilitate the continuing education of physical therapists.

Critical inquiry

Pediatric physical therapists have a responsibility to the profession to critically examine research findings and apply them when appropriate to their daily practice. In addition, physical therapists should look for ways to conduct and/or participate in research to evaluate the effectiveness of interventions and philosophies used in the profession.

Administration and supervision

The pediatric physical therapist must be concerned with administrative activities related to human resources, equipment, finances, and facilities. Supervision of physical therapist assistants, student physical therapists and assistants, and physical therapy aides is often a responsibility. This responsibility may include monitoring quality of care and productivity as well. The physical therapist is directly responsible for the actions of these individuals and therefore should adhere to American Physical

Therapy Association guidelines stipulating the levels of supervision required.

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Pedodontics see **Dental specialties**

Pelvic ultrasound

Definition

Pelvic ultrasound is a procedure in which high-frequency sound waves are used to create images of the pelvic organs by projecting the sound waves into the pelvis and measuring how the sound waves reflect, or echo, back from the different tissues.

Purpose

Ultrasound is a preferred method of examining the pelvis and functions as an extension of a **physical examination**, particularly for obese patients. It is a common initial step after physical examination when a patient complains of pelvic **pain** or abnormal vaginal bleeding. The procedure is performed routinely during **pregnancy** and examinations to determine the cause of **infertility**. Ultrasound has the ability to detect the size and shape of

pelvic organs, such as the bladder, and is useful in evaluating the cause of bladder dysfunction. In women, pelvic ultrasound is used to examine the uterus, ovaries, and vagina. In general, ultrasound can detect inflammation, free fluid, cysts (abnormal fluid-filled spaces), and tumors in the pelvic region.

A primary use of pelvic ultrasound is during pregnancy. In early pregnancy (at about five to seven weeks), ultrasound may determine the size of the uterus or the fetus to confirm the suspected due date, to detect multiple fetuses, or to confirm that the fetus is alive (or viable). Ultrasound is particularly useful in distinguishing between intrauterine (within the uterus) and ectopic (outside the uterus) pregnancies. Toward the middle of the pregnancy (at about 16–20 weeks), the procedure can confirm fetal growth, reveal defects in the anatomy of the fetus, and check the placenta. Toward the end of pregnancy, it may be used to evaluate fetal size, position, growth, or to check the placenta.

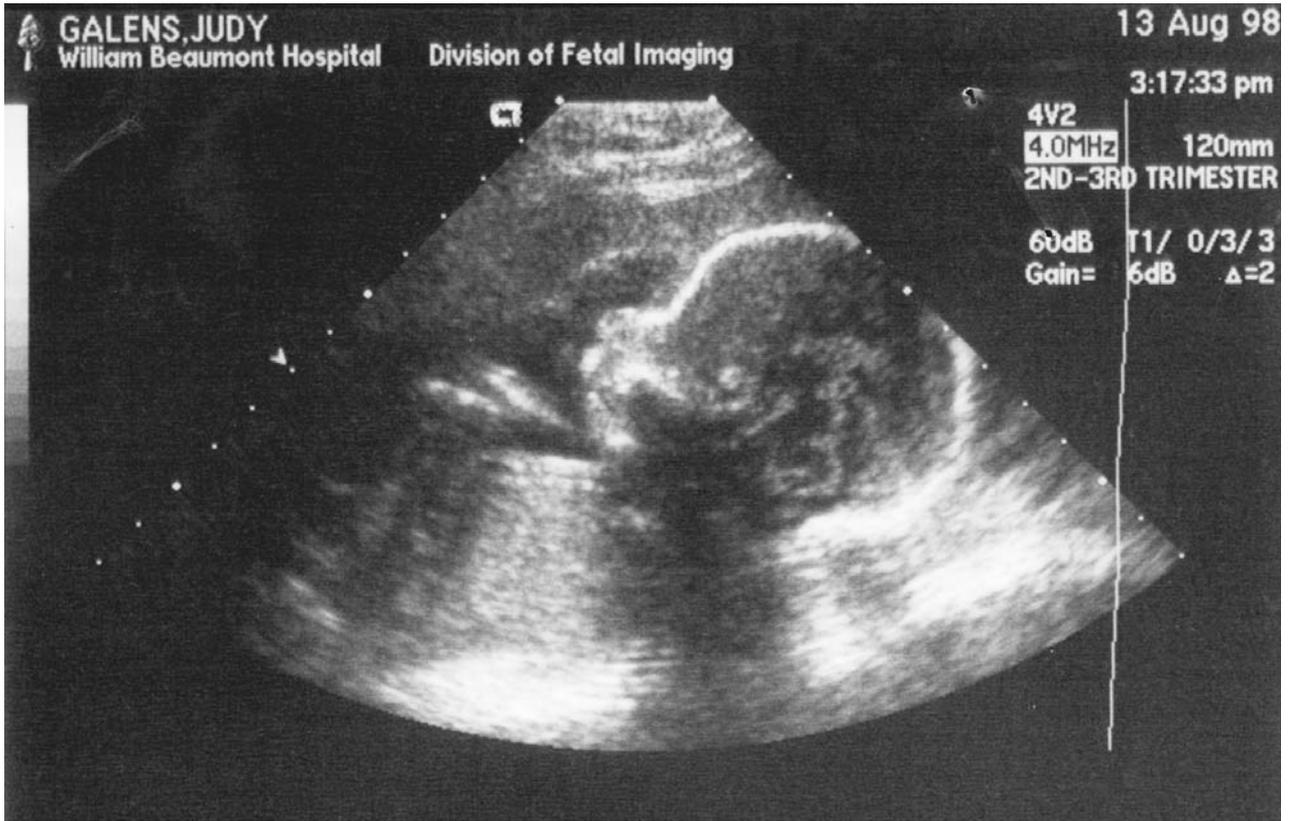
Doctors may use ultrasound to guide the biopsy needle during **amniocentesis** and **chorionic villus sampling**. The imaging allows precise placement of the long needle that is inserted into the patient's abdomen to collect cells from the placenta or amniotic fluid.

Precautions

There are no special precautions recommended before an ultrasound examination. Unlike x rays, ultrasound does not produce harmful radiation so it does not pose a risk to the technologist, patient, or a fetus.

Description

Depending on the goal of the procedure, a pelvic ultrasound can also be called a **bladder ultrasound**, pelvic gynecologic sonogram, or obstetric sonogram. Ultrasound examinations are often done in a doctor's office, clinic, or hospital setting. Typically, the patient will lie on an examination table with the pelvis exposed. Special gel is applied to the area to make sure that there is no air between the hand-held transducer and the skin and to facilitate moving the transducer. The doctor or technologist will move the transducer over the abdomen. The transducer both creates and receives the echos of the high-frequency sound waves (usually in the range of 3.5–10.0 megahertz). An ultrasound scan reveals the shape and densities of organs and tissues. By performing repeated scans over time, much like the frames of a movie, ultrasound can also reveal movement, like the movement of a fetus. This technique is called real-time ultrasound.



Fetal ultrasound during the second to third trimester. (Brigham Narins. Reproduced by permission.)

Using a computerized tool, called a caliper, the ultrasound technologist can measure various structures shown in the image. For example, the length of the upper thigh bone (femur) or the distance between the two sides of the **skull** can indicate the age of the fetus.

Ultrasound technology has been used safely in medical settings for over 30 years, and several significant extensions to the procedure has made it even more useful. A specially designed transducer probe can be placed in the vagina to provide better ultrasound images. This transvaginal or endovaginal scan is particularly useful in early pregnancy or in cases where ectopic pregnancy is suspected. In men, transrectal scans, where the probe is placed in the rectum, are done to check the prostate. Doppler ultrasound has the ability to follow the flow of **blood** through veins and arteries and can be useful in detecting abnormalities such as abnormal blood flow associated with ovarian torsion, a twisted blood supply that causes pelvic pain. Color enhancement is particularly useful in Doppler imaging, where shades of red signify flow away from the transducer and shades of blue signify flow toward.

Hysterosonography is another variant ultrasound procedure. It involves the injection of saline solution into

the uterus during an endovaginal scan. The saline distends the uterine cavity and simplifies the identification of polyps, fibroids, and tumors. The saline outlines the lesion, making it easier to find and evaluate. Hysterosonography can also be used in the testing of patency (openness) of the fallopian tubes during infertility evaluations.

Preparation

Before undergoing a pelvic ultrasound, the patient may be asked to drink several glasses of water and to avoid urinating for about one hour before the examination. When the bladder is full, it forms a convenient path, called an acoustic window, for the ultrasonic waves. A full bladder is not necessary for an endovaginal examination, sometimes making it a preferred choice for emergency situations. Women usually empty their bladders completely before an endovaginal exam.

Aftercare

For a diagnostic ultrasound, the lubricating gel applied to the abdomen is wiped off at the end of the pro-

cedure and the patient can immediately resume normal activities.

Complications

Ultrasound carries with it almost no risk for complications.

Results

A normal scan reveals no abnormalities in the size, shape, or density of the organs being scanned. For a scan taken during pregnancy, a normal scan reveals a viable fetus, of expected size and developmental stage. Although ultrasound is an extremely useful tool, it cannot detect all problems in the pelvic region. If a tumor or other lesion is very small or if it is masked by another structure it may not be detected. When used during pregnancy, patients should be advised that all fetal abnormalities may not be seen with ultrasound. Additionally, the reliability of ultrasound readings can depend on the skill of the technologist or doctor performing the scan.

An abnormal scan may show the presence of inflammation, cysts, tumors, or abnormal blood flow patterns. These results may suggest further diagnostic procedures or surgical or pharmacological treatment. Ultrasound examinations in obstetrics may alter the anticipated due date or detect abnormalities or defects in the fetus. This information may reveal that the fetus cannot survive on its own after birth or that it will require extensive treatment or care. The technologist performing the ultrasound should be sure to consult with a radiologist or other doctor if any questionable results appear.

Health care team roles

Ultrasound units are often run by specially trained ultrasound technologists. These technologists are thoroughly trained in the use of the **ultrasound unit** to produce diagnostically useful images. Nurses aid in patient preparation and education about the procedure. A physician such as a radiologist or gynecologist does the final review and diagnosis based on the results of the ultrasound. The doctor can be present for the exam or may make the final review and diagnosis based on saved images.

Patient education

It is very important that patients understand the limitations of ultrasound, particularly when it is performed during a normal pregnancy. Many fetal malformations are not detectable, or are unreliably detectable, using ultrasound alone. The patient must understand that a nor-

KEY TERMS

Acoustic window—Area through which ultrasound waves move freely.

Amniocentesis—A procedure where a needle is inserted through the pregnant woman's abdomen and into the uterus to draw off some of the amniotic fluid surrounding the fetus.

Chorionic villus sampling—A procedure where a needle is inserted into the placenta to draw off some of the placenta's inner wall cells surrounding the fetus.

Ectopic pregnancy—A pregnancy where the fertilized egg becomes implanted somewhere other than in the uterus; if in a fallopian tube it is called a tubal pregnancy.

Real-time—A type of ultrasound involving the taking of multiple images over time in order to record movement.

Sonographer—A technologist who uses an ultrasound unit to take ultrasound images of patients.

Transducer—The handheld part of the ultrasound unit that produces the ultrasound waves and receives the ultrasound echos.

Ultrasound—Sound above what can be heard by the human ear, generally above 20,000 Hz (cycles per second).

mal ultrasound result does not necessarily guarantee that the fetus is normal.

Training

Being hired as an ultrasound technologist to perform pelvic ultrasounds usually involves successful completion of a training program at a two-year college or vocational program. Certification of ultrasound technologists is available through the American Registry of Diagnostic Medical Sonographers as a registered diagnostic medical sonographer (RDMS). Specialty areas within the sonographer credentials that might be useful for performing pelvic ultrasounds include abdomen or obstetrics and gynecology.

Resources

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American Institute of Ultrasound in Medicine. 14750 Sweiter Lane, Suite 100, Laurel, MD 20707-5906. (301) 498-4100. (800) 638-5352. <<http://www.aium.org>>.
 American Registry of Diagnostic Medical Sonographers (ARDMS). 600 Jefferson Plaza, Suite 360, Rockville, MD 20852-1150. (301) 738-8401. (800) 541-9754. <<http://www.ardms.org>>.

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Percutaneous transhepatic cholangiography

Definition

Percutaneous transhepatic cholangiography (PTHC) is used to identify obstructions that slow or stop the flow of bile from the **liver** to the **digestive system**.

Purpose

PTHC allows doctors to determine what is causing a patient's **jaundice** (an obstructed bile duct or liver disease) and why upper abdominal **pain** continues after **gallbladder** surgery. It is not a first line test due to its invasive nature. PTHC is usually done only after computed tomography or ultrasound tests have been performed, when those tests indicate the need for PTHC to further delineate biliary anatomy.

Precautions

Patients should report allergic reactions to:

- anesthetics
- contrast media (dyes) used in radiographic tests
- iodine
- shellfish

PTHC should not be performed on anyone who has:

- cholangitis (inflammation of the bile ducts)
- massive ascites
- a severe allergy to iodine
- a serious uncorrectable or uncontrollable bleeding disorder

Description

The patient lies on a movable x-ray table and is given a local anesthetic. A footrest and shoulder rest prevent the patient from sliding when the position of the table is changed. The patient will be told to hold his or her breath, and a doctor, usually a radiologist, will place a needle into the liver and then inject contrast medium into the liver as the patient exhales.

The patient may feel a twinge when the needle penetrates the liver, a pressure or fullness, or brief discomfort in the upper right side of the back. Hands and feet may become numb during the 30–60 minute procedure.

The x-ray table will be tilted several times during the test, and the patient helped to assume a variety of positions. A special x-ray machine called a **fluoroscope** will track the contrast medium's passage through the bile ducts and show whether the fluid is moving freely or how its passage is obstructed. After the x rays have been taken, the needle is removed.

PTHC costs about \$1,600. The test may have to be repeated if the patient moves while x rays are being taken.

Preparation

An intravenous antibiotic may be given every four to six hours during the 24 hours before the test. The patient will be told to fast overnight and may be given a sedative a few minutes before the test begins.

Aftercare

A nurse will monitor the patient's **vital signs** until they return to normal and watch for:

- itching
- flushing
- nausea and vomiting
- sweating
- excessive flow of saliva
- occasional serious allergic reactions to contrast dye

KEY TERMS

Ascites—Abnormal accumulation of fluid in the abdomen.

Bile ducts—Tubes that carry bile, a thick yellowish green fluid that is made by the liver, stored in the gallbladder, and helps the body digest fats.

Fluoroscope—An x-ray machine that projects images of organs.

Granulomatous disease—Disease characterized by the growth of tiny blood vessels and connective tissue, which forms tissues known as granulomas.

Jaundice—Disease that causes bile to accumulate in the blood, causing the skin and whites of the eyes to turn yellow. Obstructive jaundice is caused by blockage of bile ducts. Non-obstructive jaundice is caused by disease or infection of the liver that causes liver dysfunction.

The patient should stay in bed for at least six hours after the test, lying on the right side to prevent bleeding from the injection site. The patient may resume normal eating habits and gradually resume normal activities.

Complications

Septicemia (**blood poisoning**) and bile peritonitis (a potentially fatal **infection** or inflammation of the membrane covering the walls of the abdomen) are rare but serious complications of this procedure.

Contrast material occasionally leaks from the liver into the abdomen, and there is a slight risk of bleeding or infection.

Results

Normal x rays show contrast material evenly distributed throughout the bile ducts. **Obesity**, gas, and failure to fast can affect test results.

Enlargement of bile ducts may indicate:

- obstructive or non-obstructive jaundice
- cholelithiasis (gallstones)
- cancer of the bile ducts or **pancreas**
- hepatitis (inflammation of the liver)
- cirrhosis (chronic liver disease)
- granulomatous disease

Health care team roles

PTHC is performed in a hospital, doctor's office, or outpatient surgical or x-ray facility. The procedure is usually performed by a radiologist, with the assistance of a radiologic technologist.

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Periapical abscess see **Dental abscess**

Periodontitis

Definition

Periodontitis is a form of periodontal disease resulting in inflammation within the supporting structures of the teeth, progressive attachment, and bone loss. If left untreated, periodontitis can lead to tooth loss.

Description

Periodontal diseases involve the gum, and include **gingivitis** and periodontitis. These are both serious infections that begin when **bacteria** in plaque (a sticky, colorless film that constantly forms on the teeth) cause inflammation of the gums. Undiagnosed or ignored gingivitis—in either case, untreated—can result in periodontitis. When this occurs, plaque may spread and invade below the gum line. When toxins made by the bacteria in the plaque irritate the gums, an inflammatory response is elicited. This response becomes chronic; the body turns on itself and the disease advances. Tissues and bones that support the teeth break down. Pockets, or spaces between the teeth and gums, form—the result of severe **infection** of the periodontal tissue and gums (the gingiva, periodontal ligament, cementum, and alveolar bone). With progression of periodontitis, the pockets deepen. Destruction of the gum tissue and bone worsens. Despite the frequent presentation of very mild symptoms,



Juvenile periodontal disease. (Photograph by Edward H. Gill. Custom Medical Stock Photo. Reproduced by permission)

teeth that have become loose because of these changes may have to be removed.

Description

Plaque and tartar (calculus) accumulate at the base of the teeth. Inflammation causes a pocket to develop between the gums and the teeth, which fills with plaque and tartar. Soft tissue swelling traps this plaque in the pocket, and the bacteria from the plaque begin to develop and grow. Continued inflammation and bacteria growth eventually causes destruction of the tissue surrounding the tooth. An **abscess** may also develop, which increases the rate of bone destruction. Several bacterial products that diffuse through tissue are thought to play a role in disease formation.

Bacterial endotoxin is a toxin produced by some bacteria that can kill cells. The amount of endotoxin present correlates with the severity of the periodontitis. Other bacterial products include proteolytic enzymes (molecules that digest protein found in cells), thereby causing cell destruction. The **immune response** has also been implicated in tissue destruction. As part of the normal immune response, WBCs enter regions of inflammation to destroy bacteria. In the process of destroying bacteria, periodontal tissue is also destroyed.

Onset of periodontitis at an early age and an infection characterized by necrosis of the gingival tissue, periodontal ligament, and alveolar bone, have most commonly been observed with individuals with medical conditions including **Down syndrome**, **Crohn's disease**, **AIDS**, and any disease that reduces the number of white **blood** cells (WBCs) in the body for extended periods of time. Reduction of the number of WBCs makes it difficult for the body to fight off infection.

Distinct types of periodontitis

Although there are many kinds of periodontitis, the following are the ones most often presented at the dentist's office:

- **Gingivitis.** The mildest type of periodontal disease, gingivitis is the reason that gums redden, swell, and bleed easily. Reversible with professional management and good home care, gingivitis is usually relatively painless or **pain** free.
- **Aggressive periodontitis.** This occurs in patients with relative good health, clinically. Aggressive periodontitis includes rapid ligament attachment loss and bone destruction.
- **Chronic periodontitis.** Patients with inflammation within the supporting tissues of the teeth and progressive attachment of the ligament and bone structure, characterized by pocket formation and/or recession of the gum tissue, are known to have chronic periodontitis. Although it occurs most frequently in adults, it can affect anyone, of any age. This progressive periodontitis affects gums and bones slowly, but can also be known to advance quickly.
- **Periodontitis as a manifestation of systemic disease.** In this case, the onset is often at a young age. It is generally associated with one of several physiogenic diseases, such as diabetes.
- **Necrotizing periodontal disease.** This type of periodontal disease is characterized by necrosis (cell death) of gingival tissues, periodontal ligament, and alveolar bone. People with systemic conditions usually present with these symptoms; they may be malnourished, immunosuppressed, or have the human **immunodeficiency** virus (HIV).

Causes and symptoms

The initial symptoms of periodontitis are bleeding, inflamed gums, and bad breath. Periodontitis follows cases of gingivitis, which may not be severe enough to cause a patient to seek dental help. Although the symptoms of periodontitis are also seen in other forms of periodontal diseases, the key characteristic in periodontitis is a large pocket that forms between the teeth and gums. Another characteristic of periodontitis is that pain usually does not develop until late in the disease, when a tooth loosens or an abscess forms.

Several risk factors play a role in the development of periodontal disease. The most important are age and **oral hygiene**. The number and type of bacteria present on the gingival tissues also play a role in the development of periodontitis. The presence of certain species of bacteria

in large enough numbers in the gingival pocket and related areas correlates with the development of this disease.

There are a number of other factors that can affect gum health. These include smoking and using tobacco, genetics, **pregnancy**, **puberty**, **stress**, medications, clenching or grinding one's teeth, diabetes, poor **nutrition**, and other systemic diseases. For example, poor nutrition can contribute to compromising the body's **immune system**. This will make it more difficult for it to fight infection. There are also some drugs—such as a few **heart** medicines, antidepressants, and oral contraceptives—that can affect one's health. Smoking can cause bone loss and gum recession; they are much more likely than nonsmokers to have calculus form on their teeth, even when no periodontal disease is indicated. Smoking exacerbates inflammation by an overactive response of the immune system. It contributes to the early onset of periodontal disease. Serious diseases, such as heart disease, respiratory disease, or diabetes, may put one at higher risk for the development of infection of the gums. Individuals with diabetes may have more difficulty controlling infections.

Contrary to general opinion, age may not be a risk factor in the development of periodontal disease. There are risk factors that may make older people more prone to health problems, such as decreased immune status, taking medications, diminished saliva flow, depression, and general poor health. However, aging, in and of itself, does not constitute a serious risk factor for periodontal disease.

Symptoms of periodontitis are:

- gum tissue that is red, swollen, or tender
- gum tissue that bleeds easily; for example, during brushing or flossing
- gums that seem to have pulled away from the teeth
- a bad **taste** in the mouth; persistent bad breath due to the collection of debris and bacteria in the mouth
- pus between the gums and teeth
- loose or separating teeth
- changes in the way the teeth meet when the mouth closes

Early signs of periodontitis may be mistaken for gingivitis, but warning signs should be heeded and professional dental care attention should be sought promptly.

Diagnosis

Diagnosis is made by clinical and radiologic evaluation of infected gums and bones. A medical history will be taken by the health care provider to assess the

Periodontal case types

Case Type I— gingival disease	Inflammation of the gingiva characterized by changes in color, gingival form, position, surface appearance, and presence of bleeding and/or exudate.
Case Type II— early or slight periodontitis	Progression of the gingival inflammation into the deeper periodontal structures and alveolar bone crest, with slight bone loss. There is usually a slight loss of connective tissue attachment and alveolar bone.
Case Type III— moderate periodontitis	A more advanced stage of the preceding condition, with increased destruction of the periodontal structures and noticeable loss of bone support, possibly accompanied by an increase in tooth mobility. There may be furcation involvement in multirrooted teeth.
Case Type IV— advanced periodontitis	Further progression of periodontitis with major loss of alveolar bone support usually accompanied by increased tooth mobility. Furcation involvement in multirrooted teeth is likely.
Case Type V— refractory progressive periodontitis	Includes patients with multiple disease sites that continue to demonstrate attachment loss after appropriate therapy. These sites presumably continue to be infected by periodontal pathogens no matter how thorough or frequent the treatment provided. Also includes patients with recurrent disease at single or multiple sites.

SOURCE: American Academy of Periodontology, 1991.

patient's overall systemic health. The patient may have a condition that is contributing to the presenting infection. A general dentist is usually the first person to diagnose and characterize the various stages of periodontitis.

Diagnosis of periodontitis includes measuring the size of the pockets formed between the gums and teeth. Normal gingival pockets are shallow. If periodontal disease is severe, bone loss will be detected in x-ray images of the teeth. If too much bone is lost, the teeth become loose and can change position. This will also be seen in x-ray images.

Treatment

The goal of treating periodontitis is to reduce inflammation and rid the mouth of the causes of the disease. Treatment requires professional dental care, commonly accomplished in the dental office by a registered dental hygienist (RDH). The pockets around the teeth must be cleaned, and all tartar and plaque removed. In periodontitis, tartar and plaque can extend far down the tooth root. Normal dental hygiene—brushing and flossing—cannot reach deep enough to be effective in treating periodontitis. In cases where pockets are very deep (more than one quarter inch),

KEY TERMS

Alveolar bone—A set of ridges from the jawbones.

Inflammation—A painful redness and swelling of an area of tissue in response to infection or injury.

Periodontist—A dentist who specializes in treating the gum tissue and bones of the mouth.

Systemic—Not just one area, but the whole system, as in a whole body infection.

surgery is required to clean the pocket. Over-the-counter (OTC) pain medications can be useful if the treatment is uncomfortable. These include Tylenol (acetaminophen), Advil (ibuprofen), and Motrin (ibuprofen).

A periodontist performs surgery in a dental office as an out patient procedure. Sections of gum that are not likely to reattach to the teeth may be removed to promote healing by healthy sections of gum. Abscesses are treated with a combination of **antibiotics** and surgery. The antibiotics may be delivered directly to the infected gum and bone tissues to ensure that high concentrations of the antibiotic reach the infected area such as Periostat. Abscess infections, especially of bone, are difficult to treat and require long-term antibiotic treatments to prevent a recurrence of infection, such as augmentin or tetracycline.

Prognosis

Periodontitis can be treated. Prognosis will be good if bone loss has not been too extreme. Removal of the plaque and tartar may be uncomfortable, but any discomfort will subside as the healing process begins. Bleeding and tenderness of the gum tissue will diminish within one or two weeks after treatment. The gums usually heal and resume their normal shape and function. After successful treatment for periodontitis, pathologic pockets are less deep, and reattachment of the ligament will have occurred in most areas.

Health care team roles

A general dentist is commonly the first person seen in the dental field by a patient presenting periodontitis. The dentist evaluates the case and may recommend that the patient see a periodontist for further treatment. The Periodontist will then re-evaluate the case and refer for deep pocket scaling and cleanings by the RDH or suggest

surgery. The Registered Dental Assistant (RDA) may assist the general dentist or periodontist in treatment and aiding in **patient education**. All staff members are part of the team effort to treat a patient with periodontitis. Patient care and understanding will aid in the reduction of this disease and the reduction of the time spent in the office. Patient education is vital in this treatment.

Prevention

Periodontitis can be prevented with good oral hygiene, including thorough toothbrushing and flossing. Regular professional dental cleanings and dental check ups are the best measures of prevention. Daily use of a toothbrush and flossing is sufficient to prevent most cases of periodontitis. Tartar control toothpastes help prevent tartar formation, but do not remove tartar once it has formed. Patient education is also important in teaching what environmental products aid in the development of periodontitis and what to avoid.

Resources

PERIODICALS

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- Armitage, Gary C. "Development of a Classification System for Periodontal Diseases and Conditions." *Annals of Periodontology* (December 1999).
- Mullally, Brian H., Blanaid Breen, and Gerard J. Linden. "Smoking and Patterns of Bone Loss in Early-onset Periodontitis." *Journal of Periodontology* (April 1999).

ORGANIZATIONS

- Adam.com Health and Medical Association Online. Atlanta Corporate Office 1600 River Edge Parkway, Suite 800 Atlanta, Georgia 30328 (770) 980-0888. <<http://www.adam.com/home.htm>>.
- American Academy of Periodontology, 4157 Mountain Road, PBN 249 Pasadena, MD 21122. (410) 437-3749. <<http://www.perio.org>>.
- American Dental Association, 211 East Chicago Avenue, Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org>>.

OTHER

- "Periodontal Disease." WebMDHealth. <http://www.my.webmd.com/content/dmk/dmk_article_40068.htm>.
- "Periodontitis Overview." Adam.com Health Issues. <<http://merckmedco.adam.com/ency/article/001059.htm>>.

Cindy F. Ovard, RDA

Perinatal infection

Definition

Perinatal infections are those infections affecting the mother during a **pregnancy**, and may be transmitted to the fetus during pregnancy, during delivery through the birth canal, or after delivery through the breast milk.

Description

Perinatal infections may be bacterial, fungal, or viral in nature. The degree to which the mother is affected by the **infection** is not an indication of its impact on the fetus. The mother may have slight or no symptoms, and yet the fetus may be significantly affected by the infection. The woman's sexual partner(s) may also be affected by these infections and should seek medical treatment. The more common perinatal infections significantly affecting the fetus are discussed below.

Causes and symptoms

Chlamydia

According to the Centers for Disease Control (CDC), chlamydia trachomatis is the most frequently reported bacterial sexually transmitted disease in the United States, with about 650,000 cases reported in 1999. It is often referred to as a silent disease, because so many infected individuals are asymptomatic. While about 75% of women are unaware of their infection, symptoms include purulent endocervical discharge, inflammation, **edema**, and bleeding. Chlamydial infection can permanently damage the reproductive tract. While asymptomatic, women can experience inflammation of the fallopian tubes, chronic pelvic **pain**, pelvic inflammatory disease, an increased risk for ectopic pregnancy, and **infertility**. For pregnant woman, chlamydial infection increases the risk for premature rupture of membranes, preterm delivery, and neonatal conjunctival or pneumonic infection. About 65% of infected neonates acquired the disease during a vaginal delivery.

Cytomegalovirus (CMV)

CMV is a common congenital viral infection, belonging to the herpes virus group of infections. Maternal infection usually occurs through sexual intercourse, including kissing, with an infected individual. Maternal infection may be asymptomatic, or the mother may present with mononucleosis-like symptoms, fatigue, lymphadenopathy, or **fever**. Transmission to the fetus can occur if the mother becomes infected during pregnancy, or if she has a flaring of a pre-existing CMV infection.

Some immunity is transferred to the fetus if the mother has had a prior CMV infection. Infants infected in utero with CMV may be asymptomatic, or may have a delayed reaction, manifesting as mental retardation or deafness. About 10% of newborns with congenital CMV have evidence of disease at birth. CMV can also be acquired by the newborn through cervical secretions, saliva, urine, or breast milk. It can also be acquired in the newborn nursery by contact with infected individuals. Individuals with a compromised **immune system**, organ recipients, and those with HIV/AIDS are more likely to suffer severe consequences.

Genital herpes

Genital herpes is a sexually transmitted disease (STD) caused by the herpes simplex virus (HSV), and is considered a life-long infection. It may be contracted in two types, HSV-1 and HSV-2. According to a June 2001 report by the CDC, about 45 million Americans aged 12 and older have contracted HSV-2. The infections may exist subclinically, and later erupt in lesions. The risk of contracting the disease increases with the number of sexual partners. If genital herpes occurs for the first time during pregnancy, first trimester **miscarriage** and third trimester preterm birth may be the result. The greatest risk for the fetus occurs when genital herpes is contracted near term. Intrauterine transmission does occur, although it is more rare, and can take place across the placenta. After birth, neonates can also contract the disease from an infected newborn in the nursery.

Hepatitis B virus (HBV)

HBV is contracted through direct contact with the **blood** or other body fluids of an infected individual. It is sexually transmitted, through infected blood or blood products, and to the infant during a vaginal birth. In infants with HBV, 90% contract it at birth. The disease may present in very mild form, with no symptoms and only detected through **liver function tests**, or may be severe, even fatal, if it has advanced to **liver** necrosis. Symptoms of HBV infection include:

- **jaundice**
- fatigue
- rash
- fever that is usually either not present, or very mild
- vague abdominal discomfort
- abdominal pain
- loss of appetite
- nausea

- vomiting
- joint pain

Human immunodeficiency virus (HIV)

HIV is transmitted through direct contact with an infected individual's blood and body fluids (such as semen, amniotic fluid, breast milk, and vaginal and cervical secretions), and leads to the development of acquired **immunodeficiency syndrome (AIDS)**. The majority of pediatric AIDS cases are due to vertical transmission from the mother to the fetus, and is a leading cause of death in children aged one to four years old. Transmission from the mother to the fetus occurs during pregnancy through the placenta, during a vaginal delivery or with premature rupture of membranes, or through the breast milk. Symptoms of an impaired immune system suspicious of HIV infection include:

- fever
- weight loss
- malaise
- oral candidiasis
- **central nervous system** dysfunction

Human papillomavirus (HPV)

HPV is a STD than can cause genital warts. However, many infected individuals are asymptomatic. This variability is due to the fact that there are about 30 types of HPV. The CDC estimates about 5.5 million new cases of HPV a year, with about 20 million people infected to date. About 28–46% of women under the age of 25 have HPV. Individuals who are immunocompromised, such as those with HIV, are at higher risk of contracting the disease. This is also true of those who are pregnant. Genital warts appear to grow more quickly during pregnancy, and can be large enough to obstruct the cervix for a vaginal delivery. Disruption to the warts of the genital tract during pregnancy or delivery can lead to significant maternal blood loss.

Rubella

Rubella is a contagious disease, and is spread through the respiratory tract. Because of effective **vaccination**, it is rare in pregnancy. However, it can be passed to the fetus through the placenta if the mother becomes infected during pregnancy. Maternal symptoms include:

- low-grade fever
- swollen glands

- rash starting at the face and moving down toward the extremities
- joint pain
- conjunctivitis

Streptococcus

Group B streptococcus (GBS) is a contagious, bacterial infection that is particularly harmful to pregnant women, newborns, the elderly, and those who are immunocompromised by other illnesses. According to the CDC, it is the most common cause of life-threatening illness in neonates. In pregnant women it can cause bladder infections, amnionitis, endometritis, and stillbirth. Newborns may develop early-onset disease, from day one to day seven, or late-onset disease, from day seven to several months postpartum. In early-onset disease, infants may present with sepsis, respiratory distress, apnea, **pneumonia**, **shock**, or **meningitis**. Late-onset disease may present as sepsis or meningitis. Individuals may harbor GBS without symptoms, but be able to transmit it to another individual. **Premature infants** are particularly vulnerable.

Syphilis

Syphilis is a sexually-transmitted disease caused by the bacterium *Treponema pallidum*. It progresses in three stages. In the primary stage, shortly after infection, a small, round, firm chancre sore develops at the site of transmission. Multiple sores may also exist, usually in the vagina, anus, rectum, lips, or mouth. It heals on its own, and may go unnoticed. Untreated, the disease progresses to the secondary stage. In this stage multiple locations break out in a rash of red or brown spots that do not itch. It may be accompanied by fever, weight loss, fatigue, or muscle pain. If untreated, the disease can progress to late-stage syphilis. In this stage, damage to internal organs, the central nervous system, and body systems develops. This stage can lead to **paralysis**, numbness, blindness, **dementia**, and death. A mother can pass the disease on to her fetus, who may be stillborn or die shortly after birth.

Toxoplasmosis

A pregnant woman can become infected with toxoplasmosis either by handling infected cat feces, or by ingesting raw or undercooked infected meat. The risk of maternal to fetal transmission is greater when the mother is suffering from an acute, rather than a chronic, infection of toxoplasmosis.

Diagnosis

Chlamydia

In women, chlamydia is diagnosed by evaluating a sample taken of the cervical secretions. A urine test is also available. The Pap smear does not test for chlamydia. To properly diagnose the disease, the endocervical sample needs to be adequate in amount and contain columnar epithelial cells.

Cytomegalovirus

A blood sample can be evaluated for the presence of a CMV-specific antibody, but about 20% of women will show no antibody presence. Prevalence of CMV among the adult general population is high, in some regions occurring in 40–100% of the population. About 33–66% of pregnant women test positive to the CMV IgG antibody. Ultrasound can detect fetal infection, presenting as intrauterine growth retardation, polyhydramnios, and central nervous system abnormalities.

Genital herpes

When lesions are present, tissue sample scrapings or a biopsy can be taken and cultured to confirm the diagnosis. When the condition is latent, diagnosis is more difficult. Blood tests are available, but accuracy of results is not guaranteed. At the first prenatal visit, mothers should be questioned about a prior history of lesions.

Hepatitis B

Diagnosis for HBV is through evaluation of a blood sample for the presence of antigens or antibodies.

Human immunodeficiency virus (HIV)

The HIV infection affects the immune system, causing progressive deterioration during which the individual becomes susceptible to infections and neoplasms rarely seen in those with an intact immune system, such as wasting syndrome, *Pneumocystis carini*, and Kaposi's sarcoma. The diagnosis of these conditions promotes further evaluation for the presence of HIV/AIDS. The average latency between HIV infection and the development of AIDS is about 11 years. A blood sample is used to detect the presence of HIV infection.

Human papillomavirus

Genital warts are diagnosed during a clinical exam.

Rubella

Because rashes can mimic several diseases, the best diagnostic evaluation for rubella is a blood test for the

presence of a rubella-specific IgM antibody. The test can also be performed by evaluating samples of nasal or throat secretions, as well as cerebrospinal fluid.

Streptococcus

Diagnosis is done through cultures of rectal or vaginal secretions taken during the third trimester. In the neonate, blood samples can be taken.

Syphilis

Syphilis diagnoses are often missed because the signs can mimic other conditions or be so mild in appearance as to go unnoticed. Samples from chancre sores can be evaluated for the presence of syphilis, or a blood test can be run. While antibodies do develop, they diminish as time passes, and the individual may become reinfected.

Toxoplasmosis

Maternal infection with toxoplasmosis may be asymptomatic. About 10–20% of infected women may present with lymphadenopathy. Fatigue and mononucleosis-like symptoms may also be present. A blood sample can be evaluated for the maternal presence of a toxoplasmosis-specific IgM antibody. Amniotic sampling can detect fetal infection. Infected neonates may present with liver or spleen enlargement, jaundice, fever, hydrocephalus, or microcephalus.

Treatment

Chlamydia

The drugs azithromycin, doxycycline, and ofloxacin are the first-choice treatment for chlamydia, but are contraindicated in pregnancy. Erythromycin and amoxicillin are used during pregnancy. Repeat testing is recommended three weeks after the conclusion of treatment.

Cytomegalovirus

Since no fetal treatment exists for CMV, maternal testing is usually not recommended. In affected infants, acyclovir (Zovirax) and ganciclovir have been used to suppress the infection. However, the infection reappears once the medication is discontinued.

Genital herpes

Antiviral medical treatment does not cure herpes, but rather shortens the course of the disease. For severe maternal complications, intravenous acyclovir may be used. Acyclovir should be given to all neonates with the disease. Treatment can prevent disease progression to serious consequences. Even with antiviral treatment, if

the HSV has spread throughout the infant, mortality may be as high as 50%.

Hepatitis B

Because HBV affects the liver, alcohol should be avoided. HBV-infected individuals should have their liver evaluated for signs of disease. The CDC reports that the use of alpha interferon and lamivudine are effective for about 40% of patients. The use of these medications in pregnancy is contraindicated.

Human immunodeficiency virus (HIV)

Careful monitoring of the mother's immune status is an essential component of HIV management. For pregnant HIV-positive women, the medical focus is to maximize benefit for the mother herself, while avoiding vertical transmission, if at all possible. The use of zidovudine (ZDV) reduces the incidence of maternal transmission to the fetus. The pregnant state also balances the side effects of treatment on the mother. The use of ritonavir and nelfinavir (Virocept) are first-line protease inhibitor choices for the pregnant woman. The treatment plan of the HIV-infected individual is determined by the amount of virus present in the body, referred to as *viral load*. The greater the viral load, the greater the degree to which the maternal immune system is compromised, and the higher the risk of transmission to the fetus. During the first trimester of pregnancy, the teratogenic effects of the antiviral agents given to the mother are the greatest for the fetus.

Human papillomavirus

Direct treatment of the warts is done to provide symptomatic relief. However, the nearby normal-looking tissue can also harbor the HPV. The drugs podophyllin, podofilox, and imiquimod are not used during pregnancy. Instead, laser therapy, surgical excision, cryosurgery, or trichloroacetic acid may be used. To avoid transmission of the disease during vaginal delivery, cesarean birth may be performed. Despite the treatment used, the likelihood of recurrence is high.

Rubella

There is no antiviral treatment for rubella. Prevention through vaccination is the best means of avoiding contracting the disease.

Streptococcus

Penicillin or ampicillin are the drugs of choice, but penicillin-resistant strains exist. Severe infection may warrant the use of an aminoglycoside in addition to the penicillin.

Syphilis

If the infection is within a year, a single dose of penicillin can cure the disease, according to the CDC. A greater dose will be needed if the infection has been present for more than a year. The antibiotic will cure the disease, but not any damage that has already occurred. Mothers with syphilis can be treated while pregnant. The infant may require antibiotic treatment as well after birth.

Toxoplasmosis

Pregnant women infected with toxoplasmosis may be treated with pyrimethamine, folic acid, spiramycin, and sulfonamide. Maternal treatment may prevent transmission to the fetus. Pyrimethamine can be teratogenic if given in the first trimester.

Prognosis

Chlamydia

Chlamydia infection can have serious consequences for the fetus and neonate. These include:

- spontaneous abortion
- premature rupture of membranes
- preterm delivery
- stillbirth
- neonatal death
- pneumonia

The prognosis for the mother depends on the degree of damage to the reproductive tract prior to treatment. Chlamydia responds well to antibiotic treatment.

Cytomegalovirus

Prognosis overall is good, as many infected individuals are asymptomatic. However, fetal death may occur, and infected infants born with mental retardation, chronic liver disease, motor disabilities, or deafness have life-long consequences.

Genital herpes

About 30–50% of infants exposed to genital herpes near term will contract the disease. This is in comparison to the 3–5% rate of infection for infants exposed to recurrent genital herpes during pregnancy. Infants exposed to the virus during a vaginal birth have higher rates of the disease than those born via cesarean delivery. Infants with HSV localized to the eyes, skin, or mouth have the best outcome. HSV in infants can lead to death through disseminated intravascular coagulation, pneumonitis, or encephalitis.

Hepatitis B

According to the CDC, the number of new infections has declined from 450,000 in the 1980s to 80,000 in 1999. The area of highest growth is in those aged 20 to 49. Because of vaccinations of younger children, those numbers are declining.

Human immunodeficiency virus (HIV)

While long-term prognosis remains poor, short-term prognosis has been improving. Most studies have been done on men, with research focused on women trailing behind. Pregnancy does not appear to alter the course of the disease.

Human papillomavirus

HPV puts women at increased risk for cervical and anal **cancer**. Infants born via vaginal delivery may also develop papillomas in the larynx or conjunctiva.

Rubella

Rubella is most commonly seen in non-vaccinated children. In children, the disease course is milder than in adults. Fetal contraction of the disease can lead to fetal death, preterm delivery, and congenital defects such as **heart** anomalies, mental retardation, blindness, and deafness. The stage of gestation is a critical factor in the degree of impairment to the fetus. All fetal body organs and systems can be affected.

Streptococcus

GBS responds well to antibiotic treatment. Unrecognized or untreated, the effect on the neonate can be severe, including sepsis, pneumonia, or meningitis.

Syphilis

Prognosis depends on the stage to which the disease has progressed. Untreated infants may be asymptomatic, and if untreated may have seizures and die soon after birth.

Toxoplasmosis

The later in the pregnancy the infection is contracted, the better the chance of recovery. A chronic infection in which the mother is infected prior to pregnancy is less likely to be transmitted to the fetus. Fetal death may occur in about 10% of cases occurring in the first trimester of pregnancy. Fetal death is rare when the infection occurs in the third trimester. An acute infection is associated with premature birth and stillbirth. Spontaneous abortion is rare.

Health care team roles

Laboratory technicians and phlebotomists need to observe standard **universal precautions** in drawing and handling blood and other body fluids, as the complete infection status of a patient will not be known. This includes the use of gloves, eye protection such as a face-mask or goggles, and personal protective clothing. Radiology technicians will be involved in ultrasound scanning to detect fetal compromise as a result of infection. Ultrasound-guided sampling of amniotic fluid or fetal tissue may be used to diagnose fetal infection. Through individual discussion, waiting room videos, and pamphlets, nurses can educate pregnant mothers during routine visits about ways to prevent infection by these agents. Nurses can play a significant role in emphasizing the need for retesting after treatment (when required) and discussing the importance of having the woman's sexual partner tested and treated to avoid reinfection.

Prevention

Chlamydia

When a woman has multiple partners, the use of condoms every time a woman has sexual intercourse can decrease the risk of becoming infected. Limiting the number of sexual partners also decreases the risk of chlamydial infection.

Cytomegalovirus

CMV can be shed in body fluids, so care must be taken when handling these substances. This includes the handling of diapers, especially in day care environments. Those working in a hospital environment should always observe universal precautions when handling any body fluid or secretion. Careful hand washing can decrease the risk of transmission. Since CMV is shed in cervical secretions, cesarean birth may decrease the risk of transmission, although infection during the first two trimesters of pregnancy carries the greatest fetal risk. Research is investigating the usefulness of a preconception vaccine.

Genital herpes

Cesarean delivery can substantially reduce **disease transmission** to the neonate. For mothers with genital herpes, delivery following premature rupture of membranes (PROM) should be considered, as the risk of disease transmission increases by six hours after PROM. If maternal HSV is suspected, a fetal scalp monitor should be avoided, as this creates a direct portal of entry for the infection.

KEY TERMS

Lymphadenopathy—A disorder affecting the lymph nodes or lymphatic vessels.

Perinatal—The time during pregnancy, delivery, and until about one month postpartum.

Sexually transmitted diseases (STDs)—Those diseases transmitted from one individual to another during sexual interaction. They may also be referred to as venereal diseases.

Teratogenic—Tending to produce irregularities of formation.

Vertical transmission—The transmission of a disease or condition from one generation to the next, either through genetics, through the uterine environment, or through the breast milk.

Hepatitis B

The HBV vaccine is considered the best prevention. It is a series of three injections over seven months. It is not contraindicated in pregnancy. Use of latex condoms will help reduce the risk of transmission. Avoiding high-risk contact, such as contact with blood and other body fluids, will also lessen the risk of HBV. The CDC recommends that newborns born to HBV-infected mothers receive hepatitis B immune globulin after birth as well as the first dose of the vaccine within 12 hours postpartum.

Human immunodeficiency virus (HIV)

In the early 1990s, studies of ZDV used during pregnancy and given to the neonate for six weeks postpartum resulted in a 70% decrease in maternal HIV transmission to the infant. Cesarean birth also reduces transmission, as compared with vaginal birth. Knowledge of the mother's HIV status during pregnancy is therefore important in reducing the transmission risk. Testing for HIV status should be offered to all pregnant women. Avoidance of breast-feeding can also decrease the risk of transmission. If untreated, about 20% to 30% of infants born to HIV-positive women will be infected. Treatment with ZDV and avoidance of breast-feeding has been reported to lower transmission to about 2% to 3%. In 1999, a Ugandan study reported that a single dose of nevirapine given to infected mothers during labor in addition to a single dose given to the neonate within three days of birth cut the transmission rate in half, as compared with those treated with AZT throughout pregnancy and during the first six weeks of life.

Human papillomavirus

Use of a condom and limiting the number of sexual partners decreases the risk of contracting the disease.

Rubella

Women in childbearing age should have a titer draw to test for immune status. If they have not been exposed to rubella, they can be vaccinated against the disease, but should not become pregnant for three months following the vaccination, due to potential devastating effects on the fetus.

Streptococcus

Prevention of transmission of GBS from the mother to the infant can be enhanced by careful monitoring of the mother during labor for potential signs of infection such as fever, urinary tract infection, or PROM before 37 weeks or 18 hours or more before delivery. Treating the mother with IV **antibiotics** during labor limits the risk of transmission.

Syphilis

Use of a latex condom can reduce the risk of contracting the disease. However, the condom may not cover the area of infection. A blood test is the best way of finding out if one has syphilis, as the sores may be in hidden areas.

Toxoplasmosis

Prevention of infection through cat feces is best done by having someone other than the mother clean the cat litter, and to avoid inhalation of airborne oocytes. If this is not possible, cat litter should be changed daily, as spores develop in one to five days in the litter. Cats become infected by eating contaminated wildlife, so keeping the cat completely indoors significantly reduces the risk of contagion. Infection through meat can be avoided by avoiding raw meat and by cooking meat to at least 159°F (71°C). Garden soil can be contaminated, so the use of gloves when gardening with thorough hand washing afterwards can decrease infection. Outdoor sandboxes should be covered to avoid contamination by stray cats.

Resources

BOOKS

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ORGANIZATIONS

Centers for Disease Control. <<http://www.cdc.gov>>.

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Periodontal abscess see **Dental abscess**

Periodontal charting see **Dental and periodontal charting**

Periodontal disease see **Periodontitis**

Periodontal index see **Dental indices**

Periodontics see **Dental specialties**

Peripheral nervous system see **Nervous system, somatic**

Peripheral neuropathy see **Polyneuropathies**

Peripherally inserted central catheter maintenance see **Central catheter maintenance**

Peritoneal dialysis

Definition

Peritoneal dialysis is one of the two processes used to remove waste products that build up in the **blood** when the **kidneys** are not able to do so on their own.

Purpose

Though known since the 1940s, peritoneal dialysis became a standard treatment used in removing waste products from the body in 1976. An estimated 260,000 people in United States suffer from chronic renal (kidney) failure, and 50,000 die each year from conditions secondary to this disease. The human and financial cost of kidney disease is incalculable, but very expensive. Eighty percent of the financial cost of kidney disease treatment is now provided by the federal government.

On average, approximately one-fifth of the total blood supply of the human body—1.3 qt (1.2 l) of blood—passes through the kidneys every minute. Twelve times every hour, the entire amount of blood present in the body circulates through the kidneys. Through an

osmotic process called glomerular filtration, selective fluids and dissolved chemicals are filtered out, but necessary nutrients such as **proteins** are retained. The filtered-out solution enters a part of the kidney called Bowman's capsule, then passes through a system of tubes that reabsorb nearly all (99%) of the fluid. The remaining 1% that contains the waste products is sent down through two slender tubes, called ureters, to the bladder. From the bladder, the urine created in the kidneys, on average, 1.6 qt (1.5 l), is excreted.

When the kidneys become unable to carry this workload regulation of **fluid balance** in the body—the kidney's most important function—becomes ineffective or ceases completely. This is called renal failure. Renal failure can be either acute or chronic. Acute renal failure occurs when there is a sudden reduction in kidney function that results in nitrogenous wastes accumulating in the blood. The chief causes are:

- severe blood loss resulting in an insufficient blood supply
- insufficient fluid present in the body due to dehydration
- blockage of **blood vessels** due to injury
- decline in the heart's pumping ability, such as in **heart failure**
- low **blood pressure** leading to shock
- liver failure
- allergic reactions to potentially toxic chemicals
- blocked arteries or veins within the kidneys
- crystals, proteins, or other substances in the kidneys

Chronic renal failure is long term and permanent. The chief causes are:

- high blood pressure
- obstruction of the urinary tract
- glomerulonephritis
- abnormalities of the kidneys, such as polycystic kidney disease
- diabetes mellitus
- autoimmune disorders such as lupus erythematosus

The purpose of peritoneal dialysis is to remove the wastes, such as urea and creatinine, that build up in the blood when the kidneys are unable function properly. Peritoneal dialysis attempts to keep fluid and electrolytes (vital chemicals within the body) in proper proportions. Frequently for people with acute renal failure, dialysis may be a temporary measure, used until the kidneys regain their normal function. But though chronic renal failure does not always show symptoms in its earliest

KEY TERMS

Bowman's capsule—The expanded end of a kidney tubule or nephron that acts as a filter to produce urine.

Diabetes mellitus—A disorder in which the pancreas secretes little or no insulin, the hormone responsible for the metabolism of carbohydrates.

Glomerulonephritis—Inflammation of the glomeruli, the filtering units of the kidney.

Hilum—The recessed area at the entrance of the renal artery entering, and the renal vein exiting the kidney.

Inferior vena cava—One of two of the largest veins in the body that enter the right atrium of the heart.

Lupus erythematosus—A chronic disease characterized by inflammation of the connective tissue. The more serious form of this disease affects the kidneys.

Osmosis—The process of a liquid passing through a semi-permeable membrane from a less concentrated solution to a more concentrated one until both solutions have the same strength.

Uremic encephalopathy—The presence of too much urea, a waste product produced by the breakdown of proteins, and other toxins that cause abnormality within the brain. Uremia occurs as a result of kidney failure.

Ureter—One of the two long, slender tubes approximately 10–20 in (25.4–50.8 cm) in length that carry urine from the kidney to the bladder.

stages, depending upon its severity, it is a progressively more serious condition that will eventually result in death unless a kidney transplant is performed.

The decision to begin dialysis is often based upon the presence of any or all of the following medical conditions resulting from impaired kidney function:

- Uremic encephalopathy: abnormal functioning of the **brain**.
- Pericarditis: inflammation of the sac surrounding the heart.
- High acidity of the blood that is unresponsive to other medical treatments.
- Heart failure.

- Hyperkalemia: high blood concentrations of potassium that can cause irregular heart beat and even cardiac arrest.

Precautions

Diet is of special importance for people undergoing dialysis. Their appetites are often poor due to their illness, and proteins are lost during peritoneal dialysis. This makes increasing the protein in their diets very necessary, but patients often have difficulty eating adequate amounts. Sodium and potassium must be restricted to less than 0.12 oz (4 g) of each per day, and **phosphorus** may also be limited. Fluid retention is monitored by weighing the person regularly, but fluids are not usually restricted unless the concentration of sodium in the blood is steadily decreasing or already very low. Contraindications to the use of peritoneal dialysis would be recent abdominal **wounds** or **infection**, or a newly-installed artificial blood vessel graft such as might be placed in repairing a ruptured aorta.

Description

There are two methods of dialysis, hemodialysis and peritoneal dialysis. In hemodialysis the blood is pumped out of the body and through an artificial kidney machine. The purified blood is then returned to the body. In peritoneal dialysis, the mucous membrane that surrounds abdominal organs (the peritoneum) is used as a natural filter. A soft catheter is either surgically inserted into the abdomen and implanted in the peritoneum, or is put in place each time a treatment is done. A sterile cleansing fluid called a dialysate is put into the peritoneum through the catheter. Body wastes then are removed as this dialysate is washed in and out of the abdomen. Each of these peritoneal fluid cycles are called an exchange.

Peritoneal dialysis is usually done at a medical facility called a dialysis center, and can be done in two different ways: continuous ambulatory peritoneal dialysis (CAPD) or continuous cycling peritoneal dialysis (CCPD).

Continuous ambulatory peritoneal dialysis

Either the patient or healthcare provider at the center hangs a sterile plastic bag containing approximately 2 qt (1.8 l) of the dialysate solution. This plastic bag is then placed above shoulder level, causing the fluid in the bag to enter the abdomen slowly. The fluid is then left in the abdomen for four or five hours during which time extra

fluid and wastes are drawn out of the blood supply passing through the peritoneum into the dialysate. The used fluid is then drained out of the abdomen through the catheter (this time placing the bag below the level of the abdomen), and the waste-filled fluid is discarded. CAPD is probably the procedure that least interferes with normal events of daily living as the person can go about normal activities without being hooked up to a machine.

Continuous cycling peritoneal dialysis

CCPD puts the same amount of fluid into the peritoneum, but it is done by a machine called a cyclor. CCPD treatments are usually carried out while the person sleeps, and take about an hour and a half for each sequence that repeats throughout the night.

Preparation

Preparation for peritoneal dialysis includes a thorough explanation of what is to be done and why. This is particularly important for the patient just beginning treatments. Most patients are eventually taught how to do their own dialysis if they are mentally alert and physically able to do so.

Aftercare

Monitoring of weight, **vital signs**, and chemicals in the blood will all be done following treatments to assess the person's physical status and the effectiveness of the treatment.

Complications

Complications, though not considered common with this procedure, are possible. They include:

- bleeding from the site where the catheter is inserted or within the abdomen
- perforation of abdominal organs by the catheter during placement
- fluid flow blockage caused by blood clots
- infections at the site of catheter insertion (these can sometimes result in the formation of an abscess)
- an abnormally low blood albumin
- development of scar tissue within the peritoneum that can result in partial intestinal obstruction
- hernias of the abdomen or groin (occur in approximately 10% of all patients undergoing peritoneal dialysis)
- very low thyroid hormone levels
- high blood sugar, especially in diabetic patients

- constipation
- hyperlipidemia, or excessive levels of certain fatty compounds in the blood

Results

The desired results from peritoneal dialysis include removal of adequate quantities of the body's waste products. The patient can then continue to live as comfortably and independently as possible until the kidney condition either resolves itself or a kidney transplant is performed.

Health care team roles

- Renal specialists are responsible for the decision to begin peritoneal dialysis treatments based upon the person's condition. A surgeon would insert a permanent catheter for this treatment.
- Both registered nurses (RNs) and licensed practical nurses (LPNs) will be involved in the administering of peritoneal dialysis treatments as well as patient teaching about both the nature and mechanics of the treatment.
- Registered dietitians will be very important in the patient's treatment planning and education, as diet is an essential part of treatment.
- Social workers will usually be involved in helping the patient to obtain the necessary financial assistance to deal with the tremendous financial burden kidney disease can impose. They may also counsel the patient or family in coping with this difficult illness.
- Clinical laboratory scientists have specialized training and must pass a state examination. They draw blood samples or test urine specimens to determine the level of various chemicals in the blood stream or urine.

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ORGANIZATIONS

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Peritoneal dialysis management

Definition

Dialysis is the process of removing fluid and waste products from the body, a function usually performed by the **kidneys**, through artificial means. There are two types of dialysis: hemodialysis and **peritoneal dialysis**. Peritoneal dialysis accomplishes the removal of waste and excess fluid by using the abdominal lining, called the peritoneal membrane, as a filter.

Purpose

The purpose of peritoneal dialysis is to replace the function of the kidneys in patients who have failing kidneys due to disease. Because peritoneal dialysis can be done continuously, it more closely imitates the function of the kidneys than hemodialysis does. Peritoneal dialysis is also easy to do when away from home, which makes it an appealing choice for patients who do not wish to be tied down to a dialysis infusion site's location or schedule.

Peritoneal dialysis is a relatively slow process compared to hemodialysis. This is especially useful for patients with cardiovascular disease because rapid changes in **blood** urea (a waste product), glucose, electrolytes, or fluid volume can exacerbate cardiovascular disease. Peritoneal dialysis is a commonly prescribed method of dialysis for diabetic patients because insulin can be added to the dialysate. It also reduces the risk of retinal hemorrhage since, unlike with hemodialysis, heparin (an anticoagulant) is not used. Peritoneal dialysis is the treatment of choice for children as it does not interfere with growth.

Precautions

Peritoneal dialysis is contraindicated in patients with hypercatabolism because adequate clearance of uremic toxins cannot be achieved with this method of dialysis. Peritoneal adhesions and scarring are also contraindications. Caution should be used when prescribing peritoneal dialysis for patients with a history of ruptured diverticuli, respiratory disease, recurrent peritonitis (**infection** of the peritoneum), abdominal malignancies, severe vascular disease, back problems, and those who are obese.

Description

Before peritoneal dialysis begins, patients have a catheter surgically inserted into their peritoneal cavity.

The catheter is usually placed 1.2–2 in (3–5 cm) below the umbilicus. When dialysis is ready to begin, a bag of fluid (dialysate) containing sterile water, normal plasma, electrolytes, and glucose is infused into the abdominal cavity. The volume of dialysate used can range from 1.5–3 qt (1.5–3 l), and the concentration of electrolytes and glucose is altered according to what the physician prescribes. The dialysate is left in the abdominal cavity for anywhere from one hour to 10 hours, depending on the type of dialysis. The period of time that the dialysate is left in the abdominal cavity is called the dwell time. At the end of the prescribed dwell time, the dialysate is drained out of the abdominal cavity through the catheter. The drained dialysate takes waste products with it. This process of instilling a bag of dialysate, dwell time, and emptying the dialysate is called an exchange. The amount and timing of exchanges performed by patients depends on the type of dialysis, the recommendation of the physician, and the lifestyle of the patient.

Peritoneal dialysis works based on the principles of osmotic pressure and diffusion. Osmotic pressure is the moving of fluid toward the solution with a higher solute concentration. Diffusion is the passing of particles from an area of high concentration to an area of lower concentration. The dialysate infused into the abdominal cavity is prepared with specific concentrations of electrolytes and glucose that will draw the waste products and excess fluid across the peritoneal membrane using diffusion and osmotic pressure. The pores in the peritoneal membrane are large enough to allow the waste to pass through into the abdominal cavity, but small enough that blood cells and other protein molecules are unable to pass through.

There are two types of peritoneal dialysis: continuous ambulatory peritoneal dialysis (CAPD) and automated peritoneal dialysis (APD). Within APD, there are three different scheduling methods, including continuous cyclic peritoneal dialysis (CCPD), intermittent peritoneal dialysis (IPD), and nightly peritoneal dialysis (NPD).

With CAPD, dialysate is instilled into and drawn out of the abdominal cavity by gravity alone. No machine is needed. The dwell time for CAPD ranges from four to 10 hours. The CAPD patient usually performs four exchanges per day, including an eight-hour overnight dwell. This continuous exchange most closely resembles normal renal function, and it is also convenient because the exchanges can be performed anywhere since no equipment is required.

The automated dialysis methods require a peritoneal cycling machine. Patients using CCPD set their cyclers to do three exchanges at night and one eight-hour daytime dwell, which frees up the patient during the day. NPD performs several exchanges at night over an eight- to 12-

hour period, and does not require a daytime dwell. This is preferred by many patients who are self-conscious about the way they look with the extra fluid in their abdominal cavity. IPD is performed for 10 to 14 hours three to four times a week. This type of treatment is usually performed in the hospital.

Preparation

Strict sterile technique should be used when preparing to do an exchange to prevent infection. Dialysate should be warmed to 98.6°F (37°C) to provide comfort to the patient; this also is the optimal temperature for clearance of uremic metabolites. The catheter tubing should be flushed so that air does not enter the abdominal cavity.

Aftercare

When not in use, the dialysis catheter can be clamped and tucked under clothing for concealment. If a method of peritoneal dialysis is chosen with dwell times during the day, the patient may have to wear larger, loose-fitting clothes to account for the additional fluid in the abdominal cavity.

Complications

The major complication that can be encountered by peritoneal dialysis patients is peritonitis, an infection of the peritoneum. Symptoms of peritonitis include **fever**, rebound tenderness, nausea, malaise, and cloudy dialysate output. Peritonitis is treated with **antibiotics** placed in the dialysate or taken orally. To avoid peritonitis, patients must be taught to handle the catheter and other dialysis equipment with sterile technique.

Other complications associated with peritoneal dialysis are problems with the catheter such as obstruction, as well as bowel and bladder perforations caused by the insertion of the catheter. Dialysis-related complications include fluid and electrolyte imbalances, hypotension, **pain**, hyperglycemia (high blood glucose levels), and respiratory difficulties due to the presence of the dialysate fluid and the pressure it puts on the diaphragm.

Results

When the proper type of peritoneal dialysis is prescribed, and the patient complies with the regimen, peritoneal dialysis can be very successful in maintaining the fluid and **electrolyte balance** and removing waste when the kidneys are unable to perform these tasks. Peritoneal dialysis allows patients to live full and productive lives by providing flexibility of time and place in dialysis treatment.

KEY TERMS

Automated peritoneal dialysis (APD)—A type of peritoneal dialysis that requires a cyclic machine to complete exchanges.

Continuous ambulatory peritoneal dialysis (CAPD)—A type of peritoneal dialysis that uses gravity to infuse and empty dialysate instead of a machine.

Dialysate—The solution that is used during peritoneal dialysis.

Dialysis—The process of removing fluid and waste products from the body through artificial means.

Dwell time—Stage of a dialysis exchange when the dialysate is inside the abdominal cavity, which is when the filtration takes place.

Exchange—A complete dialysis cycle, starting with infusing the dialysate and ending with the emptying out of the used dialysate solution.

Hypercatabolism—A state in which the body is metabolizing proteins at an exaggerated rate.

Peritoneal dialysis—A removal system for waste products and excess fluid in patients whose kidneys are failing. This system uses the abdominal lining or peritoneal membrane as a filter.

Peritonitis—An infection of the peritoneum.

Uremic toxins—Waste products carried in the blood stream that are usually excreted by the kidneys.

Health care team roles

Peritoneal dialysis is primarily performed at home by patients and their family members. It is the responsibility of health care providers to educate patients in the proper use of peritoneal dialysis so that the patient complies with the regimen and avoids complications. **Patient education** must include instruction on aseptic measures to prevent infection, timing and number of exchanges to be performed, appropriate dwell times, use of the cycler if automated dialysis is chosen, obtaining the proper dialysate solutions, and storage of solutions and equipment.

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Peritoneal fluid analysis *see* **Paracentesis**

Permanent tooth development *see* **Tooth development, permanent**

Personal oral hygiene *see* **Oral hygiene**

Personality disorders

Definition

Personality disorders are a group of personality flaws defined by the fourth (1994) edition of the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* as “enduring pattern[s] of inner experience and behavior” that are sufficiently rigid and deep-seated to bring a person into repeated conflicts with his or her social and occupational environment. *DSM-IV* specifies that these dysfunctional patterns must be regarded as non-conforming or deviant by the person’s culture, and cause significant emotional **pain** and/or difficulties in relationships and occupational performance. In addition, the patient usually sees the disorder as being consistent with his or her self-image (ego-syntonic) and may blame others.

Description

To meet the diagnosis of personality disorder, which is sometimes called character disorder, the patient’s problematic behaviors must appear in two or more of the following areas:

- perception and interpretation of the self and other people
- intensity and duration of feelings and their appropriateness to situations
- relationships with others
- ability to control impulses

Personality disorders have their onset in late adolescence or early adulthood. Doctors rarely give a diagnosis of personality disorder to children on the grounds that

children’s personalities are still in the process of formation and may change considerably by the time they are in their late teens. But, in retrospect, many individuals with personality disorders could be judged to have shown evidence of the problems in childhood.

It is difficult to accurately estimate the percentage of the population that suffer from personality disorders. Patients with certain personality disorders, including antisocial and borderline disorders, are more likely to get into trouble with the law or otherwise attract attention than are patients whose disorders chiefly affect their capacity for intimacy. On the other hand, some patients, such as those with narcissistic or obsessive-compulsive personality disorders, may be outwardly successful because their symptoms are useful within their particular occupations. It has, however, been estimated that about 15% of the general population of the United States suffers from personality disorders, with higher rates in poor or troubled neighborhoods. The rate of personality disorders among patients in psychiatric treatment is between 30% and 50%. It is possible for patients to have a so-called dual diagnosis; for example, they may have more than one personality disorder, or a personality disorder together with a substance-abuse problem.

DSM-IV classifies personality disorders into three clusters based on symptom similarities:

- Cluster A (paranoid, schizoid, schizotypal): Patients appear odd or eccentric to others.
- Cluster B (antisocial, borderline, histrionic, narcissistic): Patients appear overly emotional, unstable, or self-dramatizing to others.
- Cluster C (avoidant, dependent, obsessive-compulsive): Patients appear tense and anxiety-ridden to others.

The *DSM-IV* clustering system does not mean that all patients can be fitted neatly into one of the three clusters. It is possible for patients to have symptoms of more than one personality disorder or to have symptoms from different clusters.

Since the criteria for personality disorders include friction or conflict between the patient and his or her social environment, these syndromes are open to redefinition as societies change. Successive editions of *DSM* have tried to be sensitive to cultural differences, including changes over time, when defining personality disorders. One category that had been proposed for *DSM-III-R*, self-defeating personality disorder, was excluded from *DSM-IV* on the grounds that its definition reflected prejudice against women. *DSM-IV* recommends that doctors take a patient’s background, especially recent immigration, into account before deciding that he or she has a personality disorder. One criticism that has been made of the

general category of personality disorder is that it is based on Western notions of individual uniqueness. Its applicability to people from other cultures is thus open to question. Furthermore, even within a culture, it can be difficult to define the limits of “normalcy.”

The personality disorders defined by *DSM-IV* are described below. Certain personality disorders, such as paranoid, schizoid, and schizotypal, should not be confused with psychotic disorders with the same or similar names. Psychotic disorders are characterized by more seriously disordered thinking, frequently involving hallucinations (seeing things that aren't present or hearing voices) and delusions (having unrealistic beliefs, such as thinking one has god-like powers), with an inability to distinguish reality from fantasy.

Paranoid

Patients with paranoid personality disorder are characterized by suspiciousness and a belief that others are out to harm or cheat them. They have problems with intimacy and may join cults or groups with paranoid belief systems. Some are litigious, bringing lawsuits against those they believe have wronged them. Although not ordinarily delusional, these patients may develop psychotic symptoms under severe **stress**. It is estimated that 0.5–2.5% of the general population meet the criteria for paranoid personality disorder.

Schizoid

Schizoid patients are perceived by others as “loners” without close family relationships or social contacts. Indeed, they are aloof and really do prefer to be alone. They may appear cold to others because they rarely display strong emotions. They may, however, be successful in occupations that do not require personal interaction. About 2% of the general population has this disorder. It is slightly more common in men than in women.

Schizotypal

Patients diagnosed as schizotypal are often considered odd or eccentric because they pay little attention to their clothing and sometimes have peculiar speech mannerisms. They are socially isolated and uncomfortable in parties or other social gatherings. In addition, people with schizotypal personality disorder often have oddities of thought, including “magical” beliefs or peculiar ideas (for example, a belief in telepathy) that are outside of their cultural norms. It is thought that 3% of the general population has schizotypal personality disorder. It is slightly more common in males. There is some evidence that schizotypal personality disorder and the psychotic disorder, **schizophrenia**, are genetically related.

Antisocial

Patients with antisocial personality disorder are sometimes referred to as sociopaths or psychopaths. They are characterized by lying, manipulateness, and a selfish disregard for the rights of others; some may act impulsively. People with antisocial personality disorder are frequently chemically dependent and sexually promiscuous. It is estimated that 3% of males in the general population and 1% of females have antisocial personality disorder.

Borderline

Patients with borderline personality disorder (BPD) are highly unstable, with wide mood swings, a history of intense but stormy relationships, impulsive behavior, and confusion about career goals, personal values, or sexual orientation. These often highly conflicting ideas may correspond to an even deeper confusion about their sense of self (identity). People with BPD frequently cut or burn themselves, or threaten or attempt suicide. Many of these patients have histories of severe childhood abuse or neglect. About 2% of the general population have BPD; 75% of these patients are female.

Histrionic

Patients diagnosed with this disorder impress others as overly emotional, overly dramatic, and hungry for attention. They may be flirtatious or seductive as a way of drawing attention to themselves, yet they are emotionally shallow. Histrionic patients often live in a romantic fantasy world and are easily bored with routine. About 2–3% of the population is thought to have this disorder. Although historically, in clinical settings, the disorder has been more associated with women, there may be bias toward diagnosing women with this personality disorder.

Narcissistic

Narcissistic patients are characterized by a sense of self-importance, a craving for admiration, and exploitative attitudes toward others. They have unrealistically inflated views of their talents and accomplishments, and may become extremely angry if they are criticized or outshone by others. Narcissists may be professionally successful but rarely have long-lasting intimate relationships. Fewer than 1% of the population has this disorder; about 75% of those diagnosed with it are male.

Avoidant

Patients with avoidant personality disorder are fearful of rejection and shy away from situations or occupations that might expose their supposed inadequacy. They

may reject opportunities to develop close relationships because of their fears of criticism or humiliation. Patients with this personality disorder are often diagnosed with dependent personality disorder as well. Many also fit the criteria for social phobia. Between 0.5–1.0% of the population have avoidant personality disorder.

Dependent

Dependent patients are afraid of being on their own and typically develop submissive or compliant behaviors in order to avoid displeasing people. They are afraid to question authority and often ask others for guidance or direction. Dependent personality disorder is diagnosed more often in women, but it has been suggested that this finding reflects social pressures on women to conform to gender stereotyping or bias on the part of clinicians.

Obsessive-compulsive

Patients diagnosed with this disorder are preoccupied with keeping order, attaining perfection, and maintaining mental and interpersonal control. They may spend a great deal of time adhering to plans, schedules, or rules from which they will not deviate, even at the expense of openness, flexibility, and efficiency. These patients are often unable to relax and may become “workaholics.” They may have problems in employment as well as in intimate relationships because they are very “stiff” and formal, and insist on doing everything their way. About 1% of the population has obsessive-compulsive personality disorder; the male/female ratio is about 2:1.

Causes and symptoms

Personality disorders are thought to be a disparity between a child’s temperament or character and his or her family or social relationships. Temperament can be defined as a person’s innate or biologically shaped basic disposition. Human infants vary in their sensitivity to light or noise, their level of physical activity, their adaptability to schedules, and other aspects. Even traits such as “shyness” and “novelty-seeking” may be, at least in part, determined by the biology of the **brain** and the genes one inherits.

Character is defined as the set of attitudes and behavior patterns that the individual acquires or learns over time. It includes such personal qualities as work and study habits, moral convictions, neatness or cleanliness, and consideration of others. Since children must learn to adapt to their specific families, they may develop personality disorders in the course of struggling to survive psychologically in disturbed or stressful families. For

example, nervous or high-strung parents might be unhappy with a baby who is very active and try to restrain him or her at every opportunity. The child might then develop an avoidant personality disorder as the outcome of coping with constant frustration and parental disapproval. As another example, **child abuse** is believed to play a role in shaping borderline personality disorder. One reason that some therapists use the term developmental damage instead of personality disorder is that it takes the presumed source of the person’s problems into account.

Some patients with personality disorders come from families that appear to be stable and healthy. It has been suggested that these patients are biologically hypersensitive to normal family stress levels. Levels of the brain chemical (neurotransmitter) dopamine may influence a person’s level of novelty-seeking, and serotonin levels may influence aggression.

Diagnosis

Diagnosis of personality disorders is complicated by the fact that persons suffering from them rarely seek help until they are in serious trouble or until their families (or the law) pressure them to get treatment. The reason for this slowness is that the problematic traits are so deeply entrenched that they seem normal (ego-syntonic) to the patient. Diagnosis of a personality disorder depends in part on the patient’s age. Although personality disorders originate during the childhood years, they are considered to be adult disorders. Some patients, in fact, are not diagnosed until late in life because their symptoms had been modified by the demands of their job or by marriage. After retirement or the spouse’s death, however, these patients’ personality disorders become fully apparent. In general, however, if the onset of the patient’s problem is in mid- or late-life, the doctor will rule out substance abuse or personality change caused by medical or neurological problems before considering the diagnosis of a personality disorder. It is unusual for people to develop personality disorders “out of the blue” in mid-life.

There are no tests that can provide a definitive diagnosis of personality disorder. Most doctors will evaluate a patient on the basis of several sources of information collected over a period of time in order to determine how long the patient has been having difficulties, how many areas of life are affected, and how severe the dysfunction is. These sources of information may include:

Interviews

The doctor may schedule two or three interviews with the patient, spaced over several weeks or months, in order to rule out an adjustment disorder caused by job

loss, bereavement, or a similar problem. An office interview allows the doctor to form an impression of the patient's overall personality as well as obtain information about his or her occupation and family. During the interview, the doctor will note the patient's appearance, tone of voice, body language, eye contact, and other important non-verbal signals, as well as the content of the conversation. In some cases, the doctor may contact other people (family members, employers, close friends) who know the patient well in order to assess the accuracy of the patient's perception of his or her difficulties. It is quite common for people with personality disorders to have distorted views of their situations, or to be unaware of the impact of their behavior on others.

Psychological testing

Doctors use psychological testing to help in the diagnosis of a personality disorder. Most of these tests require interpretation by a professional with specialized training. Doctors usually refer patients to a clinical psychologist for this type of test.

PERSONALITY INVENTORIES. Personality inventories are tests with true/false or yes/no answers that can be used to compare the patient's scores with those of people with known personality distortions. The single most commonly used test of this type is the Minnesota Multiphasic Personality Inventory, or MMPI. Another test that is often used is the Millon Clinical Multiaxial Inventory, or MCMI.

PROJECTIVE TESTS. Projective tests are unstructured, meaning that instead of giving one-word answers to questions, the patient is asked to talk at some length about a picture that the psychologist presents, or to supply an ending for the beginning of a story. Projective tests allow the clinician to assess the patient's patterns of thinking, fantasies, worries or anxieties, moral concerns, values, and habits. Common projective tests include the Rorschach, in which the patient responds to a set of 10 inkblots; and the Thematic Apperception Test (TAT), in which the patient is shown drawings of people in different situations and then tells a story about the picture.

Prognosis

At one time psychiatrists thought that personality disorders did not respond very well to treatment. This opinion was derived from the notion that human personality is fixed for life once it has been molded in childhood, and from the belief among people with personality disorders that their own views and behaviors are correct, and that others are the ones at fault. More recently, how-

KEY TERMS

Character—An individual's set of emotional, cognitive, and behavioral patterns learned and accumulated over time.

Character disorder—Another name for personality disorder.

Developmental damage—A term that some therapists prefer to personality disorder, on the grounds that it is more respectful of the patient's capacity for growth and change.

Ego-syntonic—Consistent with one's sense of self, as opposed to ego-alien or dystonic (foreign to one's sense of self). Ego-syntonic traits typify patients with personality disorders.

Neuroleptic—Another name for older antipsychotic medications, such as haloperidol. The term does not apply to newer "atypical" agents, such as clozapine (Clozaril).

Personality—The organized pattern of behaviors and attitudes that makes a human being distinctive. Personality is formed by the ongoing interaction of temperament, character, and environment.

Projective tests—Psychological tests that probe into personality by obtaining open-ended responses to such materials as pictures or stories. Projective tests are often used to evaluate patients with personality disorders.

Rorschach—A well-known projective test that requires the patient to describe what he or she sees in each of 10 inkblots. It is named for the Swiss psychiatrist who invented it.

SSRI medications—A group of antidepressants known as selective serotonin reuptake inhibitors.

Temperament—A person's natural or genetically determined disposition.

ever, doctors have recognized that humans can continue to grow and change throughout life. Most patients with personality disorders are now considered to be treatable, although the degree of improvement may vary. The type of treatment recommended depends on the personality characteristics associated with the specific disorder.

Treatment

A number of treatments are available for patients with personality disorders. One of the newer treatments

is the use of certain antidepressant medications such as the SSRI (selective serotonin reuptake inhibitors) antidepressants.

Hospitalization

Inpatient treatment is rarely required for patients with personality disorders, with two major exceptions: borderline patients who are threatening suicide or suffering from drug or alcohol withdrawal; and patients with paranoid personality disorder who are having psychotic symptoms.

Psychotherapy

Psychoanalytic **psychotherapy** is suggested for patients who can benefit from insight-oriented treatment. These patients typically include those with dependent, obsessive-compulsive, and avoidant personality disorders. Doctors usually recommend individual psychotherapy for narcissistic and borderline patients, but often refer these patients to therapists with specialized training in these disorders. Psychotherapeutic treatment for personality disorders may take as long as three to five years.

Insight-oriented approaches are not recommended for patients with paranoid or antisocial personality disorders. These patients are likely to resent the therapist and see him or her as trying to control or dominate them.

Supportive therapy is regarded as the most helpful form of psychotherapy for patients with schizoid personality disorder.

Cognitive-behavioral therapy

Cognitive-behavioral approaches are often recommended for patients with avoidant or dependent personality disorders. Patients in these groups typically have mistaken beliefs about their competence or likableness. These assumptions can be successfully challenged by cognitive-behavioral methods.

Group therapy

Group therapy is frequently useful for patients with schizoid or avoidant personality disorders because it helps them to break out of their social isolation. It has also been recommended for patients with histrionic and antisocial personality disorders. These patients tend to act out, and pressure from peers in group treatment can motivate them to change. Because patients with antisocial personality disorder can destabilize groups that include people with other disorders, it is usually best if these people meet exclusively with others with the same disorder (in "homogeneous" groups).

Family therapy

Family therapy may be suggested for patients whose personality disorders cause serious problems for members of their families. It is also sometimes recommended for borderline patients from overinvolved or possessive families.

Medications

Medications may be prescribed for patients with specific personality disorders. The type of medication depends on the disorder.

ANTIPSYCHOTIC DRUGS. **Antipsychotic drugs**, such as haloperidol (Haldol), may be given to patients with paranoid personality disorder if they are having brief psychotic episodes. Patients with borderline or schizotypal personality disorder are sometimes given antipsychotic drugs in low doses; however, the efficacy of these drugs in treating personality disorder is less clear than in schizophrenia.

MOOD STABILIZERS. Carbamazepine (Tegretol) is a drug that is commonly used to treat seizures, but is also helpful for borderline patients with rage outbursts and similar behavioral problems. Lithium and valproate may also be used as mood stabilizers, especially among people with borderline personality disorder.

ANTIDEPRESSANTS AND ANTI-ANXIETY MEDICATIONS. Medications in these categories are sometimes prescribed for patients with schizoid personality disorder to help them manage **anxiety** symptoms while they are in psychotherapy. Antidepressants are also commonly used to treat people with borderline personality disorder.

Treatment with medications is not recommended for patients with avoidant, histrionic, dependent, or narcissistic personality disorders. The use of potentially addictive medications should be avoided in people with borderline or antisocial personality disorders. However, some avoidant patients who also have social phobia may benefit from monoamine oxidase inhibitors (MAO inhibitors), a particular class of antidepressant.

Prognosis

The prognosis for recovery depends in part on the specific disorder and the existence of a mood disorder or coexisting psychiatric diagnosis. Although some patients improve as they grow older and have positive experiences in life, personality disorders are generally life-long disturbances with periods of worsening (exacerbations) and periods of improvement (remissions). Others, particularly schizoid patients, have better prognoses if they are given appropriate treatment. Patients with paranoid per-

sonality disorder are at some risk for developing delusional disorders or schizophrenia. The personality disorders with the poorest prognoses are the antisocial and the borderline. Borderline patients are at high risk for developing substance abuse disorders or bulimia. About 80% of hospitalized borderline patients attempt suicide at some point during treatment, and about 5% succeed in committing suicide.

Health care team roles

Nursing staff and allied health professionals can assist in the treatment of personality disorders by being aware of the symptoms of each cluster. Since personality disorders often present as relationship difficulties, nursing staff and allied health professionals may recognize personality disorders in particularly problematic patients.

During the treatment phase, nursing staff and allied health professionals can help patients by providing them with appropriate educational materials and referrals for ongoing psychotherapy or group therapy, if applicable.

Prevention

The most effective preventive strategy for personality disorders is early identification and treatment of children and adults who are at risk. High-risk groups include abused children, children from troubled families, children with close relatives diagnosed with personality disorders, children of substance abusers, and children who grow up in cults or political extremist groups.

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Bethanne Black

PET scan see **Positron emission tomography (PET)**

PET unit see **Positron emission tomography (PET) unit**

Pharmacology

Definition

Pharmacology is the study of how drugs act on biological systems.

Description

Pharmacology is the science of understanding how drugs act on the body and conversely, how the body acts on drugs. This is not to be confused with pharmacy, which deals with the preparation and dispensing of drugs. Drugs can be defined as chemical compounds with a specific therapeutic function, such as aspirin. Pharmacology focuses on how a drug gets into the body, where in the body the drug acts, and how the body gets rid of a drug. In addition, a pharmacologist will also study the therapeutic potential of a drug, the interaction of a drug with other drugs, and analyze adverse drug reactions, otherwise known as toxicities. There are several subdivisions and sub-disciplines of pharmacology which use the basic principles of pharmacology in different ways.

Pharmacology can be divided into subdivisions based on the body organ being studied. These include, but are not limited to, neuropharmacology, cardiovascular pharmacology, endocrine pharmacology, and **chemotherapy**. Neuropharmacology deals with the effect of drugs on the nervous system, which includes the **brain, spinal cord**, and nerves. Neuropharmacology includes the study of drugs of abuse such as heroin and also drugs used to treat nervous system disorders such as L-dopa, which is given to **Parkinson's disease** patients. Cardiovascular pharmacology focuses on drugs that modify the **heart** and vascular system. **Blood pressure** medications would be studied under this category. Endocrine pharmacology focuses on the interaction of drugs with various hormones or hormonal systems. Birth control pills would fall under the division of endocrine pharmacology. Lastly, the division of chemotherapy studies the pharmacology of drugs used to treat **cancer** such as tamoxifen used in **breast cancer**.

In addition to dividing the field of pharmacology on the basis of the targeted organ system, pharmacology can also be divided into sub-disciplines. These sub-disciplines include, but are not limited to, molecular pharmacology, behavioral pharmacology, and clinical pharmacology. Molecular pharmacology studies the interaction of drugs at the cellular level. This includes studies on the interaction of drugs with protein receptors expressed on the surface of the cell. For example, the **asthma** drug, albuterol, interacts with beta receptors in the lung to increase airflow. The effect of drugs on behavior is the

KEY TERMS

Efficacy—The effectiveness of a drug in treating a disease or condition.

Pharmacodynamics—The way a drug acts on tissues and cells in the body.

Pharmacokinetics—The route and rate at which a drug gets in and out of the body.

basis for the behavioral pharmacology discipline. Behavioral pharmacology includes addiction research which tries to understand why people become addicted to drugs like alcohol. The field of clinical pharmacology focuses more on the therapeutic use of drugs, the interactions of drugs with one another in the body, and the nature of adverse drug reactions.

The various subdivisions and disciplines of pharmacology pursue the discovery and understanding of drugs for the purpose of treating a disease or condition, such as high **blood** pressure. The basic principles of pharmacokinetics, pharmacodynamics, and efficacy are universal across the various areas of pharmacology. A significant amount of pharmacology research is spent on identifying new drugs to treat disease. In addition, it is important to predict drug toxicities or adverse reactions. This is accomplished by studying the pharmacokinetics of a drug. Pharmacokinetics is basically how drugs get into the body and how they get out. It describes the relationships between drug dosage and drug blood levels, which can be influenced by individual differences in drug absorption, distribution, **metabolism**, and elimination. This is important because if a drug is eliminated by the **kidneys** and a patient has damaged kidneys, then the drug could accumulate in the patient to fatal levels. Pharmacokinetic calculations can be used to determine the dose needed to give safe and effective blood levels in this situation. A significant amount of pharmacology research is also spent on understanding how drugs act on the body. This is important to understanding adverse reactions, **drug interactions**, and also for the design of better drugs. This area is known more specifically as pharmacodynamics. Pharmacodynamics is basically how drugs interact with the body. Many drugs bind to protein receptors on the surface of a cell. Pharmacodynamics strives to understand how tightly a drug binds to its receptor and what happens inside the cell upon drug binding. Lastly, the overall outcome of drugs on the human condition is studied and this is known as efficacy. Efficacy deals with analyzing how well a drug may correct a condition such as arthritis. All three principles,

pharmacodynamics, pharmacokinetics, and efficacy, play a pivotal role in pharmacology research.

Work settings

Many pharmacologists work in a laboratory research setting conducting experiments with various drugs. These experiments may be done in animal models of disease or at the biochemical level. Pharmacologists are employed by universities, commercial companies such as a pharmaceutical company, or by the government. University settings are often associated with medical centers and pharmacology research projects are largely funded by grants from outside resources. Many pharmacologists in academic settings study very focused areas in which they are interested. Academic labs are headed by a Ph.D. scientist who will lead a team of technicians and students. Academic pharmacology projects tend to focus on how different drugs work and why. Pharmaceutical settings usually have a basic pharmacology research division, a clinical trials division, a production area, and a quality assurance team. A pharmaceutical company may hire a pharmacologist to discover new drugs or to study existing ones for adverse reactions. Pharmaceutical companies conduct very detailed clinical trials in order to have drugs approved by the FDA (U.S. Department of Health and Human Services Food and Drug Administration). Pharmaceutical companies spend a significant amount of money and employ many scientists in order to prove that a drug is safe and useful in treating a particular disease or condition. A pharmacologist may also be hired by a government agency such as the FDA to conduct research on drugs or to review drug approval applications. The FDA is also responsible for monitoring the safety of already approved drugs and therefore hires pharmacologists to monitor approved drugs as well as establish guidelines. All three settings, academic, commercial, and government, provide viable and exciting opportunities for a pharmacologist.

A typical workday for a pharmacologist depends on the sub-discipline the pharmacologist works in. A molecular pharmacologist may spend a significant portion of the day at the lab bench conducting experiments in test tubes. A behavioral pharmacologist may spend the day observing animals treated with certain drugs. A clinical pharmacologist is more likely to spend time evaluating data from patients taking certain medications. These workdays are typical of traditional research pharmacologists. Pharmacologists in more non-traditional careers may be involved in the business or legal side of science. In other words, pharmacologists are not limited to just experimental research in a laboratory setting.

Education and training

In order to become a pharmacologist, a college degree is required. High school students should take biology, chemistry, and math classes. Several undergraduate institutions now offer a bachelor of science degree in pharmacology. College level courses in biology, biochemistry, anatomy, and physiology are required. The field of pharmacology also requires the use of statistics and laboratory mathematics, and students should complete a statistics course. Undergraduate pharmacology majors should also take chemistry courses, including basic chemistry and organic chemistry. The undergraduate science courses should have a practical laboratory component to prepare students for careers in a laboratory research setting. Students should also pursue undergraduate research projects and look for internship opportunities at pharmaceutical or biotechnology companies. Research associate positions in industry are available for pharmacology college majors, but experience in a laboratory research setting is a must for many of these job opportunities. Universities also hire lab technicians with a college level pharmacology background.

Advanced education and training

Most pharmacologists have advanced degrees at the masters or Ph.D. level. Many universities offer graduate degree programs in pharmacology. Students pursuing a graduate degree should have a baccalaureate degree in biology, chemistry, or related field. Ph.D. students take in depth courses in physiology and pharmacology. In addition, a major requirement for a Ph.D. is a dissertation research project that is conducted over several years. The Ph.D. student is required to publish novel findings in peer-reviewed scientific journals. After completing a Ph.D. in pharmacology, many graduates go on to postdoctoral research training. Postdoctoral training may be in an academic or commercial setting. This training period has an indefinite time length. Many pharmacologists will then go on to become professors at universities or enter the commercial workforce as research scientists.

Future outlook

The field of pharmacology is experiencing rapid growth and prospects for pharmacologists continue to look good. The mapping of the human genome will provide new insights into designing better drugs and will create a need for more pharmacologists to make use of this new information. Many pharmaceutical companies are hiring pharmacologists for their drug discovery research projects. The pharmaceutical industry is a \$300

billion dollar a year industry and this rapid growth is expected to continue.

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Susan M. Mockus, Ph.D.

Pharmacy technician

Definition

Pharmacy technicians assist licensed pharmacists in preparing medications for patients.

Description

Pharmacy technicians, who may also be called pharmacy assistants or pharmacy aides, assist licensed pharmacists in preparing medication for patients. Depending on the work setting and the laws of the individual state, this may involve a number of different tasks.

The primary responsibility of most technicians is to fill orders or prescriptions under the direction and supervision of a pharmacist. The extent of this involvement is often subject to state law, which limits certain activities to performance by a licensed pharmacist. The following discussion will vary with the specific location.

When a medication order or prescription is received, it is reviewed by the pharmacist. This review assures that the order is properly written, and is for a safe and effective dose considering the patient's medical condition and the other drugs being taken. Once the order has been reviewed, the technician locates the medication, counts the required number of doses, prepares a label, and performs other required tasks such as pricing the prescription. This work is subject to review by the pharmacist, who is also responsible for giving the medication to the

KEY TERMS

Dispensing—The act of providing medication to a patient or their representative. This includes providing consultation on the way in which the medication should be taken or administered.

Licensed pharmacist—A pharmacist who has completed the full program of education, and has passed a state licensing examination. Also termed “registered pharmacist.”

Pharmacology—The study of the actions and uses of drugs.

Prescription—A written or verbal order for a medication, from a professional practitioners, such as a physician, dentist, nurse practitioner, podiatrist, or other health care provider.

Protocols—Detailed instructions for performing a task.

patient and for providing information about the proper way in which the medication should be taken.

Preparing medication for dispensing may take varying forms, depending on the work setting. In some hospitals, technicians, following written protocols, prepare injections. This requires familiarity with **infection control** procedures and specialized machinery. Extreme care in measuring and technical proficiency in the use of equipment are also required. Technicians may also prepare ointments, solutions, or fill capsules.

Technicians may be expected to do stock work. This may require taking inventories of drugs, checking inventories for expiration dates, preparing orders, and checking in deliveries.

Technicians may be responsible for maintaining patient medication profiles. These are records of a patient’s prescriptions or drug orders, and are used by the pharmacist to review all the drugs a patient is taking. After the order has been reviewed, the technician may transcribe the information onto the profile, either by hand or using a computer. This task requires familiarity with drugs names and doses, as well as knowledge of common medical abbreviations and terminology. The technician must be extremely diligent and precise.

Technicians commonly prepare insurance claim forms. This requires the same familiarity with terminology as preparing medication profiles, plus familiarity with insurance claims procedures.

Technicians routinely clean and maintain equipment, including computers and dispensing machinery. Because the cleaning process prevents medication from becoming contaminated by other drugs, this task requires extreme thoroughness.

In some work locations, the technician may be expected to serve as a cashier. This requires knowledge of cash register operation and additional diligence.

Work settings

Pharmacy technicians work in a pharmacy. Seventy percent work in retail pharmacies, either independent stores or those that are part of chains. The stores may be drug stores or supermarkets that contain a pharmacy. Most other pharmacy technicians work in hospitals, although a small percentage may find employment with wholesale pharmacies, clinics, or in other settings.

Pharmacy technicians normally work as part of a team, under the direction of one licensed pharmacist, with another technician or other unlicensed person. Most states limit the ratio of technicians or other unlicensed personnel who can be supervised by a single pharmacist. The most common ratio is two unlicensed people to one pharmacist, but this may vary. Other possible team members include cashiers, pharmacy interns, graduates of a college of pharmacy who have not yet been licensed, and pharmacy aides, who may do some of the stock and inventory work but do not prepare medication orders.

Hours are variable, and may include evenings, nights, week-ends, and holidays.

The physical work-load depends on circumstances, and may be very light, or may require heavy lifting.

Education and training

Training varies by state, with many states having no requirements for pharmacy technician training. California requires a formal 240-hour training program with at least 120 hours devoted to lecture, rather than on-the-job training, and a letter certifying completion of the program. Louisiana requires that all pharmacy technicians pass an examination given by the State, but does not specify how training is to be provided.

Some technical and community colleges offer courses leading to a career as a pharmacy technician, and in other places, labor unions have developed educational programs for their members. A typical program, such as the one described by the Indiana State Board of Pharmacy “includes **medical terminology** specific to the pharmacy, reading and interpreting prescriptions and defining drugs by brand name. Students receive a **phar-**

macology overview and learn dosage calculations, I.V. flow rates, drug compounding and dose conversions. Dispensing of prescriptions, inventory control, billing and reimbursement also are covered.”

A number of on-line programs and books are also available for technician training.

Although there are no formal education requirements, the Pharmacy Technician Certification Board (PTCB) administers a national certification examination. Admission to the certification examination requires a high school diploma or equivalent. Certification is not required for employment, but many employers prefer to hire certified technicians, and some states may require certification for employment in the future. Maintenance of certification requires participation in 10 hours each year of continuing education, at least one hour of which must be in the area of pharmacy law.

Advanced education and training

Pharmacy technicians may continue their studies and become pharmacists.

Future outlook

There are currently an estimated 170,000 to 200,000 pharmacy technicians in the United States, of which about 50,000 are certified. Although it has been estimated that the growth of this occupation will be no greater than average for all occupations, the current and projected shortage of licensed pharmacists may lead to increased job opportunities for trained technicians. This shortage, combined with an aging population and increased use of drug therapy, has led to recommendations that the ratio of technicians to pharmacists be increased.

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Samuel D. Uretsky, PharmD

Pharyngitis see **Sore throat**

Phenylketonuria testing see **Amino acid disorders screening**

Phlebography

Definition

Phlebography is an x-ray test that provides an image of the leg veins after a contrast dye is injected into a vein in the patient’s foot.

Purpose

Phlebography is primarily performed to diagnose deep vein thrombosis—a condition in which clots form in the veins of the leg that can lead to pulmonary embolism in which those clots break off, travel to the **lungs** and pulmonary artery. Phlebography can also be used to distinguish **blood** clots from obstructions in the veins, to evaluate congenital vein problems, to assess the function of the deep leg vein valves, and to identify a vein for arterial bypass grafting. Ultrasound has replaced phlebography in many cases; but phlebography is the “gold standard” or the best test by which others are judged, but not used as a standard practice.

Precautions

Phlebography is usually not performed in patients with kidney (renal) problems.

Description

Phlebography, also called venography, ascending contrast phlebography, or contrast phlebography, is an invasive diagnostic test that provides a constant image of leg veins on a **fluoroscope** screen. Phlebography identifies the location, extent, and degree of attachment of blood clots, and enables the condition of the deep leg veins to be assessed. It is especially useful when there is a strong suspicion of deep vein thrombosis, after noninvasive tests have failed to identify the disease.

Phlebography is the most accurate test for detecting deep vein thrombosis. It is nearly 100% sensitive and specific in making this diagnosis (pulmonary embolism is diagnosed in other ways). Accuracy is crucial since deep vein thrombosis can lead to pulmonary embolism, a condition that can be fatal.



A phlebography can show problems such as varicose veins. (Science Photo Library/Custom Medical Stock Photo. Reproduced by permission.)

Phlebography is not used often, however, because it is painful, expensive, exposes the patient to a fairly high dose of radiation, and can cause complications. In about 5% of cases, there are technical problems in conducting the test. In addition, the test is less accurate in diagnosing problems below the knee.

Phlebography takes between 30 to 45 minutes and can be done in a physician's office, a laboratory, or a hospital. During the procedure, the patient lies on a tilting x-ray table. The area where the catheter will be inserted is sometimes shaved, if necessary, and cleaned. Sometimes a local anesthetic is injected to numb the skin at the site of the insertion. A small incision may be required to make a point for insertion. The catheter is inserted and the contrast solution (or dye) is slowly injected. Injection of the dye causes a warm, flushing feeling in the leg that may spread through the body. The contrast solution may also cause slight nausea. About 18% of patients experience discomfort from the contrast solution.

In order to fill the deep venous system with dye, a tight band (tourniquet) may be tied around the ankle or below the knee of the side into which the dye is injected, or the lower extremities may be tilted. The patient is asked to keep the leg still. The doctor also observes the movement of the solution through the vein with a fluoroscope. At the same time, a series of x rays is taken. When the test is finished, fluid is injected to clear the dye from the veins, the catheter is removed, and a bandage is applied over the site of the injection.

Preparation

Fasting or drinking only clear liquids is necessary for four hours before the test, although the test may be done in an emergency even if the patient has eaten. The contrast solution contains iodine, to which some people are allergic. Patients who have **allergies** or hay **fever**, or have had a bad reaction to a contrast solution, should tell their doctor.

Aftercare

Patients should drink large amounts of fluids to flush the remaining contrast solution from their bodies. The area around the incision will be sore for a few days. If there is swelling, redness, **pain**, or fever, the doctor should be notified. Pain medication may be needed. In most cases, the patient can resume normal activities the next day.

Complications

Phlebography can cause complications such as phlebitis, tissue damage, and the formation of deep vein thrombosis in a healthy leg. A rare side effect in up to 8% of cases is a severe allergic reaction to the dye. This usually happens within 30 minutes after injection of the dye and requires medical attention.

Results

Normal phlebography results show proper blood flow through the leg veins.

Abnormal phlebography results show well-defined filling defects in veins. Findings include:

- blood clots
- consistent filling defects
- an abrupt end of a test dye column
- major deep veins that are unfilled
- dye flow that is diverted (These results confirm a diagnosis of deep vein thrombosis.)

KEY TERMS

Contrast solution—A liquid dye injected into the body that allows veins to be seen by x rays. Without the dye, the veins could not be seen on x rays.

Deep vein thrombosis—The development or presence of a blood clot in a vein deep within the leg. Deep vein thrombosis can lead to pulmonary embolism.

Invasive—A diagnostic test that invades healthy tissue; in the case of phlebography, through an incision in a healthy vein.

Pulmonary embolism—An obstruction of a blood vessel in the lungs, usually due to a blood clot that blocks a pulmonary artery. Pulmonary embolism can be very serious and in some cases is fatal.

Health care team roles

A phlebography is generally performed in a hospital, or in an outpatient or freestanding facility. A qualified x-ray lab technician, nurse, or doctor might perform the test, with a radiologist reading or interpreting the results that are presented to the patient either directly, or through the primary care physician. Because the patient will be asked to lie on the x-ray table and a vein is punctured in order for the test to be taken, an attending nurse or other medical assistant in addition to the person performing the test should be present to assist when necessary. A professional will be prepared to handle any possible complication, especially if a patient experiences an allergic reaction to the test medium.

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Lori De Milto
Stéphanie Islane Dionne

Phosphorus

Description

Phosphorus (chemical symbol P) is a mineral discovered by the German alchemist Henig Brand in 1699. It plays an essential part in multiple biochemical reactions for both plants and animals and is essential to all life. Phosphorus is found in living things, in soil and rock, mostly as chemical compounds known as phosphates. Rock and soil phosphorus are mined extensively throughout the world, but especially in the Peoples' Republic of China and the United States.

Phosphorus extracted from rock is classified as either white, red or black. White (also called yellow or common) phosphorus is a wax-like substance created by heating phosphate rock until it vaporizes and the condensation solidifies. One of this form's characteristics has given the English language the adjective *phosphorescent*, from white phosphorus's capacity to glow in the dark when exposed to air.

White phosphorus is highly toxic, causes **burns** if it comes in contact with skin, and is so combustible that it has to be stored underwater for safety. Red phosphorus is a rust-colored powder created by heating white phosphorus and exposing it to sunlight. It is not as combustible as the white form. Black phosphorus is made by heating white phosphorus under extremely high pressure until it resembles graphite.

In plants, phosphorus is necessary for photosynthesis to take place. In the human body, phosphorus works in tandem with another element, **calcium**, in much the same way that two other electrolyte components, sodium

KEY TERMS

Anorexia nervosa—A serious and sometimes fatal eating disorder characterized by intense fear of being fat and severe weight loss. It primarily affects teenage and young adult females. Sufferers have a distorted body image wherein they see themselves as being fat even when they are at normal weight or even emaciated.

Bulimia—An eating disorder characterized by bouts of gross overeating usually followed by self-induced vomiting.

Calcitonin—A hormone produced by the thyroid gland that controls the calcium level in the blood. It does this by slowing the rate that calcium is lost from bone.

Deciliter—A fluid measurement that is equal to one-tenth of a liter, or 100 cubic centimeters (27 fluid drams or teaspoons).

Diabetic ketoacidosis—A potentially serious condition in which ketones become present in the blood stream because of the metabolism of fats burned in lieu of carbohydrates that would normally be used. This occurs because there is insufficient insulin available to cause carbohydrates to be used as fuel.

Electrolyte—Substances that split into ions, or elec-

trically-charged particles, within the body to regulate many important bodily processes. Examples of electrolytes would be sodium, potassium, hydrogen, magnesium, calcium, bicarbonate, phosphates, and chlorides.

Multiple endocrine neoplasia—Tumor formation characterized by a progressive, abnormal multiplication of cells that are not necessarily malignant in any of the glands that secrete chemicals directly into the blood stream, such as the thyroid gland, adrenal glands, or ovaries.

Osteomalacia—Softening, weakening, and removal of the minerals from bone in adults caused by vitamin D deficiency.

Osteoporosis—Loss of formative protein tissue from bone, causing it to become brittle and easily fractured. It is considered to be a normal part of aging, but does have hormonal causes that make it much more common in women than men.

Sarcoidosis—A rare disease of currently unknown cause that occurs mostly in young adults. Inflammation occurs in the lymph nodes and other tissues throughout the body, usually including the lungs, liver, skin, and eyes.

and potassium, do. Though phosphorus is found in every cell of the human body and accounts for 1% of the body's total weight, its primary function is working in conjunction with calcium to form teeth and bones.

Eighty-five percent of the phosphorus found in the body is located in these structures. In a delicately balanced chemical reaction, substances known as PTH (parathyroid hormone), calcitonin, and 25-dihydroxy **vitamin D** regulate the absorption of both calcium and phosphorus from the intestinal tract, thus making it available for the production of bones and teeth. If an excessive amount of phosphorus is absorbed, this will result in the phosphorus combining with all available calcium and preventing the calcium's efficient use in making and maintaining bones and teeth.

PTH balances the proportions of calcium and phosphorus in the body by increasing the release of calcium and phosphate from bone and the loss of phosphorus via the **kidneys** while limiting the excretion of calcium. PTH also increases the activity of the 25-dihydroxy vitamin D,

which, in contrast, increases the absorption of both phosphorus and calcium from the intestinal tract.

General use

White phosphorus is a component of fertilizers, detergents and water softeners. It is also used in the manufacture of steel, plastics, insecticides, medical drugs, and animal feeds. Both white and red phosphorus are used in the making of safety matches and pesticides, including rat poison.

But the 15% of this element found in the **blood** stream and in other soft tissue also has a highly significant part to play in a variety of other body functions. Working with vitamin B, phosphorus is involved in the **metabolism of fats and carbohydrates**, in both the repair of damaged cells and tissues and the routine maintenance of healthy ones. Phosphorus is necessary for the regularity of the heartbeat, and aids in the contraction of all other muscles throughout the body. Phosphorus is needed for the functioning of the kidneys and plays a part in the conduction of impulses along the network that makes up the nervous system.

Preparations

According to the American Dietetic Association, phosphorus intake in the United States is generally above what is needed, and in recent years has actually increased. Therefore, under normal circumstances with normal food intake, there is seldom if ever a need to supplement intake of phosphorus. Persons suffering from eating disorders such as anorexia and bulimia can be deficient in phosphorus intake as well as other nutrients. As the best source of phosphorus is in protein foods such as meat, eggs, and milk products. Some vegetarians may also need to evaluate their intake of this element. Excess consumption of processed foods, and inadequate intake of whole foods, plus fertilizers and pesticides are some of the causes for excess phosphorus.

Beside high-protein foods, phosphorus is also found in decreasing quantities in whole grain breads and cereals, especially unprocessed ones, and in minute amounts in fruits and vegetables. The phosphorus present in whole grain breads and cereals, however, exists as a substance called phytin. Phytin combines with calcium to create a salt that the human body is incapable of absorbing, thus making unprocessed, unenriched grains a negligible source of phosphorus. But both commercially prepared cereals and breads may provide this element as they are frequently enriched with it. Phosphates can also be taken by mouth as a tablet.

Precautions

White phosphorus is poisonous. Red phosphorus is not. As noted, white phosphorus is a highly toxic, flammable substance capable of burning the skin if it makes contact, and of igniting at room temperature. It should be handled with extreme care. Accidental phosphorus **poisoning** can happen from both fertilizers and pesticides. Phosphates sometimes are leached into water systems through sewage and can drastically alter the chemical makeup of lakes and rivers. In sufficient quantities, they can lead to the death of nearly all forms of aquatic life.

A normal blood serum level of phosphorus is 2.4–4.1 mg per deciliter of blood. An abnormal serum phosphorus level should be evaluated by a physician.

Phosphorus levels higher than normal can indicate a diet that includes an excessive phosphorus intake, inadequate intake of calcium, or lack of PTH (parathyroid hormone) in the system. It can be related to bone metastasis associated with **cancer, liver** or kidney disease, or sarcoidosis.

Serum phosphorus levels that are below normal can be related to insufficient phosphorus or vitamin D in one's diet leading to rickets in children and osteomalacia in adults. Disorders of the parathyroid gland, causing it to secrete excessive quantities of PTH, or of the **pancreas**, causing it to secrete too much insulin, also affect blood levels of phosphorus. Diabetic ketoacidosis or too much calcium are other possible causes. Multiple endocrine neoplasia (MEN) is yet another condition that often is associated with lower than normal levels of phosphorus.

Side effects

Phosphorus preparations taken to supplement low phosphorus levels in the body can cause **diarrhea**.

Interactions

Antacids can decrease the absorption of phosphorus. **Laxatives** and **enemas** that contain the chemical compound sodium phosphate and excessive intake of vitamin D can increase phosphorus levels in the body. Administration of intravenous glucose solutions will cause phosphorus to combine with the glucose that is being absorbed by the cells.

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Joan Schonbeck

Photorefractive keratectomy see **Refractive eye surgeries**

Phototherapy

Definition

Phototherapy, or light therapy, is the administration of doses of bright light in order to treat a variety of disorders. It is most commonly used to re-regulate the body's internal clock and/or relieve depression.

Origins

Light, both natural and artificial, has been prescribed throughout the ages for healing purposes. Sunlight has been used medicinally since the time of the ancient Greeks; Hippocrates, the father of modern medicine, prescribed exposure to sunlight for a number of illnesses. In the late nineteenth and early twentieth centuries, bright light and fresh air were frequently prescribed for a number of mood and **stress** related disorders. In fact, prior to World War II, hospitals were regularly built with solariums, or sun rooms, in which patients could spend time recuperating in the sunlight.

In the 1980s, phototherapy began to make an appearance in the medical literature as a treatment for seasonal affective disorder, or SAD. Today, it is widely recognized as a front-line treatment for the disorder.

Benefits

Phototherapy is most often prescribed to treat seasonal affective disorder, a form of depression most often associated with shortened daylight hours in northern latitudes from the late fall to the early spring. It is also occasionally employed to treat sleep-related disorders such as insomnia and jet lag.

When used for SAD treatment, phototherapy has several advantages over prescription antidepressants. Phototherapy tends to work faster than medications, alleviating depressive symptoms within two to 14 days after beginning phototherapy as opposed to an average of four to six weeks with medication. And unlike antidepressants, which can cause a variety of side effects from nausea to concentration problems, phototherapy is extremely well tolerated. Some side effects are possible with light but are generally not serious enough to cause discontinuation of the therapy.

There are several other different applications for phototherapy, including:

- Full-spectrum/UV phototherapy for disorders of the skin. A subtype of phototherapy that is often prescribed to treat skin diseases, rashes, and jaundice.

- Cold laser therapy. The treatment involves focusing very low-intensity beams of laser light on the skin, and is used in laser acupuncture to treat a myriad of symptoms and illnesses, including **pain**, stress, and tendinitis.
- Colored phototherapy. In colored phototherapy, different colored filters are applied over a light source to achieve specific therapeutic effects. The colored light is then focused on the patient, either with a floodlight which covers the patient with the colored light, or with a beam of light that is focused on the area of the illness.
- Back of knee phototherapy. A 1998 report published in the journal *Science* reported that the area behind the human knee known as the popliteal region contains photoreceptors which can help adjust the body's circadian rhythms. The authors of the study found that they could manipulate circadian rhythms by focusing a bright light on the popliteal region. Further studies are needed to determine the efficacy of this treatment on disorders such as SAD and jet lag.

Description

Phototherapy is generally administered at home. The most commonly used phototherapy equipment is a portable lighting device known as a light box. The light box may be a full spectrum box, in which the lighting element contains all wavelengths of light found in natural light (including UV rays), or it may be a bright light box, in which the lighting element emits non-UV white light. The box may be mounted upright to a wall, or slanted downwards towards a table.

The patient sits in front of the box for a prescribed period of time (anywhere from 15 minutes to several hours). For patients just starting on the therapy, initial sessions are usually only 10–15 minutes in length. Some patients with SAD undergo phototherapy session two or three times a day, others only once. The time of day and number of times treatment is administered depends on the physical needs and lifestyle of the individual patient. If phototherapy has been prescribed for the treatment of SAD, it typically begins in the fall months as the days begin to shorten, and continues throughout the winter and possibly the early spring. Patients with a long-standing history of SAD are usually able to establish a time-table or pattern to their depressive symptoms, and can initiate treatment accordingly before symptoms begin.

The light from a slanted light box is designed to focus on the table it sits upon, so patients may look down to read or do other sedentary activities during therapy. Patients using an upright light box must face the light source, and should glance toward the light



A seasonal affective disorder sufferer sits next to full-spectrum light box. (A/P Wide World Photos. Reproduced by permission.)

source occasionally without staring directly into the light. The light sources in these light boxes typically range from 2,500–10,000 lux (in contrast, average indoor lighting is 300–500 lux; a sunny summer day is about 100,000 lux).

Light boxes can be purchased for between \$200 and \$500. Some health care providers and healthcare supply companies also rent the fixtures. This gives a patient the opportunity to have a trial run of the therapy before making the investment in a light box. Recently, several new light box products have become available. Dawn simulators are lighting devices or fixtures that are programmed to gradually turn on, from dim to bright light, to simulate the sunrise. They are sometimes prescribed for individuals who have difficulty getting up in the morning due to SAD symptoms. Another device, known as a light visor, was designed to give an individual more mobility during treatment. The visor is a lighting apparatus that is worn like a sun visor around the crown of the head. Patients with any history of eye problems should consult their health care professional before attempting to use a light visor.

Preparations

Full-spectrum light boxes do emit UV rays, so patients with sun-sensitive skin should apply a sun screen before sitting in front of the box for an extended period of time.

Precautions

Patients with eye problems should see an ophthalmologist regularly both before and during phototherapy. Because UV rays are emitted by the light box, patients taking photosensitizing medications should consult with their healthcare provider before beginning treatment. In addition, patients with medical conditions that make them sensitive to UV rays should also be seen by a healthcare professional before starting phototherapy.

Patients beginning phototherapy for SAD may need to adjust the length, frequency, and timing of their phototherapy sessions in order to achieve the maximum benefits. Patients should keep their healthcare provider informed of their progress and the status of their depressive symptoms. Occasionally, additional treatment measures for depression (i.e., antidepressants, herbal reme-

KEY TERMS

Neurotransmitter—A chemical in the brain that transmits messages between neurons, or nerve cells.

Seasonal affective disorder—SAD is a mood disorder characterized by depression during the winter months. An estimated 4–6% of the U.S. population suffers from SAD.

dies, **psychotherapy**) may be recommended as an adjunct, or companion treatment, to phototherapy.

Side effects

Some patients undergoing phototherapy treatments report side effects of eyestrain, headaches, insomnia, fatigue, sunburn, and dry eyes and nose. Most of these effects can be managed by adjusting the timing and duration of the phototherapy sessions. A strong sun block and eye and nose drops can alleviate the others. Long-term studies have shown no negative effects to eye function of individuals undergoing phototherapy treatment.

A small percentage of phototherapy patients may experience hypomania, a feeling of exaggerated, hyper-elevated mood. Again, adjusting the length and frequency of treatment sessions can usually manage this side effect.

Research and general acceptance

Phototherapy is widely accepted by both traditional and complementary medicine as an effective treatment for SAD. The exact mechanisms by which the treatment works are not known, but the bright light employed in phototherapy may act to readjust the body's circadian rhythms, or internal clock. Other popular theories are that light triggers the production of serotonin, a neurotransmitter believed to be related to **depressive disorders**, or that it influences the body's production of melatonin, a hormone that may be related to circadian rhythms.

Wide spectrum UV light treatment for skin disorders such as psoriasis is also considered a standard treatment option in clinical practice. However, other light-related treatments such as cold laser therapy and colored phototherapy are not generally accepted, since few or no scientific studies exist on the techniques.

Training and certification

Psychiatrists, psychologists, and other mental health-care professional prescribe phototherapy treatment for

SAD. Holistic health care professionals and light therapists who specialize in this treatment are also available; in some states, these professionals require a license, so individuals should check with their state board of health to ensure their practitioner has the proper credentials. Phototherapy for skin disorders should be prescribed by a dermatologist or other healthcare professional with expertise in skin diseases and phototherapy treatment.

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- Society for Light Treatment and Biological Rhythms. 824 Howard Ave., New Haven, CT 06519. Fax (203) 764-4324. <<http://www.sltrbr.org>>. sltrbr@yale.edu.

Paula Ford-Martin

Physical development in children see
Human growth and development

Physical examination

Definition

A physical examination is the evaluation of a body to determine its state of health. The techniques of inspection, palpation (feeling with the hands), percussion (tapping with the fingers), auscultation (listening), and **smell** are used. A complete health assessment also includes gathering information about a person's medical history and lifestyle, conducting laboratory tests, and screening for disease. These elements constitute the data on which a diagnosis is made and a plan of treatment is developed.

Purpose

The term annual physical examination has been replaced in most health care circles by periodic health examination. The frequency with which it is conducted depends on factors such as the age, gender, and the presence of risk factors for disease in the person being examined. Health care professionals often use guidelines that have been developed by organizations such as the United States Preventative Services Task Force. Organizations such as the American Cancer Society or American Heart Association, which promote detection and prevention of specific diseases, generally recommend more intensive or frequent examinations or that examinations be focused on particular organ systems of the body.

Comprehensive physical examinations provide opportunities for health care professionals to obtain baseline information about individuals that may be useful in the future. They also allow health care providers to establish relationships before problems occur. Physical examinations are appropriate times to answer questions and teach good health practices. Detecting and addressing problems in their early stages can have beneficial long-term results.

Precautions

The individual being examined should be comfortable and treated with respect throughout the examination. As the examination continues, the examiner should explain what they are doing and share any relevant findings. Using language appropriate to the person being examined improves the effectiveness of communications and ultimately fosters better relations between examiners and examinees.

Description

A complete physical examination usually starts at the head and proceeds all the way to the toes. However, the exact procedure will vary according to the needs of the person being examined and the preferences of the examiner. An average examination takes about 30 minutes. The cost of an examination will depend on the charge for the professional's time and any tests that are included. Most health plans cover routine physical examinations including some tests.

The examination

Before examiners even speak, they will observe a person's overall appearance, general health, and behavior. Measurements of height and weight are made. **Vital**



A doctor examines the abdomen of a young man. (*Science Source/Photo Researchers. Reproduced by permission.*)

signs such as pulse, breathing rate, body temperature, and **blood pressure** are recorded.

With the person being examined in a sitting position, the following systems are reviewed:

- **Skin.** The exposed areas of the skin are observed. The size and shape of any lesions are noted.
- **Head.** The hair, scalp, **skull**, and face are examined.
- **Eyes.** The external structures are observed. The internal structures can be observed using an ophthalmoscope (a lighted instrument) in a darkened room.
- **Ears.** The external structures are inspected. A lighted instrument called an **otoscope** may be used to inspect internal structures.
- **Nose and sinuses.** The external nose is examined. The nasal mucosa and internal structures can be observed with the use of a penlight and a nasal speculum.
- **Mouth and pharynx.** The lips, gums, teeth, roof of the mouth, tongue, and pharynx are inspected.



Measuring infant head circumference. (Delmar Publishers, Inc. Reproduced by permission.)

- Neck. The lymph nodes on both sides of the neck and the **thyroid gland** are palpated (examined by feeling with the fingers).
- Back. The spine and muscles of the back are palpated and checked for tenderness. The upper back, where the **lungs** are located, is palpated on the right and left sides and a **stethoscope** is used to listen for breath sounds.
- Breasts and armpits. A woman's breasts are inspected with the arms relaxed and then raised. In both men and women, the lymph nodes in the armpits are felt with the examiner's hands. While the person is still sitting, movement of the joints in the hands, arms, shoulders, neck, and jaw can be checked.

While the person is lying down on the examining table, the examination includes:

- Breasts. The breasts are palpated and inspected for masses.
- Front of chest and lungs. The area is inspected with the fingers, using palpation and percussion. A stethoscope is used to listen to internal breath sounds.

The head should be slightly raised for:

- Heart. A stethoscope is used to listen to the heart's rate and rhythm. The **blood vessels** in the neck are observed and palpated.

The person being examined should lie flat for:

- Abdomen. Light and deep palpation is used on the abdomen to feel the outlines of internal organs includ-

ing the **liver**, spleen, **kidneys**, and aorta, a large **blood vessel**.

- Rectum and anus. With the person lying on the left side, the outside areas are observed. An internal digital examination (using a gloved finger), is usually done for persons over 40 years old. In men, the prostate gland is also palpated.
- Reproductive organs. The external sex organs are inspected and the area is examined for hernias. In men, the scrotum and testicles are palpated. In women, a pelvic examination is completed using a speculum and a Papanicolaou test (Pap test) may be taken.
- Legs. While lying flat, the legs are inspected for swelling, and pulses in the knee, thigh, and foot area are found. The groin area is palpated for the presence of lymph nodes. The joints and muscles are observed.
- Musculoskeletal system. With the person standing, the straightness of the spine and the alignment of the legs and feet is noted.
- Blood vessels. The presence of any abnormally enlarged veins (varicose), usually in the legs, is noted.

In addition to evaluating a person's alertness and mental ability during the initial conversation, additional inspection of the nervous system may be conducted:

- Neurologic screen. The person's ability to take a few steps, hop, and do deep knee bends is observed. The strength of the hand grip is felt. While sitting in an upright position, the **reflexes** in the knees and feet can be tested with a small hammer. The sense of touch in the hands and feet can be evaluated by testing reaction to **pain** and vibration.
- Sometimes additional time is spent examining the 12 nerves in the head (cranial) that are connected directly to the **brain**. They control the senses of smell and **taste**, strength of muscles in the head, reflexes in the eye, facial movements, gag reflex, **vision**, **hearing**, and muscles in the jaw. General muscle tone and coordination, and the reaction of the abdominal area to stimulants like pain, temperature, and touch may also be evaluated.

Preparation

Before visiting a health care professional, individuals should write down important facts and dates about their own medical history, as well as those of family members. There should be a complete listing of all medications and their dosages. This list should include over-the-counter preparations, **vitamins**, and herbal supplements. Some people bring their bottles of medications

with them. Any questions or concerns about medications should be written down.

Before the physical examination begins, the bladder should be emptied. A urine specimen is usually collected in a small container at this time. The urine is tested for the presence of glucose (sugar), protein, and blood cells. For some blood tests, individuals may be told ahead of time not to eat or drink after midnight.

Individuals being examined usually remove all clothing and put on a loose-fitting hospital gown. An additional sheet is provided to keep persons covered and comfortable during the examination.

Aftercare

Once a physical examination has been completed, the person being examined and the examiner should review what laboratory tests have been ordered, why they have been selected, and how the results will be shared with the patient. A health professional should discuss any recommendations for treatment and follow-up visits. Special instructions should be put in writing. This is also an opportunity for persons to ask any remaining questions about their own health concerns.

Complications

Complications with the process of a physical examination are unusual. Occasionally, a useful piece of information or data may be overlooked. More commonly, results of associated laboratory tests compel physicians to recheck an individual or to re-examine portions of the body already reviewed. In a sense, complications may arise from the findings of a physical examination. These usually trigger further investigations or initiate treatment. They are really more beneficial than negative as they often begin a process of treatment and recovery.

Results

Normal results of a physical examination correspond to the healthy appearance and normal functioning of the body. For example, appropriate reflexes will be present, no suspicious lumps or lesions will be found, and vital signs will be normal.

Abnormal results of a physical examination include any findings that indicate the presence of a disorder, disease, or underlying condition. For example, the presence of lumps or lesions, **fever**, muscle weakness or lack of tone, poor reflex response, heart arrhythmia, or swelling of lymph nodes will indicate possible health problems.

KEY TERMS

Auscultation—The process of listening to sounds that are produced in the body. Direct auscultation uses the ear alone, such as when listening to the grating of a moving joint. Indirect auscultation involves the use of a stethoscope to amplify sounds from within the body, such as those coming from the heart or intestines.

Hernia—The bulging of an organ, or part of an organ, through the tissues normally containing it; also called a rupture.

Inspection—The visual examination of the body using the eyes and a lighted instrument if needed. The sense of smell may also be used.

Ophthalmoscope—Lighted device for studying the interior of the eyeball.

Otoscope—An instrument with a light for examining the internal ear.

Palpation—The examination of the body using the sense of touch. There are two types: light and deep.

Percussion—An assessment method in which the surface of the body is struck with the fingertips to obtain sounds that can be heard or vibrations that can be felt. It can determine the position, size, and consistency of an internal organ. It is performed over the chest to determine the presence of normal air content in the lungs, and over the abdomen to evaluate air in the loops of the intestine.

Reflex—An automatic response to a stimulus.

Speculum—An instrument for enlarging the opening of any canal or cavity in order to facilitate inspection of its interior.

Stethoscope—A Y-shaped instrument that amplifies body sounds such as heartbeat, breathing, and air in the intestine. Used in auscultation.

Varicose veins—The permanent enlargement and twisting of veins, usually in the legs. They are most often seen in people working in occupations requiring long periods of standing, and in pregnant women.

Health care team roles

When considering a physical examination, the leader of a health care team is usually an examining physician,

although **advanced practice nurses** and physician assistants also perform the procedures. This individual has the responsibility for coordinating and interpreting the results of any needed laboratory tests and managing any post-examination activities or treatment. A physician assistant may perform some components of a routine physical examination. A nurse may assist in aspects of many examinations. Laboratory technicians collect and analyze bodily samples such as blood, urine, sputum and tissue. They supply data to an examining physician for analysis and interpretation.

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L. Fleming Fallon, Jr., MD, PhD, DrPH

Physical restraint use see **Restraint use**

Physical therapy

Definition

Physical therapists provide services to restore function, improve mobility, relieve **pain**, and prevent or limit permanent physical disabilities among those suffering from injuries, disabilities, or disease.

Description

Organized physical therapy began during World War I with 800 reconstruction aides. Today there are more

than 80,000 licensed physical therapists in the United States.

Physical therapists treat patients with a variety of health conditions and diseases including accident victims and individuals with disabling conditions such as low back pain, arthritis, **heart** disease, **fractures**, head injuries, and **cerebral palsy**.

In an effort to restore, maintain, and promote overall fitness and health, physical therapists examine patients' medical histories, as well as test and measure patients' strength, range of motion, balance, coordination, posture, muscle performance, respiration, and motor function. Physical therapists determine patients' ability to be independent and reintegrate into the community or workplace. Based on a patient's medical history and test results, physical therapists develop treatment plans that describe treatment strategy, purpose, and anticipated outcome.

A physical therapist's treatment often includes **exercise** for patients who have been immobilized or who lack flexibility, strength, or endurance. As part of the treatment, physical therapists encourage patients to improve flexibility, range of motion, strength, balance, coordination, and endurance. The goal is to improve an individual's function at work and home.

Physical therapists may use electrical stimulation, hot packs, cold compresses, or ultrasound to relieve pain and reduce swelling. They may use traction or deep-tissue massage to relieve pain. Therapists also teach patients to use assistive and adaptive devices including crutches, prostheses, and wheelchairs. They may also show patients how to perform exercises to do at home.

During treatment, physical therapists document the patient's progress, conduct periodic examinations, and modify treatments when necessary. Physical therapists rely on this documentation to track the patient's progress and identify areas requiring more or less attention.

Physical therapists often consult and practice with physicians, dentists, nurses, educators, social workers, occupational therapists, speech-language pathologists, and audiologists.

Some physical therapists treat a wide range of ailments while others specialize in areas such as pediatrics, geriatrics, orthopedics, sports medicine, neurology, and cardiopulmonary physical therapy.

Physical therapist assistants and aides

Physical therapist assistants, under the direction and supervision of a physical therapist, may be involved in implementing patient treatment plans. For example, physical therapist assistants perform treatment proce-



A patient on a physical therapy machine. (UPI/Corbis Bettmann. Reproduced by permission.)

dures including exercises, massages, electrical stimulation, paraffin baths, hot and cold packs, traction, and ultrasound. Physical therapist assistants record patients' treatment responses and report these responses to the physical therapist.

Physical therapist aides work under the direct supervision of a physical therapist or a physical therapist assistant. Aides help make therapy sessions productive and are often responsible for keeping the treatment area clean and organized, preparing for each patient's therapy, and assisting patients who need help in moving to or from a treatment area. Because they are not licensed, aides are only able to perform a limited range of tasks.

Physical therapist aides' duties include clerical tasks such as ordering supplies, answering the phone, filling out insurance forms, and other paperwork. The extent of an assistant's or an aide's clerical responsibilities depend on the size and location of the facility.

Work settings

Physical therapists practice in hospitals, clinics, and private offices. They may also treat patients in the patient's home or at school.

Most physical therapists work a 40-hour week, which may include some evenings and weekends depending on their patients' schedules. The job can be physically demanding, because therapists often have to stoop, kneel, crouch, lift, or stand for long periods of time. In addition, physical therapists move heavy equipment, lift patients, or help them turn, stand, or walk.

In 1998, approximately 75% of the physical therapists employed in approximately 120,000 jobs worked full time. Approximately 10% of physical therapists held more than one job.

Over two-thirds of physical therapists are employed in either hospitals or physical therapists' offices. Other work settings include home health agencies, outpatient rehabilitation centers, physicians' offices and clinics, and **nursing homes**. Some physical therapists maintain a private practice and provide services to individual patients or contract to provide services in hospitals, rehabilitation centers, nursing homes, home health agencies, adult day-care programs, or schools. They may be engaged in individual practice or be part of a consulting group. Some physical therapists teach in academic institutions and conduct research.

Physical therapist assistants and aides

Physical therapist assistants and aides work varying schedules, depending on the facility and whether they are full or part-time employees. To accommodate patients' schedules, many outpatient physical therapy offices and clinics remain open during evenings and weekends.

Physical therapist assistants and aides are required to have a moderate degree of strength due to the physical exertion needed in assisting patients with their treatment. In some cases, for example, assistants and aides help lift patients. In addition, these jobs typically require a good deal of kneeling, stooping, and standing for long periods.

Physical therapist assistants and aides held 82,000 jobs in 1998. Although they work alongside physical therapists in a variety of settings, over two-thirds of all assistants and aides work in hospitals or physical therapists' offices. Other assistants and aides work in nursing and personal care facilities, outpatient rehabilitation centers, physicians' offices and clinics, and home health agencies.

Education and training

Before they can practice, physical therapists are required to pass a licensure exam after graduating from an accredited physical therapist educational program.

According to the American Physical Therapy Association, in 1999 there were 189 accredited physical therapist programs. Of the accredited programs, 24 offered bachelor's degrees, 157 offered master's degrees, and eight offered doctoral degrees. By 2002, the Commission on Accreditation in Physical Therapy Education will require all physical therapist programs seeking accreditation to offer degrees at the post-baccalaureate level.

Physical therapist programs start with basic science courses such as biology, chemistry, and physics, followed by specialized courses such as biomechanics, neuroanatomy, **human growth and development**, manifestations of disease, examination techniques, and therapeutic procedures. Besides classroom and laboratory instruction, students receive supervised clinical experience.

Admission to physical therapist education programs is very competitive. Interested students may improve their admission potential by attaining superior grades, especially in science courses. Interested students should take courses such as anatomy, biology, chemistry, social science, mathematics, and physics. Before granting admission, many programs require that the student at least have experience as a volunteer in a hospital or clinic physical therapy department.

Physical therapists need strong interpersonal skills to successfully educate patients about their physical therapy treatments and to interact with the patient's family. Therapists should also be compassionate and possess a desire to help patients.

Physical therapists are expected to remain current in their professional development by participating in continuing education courses and workshops. A number of states require continuing education to maintain licensure.

In 1998, physical therapists earned a median annual income of \$56,600. The lowest 10% earned less than \$35,700 while the highest 10% earned in excess of \$90,870 a year. Those in the middle 50% earned between \$44,460 and \$77,810 a year. In 1997, physical therapists' median annual earnings in the industries employing the largest number of physical therapists included home health care services, \$65,600; nursing and personal care facilities, \$60,400; health care practitioner offices, \$56,600; physicians' offices and clinics, \$55,100; and hospitals, \$50,100.

Physical therapist assistants and aides

Physical therapist assistants typically have earned an associate's degree from an accredited physical therapist assistant program. As of January 1997, 44 states and Puerto Rico regulated assistants. Physical therapist assistants are also required to have certifications in **CPR** and other **first aid**, along with a specified minimum number of hours of clinical experience. Physical therapist aides are also trained on the job.

In 1999, according to the American Physical Therapy Association, there were 274 accredited physical therapist assistant programs in the United States. Accredited physical therapist assistant programs are designed to last two years or four semesters. Those who successfully complete the program are awarded an associate's degree. Admission into physical therapist assistant programs is competitive. Programs are divided into academic study and hands-on clinical experience. Academic coursework includes algebra, anatomy, physiology, biology, chemistry, and psychology. Before students begin their clinical field experience, many programs require that they complete a semester of anatomy and physiology and have certifications in CPR and other first aid. Employers and educators view clinical experience as essential to ensuring that students understand the responsibilities of a physical therapist assistant.

Employers typically require physical therapist aides to have a high school diploma, strong interpersonal skills, and a desire to assist people in need. Most employers provide clinical on-the-job training.

Future outlook

Employment for physical therapists is expected to grow by 21–35% through 2008. For a variety of reasons, the demand for physical therapists should continue to rise. As the baby boom generation ages, the number of individuals with disabilities requiring therapy services should increase, as well as patients who will require cardiac and physical rehabilitation after a heart attack or stroke. In addition, the need for physical therapy will be increased as technological advances save the lives of a larger number of newborns with severe birth defects.

Future medical developments will also increase trauma victims' survival rate, thereby creating additional demand for rehabilitative care. Growth may also result from advances in medical technology which permit treatment of more disabling conditions.

Widespread interest in health promotion may also increase demand for physical therapy services. A growing number of employers are seeking the services of physical therapists to evaluate worksites, develop exercise programs, and teach safe work habits to employees in the hope of reducing injuries.

Physical therapist assistants and aides

Employment for physical therapist assistants and aides is expected to increase by at least 36% through the year 2008. As with the future outlook for physical therapists, the demand for physical therapist assistants and aides will continue to rise to keep pace with the increase in the number of individuals with disabilities and the rapidly growing elderly population, many of whom are particularly vulnerable to chronic and debilitating conditions that require therapeutic services. These patients often need additional assistance in their treatment, making the roles of assistants and aides vital. As the large baby-boom generation reaches the prime age for heart attacks and strokes, the demand for cardiac and physical rehabilitation will also increase. In addition, future medical developments should permit an increased percentage of trauma victims to survive, creating an additional demand for therapy services.

In 1998, physical therapist assistants and aides earned a median annual income of \$21,870. The lowest 10% earned less than \$13,760 while the highest 10% earned more than \$39,730 a year. The middle 50% earned between \$16,700 and \$31,260 a year. In 1997, the median annual income earned by physical therapist assistants and aides working in the industries employing the largest number of physical therapist assistants and aides included hospitals, \$21,200; health care practitioners offices,

\$20,700; and nursing and personal care facilities, \$19,200.

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ORGANIZATIONS

The American Physical Therapy Association, 1111 North Fairfax Street, Alexandria, VA 22314-1488.
<<http://www.apta.org>>.

Bill Asenjo, MS, CRC

PIH see **Preeclampsia and eclampsia**

Physical therapy assisting

Definition

The professional field consists of skilled health care providers who work under the direction or supervision of a physical therapist or physical therapists. Their role is to facilitate care and treatment of patients with injuries, diseases, or disabilities that involve mobility or other basic physical functioning. Duties include patient instruction and monitoring, reporting progress and problems to the therapist, and providing or assisting in various forms of treatment.

Description

Physical therapy assisting is an adjunct to the profession of physical therapy and comprises workers with at least a two-year education and clinical experience. Physical therapist assistants (PTAs) are in the role of supporting the physical therapist by providing different types of patient treatment and education, and tracking patient progress. Some kinds of treatment PTAs can provide or assist with include massage, heat and cold therapy, traction, ultrasound, electrical stimulation, and helping patients learn and perform various therapeutic exercises. PTAs may also work with patients who need to



Physical therapy assistants help with many aspects of a patient's therapy under the supervision or direction of a physical therapist. (M. Goldstein/Custom Medical Stock Photo. Reproduced by permission.)

learn to use corrective equipment, such as braces or prostheses, wheelchairs or crutches, or other supportive devices. Other PTA responsibilities include organization and maintenance of treatment areas and equipment, and occasional performance of clerical tasks.

Patients with whom PTAs work may include children, the elderly, athletes, accident victims, and those with diseases like low back **pain**, arthritis, **cerebral palsy**, as well as people who have sustained **fractures** and head injuries. PTAs also assist people who need help managing pain and restoring, acquiring, or maintaining mobility and other functions. Coworkers may include physical therapists, other health care and rehabilitation professionals. Physical therapy aides also work with PTAs; aides perform a more limited range of functions, albeit similar, along with clerical, maintenance, and other supportive duties. Aides usually receive their training on the job.

Work settings

Physical therapy assistants may work in hospitals, private physical therapy offices, **nursing homes**, rehabilitation centers, sports facilities, schools, and other institutions. Some degree of bodily strength and endurance is necessary because of the physical handling of patients with limited mobility.

Education and training

A two-year associate's degree, usually from a community or junior college, is generally required. More than half of the states in the United States require licensure, registration, or an American Physical Therapy Association (APTA) certification. **Cardiopulmonary resuscitation** and **first aid** certification and clinical experience hours are also required, although the amount of hours varies by state.

Advanced education and training

Some PTAs may choose to complement their education by obtaining a baccalaureate degree in a related health field (APTA). The PTA curriculum does not meet the prerequisites for a physical therapy degree. PTAs, therefore, cannot directly advance to the status of physical therapist through supplementary education. There are programs, however, that help PTAs earn a master's degree in physical therapy while remaining employed as PTAs. PTAs who would like to participate in the clinical education of PTA students can also earn a Clinical Instructor Credentialing Certificate from the APTA.

Future outlook

According to the *Occupational Outlook Handbook (OOH)*, employment opportunities for PTAs (and physical therapy aides) are expected to grow faster than average through 2008, with the majority of the growth in the latter part of the period. Some of the reasons for expected growth are an increasing elderly population, the aging of the baby boom generation, and increased survival potential of trauma victims. In California, for example, physical therapy assistants and aides are in the Top Fifty Fastest Growth Occupations, as noted by California's Employment Development Department.

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KEY TERMS

CPR—Cardiopulmonary resuscitation.

Prosthesis—An artificial limb or other body part.

PTA—Physical therapy assistant or physical therapist assistant.

ORGANIZATIONS

American Physical Therapy Association (APTA). 1111 North Fairfax Street. Alexandria, VA 22314. (703) 684-2782. (800) 999-2782. <<http://www.apta.org>>.

State of California, Employment Development Department. Labor Market Information Division. Information Services Group. (916) 262-2162.

Diane Fanucchi, B.A., C.M.T.

Pitocin see **Uterine stimulants**

Pituitary gland

Definition

The pituitary gland is located at the base of the **brain** and is part of the **endocrine system**. It is sometimes called the hypophysis, from two Greek words that mean “to grow beneath.” The pituitary is responsible for the hormonal regulation of several body processes, including water retention, breast milk synthesis and release, human growth, and **thyroid gland** secretions.

Description

The pituitary is one of the most extensively researched glands in the endocrine system. In humans, it is located at the base of the brain just beneath the hypothalamus. There are three separate lobes (or sections) of the pituitary: the anterior lobe, the posterior lobe and the intermediate lobe. Therefore, it is sometimes considered as three different glands. In addition, there is a small stem called the pituitary stalk that connects the pituitary to the hypothalamus.

The pituitary gland is formed during early **fetal development**. An understanding of its formation explains its position in the endocrine system as well as its neurological importance. Early in the development of the fetus, a small sac of cells forms at the top of the oral cavity and moves upward. These cells are known as Rathke’s

pouch. At the same time, a small fold of neural tissue extends downward from the hypothalamus. During fetal development, the two structures continue to move toward each other; they meet and fuse to form the anterior (originally Rathke’s pouch) and posterior (from the hypothalamus) lobes of the pituitary.

The hypothalamus, which is located just above the pituitary gland, is a region in the forebrain that is responsible for regulating all lobes of the pituitary. The pituitary releases, but does not necessarily synthesize, nine different hormones. Neurohormones are synthesized by the hypothalamus and transported to the posterior pituitary. The release of hormones from each lobe of the pituitary is regulated differently.

Anterior pituitary

The anterior pituitary is sometimes called the adenohypophysis. It constitutes about 80% of the pituitary by weight. The cells of the anterior pituitary act like true endocrine cells. Instead of containing **neurons**, the anterior pituitary receives chemical signals through the **blood** and releases hormones in response. It has a direct connection with the hypothalamus through **blood vessels**. Various cells in the anterior pituitary release the following hormones:

- Gonadotrophs release luteinizing hormone (LH) and follicle-stimulating hormone (FSH).
- Lactotrophs release prolactin (PRL).
- Corticotrophs release adrenocorticotrophic hormone (ACTH).
- Somatotrophs release growth hormone (GH).
- Thyrotrophs release thyroid-stimulating hormone (TSH).

Posterior pituitary

The posterior pituitary is sometimes referred to as the neurohypophysis because it acts like an extension of the nervous system. As opposed to the anterior pituitary, which is connected to the hypothalamus via the circulatory system, the posterior pituitary receives nerve impulses from the same nerve cells that innervate the hypothalamus. The posterior pituitary releases oxytocin and antidiuretic hormone (ADH, or vasopressin).

Intermediate pituitary

The intermediate lobe is not a complete “lobe” in humans. Instead it is a simple structure comprised of just a few cells. The intermediate pituitary is an important structure in many lower vertebrates, but it has very little significance in humans. In lower vertebrates, the inter-

KEY TERMS

Acromegaly—Abnormal enlargement of such parts of the body as the hands, face, head, and feet.

Adenohypophysis—Another name for the anterior lobe of the pituitary.

Antidiuretic hormone (ADH)—A hormone released by the posterior lobe of the pituitary gland that increases the absorption of water by the kidneys. It is also known as vasopressin.

Diabetes insipidus—A disorder characterized by increased urine production resulting from inadequate levels of ADH.

Gonadotropins—Hormones that affect the development or activity of the ovaries or testes.

Hypophysis—Another name for the pituitary gland.

Hypopituitarism—A condition produced by deficient activity of the anterior lobe of the pituitary gland. It is characterized by obesity, incomplete sexual maturation, and in extreme cases, dwarfism.

Hypothalamus—A region in the forebrain that regulates the functions of the autonomic nervous system by vascular communication. The hypothalamus governs the functions of both lobes of the pituitary gland.

Neurohypophysis—Another name for the posterior lobe of the pituitary.

Oxytocin—A hormone produced by the posterior pituitary that stimulates the movement of breast milk from the sacs in which the milk is produced to the larger ducts from which the milk is ejected.

Peptide—A compound containing two or more amino acids, in which the carboxyl group of one acid is linked to the amino group of the other.

Vasopressin—Another name for ADH.

mediate pituitary releases melanocyto-stimulating hormone. This hormone stimulates the growth of melanocytes, which are cells that produce a dark pigment called melanin.

Function

The pituitary gland is an organ that is part of the endocrine system, along with many other glands and

organs. It is regulated by the hypothalamus, and it in turn regulates the secretion of many different hormones that are essential to human health.

Role in human health

Hormones released from the anterior and posterior pituitary have far-reaching effects on many different organ systems and physiological processes.

Hormones of the anterior pituitary

Luteinizing hormone and follicle stimulating hormone are called gonadotropins. As the name suggests, the target tissues of these hormones are the gonads (ovaries and testes). They have two main functions. The first is to promote the development and maturation of sperm and eggs. Second, they stimulate the production and release of such sex steroid hormones as estradiol and testosterone in women and men respectively.

Prolactin is responsible for stimulating cells in the female breast to produce milk. Therefore, lactotrophs located in the anterior pituitary of women that are breastfeeding are large and numerous, indicating an increased amount of prolactin production. These lactotrophs comprise about 30% of the cells in the anterior pituitary. The pituitary in women doubles in size during **pregnancy** because of the increase in size and number of lactotrophs.

The target tissue of adrenocorticotrophic hormone is the adrenal cortex (part of the adrenal gland that is located above the kidney). ACTH stimulates the production of cortisol and also causes the cells of the adrenal gland to grow. Cortisol has many effects on **metabolism** in various tissues.

Growth hormones have many different target tissues and promote the growth of each of them. For this reason human growth hormone (GH) is considered an anabolic hormone, indicating that it is responsible for building tissue **proteins**. For example, GH directly increases protein synthesis in muscles and the **liver**; and it decreases the size of adipose tissue. It also has an indirect effect by stimulating other hormones. Growth hormones indirectly affect the bones by increasing protein synthesis, collagen synthesis and cell proliferation. In many other tissues, the indirect effects of growth hormone are responsible for protein, RNA and DNA synthesis. The overall effect of growth hormone is to promote skeletal growth and a lean body mass.

As its name implies, thyroid-stimulating hormone (TSH) promotes cell growth in the thyroid gland. TSH also triggers the secretion of thyroid hormones that affect many metabolic processes in the body.

Hormones of the posterior pituitary

Both oxytocin and antidiuretic hormone (ADH) are peptide hormones that are synthesized in the cell bodies of the nerves originating in the hypothalamus and then delivered through the axons to the posterior pituitary. Thus, they are good examples of neuroendocrine hormones.

The primary target organ of ADH is the kidney. ADH is responsible for increasing water retention by the kidney, resulting in an increase in extracellular fluid and a decrease in urine volume. Receptors in the hypothalamus called osmoreceptors can sense the concentration of water in the extracellular fluid through changes in extracellular fluid osmolarity. The osmoreceptors in turn determine the release of ADH by the posterior pituitary. The consumption of alcohol decreases the amount of ADH released. As a result, more fluid is lost through urination, resulting in excessive water loss and thirst.

The primary site of action of oxytocin is female breast tissue. Oxytocin stimulates the contraction of smooth muscle cells in the breast, transferring milk from the place of synthesis to the larger ducts of the breast. Oxytocin is secreted by the stimulation of touch sensors when an infant is suckling. Other psychological factors, such as the sound of a baby crying, can stimulate the release and action of oxytocin. The role of oxytocin in the onset of labor contractions is not fully clear. There is no known stimulus for the secretion of oxytocin in the human male.

Common diseases and disorders

Hypopituitarism

Disorders of the pituitary gland can have severe effects on normal growth and sexual maturation. A general condition known as **hypopituitarism**, also known as pituitary dwarfism, is characterized by a decrease in one or more of the hormones produced by the anterior pituitary. Sexual immaturity and metabolic dysfunction leading to **obesity** are symptoms of this syndrome. When hypopituitarism occurs in childhood, growth is slowed. Tumors are often the cause of hypopituitarism; however, sometimes there is no identifiable cause. If there is a decrease in the levels of hormones released from the hypothalamus, then hypopituitarism results. The symptoms vary according to the number and amount of hormones that are deficient. The most effective treatment is the administration of replacement hormones.

Hyperpituitarism

The overproduction of growth hormone during childhood produces a condition known as gigantism or

acromegaly. Excessive secretion of anterior pituitary hormones is known as hyperpituitarism. Growth hormone influences the overgrowth of the skeleton and all other tissues. A person may grow to 8 ft (2.4 m) or more in height. It is still unclear, but researchers think that overproduction of growth hormone may be caused by an adenoma (tumor) on the anterior pituitary. Sometimes, this condition occurs in more than one member of the family, suggesting that there is a genetic component. Gigantism is treated by removing the tumor and administering medications (bromocriptine and octreotide) that inhibit the production of growth hormone.

Diabetes insipidus

A disorder related to both the hypothalamus and the posterior lobe of the pituitary is diabetes insipidus, not to be confused with **diabetes mellitus**. Diabetes insipidus, or DI, is caused by a deficiency of antidiuretic hormone (ADH). As a result, water is rapidly released from the body through large volumes of urine (3–30 quarts per day). DI may result from an inherited trait; from damage to the hypothalamus, which synthesizes ADH; or from damage to the posterior pituitary, which stores the ADH. Diabetes insipidus occurs more frequently in men than in women. In mild cases, no treatment is necessary other than water replacement. In extreme cases, the patient can be treated by hormone replacement therapy.

Resources

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Pituitary hormone tests

Definition

Pituitary hormones include growth hormone, adrenocorticotropic hormone, thyroid stimulating hormone, follicle stimulating hormone, luteinizing hormone, prolactin, antidiuretic hormone, and oxytocin. The first six of these are made in the anterior **pituitary gland**, under the control of the hypothalamus. The last two are made during transport to the posterior pituitary from precursor peptides produced by the hypothalamus. This cluster of hormones has a vast and complex impact on the growth, fertility, and function of the human body via the effect of the hormones on their target organs.

Growth hormone (hGH), or somatotropin, is responsible for normal body growth and development, and regulates carbohydrate and protein **metabolism**. Adrenocorticotropic hormone (ACTH) regulates cortisol release from the **adrenal glands**. Thyroid stimulating hormone (TSH) regulates the synthesis and release of thyroid hormones. Follicle stimulating hormone (FSH) controls the maturation of the ovarian follicle in females and the development of the seminiferous tubules and sperm production in males. In females, luteinizing hormone (LH) causes release of the ovum from the ovary and supports the corpus luteum after ovulation. In males, LH supports testosterone production. Both FSH and LH are found at highest concentrations in plasma immediately before a woman ovulates. Prolactin promotes **lactation**, or milk production, after **childbirth**. Antidiuretic hormone (ADH), also called vasopressin, acts on the **kidneys** (collecting tubules) to increase the reabsorption of water. Oxytocin is released during labor and breastfeeding. It causes smooth muscle contractions needed for delivery and promotes the release of breast milk.

Purpose

Measurement of several pituitary hormones may be requested to investigate pituitary dysfunction in general. The entire gland may cease to function normally due to a hypothalamic disease, surgery, pituitary tumor, or trauma (e.g., Sheehan's syndrome, pituitary failure caused by hemorrhage into the gland after obstetric delivery). Alternatively, one or more specific hormones may be measured to investigate dysfunction of a target organ. For example, LH, FSH, and prolactin are commonly measured along with estrogen (estradiol) and progesterone to investigate ovarian failure. ACTH is needed to investigate the cause of adrenocortical excess or insufficiency. TSH is specifically used to diagnose thyroid under- or overactivity. Growth hormone is used to test for growth

impairment or acromegaly. ADH testing is used to investigate disturbances in electrolytes (sodium and potassium) that will be abnormal when either too much or too little water is reabsorbed by the kidneys. Oxytocin is rarely measured, but may be used to identify ectopic production by tumor cells (e.g., lung carcinoma) that secrete the hormone.

Precautions

Each of these hormones is involved in intricate relationships with other organ systems. Levels may vary markedly depending on time of sampling (hGH, ACTH, prolactin), phase of the menstrual or reproductive cycle (FSH, LH), age, sex, physical activity, and a variety of psychological and nutritional factors. A thorough history of the patient's physical activities and medications is very helpful in interpreting **blood** test results. Pituitary hormones may be measured on plasma or urine. The nurse or phlebotomist collecting the sample should observe **universal precautions** for the prevention of transmission of bloodborne pathogens.

Many drugs are known to affect the level of pituitary hormones. For example, TSH test results may be influenced by such medications as lithium, potassium iodide, aspirin, dopamine, heparin, and **corticosteroids**. In addition, small fibrin clots and heterophile antibodies (HAMA) have been known to cause erroneous results with some immunoassays.

Description

Growth hormone

Human growth hormone (hGH), or somatotropin, is a protein made up of 191 amino acids. It is secreted by the anterior pituitary gland and coordinates normal growth and development. Human growth is characterized by two spurts, one at birth and the other at **puberty**. hGH plays an important role at both of these times. Receptors that respond to hGH exist on cells and tissues throughout the body. The most pronounced effect of hGH is on linear skeletal development, but hGH also greatly increases lean muscle mass. Humans have two forms of hGH, and the functional difference between the two is unclear. hGH is produced in the anterior portion of the pituitary gland by somatotrophs under the control of hormonal peptides from the hypothalamus. The primary hypothalamic hormone regulating hGH is growth hormone-releasing hormone (GHRH). When blood glucose levels fall, GHRH triggers the secretion of stored hGH. As blood glucose levels rise, GHRH release is turned off. Increases in blood protein levels trigger a similar response. GHRH is opposed by growth hormone-inhibiting hormone

(GHIH), which is a neuropeptide causing decreased release of hGH and TSH and which inhibits gastrin, secretin, and insulin. As a result of this hypothalamic feedback loop, hGH levels fluctuate throughout the day.

Because of its critical role in producing hGH and other hormones, an aberrant pituitary gland will often yield altered growth. Dwarfism (very small stature) can be caused by underproduction of hGH or insulin-like growth factor I (IGF-I), or by a flaw in the target tissue response to either of these. Overproduction of hGH or IGF-I, or an exaggerated response to these hormones, can lead to gigantism or acromegaly, both of which are characterized by a very large stature. Gigantism is the result of hGH overproduction in early childhood, leading to a skeletal height up to 8 feet (2.4 m) or more. In this condition, the epiphyseal plates of the long bones do not close, and they remain responsive to hGH. Acromegaly results when hGH is overproduced after the onset of puberty. This disorder is characterized by an enlarged **skull**, hands and feet, nose, neck, and tongue owing to proliferation of connective tissue.

Growth hormone in plasma or urine is usually measured by radioimmunoassay (RIA). Some fluorescent and chemiluminescent enzyme immunoassays are available, as well. In children, hGH in plasma is often too low to detect or permit differentiation of normal and deficient levels. A child below average in height who has normal pituitary function may have a low level of growth hormone as a result of normal physiological variation. Diagnosis is made either by a provocative test or measurement of IGF-I. A deficiency of IGF-I occurs in both hGH deficiency and protein malnutrition. Provocative testing for hGH deficiency involves administration of a drug known to stimulate release of growth hormone, or vigorous **exercise**, which does the same. Drugs used include arginine, insulin, glucagon, and propranolol. In the exercise test, a blood sample is measured for hGH immediately following exercise performed vigorously for 20 minutes. A level greater than 6 nanograms per mL rules out growth hormone deficiency. A lower response is suggestive and is followed by a drug stimulation test. Growth hormone is increased in approximately 90% of persons with acromegaly. Acromegaly is caused by an adenoma in the pituitary that produces hGH. For suspected cases that do not demonstrate an elevated plasma level, a glucose suppression test is needed for diagnosis. The test is performed by giving 100 grams of glucose orally, and collecting a blood sample one hour later. The glucose should suppress hGH to below 1 ng/mL. Failure to do so is evidence of acromegaly.

Adrenocorticotrophic hormone

ACTH production is controlled by the production of corticotropin-releasing hormone (CRH) by the hypothalamus. The release of this neuropeptide is inhibited by plasma cortisol via negative feedback. When plasma cortisol is elevated, CRH is inhibited and less ACTH is produced. As a result the adrenal cortex produces less cortisol and ACTH levels return to normal. Conversely, if cortisol levels fall, CRH is released, causing increased secretion of ACTH by the pituitary. ACTH levels rise in response to **stress**, emotions, injury, **infection**, **burns**, surgery, and decreased **blood pressure**.

Cushing's disease is caused by an abnormally high level of circulating cortisol (hydrocortisone). The high level may be the result of an adrenal gland tumor; enlargement of both adrenal glands due to a pituitary tumor; production of ACTH by a tumor outside the pituitary gland (ectopic production); or excessive administration of corticosteroid drugs. Corticosteroid drugs are widely used for reducing inflammation in such disorders as rheumatoid arthritis, inflammatory bowel disease, and **asthma**.

Addison's disease is a rare disorder in which symptoms are caused by a deficiency of cortisol and aldosterone. The most common cause of this disease is an autoimmune disorder. Addison's disease generally progresses slowly, with symptoms developing gradually over months or years. However, acute episodes, called Addisonian crises, are brought on by infection, injury, or other stresses.

ACTH is measured by RIA or fluorescent and chemiluminescent enzyme immunoassay. ACTH in plasma is measured in order to help differentiate the cause of Cushing's disease. Approximately half of persons with Cushing's disease (pituitary Cushing's) have a normal ACTH level and half will have an elevated level. Most persons with adrenal tumors will have low (less than 10 picograms/L) or undetectable ACTH in the plasma owing to suppression by cortisol. Most persons with ectopic ACTH secreting tumors will have elevated levels in excess of 200 pg/L. Persons with primary Addison's disease will usually have high ACTH levels (greater than 150 picograms/L) caused by negative feedback (low cortisol) while those with secondary Addison's disease will have low or normal ACTH levels owing to pituitary failure or hypothalamic suppression.

Thyroid stimulating hormone

Thyroid stimulating hormone is released by the anterior pituitary in response to thyroid releasing hormone (TRH) from the hypothalamus. It results in synthesis, storage, and release of T3 and T4, the thyroid hormones.

Elevated levels of free T3 and T4 exert negative feedback on the hypothalamus inhibiting the release of TRH which reduces TSH. Thyroid hormones have pronounced effects on the body's rate of metabolism. Decreased levels are responsible for myxedema, which produces a constellation of such symptoms as **edema**, low **heart** rate, intolerance to cold, hyperlipidemia, and anemia. The most common cause of myxedema is Hashimoto's disease, an autoimmune condition causing chronic hypothyroidism. Increased levels of the thyroid hormones (hyperthyroidism) causes a condition called thyrotoxicosis. It is characterized by exophthalmia (protruding eyeballs), tachycardia, insomnia, and weight loss. The most common cause of hyperthyroidism is Graves' disease.

TSH is commonly measured by enzyme immunoassay, and is the best screening test for diagnosis of both hypothyroidism and hyperthyroidism. In primary hypothyroidism, the plasma level of free T4 will be low and TSH will be elevated. In primary hyperthyroidism, the plasma level of free T3 will be high and TSH will be low. In thyroid disease caused by pituitary failure, the TSH and thyroid hormones will move in the same direction. For example, in secondary hypothyroidism, both free T4 and TSH will be low.

Follicle stimulating hormone and luteinizing hormone

Both FSH and LH are regulated by the hypothalamic release of gonadotropin-releasing hormone. In males, both hormones are inhibited via negative feedback by testosterone. In females, both hormones are inhibited via negative feedback by estrogen and progesterone. Levels of these hormones show pulse variation; this is especially true of LH and for this reason, 24-hour urine levels are preferred by some clinicians over plasma measurements. FSH and LH are performed when a person exhibits abnormal reproductive function. In women such conditions as precocious puberty, polycystic ovaries, failure to ovulate, dysmenorrhea, and the onset of **menopause** are the primary reasons for measuring these hormones. In males, these hormones are measured along with testosterone to diagnose and differentiate the cause of gonadal failure.

Levels of FSH and LH are somewhat constant prior to puberty. At puberty, both hormone levels increase significantly. In women the levels of both hormones varies with the phase of the menstrual cycle. Both FSH and LH peak in the midcycle just prior to ovulation. Prior to this peak levels are somewhat higher than they are after ovulation. The midcycle peak has been used to identify the best opportunity to conceive. A urine LH detection kit is available for use at home. This test is sometimes called

an "ovulation test" and is similar to a home **pregnancy test**. A sample of the woman's first morning urine is tested with the materials provided in the kit. These home tests may be used by women who want to become pregnant. By monitoring levels of LH and watching for the surge signaling ovulation, a couple can time sexual intercourse to increase the chance that the egg will be fertilized.

LH and FSH are measured mainly by enzyme or chemiluminescent immunoassays. In males, testosterone RIA is used along with FSH and LH to differentiate the cause of gonadal failure. A low testosterone with low LH or FSH points to a hypothalamic-pituitary cause. A low testosterone with an increased LH and/or FSH indicates primary testicular failure. In females, LH and FSH are measured along with estrogen, progesterone, and prolactin to investigate the cause of abnormal gonadal function. In menopause, the midcycle peaks for both LH and FSH are usually higher than in normal menstruating females. Prior to menopause, the LH peak is greater in magnitude than FSH. However, in menopause, this pattern reverses. In females, low plasma estrogen and progesterone seen with elevated serum or urinary levels of LH and FSH signal primary ovarian failure. Conversely, low estrogen and progesterone in association with low levels of LH and FSH indicate pituitary (secondary) hypogonadism. Prolactin levels should also be performed when evaluating hypogonadism in females. High plasma prolactin caused by pituitary adenoma causes inhibition of LH and FSH by negative feedback. Therefore, prolactinoma may be responsible for ovarian failure.

Prolactin

Prolactin is also known as the lactogenic hormone or lactogen. It is essential for enlargement of the mammary glands during **pregnancy**, and for stimulating and maintaining lactation after childbirth. Like hGH, prolactin acts directly on tissues, and levels rise in response to sleep and to physical or emotional stress. During sleep, prolactin levels in nonpregnant females can reach as high as those seen in pregnant women (as high as ten to twenty times the normal level). Prolactin secretion is controlled by prolactin-releasing and prolactin-inhibiting factors secreted by the hypothalamus. In addition, TRH can also stimulate prolactin secretion.

Prolactin deficiency is rare, and like hGH it cannot be diagnosed without a provocative test because low and normal levels overlap. As with hGH, a normal or elevated level will rule out a deficiency. Documentation of prolactin deficiency requires the use of the TRH stimulation test and demonstration of a subnormal response. Elevated prolactin is the most common pituitary abnormality.

Microadenomas of the pituitary that produce prolactin are the most common pituitary tumors. Depending on the type of cell involved, these tumors are also called prolactin-secreting pituitary acidophilic or chromophobic adenomas. However, there are several other conditions that increase plasma prolactin including pregnancy, drugs, hypothyroidism, and renal failure. Prolactinoma is typically associated with a plasma prolactin level greater than 200 nanograms per mL. Because about half of microadenomas are too small to see by imaging tests such as **CT scans**, plasma prolactin levels above 200 ng/mL, together with the absence of other known causes, are used to diagnose prolactinoma.

Pituitary neoplasia

Pituitary tumors are often responsible for increases in one or more pituitary hormones. About 30% of pituitary adenomas produce prolactin and about 20% of produce FSH. Ectopic hormones may also be produced, for example, ACTH by squamous cell carcinoma of the lung. In addition, the pituitary gland is often involved in multiple endocrine neoplasia, type 1 (MEN-1). This condition is inherited as an autosomal dominant disorder. It involves enlargement of at least two endocrine glands, which may be the result of hyperplasia, adenoma, or adenocarcinoma. One or more pituitary hormones will be secreted when the gland is involved. Therefore, plasma levels of pituitary hormones are sometimes measured to diagnose and to monitor various malignant diseases.

Posterior pituitary hormones

The purpose of ADH is to control the amount of water reabsorbed by the kidneys. Water is continually being taken into the body in food and drink, as well as being produced by chemical reactions in cells. Water is also continually lost in urine, sweat, feces, and in the breath as water vapor. ADH acts to keep blood and extracellular fluid volumes constant under conditions of constantly changing water and solute intake. Under normal conditions, the blood volume expands when excess water is absorbed. This reduces the plasma osmolality, which inhibits the release of ADH, causing water to be lost in the urine. Under conditions of water deprivation, plasma osmolality increases. This stimulates the osmoreceptors in the carotid sinus and ADH is released. The distal collecting tubule of the kidney reabsorbs more water, causing the osmolality to fall until blood volume is restored. Various factors can affect ADH production, thereby disturbing the body's water balance. Physical stress, surgery, and high levels of **anxiety** can stimulate ADH release. Alcohol consumption reduces ADH production by direct action on the **brain**, resulting in a temporarily increased production of urine. Abnormal water balance

occurs in diabetes insipidus, when the pituitary gland produces insufficient ADH; and in chronic renal disease, when the kidneys fail to respond to ADH. The reverse effect, water retention, can result from temporarily increased ADH production after a major operation or accident. Water retention may also be caused by the secretion of ADH by some tumors, especially of the brain and lung. Any condition other than the thirst response that causes increased release of ADH is referred to as the syndrome of inappropriate ADH release (SIADH). Ectopic ADH production by tumors is the most common cause.

Antidiuretic hormone is measured by RIA. It is used in conjunction with serum and urine osmolality or sodium measurements to differentiate SIADH from psychogenic polydipsia and other causes of low electrolytes and to differentiate neurogenic (pituitary) diabetes insipidus from nephrogenic (renal) diabetes insipidus.

Oxytocin is released by the posterior pituitary to cause strong uterine contractions in labor and delivery, and it also acts on muscle cells in lactating breast tissue to aid in the release of milk. Oxytocin levels are rarely measured, but oxytocin is often used in the hospital setting to induce or reinforce uterine contractions in labor. It is also useful in its natural or commercial form for helping the uterus to stay small and contracted after delivery, minimizing blood loss. Oxytocin is produced by males as well, and its function is thought to be related to sperm transportation.

Preparation

Pituitary hormones demonstrate both diurnal and pulse variation, and it is important to note the time of day that the sample is collected. Samples for both ACTH and ADH should be drawn in the fasting state. Blood for ACTH is usually drawn early in the morning, when ACTH is anticipated to be at its peak; and is also assessed in the evening, when it is expected to be at its lowest level. ACTH is very labile and should be collected in EDTA, using plastic tubes. The blood should be centrifuged immediately (preferably in the cold) and the plasma removed and frozen until the time of assay. FSH and LH vary greatly depending upon the time of collection. For this reason, results should be evaluated with regard to the time of sampling. Since levels vary greatly during the menstrual cycle, the levels must be evaluated with regard to the menstrual phase. Some clinicians prefer to pool plasma specimens collected across the menstrual cycle for a single measurement, or to use 24-hour urine samples for measurement. Growth hormone specimens should be collected using heparin or EDTA from a fasting patient. The various tests used to investigate

human growth hormone are highly influenced by the fasting or non-fasting state, as well as the presence or absence of recent exercise. Prolactin levels should be drawn in the morning at least two hours after the patient wakes (samples drawn earlier may show sleep-induced peak levels). No specific preparation is necessary for drawing TSH levels, but illness and stress can affect results significantly.

Aftercare

No special care is necessary after collection of blood or urine for pituitary hormone assessment. Patients should return to normal eating and exercise, and resume routine medications. Following venipuncture for blood plasma hormone tests, the laboratory technologist, nurse, or phlebotomist drawing the sample should inspect the venipuncture site to make sure that the wound has closed and no bleeding is present. The site should be covered with an adhesive bandage. There is no notable aftercare for patients undergoing 24-hour urine hormone tests. Patients should be reminded to resume foods and medications that were restricted prior to testing.

Complications

Complications from drawing blood are minimal and may include slight bleeding from the venipuncture site, fainting, or lightheadedness after the blood sample is drawn. Blood may accumulate under the puncture site (hematoma) if pressure is not applied to the site immediately after drawing blood. There are no complications for the urine test. Some of the test protocols for growth hormone assessment involve administering drugs, such that nausea, sleepiness, sweating and/or nervousness may occur. Severe hypoglycemia could theoretically occur with insulin, but this is unlikely if the patient is closely monitored and treated appropriately.

Results

The normal ranges for pituitary hormone tests are highly method-dependent, resulting in significant laboratory variation. Also, age, sex, and sampling time must be taken into consideration when interpreting results.

Generally, hGH ranges from undetectable to 5ng/mL for adult men, up to 10 ng/mL for adult women, and as high as 16 ng/mL in children over six years. Arginine (an amino acid), insulin, and other substances are sometimes used to try to elicit higher levels of hGH to investigate a possible deficiency. Decreased levels are seen in hGH deficiency, dwarfism, hyperglycemia, failure to thrive, and delayed sexual maturity. Excess hGH is responsible for the syndromes of gigantism and acromegaly. Excess

secretion is stimulated by anorexia nervosa, stress, hypoglycemia, and exercise.

Representative normal values for ACTH range from 8-100 pg/mL between 4 and 8 AM, and less than 50 pg/mL between 8 and 10 PM. High levels of ACTH may be caused by ACTH-producing tumors. These tumors may be either in the pituitary or in another area (such as tumors from **lung cancer** or **ovarian cancer**). In Addison's disease, the adrenal glands fail, and the pituitary gland secretes very high levels of ACTH in an attempt to restore normal adrenal hormone. Low levels of ACTH may occur because of decreased pituitary function. Low ACTH levels may result from adrenal adenoma which causes high levels of cortisol. The cortisol causes negative feedback to the pituitary.

Representative adult normal values for TSH are 0.2 to 4.7 microunits per mL (uU/mL). Higher values may be caused by congenital hypothyroidism (cretinism) or primary hypothyroidism (**thyroid gland** failure). Low values may be due to hyperthyroidism such as in Graves' disease or thyroiditis, or secondary hypothyroidism (hypothalamic or pituitary failure).

FSH test results vary according to age and sexual maturity. The phase of a woman's menstrual cycle or use of birth-control pills also affects test results. For an adult male, normal results range from 4-25 U/L. For a premenopausal woman, normal values range from 4-30 U/L. In a pregnant woman, FSH levels are too low to measure. After menopause, normal values range from 40-250 U/L. FSH levels fluctuate during premenopause. If no other symptoms are present, an elevated FSH level should not be interpreted as proof that menopause has begun. Anorexia nervosa and disorders of the hypothalamus or pituitary gland can result in abnormally low FSH levels. Abnormal levels can also indicate precocious puberty, **hypopituitarism** (diffuse failure of the pituitary to make hormones), Klinefelter's syndrome (in men), Turner syndrome, testicular failure, and polycystic ovarian syndrome.

The normal range for LH in males is 1-8 mU/mL and in children is 1-5 mU/mL. Levels in females vary dramatically based upon the phase of the menstrual cycle. In the follicular phase, levels are normally in the range of 1.7-15 mU/mL; in the midcycle peak they are normally between 16-104 mU/mL; and in the luteal phase they normally range from 0.6-16 mU/mL. LH in postmenopausal women is normally in the range of 16-66 mU/mL. Abnormally high levels may be found in primary gonadal dysfunction, polycystic ovarian syndrome, and pituitary adenoma. Abnormally low levels can be seen with delayed puberty, congenital adrenal hyperplasia.

sia, stress, malnutrition and diffuse pituitary or hypothalamic problems.

Reference ranges for prolactin vary from laboratory to laboratory, but are generally between 3-15 ng/mL for adult males and 3.8-23 ng/mL for nonpregnant adult females. Prolactin levels in pregnancy vary greatly with the time of gestation. Normal values in the third trimester are 95-475 ng/mL. Increased prolactin levels are found in galactorrhea, amenorrhea, hypothyroidism, prolactin-secreting pituitary tumors, infiltrative diseases of the hypothalamus, and metastatic cancer of the pituitary gland. Higher levels than normal are also seen in stress, which may be produced by anorexia nervosa, surgery, strenuous exercise, trauma, and in renal (kidney) failure. Decreased prolactin levels are seen in pituitary failure.

ADH normal ranges are also laboratory-specific but can range from 1-5 pg/mL or 1-5 ng/L (SI units). Patients who are dehydrated; who have a decreased amount of blood in the body (hypovolemia); or who are undergoing severe physical stress (e.g., trauma, **pain** or prolonged mechanical ventilation) may exhibit increased ADH levels as a normal response to the needs of the body. Similarly, patients who are overly hydrated may have decreased ADH levels. Abnormal conditions that cause increased levels (SIADH) include **central nervous system** tumors, ectopic tumors, and infection. ADH deficiency is called diabetes insipidus, and results in severe water losses from the body. It is easily treated with nasally administered vasopressin.

Health care team roles

A physician will order pituitary tests and will interpret the results often with the aid of an endocrinologist. A nurse or phlebotomist will draw blood samples and give instructions for 24-hour urine collection if needed. Nurses are also responsible for accurate history-taking in order to document medications, stressors, or exercise that may influence test results. Clinical laboratory scientists/medical technologists perform the various hormone assays. Tests for hGH, ACTH, and ADH are usually performed by reference laboratories.

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KEY TERMS

Adrenal glands—A pair of endocrine glands that lie on top of the kidneys, which produce natural steroid-based hormones.

Anovulatory bleeding—Bleeding without release of an egg from an ovary.

Klinefelter's syndrome—Inheritance of an extra X chromosome that results in small testes and male infertility.

Polycystic ovarian syndrome—A condition in which a woman has little or no menstruation, is infertile, has excessive body hair, and is usually obese. The ovaries may contain several cysts.

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Erika J. Norris

Pivot joint

Definition

A pivot joint is a synovial joint in which the ends of two bones meet—one end being a central bony cylinder, the other end being a ring (or ring-like structure) made of bone and ligament. In some joints, the cylinder rotates inside the ring. In other joints, the ring rotates around the cylinder. The rotation of the **skull** is made possible by a pivot joint. (A synovial joint is the living material that holds two or more bones together but also permits these bones to move relative to each other.)

A more precise rendering of the international Latin anatomical term for pivot joint would be “wheel joint.” A wheel rotates around an axis or pivot (for example, the axle around which automobile tires rotate). The Latin term (itself borrowed from Greek) refers directly to the

KEY TERMS

Articulation—A synonym of “joint.”

Carpals—The eight small bones that form the wrist and are joined to the metacarpals of the hand and to the bones of the forearm.

Humerus—The bone of the upper part of the arm.

Neoplasm—New and abnormal growth of tissue, which may be non-cancerous (benign) or cancerous (malignant).

Pronation—Motion of the forearm and hand by which, after one bends the elbow, the palm is turned downward.

Radius—One of the two bones of the forearm. A pivot joint joins it to the ulna near the elbow. A second pivot joint joins the other end of the radius to the other end of the ulna near the wrist.

Supination—Motion by which, after one bends one’s elbow, a palm is turned upward.

Synovial fluid—A transparent, sticky fluid that lubricates joints and nourishes the cartilage in a joint. (It is also found in tendons, sheaths, and bursae.)

Ulna—One of the two bones of the forearm. Two pivot joints join it to the radius, one near the elbow, one near the wrist.

ring made of bone and ligament. The English term refers directly to the cylindrical end of the bone.

Description

Pivot joints hold the two bones of the forearm together. That is, a pivot joint, located near the elbow, joins the bones of the forearm (called the ulna and the radius) to each other. These two bones are also joined to each other near the wrist by another pivot joint. A different pivot joint, located at the base of the skull, joins the first vertebra of the spine to the second vertebra and thus permits the head to rotate (since the first vertebra is joined to the skull).

If the bony surfaces of two bones that meet at a joint actually touched each other, then motion would cause friction, which would soon produce wear and tear on the touching ends of the bones. An engineer designing a mechanical counterpart would arrange for lubricating oil to prevent such wear and tear and facilitate smooth movement between the two metal “bones.” A joint thus

holds bones together (it is called a “joint” because it “joins” them) but also keeps them slightly separated to prevent their damaging each other in motion.

A kind of cartilage special to joints covers the ends of the bones being joined. A membrane hermetically seals two (or more) bone-ends with their cartilage, enclosing them in a kind of living capsule. For the sake of simplicity, the following example discusses a joint with only two bones. Inside this membrane capsule, there is a short distance between the cartilage of one bone and the cartilage of the other, because even cartilage rubbing directly against cartilage would produce wear and tear. But the gap between the cartilage surfaces is not a vacuum and is not filled with air. It is filled with synovial fluid. This fluid is in a sense the equivalent of the motor oil that lubricates moving parts of an automobile engine.

The interior of a synovial joint has negative pressure in relation to air pressure. For this reason, air pressure pushes the bones together tightly into the membrane capsule while the fluid keeps them from actually touching. The hermetically sealed membrane capsule in this paradoxical fashion aids the tight joining while it ensures the slight separation.

This negative pressure in the joint continues to work even after death. Of course, the two bones are kept together in a living body not only by the membrane capsule and the synovial fluid, but also by the tissues around the bones. If, while dissecting a corpse, one removes the tissues leaving only the membrane capsule, the pair of bones will remain tightly joined. But if one pierces the capsule and allows air to rush inside, one then has normal atmospheric pressure inside the capsule instead of the negative pressure of the interior of the living joint when it is hermetically sealed by the capsule, and now the bones come easily apart.

Synovial fluid has another important quality. Most bodily tissues are nourished by **blood vessels**, but the cartilage on bone-ends in joints does not have **blood vessels**. Synovial fluid provides the **nutrition** for the cartilage that keeps it alive, strong, and healthy. The wall of the membrane capsule has two layers. The outer layer is fibrous. The inner layer produces the synovial fluid, and hence is called the synovial layer.

Function

A pivot joint allows movement in one plane, such as rotation about an axis. Pivot joints, for example, permit one, after bending the elbow, to turn the palm of one’s hand upward or downward by rotating the forearm. The two bones of the forearm (the ulna and the radius) twist around each other using a pivot joint.

Role in human health

The role of pivot joints in human health (the same as that played by the other types of synovial joints) is to allow freedom of movement and thus provide flexibility to the skeleton.

Common diseases and disorders

The pivot joints (and the other joints) can be affected by such conditions as the following:

- **Ankylosis:** The fusion of bones across a joint. It is often a complication of arthritis.
- **Ankylosing spondylitis:** A type of inflammatory arthritis that progresses to ankylosis. It occurs chiefly in young men.
- **Capsulitis:** Inflammation of the membrane capsule that produces and encloses the synovial fluid.
- **Dislocation:** The displacing of a bone from its normal position, causing tendons to stretch and strain.
- **Neoplasms:** Abnormal growths (neoplasms) involving the pivot joints are rare. Such growths as do occur usually involve non-cancerous (benign) growths of cartilage or of tendons and their sheaths. Synovial sarcoma is a cancerous (malignant) growth of cells resembling those of the synovial layer of the membrane capsule. It is found at the contact surfaces of bones in a joint, usually in the larger joints of young adults.
- **Rheumatoid arthritis:** A common form of chronic inflammation of the joints. It causes swelling, **pain**, stiffness, elevated temperature, and redness of the joints. It is a disease of connective tissue and leads to the destruction of bone, cartilage, and ligaments in the joints.

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Monique Laberge, Ph.D.

Placenta previa

Definition

Placenta previa is an abnormal condition of **pregnancy** in which the placenta is attached to the lower section of the uterus, partially or completely covering the cervix. It occurs in about 0.5% of pregnancies.

Description

The placenta is a hormone-producing fetal organ, rich in **blood vessels**, that connects the baby to the mother via the umbilical cord. It begins to develop along with the embryo right after conception. The placenta normally implants high on the uterine wall and securely attaches into the wall through finger-like projections. The umbilical cord is created by the interweaving of two arteries and one vein that connect the placenta to the fetus. The nutrients and oxygen from the mother pass through the placenta and into the fetus. Carbon dioxide and waste products excreted by the fetus pass through the placenta and into the mother's circulation for removal. The placenta functions as a lifeline for the fetus.

In placenta previa, the placenta has attached itself towards the bottom of the uterus, near or on the cervix. Its usual implantation site is high up on the uterine wall. During a vaginal birth the cervix thins and opens sufficiently for the fetus to pass through the cervix, into the birth canal, and out the mother's vagina. As the cervix begins to dilate during labor, the force on the low-lying placenta causes tearing and subsequent bleeding. Excessive bleeding, or hemorrhage, can be dangerous for both the mother and fetus. If the placenta tears, the fetus is deprived of nutrients and oxygen and can suffer **brain damage** or even death.

In some pregnancies, the low placement may not provide a sufficiently large area for good exchange of nutrients and gases. This lack may impede fetal growth. In most cases of placenta previa, the condition becomes a concern towards the end of the pregnancy, often around 30 weeks gestation. At this point the uterus starts to undergo changes in preparation for labor and delivery. It is when these changes occur that the placenta may begin to tear and bleed. Infants born to mothers with placenta previa also have a greater risk of **respiratory distress syndrome**. In a study published in October of 2000, researchers found that mothers carrying a male fetus are at greater risk of placenta previa than those carrying a female fetus.

There are four degrees of placenta previa:

KEY TERMS

Cervix—The cervix, or cervical os, is the opening between the vagina and the uterus. During labor the cervix thins and dilates, allowing the fetus to pass through, entering the birth canal and leaving through the vagina.

Cesarean birth—The terms cesarean section, birth, or delivery may be used interchangeably. This procedure to deliver a baby involves an abdominal incision made through the abdominal wall and into the uterus to extract the baby.

Hemorrhage—Hemorrhage refers to an excessive amount of blood lost within a very short time period. With massive blood loss the mother may have a rapid, weak pulse, drop in blood pressure, dizziness, pallor, clammy skin and appear disoriented. Hemorrhage is an emergency situation.

Placental abruption—This condition of pregnancy, also called abruptio placentae, is characterized by sharp pain, a hard, rigid abdomen, and vaginal bleeding due to the detachment of the placenta from the uterine wall, placing the mother and fetus at great risk.

- Low-lying implantation. The placenta lies abnormally low on the uterine wall, but is not yet approximating the cervix.
- Marginal implantation. The placenta is within 2 centimeters of the internal cervical os.
- Partial previa. The placenta covers part of the cervix. The distinction between partial and complete previa is somewhat unclear while the cervix is still closed.
- Total previa. The placenta completely covers the cervical os.

Causes and symptoms

The exact cause of placenta previa is unknown. However, contributing factors include:

- uterine shape abnormality
- increased parity, i.e. the mother has been pregnant before
- previous cesarean births
- older maternal age (Women over the age of 35 have an increased risk of placenta previa by 4.7 times. When the mother is over 40, the risk rises to 9 times.)
- previous dilation and curettage of the uterus

- multiple gestation (twins, triplets, etc.)
- previous placenta previa
- cigarette smoking

Placenta previa is characterized by painless vaginal bleeding that often starts abruptly. The bleeding may continue, or it may stop as abruptly as it started. By the time the woman is seen by her obstetrical provider, there may be some spotting, or perhaps no bleeding at all. Even if the bleeding has stopped, placenta previa is an emergency situation and the mother needs to be seen right away. Bleeding indicates that the placenta has begun to tear. The mother is now at risk of hemorrhage if no intervention is made. The fetus may be compromised, as the level of oxygen available to it has changed.

Diagnosis

Most pregnant women undergo at least one routine ultrasound during their pregnancy. During the ultrasound the placement and position of the placenta is identified. When a low-lying placenta is detected, the degree to which the placenta covers the cervical os is described in percentages. For example, a complete placenta previa is 100%. Once placenta previa has been diagnosed, the pregnancy is considered high-risk. However, the position of the placenta can change as the uterus grows, and so periodic ultrasounds may be ordered. A transvaginal ultrasound may be ordered following an **abdominal ultrasound** to more accurately assess how low the placenta is lying. There is a false-negative and false-positive risk of 7% with abdominal ultrasound. For this condition, transvaginal ultrasound appears to be far more reliable. In addition, the placenta is able to creep upwards over time.

If a woman experiences sudden, painless, bright red bleeding at any point in the pregnancy, she should be seen right away, even if the bleeding has stopped. An ultrasound will usually be done in order to reassess the position of the placenta, and to evaluate the fetus. A manual examination of the cervix is not done, as this could disturb the placenta.

Treatment

The treatment plan will depend on the gestational age, the severity of the bleeding, and the risks to mother and fetus. If the fetus is sufficiently mature and the pregnancy is near term, immediate cesarean birth may be suggested. If it is too early for the fetus to survive outside the womb, and the mother's condition is stable, the mother may be placed on bed rest in the hospital with medications to prevent uterine contractions. Close monitoring of the fetus and mother will continue. If there has been no bleeding for a few days, the mother may be sent home, and may

be prescribed medication to improve the fetus' lung maturity so that if a preterm birth is necessary, the fetus has a better chance for healthy survival. The position of the placenta will determine if a vaginal birth is possible, or if the safest delivery will be by cesarean section.

Prognosis

Prognosis for mother and fetus have significantly improved with accurate imaging technology that identifies the condition in advance and allows for proper high-risk management of the pregnancy. A planned cesarean birth rather than unexpected, profuse bleeding at the time of labor is a part of placenta previa management. The prognosis for the fetus depends on how well developed it is at the time of delivery, and whether the bleeding caused any significant oxygen deprivation. The mother has an excellent prognosis unless hemorrhage occurs and is not well managed.

Health care team roles

The radiologic technologist usually performs the ultrasound, but the obstetrical provider may choose to do it if bleeding has begun. Any reassuring signs should be mentioned to the mother. Bleeding during pregnancy is frightening, and speaking in a calm voice and providing a comfortable environment can allow the mother the opportunity to relax somewhat. The nurse places the woman on her side to ensure better **blood** flow once she arrives at the health care facility, and obtains baseline **vital signs**, particularly **blood pressure** and pulse rate. Questions to ask the mother include:

- How far along is the pregnancy?
- When did the bleeding begin?
- What color was the bleeding? Bright red indicates fresh, or ongoing bleeding.
- Was there **pain** with the bleeding?
- How many sanitary pads have you used since the bleeding started? This question is to estimate amount of blood loss.
- Did you use anything to stop the blood flow, such as a tampon? Tampons will absorb the blood, and the true amount of bleeding may be masked.
- Is this the first episode of bleeding in this pregnancy? If not, obtain details about previous episodes.

The woman should be closely monitored for any signs of hemorrhage. The health of the fetus is monitored externally. Once bleeding has stopped and the mother must wait for the delivery, she can be at risk of perceiving the pregnancy as failed. This could result in her tak-

ing less care of herself, and thereby putting the fetus at risk. Continued reassurance for the mother helps prevent this from happening.

Prevention

Placenta previa is not preventable, as it is not possible to affect where the placenta will implant. However, once diagnosed, the mother may be instructed to avoid intercourse, get enough rest, and telephone the provider if any bleeding occurs.

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ORGANIZATIONS

- American College of Obstetricians and Gynecologists. 409 12th St., S.W., PO Box 96920 Washington, D.C. 20090-6920. <<http://www.acog.org>>.

Esther Csapo Rastegari, R.N., B.S.N., Ed.M.

Placental abruption

Definition

Placental abruption is a condition in **pregnancy** in which the placenta prematurely separates from the uterine wall while the fetus is still *in utero*. While it is seen most often during the third trimester of pregnancy, especially during the labor process, the term can be applied from 20 weeks gestation through term. Severe bleeding, even hemorrhage, can result, putting both the mother and fetus at significant risk. It is also known as placenta abruptio and abruptio placentae.

Description

In most cases placental abruption occurs in a normally implanted placenta, one that is located high on the uterine wall. However, it can occur in tandem with **placenta previa**. In a normal vaginal delivery, the delivery of the placenta follows that of the neonate within about 30 minutes. Because the neonate has been born and is now breathing on his or her own, the separation of the placenta from the uterine wall causes no distress. In placental abruption, however, the premature separation of the placenta deprives the fetus of the oxygen, nutrients, and **gas exchange** taking place at the site of the separation. The cost to the fetus depends on the degree and size of the separation. The risk to the mother depends on the amount of **blood** lost, and the change in circulating blood volume and its accompanying decreased tissue perfusion.

Placental abruption occurs in about one in 120 deliveries. Severe abruption leading to fetal death occurs in about one in 420 deliveries. Cocaine use increases the risk of abruption by increasing vasoconstriction, and about 10% of mothers using cocaine in the third trimester succumb to placental abruption.

Causes and symptoms

The causes of abruption are not fully understood, but it appears that it may be the end result of a series of fetal-maternal vascular abnormalities. Impaired blood vessel integrity and suppressed immune function may lie at the core of the development of abruption. Some of the factors leading to placental abruption include:

- Trauma. An abdominal blow, such as that incurred during an automobile accident, may cause abruption. Mothers experiencing a severe blow to the abdomen, with subsequent uterine contractions, should be monitored for about 24 hours, even in the absence of vaginal bleeding. This is because there could be a delay in symptoms. Observation of the mother should also include fetal monitoring to assure fetal well-being.
- Maternal **hypertension**. Mothers who have either chronic high **blood pressure** or hypertension induced by pregnancy are at increased risk of abruption.
- Maternal age. Placental abruption is seen more often in older women. However, it is unclear whether the advanced age or the increased likelihood of previous gestations is the primary factor.
- Uterine and umbilical cord abnormalities, such as a short cord or a uterine myoma at the placental implantation site.
- Placental abnormalities resulting in poor implantation.

- Cigarette smoking. As the number of cigarettes per day increases, so does the risk of abruption. This higher risk may be because of the harmful effect of nicotine on blood vessel integrity.
- Previous placental abruption. The risk of recurrence may be almost 17%.

The classic symptoms of abruption include sharp abdominal **pain**, rigid abdomen, vaginal bleeding, uterine contractions, and uterine tenderness. However, these signs are not always present. About 10% of women may have no vaginal bleeding. This is because the blood is pooling behind the placenta that has detached in the center. If the abruption occurred in tandem with labor contraction, and if the abruption is mild or moderate, the pain of labor contractions may mask the underlying abdominal pain and uterine tenderness of the abruption. This variability of symptoms emphasizes the need for careful diagnosis.

Diagnosis

Diagnosis of placental abruption, especially when mild or moderate, can be elusive. A thorough maternal history can play a significant role in identifying mothers at increased risk. Severity of abruption cannot be determined only from the volume of visible blood lost, as concealed hemorrhage may be taking place. Pain may be primarily in the back instead of abdominal. It may be sharp and severe, or dull and intermittent. It may be accompanied by nausea and vomiting. The uterine contraction pattern tends to be low in amplitude but high in frequency. If the uterus and abdomen are rigid, external monitoring or contractions may be inaccurate. Uterine tenderness may be localized to the site of detachment, but may also present as generalized. Unfortunately, ultrasound is not very reliable in establishing the presence of placental abruption. Blood work may be done to check on the presence of an abnormal clotting process. Diagnosis may become the piecing together of a puzzle of symptoms, with the experienced practitioner being more likely to solve the puzzle.

Placental abruption is categorized into four degrees of separation. These are:

- Grade 0. Abruption was diagnosed after delivery, upon inspection of the placenta. The placenta will show a small area of clotting on the side of maternal attachment. No other visible maternal or fetal signs of abruption were present.
- Grade 1. Some separation occurred with some vaginal bleeding and changes in maternal **vital signs**. No fetal distress was noted.

- Grade 2. Moderate separation, fetal distress, uterus is tender to touch.
- Grade 3. Extreme separation; without emergency intervention mother and fetus are at risk of **shock**, hemorrhage, or death.

Separation may be partial, with vaginal bleeding; partial without vaginal bleeding (known as concealed hemorrhage); complete separation, with vaginal bleeding (likely hemorrhage); or complete separation with concealed hemorrhage. Concealed bleeding is very dangerous because the lack of vaginal bleeding masks the true severity of the condition. Then, if the mother goes into shock, it may be unexpected and result in a poor outcome. If the placenta detached in the center, concealed bleeding is more likely to occur. Blood may seep into the uterine wall and result in a condition called *couvellaire uterus*, which is characterized by a hard uterus, no bleeding, and no signs of impending maternal shock. Shock results from the blood loss into the uterine tissue.

Treatment

A mother with suspected placental abruption needs to be admitted to the hospital. As complete a history as possible should be taken. If the mother is in crisis, family or friends may be able to assist with the history. Blood work to check for clotting disorders is done, as placental abruption may be accompanied by disseminated intravascular coagulation (DIC) which can lead to massive hemorrhage. Intravenous (IV) fluids and blood transfusions may be necessary to replace blood lost. Oxygen may be administered. Continuous fetal monitoring is done to assess for signs of fetal distress. Decreased maternal urine output indicates a compromised blood volume with poor tissue perfusion. The severity of the abruption determines the course of treatment. If a small separation has occurred, the pregnancy may be maintained as long as the mother is stable and the fetus does not show signs of distress. If the separation is a grade 0 or 1, and the fetus is near term, a vaginal delivery may be attempted. A separation of grade 3 or 4 necessitates delivery even if the fetus is not sufficiently mature, as the separation has compromised adequate nutrients and oxygen from reaching the fetus, and the accompanying blood loss has put the mother's well-being at risk. If DIC has begun, prompt evacuation of the uterus of the fetus and the placenta can allow for a positive prognosis for the mother. However, surgery poses great risk to the mother because of her compromised ability to clot. Severe hemorrhage, organ failure, and death could occur.

KEY TERMS

Disseminated intravascular coagulation—DIC is a serious medical complication in which the mother's blood no longer clots in the usual manner because of extreme loss of blood. Bruising is visible on the skin, and blood can seep from sites of IV insertion. This is a medical emergency, as it can quickly lead to massive hemorrhage.

Gestation—The age of the fetus in weeks since conception.

Myoma—A benign fibroid tumor of the uterine muscle.

Placenta previa—Placenta previa is a condition of pregnancy in which the placenta, which normally is implanted high on the uterine wall, is instead implanted near the cervical opening. As the uterus begins to change in preparation for labor and delivery, the force exerted on the placenta can cause it to tear, depriving the fetus of nutrition and oxygen, and putting the mother at risk of hemorrhage.

Prognosis

Prognosis is dependent on many factors, such as the frequent monitoring of vital signs, the degree of separation, amount of blood lost, such preexisting fetal complications as growth retardation and congenital abnormalities, gestational age of the fetus, any permanent organ damage to the mother, and degree of oxygen deprivation. Prompt diagnosis enhances chances for a successful outcome.

Health care team roles

Nurses play a significant role in obtaining a full and accurate patient history. Questions should include maternal symptoms, time elapsed since symptoms began, presence and quality of pain (sharp, dull, constant, intermittent), bleeding (amount and color), and any actions taken, such as medication for pain or use of tampons.

Prevention

While most factors contributing to abruption are not preventable, cigarette smoking, cocaine use, and seat belt use with proper placement are important areas on which to focus during **prenatal care**. Identifying a mother at high risk and having a management plan in place can expedite diagnosis, especially if the mother arrives

through the emergency department in crisis; and result in a more successful outcome for both mother and baby.

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ORGANIZATIONS

- American College of Obstetricians and Gynecologists. 409 12th St., S.W., PO Box 96920, Washington, D.C. 20090-6920. <<http://www.acog.com>>.

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Plasma protein tests

Definition

Plasma protein tests are laboratory tests used to evaluate the levels of specific **proteins** in the blood. A decrease or increase in the concentration of the protein is associated with one or more clinical conditions. Prior to measuring a specific protein, a comprehensive metabolic profile is usually performed. This profile includes tests for the total protein and albumin. If either of these tests is abnormal, serum protein electrophoresis may be performed in order to determine the cause. Abnormalities seen on the **protein electrophoresis test** as well as other clinical information are used to determine the necessity for specific protein tests. The most frequently measured plasma proteins include alpha-1 antitrypsin (AAT), ceruloplasmin (CER), C3 and C4 (complement proteins), C-reactive protein (CRP), haptoglobin (Hp, HAP), immunoglobulins (IgG, IgA, IgM), transferrin (TRF), and transthyretin (TTR).

Purpose

Plasma protein tests are used to determine whether a specific protein or proteins have increased or decreased in concentration. An abnormal level of total protein or of a specific protein indicates particular diseases or conditions associated with the respective change. Some protein tests are useful for establishing a diagnosis, while others are useful in determining the extent of a condition such as **dehydration** or inflammation.

Precautions

A nurse or phlebotomist who collects the sample for a plasma protein test should follow standard precautions for the prevention of transmission of bloodborne pathogens. Total protein and albumin concentrations are approximately 10% higher in ambulatory persons. Plasma total protein is approximately 0.2 - 0.4 g/dL higher than serum. Some drugs, especially estrogens and **corticosteroids**, may increase the concentration of specific proteins.

Description

Proteins are vital to the proper functioning of the body. There are more than 3,000 proteins found in a single human cell. Some proteins, such as enzymes, hormones, coagulation factors, lipoproteins, and hemoglobin, are measured routinely and are described in other topics. The proteins considered here are those which are sufficient in concentration to affect results of the total protein or protein electrophoresis tests or are measured by immunonephelometry. Each of the proteins described below, with the exception of total protein and albumin, are measured by this method. In immunonephelometry, plasma or serum is added to a buffer containing an excess of a specific antibody (e.g., anti-haptoglobin). The antibodies will bind to the haptoglobin molecules (antigen), forming small soluble immune complexes. Monochromatic light (usually 450-550 nm) passing through the reaction tube will be scattered by the immune complexes as they form. Forward-angle light scatter is measured by a light detector (photomultiplier tube) placed at an angle (usually 70 degrees) to the incident light. The combination of antibody and antigen molecules occurs rapidly, and the photodetector current increases with time until a peak signal is reached. This peak is proportional to antigen concentration. To insure that the antibody molecules are in excess, an addition of reagent antigen is injected into the reaction mixture after the peak rate is obtained. This addition will produce an increase in light scattering

provided that sufficient antibody remains. The clinical significance of each protein test is described below.

Total protein: The total protein of plasma or serum is measured by a colorimetric reaction called the biuret method. The sample is added to an alkaline solution of **copper II** sulfate. The copper ions form coordinate bonds with the carbonyl and imine groups of the protein. This causes the reagent to change from a sky blue to a purple color. The absorbance of the solution at 540 nm is proportional to protein concentration.

Total protein is increased in conditions causing dehydration. They includes vomiting, **diarrhea**, diabetes insipidus, **diabetes mellitus**, and Addison's disease. Total protein is increased in conditions that cause inflammation. These include **cancer**, autoimmune diseases, and chronic or severe infections. Total protein is also increased by monoclonal immunoglobulin production caused by benign or malignant proliferation of antibody-secreting cells (plasma cells) such as multiple myeloma. Low total protein can result from protein loss, as occurs in hemorrhage, glomerulonephritis, nephrosis, protein-losing gastroenteropathy, and **burns**; excessive hydration as occurs in salt retention syndromes and the syndrome of inappropriate antidiuretic hormone (SIADH); or decreased synthesis resulting from starvation and chronic **liver** disease.

Albumin: The albumin in plasma comprises 50-65% of the total protein. In addition to holding water in the vascular bed (maintenance of oncotic pressure) albumin is primarily a transport protein and is responsible for the protein binding of most drugs. It is measured by a dye-binding method using either bromocresol green (BCG) or bromocresol purple (BCP). These dyes selectively bind to albumin, forming a colored complex. The color formed is proportional to albumin concentration. Plasma albumin is increased by dehydration or intravenous infusion of albumin as a **blood** volume expander. It is decreased in hemorrhage, renal disease, salt retention, SIADH, liver disease, starvation, inflammation, malignancy, and **infection**.

Alpha-1 antitrypsin: ATT is a glycoprotein (molecular weight 52,000) made by the liver. ATT is an inhibitor of the enzyme trypsin as well as of other proteolytic enzymes (serine proteases) that are released from phagocytic white blood cells during inflammation. ATT reduces the damage to tissues caused by the **immune response**, and plasma levels increase up to two-fold in acute and chronic inflammatory conditions. Proteins such as ATT that are increased in response to inflammation are called acute phase proteins. They are sensitive markers for tissue injury, **myocardial infarction**, infection, malignancy, and autoimmune diseases.

A deficiency of AAT results in excessive inflammation in tissues that are exposed to **bacteria** and other foreign cells, commonly the **lungs** and gastrointestinal organs. AAT deficiency is usually inherited. Expression of the genes for AAT is codominant. The most common normal phenotype is MM. The phenotype ZZ (homozygous for the Z variant) produces only about 10% of normal activity and is most commonly associated with immunological damage. The most frequent complications involve the lungs (**emphysema**) and the hepatobiliary tract (hepatitis and cirrhosis). A deficiency of AAT is suspected when the alpha-1 band of serum protein electrophoresis is absent or below 1% of the total protein. The AAT concentration is measured by immunonephelometry and the variant proteins can be identified by high-resolution gel electrophoresis.

Ceruloplasmin: CER is a protein (molecular weight 120,000) produced by the liver. It is an acute phase protein, and increased CER may contribute slightly to the size of the alpha-2 band on electrophoresis. Ceruloplasmin is measured as an aid to the diagnosis of Wilson's disease. Wilson's disease is an autosomal recessive disease in which the binding of copper by CER and the excretion of copper into the bile are impaired. Copper accumulates in the tissues, principally the liver, **central nervous system**, and eyes. Deposition in the eyes produces Kayser-Fleischer rings (green to brown rings around the edge of the cornea), a classic sign on physical exam. Copper deposition damages tissues, causing cirrhosis of the liver and damage to the lenticular area of the **brain** (hepatolenticular degeneration). It may also cause **osteoporosis**, renal, joint, cardiac, and other damage. Plasma levels below half the lower limit of normal and low plasma copper are suggestive but are not conclusive in the absence of clinical signs. CER is measured by immunonephelometry.

C3 and C4: C3 and C4 are glycoproteins that act along with other complement proteins to facilitate lysis of antibody-coated cells. The complement system consists of nine proteins in the classical pathway and an additional five that act in the alternative pathway. Deficiencies of 10 complement proteins have been described. A deficiency of C3 or C4 is associated with systemic lupus erythematosus (SLE) and other autoimmune diseases. The deficiency of either complement component may be responsible in part for the development of the disease by preventing the effective removal of immune complexes. C3 and C4 deficiency are also associated with severe recurrent infections. In active SLE, glomerulonephritis, cirrhosis, and sepsis C3, C4 and complement activity may be reduced due to consumption by immune complex formation. In rheumatoid arthritis, rheumatic **fever**, and some chronic dermatolog-

KEY TERMS

Edematous—The state of having swelling (edema) caused by the collection of excess fluid within tissues.

Hematoma—Swelling and subsequent bruising when blood leaks from a vein into local tissues; can be caused by improper venipuncture when the needle has gone through a vein or when the needle has been inserted incorrectly.

Hemolytic—Destructive to red blood cells.

Venipuncture—Puncture of a vein with a needle for the purpose of withdrawing a blood sample for analysis.

Wilson's disease—A genetic disorder that leads to excessive amounts of copper in the body. Patients often have damaging deposits of copper in the brain, liver, and other organs, and a green discoloration from copper around the iris of the eyes. This disease is also called hepatolenticular degeneration.

ic diseases, C3 and C4 levels are elevated owing to increased complement activation.

C-reactive protein (CRP): C-reactive protein is a protein consisting of five subunits (molecular weight 120,000) produced mainly in the liver. Its name is derived from the fact that it binds to the C-polysaccharide of the capsule of *Streptococcus pneumoniae*. Increased levels are seen in patients with pneumococcal **pneumonia** as well as other acute infections and inflammatory conditions. In the absence of inflammation, CRP levels in plasma are very low (< 4 mg/L). Levels in inflammation can reach several hundred-fold above normal, causing a small but distinct band in the gamma zone on electrophoresis. Recent studies have shown that a CRP near the upper limit of normal (5-10 mg/L) in persons with a history of chronic inflammation is a risk factor for **coronary artery disease**. A new test, called high-sensitivity CRP, can measure CRP levels below 1 mg/L; and is being used by some cardiologists to predict the risk of coronary artery disease in persons with normal total cholesterol who have no history of angina or **heart** disease. CRP is measured by immunonephelometry or enzyme immunoassay.

Haptoglobin: Hp is a glycoprotein (molecular weight 85,000-100,000) made by the liver. Hp binds to free plasma hemoglobin, transporting it to the liver,

where the complex is removed by the reticuloendothelial cells. Low levels are seen in persons with intravascular hemolysis (e.g., following an intravascular transfusion reaction). Haptoglobin is also an acute phase protein. Hp and alpha-2 macroglobulin are responsible for the increased density of the alpha-2 band on electrophoresis seen in acute and chronic inflammatory states. Hp is measured by immunonephelometry.

Immunoglobulins G, A and M (IgG, IgA, and IgM): Immunoglobulins are antibodies produced by B lymphocytes and secreted by plasma cells. They will be increased in response to infections, malignancy, and autoimmune diseases—all of which produce a polyclonal response (i.e., a general increase in all three immunoglobulin classes). This response causes a diffuse increase in the density of the gamma zone on electrophoresis. In malignant or benign plasma cell disorders, proliferation of a single clone of plasma cells results in the accumulation of identical antibody molecules called a monoclonal gammopathy. This result may be recognized on electrophoresis as an area of restricted mobility in the gamma zone. Decreased plasma concentration of one or more immunoglobulin classes may be associated with immunologic impairment and result in both recurrent and opportunistic infections. Both increases and decreases of each immunoglobulin class can be detected by immunonephelometry, using antibodies specific for each. For example, rabbit anti-human IgG can be used to measure the plasma concentration of IgG.

Transferrin: TRF is a glycoprotein (molecular weight 77,000) made by the liver. It is responsible for transport of **iron** from the gut to the bone marrow. The concentration of transferrin in the plasma is directly related to the total iron binding capacity (TIBC). In iron deficiency, the transferrin level is increased, causing an increase in the density of the beta globulin band on electrophoresis. Transferrin levels are decreased in nephrosis, liver disease, starvation, and chronic illness. Like albumin, transferrin is reduced in acute and chronic inflammation and is referred to as a negative acute phase protein.

Transthyretin: Transthyretin or prealbumin is a glycoprotein (molecular weight 54,000) made in the liver. TTR has a very short half-life, making it a useful marker for protein calorie malnutrition. In persons with deficient protein intake, the plasma level of TTR decreases before those of most other proteins. The level of TTR can be monitored to assess the efficacy of dietary intervention in malnourished persons. TTR is measured by immunonephelometry.

Preparation

Prior to performing the venipuncture, the nurse or other health care professional should document any medications the patient is currently taking, and any medical conditions that could influence the protein tests. For example, oral contraceptives, estrogen-containing drugs, or **pregnancy** can increase the level of ceruloplasmin.

Aftercare

The patient may feel discomfort when blood is drawn from a vein. Bruising may occur at the puncture site, or the person may feel dizzy or faint. Pressure should be applied to the puncture site until the bleeding stops, to reduce bruising. Warm packs can also be placed over the puncture site to relieve discomfort.

Complications

In normal circumstances, a blood draw for protein tests takes only a few minutes, and the patient experiences only minor discomfort from the puncture.

Results

The physician will carefully consider the results from the specific protein test within the context of the patient's current health status to make decisions on further testing, diagnosis, and treatment. The protein test results must be interpreted by comparison with standard reference ranges provided by the laboratory that has performed the test. The normal ranges shown below are frequently cited for the methods described previously.

- total protein: 6.0-8.0 g/dL nonambulatory; 6.5-8.5 g/dL ambulatory
- albumin: 3.0-5.0 g/dL nonambulatory; 3.5-5.5 g/dL ambulatory
- alpha-1 antitrypsin: 90-200 mg/dL
- ceruloplasmin: 20-60 mg/dL
- C-reactive protein: 0.7-8.2 mg/L
- Hs-CPR: 0.08-3.1 mg/L
- C3: 90-180 mg/dL
- C4: 10-40 mg/dL
- haptoglobin: 30 - 200 mg/dL
- immunoglobulins: IgG: 700-1600 mg/dL; IgA: 70-400 mg/dL; IgM: 40-230 mg/dL
- transferrin: 200-360 mg/dL
- transthyretin: 20-40 mg/dL

Health care team roles

In accordance with the physician's orders, the nurse, phlebotomist, or laboratory professional usually prepares the patient, performs the blood draw, and readies the specimen for transport to the laboratory for analysis. A clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) or clinical laboratory technician CLT(NCA)/medical laboratory technician MLT(ASCP) performs the testing. Results are interpreted by a physician.

Resources

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ORGANIZATIONS

- The American Society for Clinical Laboratory Science. 7910 Woodmont Ave., Suite 523, Bethesda, MD 20814. (301) 657-2768. <<http://www.ascls.org>>.
- Wilson's Disease Association. 4 Navaho Dr., Brookfield, CT 06804. (800) 399-0266. <<http://www.wilsonsdisease.org>>.

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Plasma renin activity

Definition

Renin is an enzyme released by the kidneys to help control the body's sodium-potassium balance, fluid volume, and **blood pressure**. Renin splits angiotensinogen

in plasma, forming angiotensin I. This compound is acted upon by plasma-converting enzymes produced in the **lungs** to form antiotensin II or III. These powerful vasoconstrictors increase **blood** pressure and stimulate aldosterone release by the adrenal cortex.

Purpose

Plasma renin activity (PRA), also called plasma renin assay, is used to investigate the cause of **hypertension**. PRA is increased in persons with hypertension of renal origin. It is used to classify persons with essential hypertension. A PRA test, along with a measurement of the plasma aldosterone level, is used for the differential diagnosis of primary and secondary aldosteronism. The latter condition is caused by increased renin release by the kidney(s), and therefore, elevated PRA. Patients with primary hyperaldosteronism (caused by an adrenal tumor that overproduces aldosterone) will have an increased aldosterone level with decreased renin activity.

Precautions

Patients taking diuretics, antihypertensives, vasodilators, oral contraceptives, and licorice should discontinue use of these substances for two to four weeks before the test. It should be noted that renin activity is increased in **pregnancy** and in diets with reduced salt intake. Also, since renin is affected by body position, as well as by diurnal variation, blood samples should be drawn in the morning, and the position of the patient (sitting or lying down) should be noted.

The nurse or phlebotomist performing the venipuncture should follow **universal precautions** for the prevention of transmission of bloodborne pathogens. Blood should be collected in EDTA in a chilled syringe, and the sample immediately placed on ice. The plasma should be separated from the cells immediately and then frozen until assay.

Description

The **kidneys** normally release renin in response to decreased blood volume, low plasma sodium, and high plasma potassium levels. The release of renin is the first step in the renin-angiotensin-aldosterone cycle. Renin is produced and secreted by specialized cells called juxtaglomerular cells, located at the junction where the distal tubule meets the afferent and efferent arterioles. These cells secrete renin in response to a decreased flow of blood through the afferent arteriole. Renin is a proteolytic enzyme; it splits angiotensinogen in the plasma forming angiotensin I, which in turn is converted to angiotensin II or III by a converting enzyme produced by

the lungs. Angiotensins II and III are powerful blood vessel constrictors. In addition, they stimulate the release of aldosterone from the cortex of the **adrenal glands**. Aldosterone causes increased sodium reabsorption by the kidneys. As sodium is reabsorbed, the osmotic pressure (osmolality) of the plasma rises, and this rise stimulates osmoreceptors in the **central nervous system**. These cause secretion of antidiuretic hormone (vasopressin) from the posterior **pituitary gland**. Vasopressin causes more water to be reabsorbed by the kidney. Reabsorption increases blood volume and restores the blood pressure in the afferent arterioles reducing renin release. Together, angiotensin and aldosterone increase the blood volume, the blood pressure, and the blood sodium to re-establish the body's sodium-potassium and fluid volume balance.

High blood pressure affects about 20 million people in the United States and is a major risk factor for cardiovascular disease and stroke. More than 90% of hypertension is due to essential (primary) hypertension. This form of high blood pressure is genetic and its causes are unknown. Essential hypertension is aggravated by excess sodium intake, and affected individuals vary in their response to treatment. Plasma renin activity can be used to classify persons with essential hypertension into groups (high, normal, or low PRA) that respond differently to treatment. For instance, low PRA-type essential hypertension results from excessive aldosterone secretion (primary aldosteronism), and is effectively treated by diuretic therapy.

Measurement

Renin itself is not actually measured in the PRA test. There are two forms of this test. The classic test is called the plasma renin activity (PRA) test, and the newer form is called the plasma renin concentration (PRC) test. Both tests measure the conversion of angiotensinogen to angiotensin I by renin. The difference between the two is that the former uses endogenous (i.e., the patient's own) plasma angiotensinogen as the substrate, while the latter uses excess angiotensinogen from an exogenous source such as sheep plasma. To perform the activity test, the plasma is thawed and a small measured amount is added to a buffered solution at pH 6 that contains phenylmethyl sulfonyl fluoride to inhibit plasma angiotensinases that also split angiotensinogen. The mixture is incubated for one hour at 37°C and then refrigerated to stop the enzyme activity. Following this, the angiotensin I produced is measured by radioimmunoassay (RIA). To correct for the endogenous angiotensin I present beforehand, an equal amount of the thawed sample is kept at 4°C and then measured for angiotensin I activity by RIA. This value is subtracted from the test result obtained from the 37°C incubation. The plasma renin concentration test is per-

formed as described above, except that the test plasma is first treated with an acid buffer to destroy the endogenous angiotensinogen. A measured volume of the treated plasma is added to a buffered solution containing an excess amount of exogenous angiotensinogen. The amount of angiotensin I produced following the incubation is equivalent to the maximum rate of enzyme activity, and is a more accurate reflection of renin concentration because it is independent of the plasma angiotensinogen.

Both the PRA and the PRC are extremely difficult to perform. Not only is renin itself unstable, but the patient's body position and the time the specimen is collected affect the results. Also, the sample must be collected properly: drawn into a chilled syringe and collection tube, placed on ice, and sent to the laboratory immediately. Even when all these procedures are followed, results can vary significantly. An alternative method is the measurement of plasma renin mass by double antibody sandwich immunoassay. This assay uses two monoclonal antibodies, one that binds to the prorenin molecule and a second that binds to renin. This assay detects only active renin because the inactive enzyme is not bound by the second antibody. The mass unit assay is independent of angiotensinogen and therefore not as subject to procedural errors related to temperature inactivation of the enzyme.

Renin stimulation tests

A renin stimulation test is performed to help diagnose and distinguish primary from secondary aldosteronism. The test protocol involves either stimulating salt loss by administration of furosemide, a diuretic; or restricting the patient's salt intake for three to five days. A low sodium level and standing posture stimulate renin release in normal persons, resulting in a two to three fold increase in PRA. Persons with secondary aldosteronism (renin-mediated aldosteronism) typically show a five-fold increase in PRA. Persons with primary aldosteronism show no increase in PRA over the baseline.

One example of a stimulation test is performed as follows. With the patient having been on a low-salt diet and lying down for the test, a blood sample for PRA is obtained. The PRA is repeated with the patient still on the low-salt diet, but now standing upright for two or more hours. In cases of primary hyperaldosteronism, the blood volume is greatly expanded, and a change in position or reduced salt intake does not result in decreased renal blood flow or decreased blood sodium. As a result, renin levels do not increase. However, in secondary hyperaldosteronism, blood sodium levels decrease with a lowered salt intake, and when the patient is standing upright,

KEY TERMS

Aldosteronism—A disorder caused by excessive production of the hormone aldosterone, which is produced by a part of the adrenal glands called the adrenal cortex. Causes include a tumor of the adrenal gland (Conn's syndrome), or a disorder reducing the blood flow through the kidney. This leads to overproduction of renin and angiotensin, and in turn causes excessive aldosterone production. Symptoms include hypertension, impaired kidney function, thirst, and muscle weakness.

Conn's syndrome—A disorder caused by excessive aldosterone secretion by a benign tumor of one of the adrenal glands. This hypersecretion results in malfunction of the body's salt and water balance and subsequently causes hypertension. Symptoms include thirst, muscle weakness, and excessive urination.

the renal blood flow decreases as well. Consequently, renin levels will increase.

Captopril suppression test

The captopril test is a screening test for renovascular hypertension. This is a common form of secondary aldosteronism. For this test, a baseline PRA test is measured; then the patient receives an oral dose of captopril, an angiotensin-converting enzyme (ACE) inhibitor. Blood pressure measurements are taken at this time and again at 60 minutes, when another PRA test is done. Patients with kidney-based hypertension demonstrate greater falls in blood pressure and increases in PRA after captopril administration than do those with essential hypertension. Consequently, the captopril test is an excellent screening procedure to determine the need for a more invasive radiographic evaluation such as renal arteriography.

Preparation

This test requires a blood sample. For the PRA, the patient should maintain a normal diet with a normal amount of sodium (approximately 3 g per day) for three days before the test, unless specified otherwise as for a stimulation test. It is recommended that the patient be fasting (nothing to eat or drink) from midnight on the day of the test.

Aftercare

Discomfort or bruising may occur at the puncture site. Applying pressure to the puncture site until the bleeding stops helps to reduce bruising; warm packs

relieve discomfort. Some people feel dizzy or faint after blood has been drawn and should be treated accordingly.

Complications

Other than potential bruising at the puncture site, and/or dizziness, there are no complications associated with this test.

Results

Reference values for the PRA test are laboratory-specific, and depend upon the patient's diet (sodium restricted or normal), the age of the patient, and the patient's posture at the time of the test. Values are also affected if renin has been stimulated or if the patient has received an ACE inhibitor like captopril. A representative normal range for the PRA test in adults on a normal diet is 0.2-3.3 nanograms angiotensin I per mL per hour. For the monoclonal double antibody sandwich assay (direct renin assay), the normal range is 7-76 U/mL for persons not lying down.

Increased PRA levels are seen in up to 15% of persons with essential hypertension (associated with renal injury or vascular disease), malignant hypertension, and kidney-based (renovascular) hypertension. Renin-producing renal and other tumors, while rare, can also cause elevated levels; as can cirrhosis, low blood volume due to hemorrhage, and diminished adrenal function (Addison's disease). Decreased renin levels may indicate increased blood volume due to a high-sodium diet, salt-retaining steroids, primary aldosteronism, or licorice ingestion syndrome. About 25% of persons with essential hypertension will have low renin levels.

Health care team roles

Physicians order PRA tests and interpret the results. A nurse or phlebotomist usually collects the blood and is responsible for icing the sample and transporting to the laboratory. Clinical laboratory scientists/medical technologists perform the renin (and angiotensin I) tests.

Resources

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Plasmodium infection see **Malaria**

Platelet aggregation test

Definition

Platelets (thrombocytes) are small anucleate (i.e. without a nucleus) disk-shaped **blood** cells that play a major role in the blood-clotting process. When a blood vessel wall is cut or injured, platelets adhere to the damaged site and aggregate (clump) together to form a barrier to the escape of blood. The platelet aggregation test is a measure of the platelet clumping function.

Purpose

The platelet aggregation test aids in the evaluation of **bleeding disorders** by measuring the rate and degree to which platelets aggregate after the addition of a chemical, an agonist, that stimulates platelet clumping. The test can be used to differentiate between several inherited and acquired disorders of platelet function.

Precautions

There are many medications that can affect the results of the platelet aggregation test. The patient should discontinue as many of these as possible beforehand. Some of the drugs that can decrease platelet aggregation include aspirin, some **antibiotics**, beta-blockers, dextran (Macrodex), alcohol, heparin (Lipo-Hepin), **non-steroidal anti-inflammatory drugs** (NSAIDs), tricyclic antidepressants, and warfarin (Coumadin).

Description

There are many factors involved in blood clotting (coagulation). One of the first steps in the process involves small cells in the bloodstream called platelets, which are produced in the bone marrow. Platelets gather at the site of an injury, adhere to the damaged vessel wall, and aggregate together forming a plug that helps to limit the loss of blood and promote healing. Normal aggregation depends upon the release of platelet granules, normal membrane receptors on the platelets, and a normal level of plasma fibrinogen.

A defect in platelet aggregation will result in a prolonged bleeding time. Abnormal platelet aggregation may be caused by an inherited bleeding disorder (e.g., von Willebrand's disease); certain acquired bleeding disorders that occur as a consequence of another disease or condition (e.g. connective tissue or collagen disorders, kidney or **liver** failure, leukemia, myeloma); or by certain medications (e.g., aspirin, heparin, and NSAIDs).

The platelet aggregation test uses an instrument called an aggregometer to measure the optical density (turbidity) of platelet-rich plasma. The plasma should stand at room temperature for 30 minutes prior to the assay, but the tests should be performed within three hours of sample collection. Several different substances called agonists are used in the test. These agonists include adenosine diphosphate (ADP), epinephrine, thrombin, collagen, arachidonic acid, and ristocetin. The addition of an agonist to a plasma sample causes the platelets to aggregate, making the fluid more transparent. The aggregometer then measures the increased light transmission through the specimen. Some aggregometers measure platelet aggregation of whole blood. These instruments use two electrodes that measure impedance (resistance to current flow). When platelet aggregation occurs, the platelets collect at the electrode surface, increasing the impedance at the electrode.

Some inherited platelet disorders that can be differentiated by the aggregation response to different agonists include Glanzmann's thrombasthenia, von Willebrand's disease, and Bernard-Soulier disease. Glanzmann's thrombasthenia is an autosomal dominant condition. The platelet count is normal, but the bleeding time is prolonged. Aggregation is normal with ristocetin, but is abnormal with all the other agonists. Von Willebrand's disease is the most common inherited bleeding disorder. It is associated with an increased bleeding and clotting time and is caused by a deficiency of two coagulation factors, factor VIII and von Willebrand factor. The platelet count may be normal or low. It may be inherited as autosomal dominant or autosomal recessive forms. The aggregation profile in von Willebrand's disease is the reverse of that seen in Glanzmann's thrombasthenia. The aggregation with ADP, collagen, thrombin, epinephrine, and arachidonic acid is normal, but is abnormal with ristocetin. Bernard-Soulier disease is an autosomal recessive condition associated with large platelets and an abnormal bleeding time. The platelet count may be normal or low. It produces the same profile as von Willebrand's disease, but the abnormal aggregation with ristocetin cannot be reversed by addition of von Willebrand factor.

Preparation

The test requires a blood sample collected in sodium citrate. The patient should either avoid food and drink altogether for eight hours before the test, or eat only non-fat foods. High levels of fatty substances in the blood can affect test results.

Because the use of aspirin and/or aspirin compounds can directly affect test results, the patient should avoid

KEY TERMS

Aggregation—The blood cell clumping process that is measured in the platelet aggregation test.

Agonist—A chemical that is added to the blood sample in the platelet aggregation test to stimulate the clumping process.

Platelets—Small, round, anucleate disk-shaped blood cells that are involved in clot formation. The platelet aggregation test measures the clumping ability of platelets.

Turbidity—The cloudiness or lack of transparency of a solution.

von Willebrand's disease (vWD)—An autosomal dominant inherited lifelong bleeding disorder caused by a defective gene. The gene defect results in a decreased blood concentration of a substance called von Willebrand factor (vWF). Tests for vWF (and coagulation Factor VIII) are used along with platelet aggregation tests to diagnose this disorder.

these medications for at least one week before the test. The test should be completed within three hours of specimen collection. Specimens that sit at room temperature for four hours or more may lose the ability to aggregate.

Aftercare

Because the platelet aggregation test is ordered when some type of bleeding problem is suspected, the patient should be cautioned to watch the puncture site for signs of additional bleeding.

Complications

Risks for this test are minimal in normal individuals. Patients with bleeding disorders, however, may have prolonged bleeding from the puncture wound; or the formation of a bruise (ecchymosis) or blood clot (hematoma) in or under the skin where the blood was withdrawn.

Results

The platelet aggregation test produces a graph in which the x-axis is time and the y-axis is percent transmission. The platelet aggregation curve will vary depending upon the reaction conditions (e.g., pH of the platelet-rich plasma), agonist used, and agonist concentration. The typical aggregation curve is biphasic. It is

characterized by an initial increase in light transmission (primary wave) followed by a plateau and a second steeper increase in light transmission (secondary wave) caused by irreversible platelet clumping. An exception to this pattern is aggregation with collagen, which produces a single steep increase in light transmission preceded by a lag phase. An abnormal response can be a decreased or absent primary wave, secondary wave, or both.

Abnormal platelet aggregation can be found in such inherited disorders as von Willebrand's disease, as well as in some connective tissue disorders. Abnormal aggregation can also occur in leukemia or myeloma; with medications taken during recent heart/lung bypass or **kidney dialysis**; and after taking certain other drugs.

Health care team roles

The physician orders the test. The specimen will be drawn by a nurse or phlebotomist, and transported to the laboratory. The clinical laboratory scientist/medical technologist will perform the test. The results are interpreted by a hematopathologist.

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Mark A. Best

Platelet count see **Complete blood count**

Pleural fluid analysis see **Thoracentesis**

Pneumonia

Definition

Pneumonia is a serious **infection** of the lung that impairs breathing. Small air sacs in the lung (alveoli) become filled with pus, mucus or other fluid, and cannot supply oxygen to circulating **blood**. Lobar pneumonia affects one section, or lobe, of the lung; bronchial pneu-

monia, or bronchopneumonia, affects scattered areas of either lung.

Description

Pneumonia is not just one disease. Although it is commonly caused by *Streptococcus pneumoniae*, several different microorganisms—as well as toxic chemicals—or choking on food or vomit, can cause the disease.

An estimated four million Americans become ill with pneumonia each year, accounting for one million hospital admissions and over ten million hospital bed days. In the United States, pneumonia is the sixth most common disease leading to death. It is also the most common fatal infection acquired by already hospitalized patients. In developing countries, pneumonia ties with **diarrhea** as the most common cause of death.

Pneumonia is one of the most ancient known diseases. Although the incidence of pneumonia has declined because of the use of **antibiotics**, it has become a more serious health risk among elderly people. From 1980 to 1992, the overall death rate due to pneumonia increased by 20%. Nine out of every ten deaths due to pneumonia occurred among people aged 65 years and over.

Causes and symptoms

Pneumonia can have more than 30 different causes, but the five main causes are:

- **bacteria**
- **viruses**
- mycoplasmas
- other infectious pathogens, like **fungi** (including *Pneumocystis*)
- some chemicals

Common symptoms of pneumonia vary according to its cause, but may include:

- Cough. In bacterial pneumonia, the cough produces a rust-colored or greenish mucus. Pneumonia due to mycoplasmas produces only sparse whitish mucus, while viral pneumonia is generally characterized by a dry cough that worsens over time and ultimately produces a small amount of mucus that is *purulent*, or obviously infected.
- **Fever** (as high as 105°F, or 40.5°C) and chills.
- Localized **pain** in the area of the chest at the location of the lung infection; pain may be severe.
- Shortness of breath (SOB). (Severe pneumonia may cause **cyanosis**, or a bluish tinge to the skin, especially

around the lips and nailbeds, due to lack of oxygen in the blood.)

- Chattering teeth.
- Profuse sweating.
- Rapid breathing and pulse.
- Confused mental state.
- Muscle pain and weakness.

Anatomy of the lung

To better understand pneumonia, it is important to be familiar with the basic anatomic features of the **respiratory system**. The human respiratory system begins at the nose and mouth, where air is breathed in (inspired) and out (expired). The air tube extending from the nose is the nasopharynx. The tube carrying air breathed in through the mouth is the oropharynx. The nasopharynx and the oropharynx merge into the larynx. The oropharynx also carries swallowed substances, including food, water, and salivary secretion, which must pass into the esophagus and then the **stomach**. The larynx is protected by a trap door called the epiglottis, which prevents substances that have been swallowed, as well as substances that have been regurgitated (thrown up), from heading down into the larynx and toward the **lungs**.

The larynx flows into the trachea, which is the broadest part of the respiratory tree. The trachea divides into two tree limbs, the right and left bronchi. Each one of these branches off into multiple smaller bronchi, which penetrate the lung tissue. Each bronchus divides into tubes of smaller and smaller diameter, finally ending in the terminal bronchioles. The air sacs of the lung, in which oxygen-carbon dioxide exchange actually takes place, are clustered at the ends of the bronchioles like the leaves of a tree. They are called alveoli.

The tissue of the lung, which serves only in a supportive role for the bronchi, bronchioles, and alveoli, is known as lung parenchyma.

Function of the respiratory system

The main function of the respiratory system is to provide oxygen, the most important energy source for the body's cells. Inspired air (the air that is breathed in) contains oxygen and travels down the respiratory tree to the alveoli. The oxygen moves out of the alveoli and is sent into circulation throughout the body as part of the red blood cells. The oxygen in the inspired air is exchanged within the alveoli for carbon dioxide, the waste product of the human metabolic process. The air that is breathed out contains the gas carbon dioxide. During expiration,

carbon dioxide leaves the alveoli. As one breathes in oxygen, one breathes out carbon dioxide.

Respiratory system defenses

Bacteria and viruses do not normally reside in significant numbers inside the lung, part of the upper respiratory system. This absence is in contrast to parts of the gastrointestinal system, where bacteria dwell even in a healthy state. There are multiple safeguards along the path of the respiratory system. These are designed to keep organisms from invading and leading to infection.

The first line of defense against infection includes the hairs in the nostrils, which serve as a filter for larger particles. The epiglottis is a "trap door," designed to prevent food and other swallowed substances from entering the larynx and the trachea. Sneezing and coughing, both provoked by the presence of irritants within the respiratory system, help to clear such irritants from the respiratory tract.

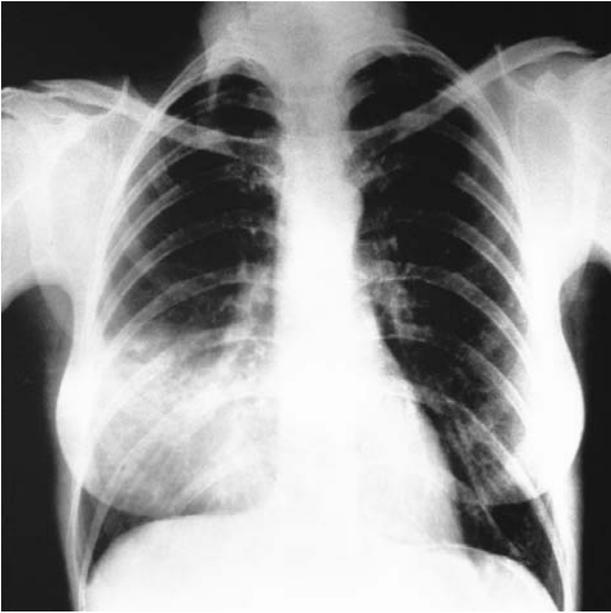
Mucus, produced through the respiratory system, also serves to trap dust and infectious organisms. Tiny hair-like projections (cilia) from cells line the respiratory tract and beat constantly, moving debris trapped by mucus upwards and out of the respiratory tract. This mechanism of protection is called the "mucociliary escalator."

The cells that line the respiratory tract produce several types of immune substances that protect against various organisms. Other cells (macrophages) along the respiratory tract actually ingest and kill invading organisms.

Thus, the organisms that cause pneumonia are usually carefully kept from entering the lungs by virtue of these host defenses. However, when an individual encounters a large number of organisms at once, the usual defenses may be overwhelmed and infection may occur. This may occur either when contaminated air droplets are inhaled, or when aspiration of organisms that inhabit the upper airways takes place.

Conditions predisposing to pneumonia

In addition to exposure to sufficient quantities of causative organisms, certain conditions may make an individual more likely to become sick with pneumonia. Certainly, the lack of normal anatomical structure could result in an increased risk of pneumonia. There are certain inherited defects of cilia that can result in less effective protection. Cigarette smoke, inhaled directly by a smoker or secondhand by an innocent bystander, interferes significantly with ciliary function; and inhibits macrophage (a large white blood cell [WBC] that ingests particles and infectious microorganisms) function.



X ray showing pneumonia in the right lung. (National Aududon Society Collection/Photo Researchers, Inc. Reproduced by permission.)

Stroke, seizures, alcohol, and various drugs interfere with the function of the epiglottis. This interference can lead to a leaky seal on this “trap door,” with possible contamination by swallowed substances and/or regurgitated stomach contents. Alcohol and some drugs may also interfere with the normal cough reflex. An inadequate cough reflex further decreases the success of clearing unwanted debris from the respiratory tract.

Viruses or such other microorganism invaders as bacteria, may interfere with ciliary function and lead to access to the lower respiratory tract. One of the most invasive viruses is HIV (human **immunodeficiency** virus), the causative virus in **AIDS** (acquired immunodeficiency syndrome). In recent years, this virus has resulted in a significant increase in the incidence of pneumonia. Because AIDS results in a general decreased efficiency of many protective mechanisms of the host’s **immune system**, a patient with AIDS may be susceptible to all kinds of pneumonia. This vulnerability includes some parasitic types considered rare prior to the emergence of AIDS in the 1980s. These rare parasites are incapable of causing illness in an individual with a normal immune system.

The elderly have a less effective mucociliary escalator, as well as changes in their immune system that compromise their ability to fight infection. These factors cause this age group to be at greater risk for the development of pneumonia.

Various chronic conditions predispose a person to infection with pneumonia. These conditions include **asthma**, **cystic fibrosis**, and neuromuscular diseases, which may interfere with the seal of the epiglottis. Esophageal disorders may result in stomach contents passing upwards into the esophagus. This increases the risk of aspiration into the lungs of stomach contents (with their normally resident bacteria). Diabetes, sickle cell anemia, lymphoma, leukemia, and **emphysema** also predispose a person to pneumonia.

Pneumonia is one of the most frequent infectious complications of all types of surgery. Many drugs used during and after surgery may increase the risk of aspiration, impair the cough reflex, and cause a patient to underfill his or her lungs with air. Pain after surgery also discourages a patient from breathing deeply enough, and from coughing effectively.

The number of organisms that can cause pneumonia is very large, and includes nearly every class of infectious organism, including viruses, bacteria, bacteria-like organisms, fungi, and parasites (including certain worms). Different organisms are more frequently encountered by different age groups. Further, other characteristics of an individual may place him or her at greater risk for infection by particular types of organisms:

- Viruses cause the majority of pneumonias in young children (especially respiratory syncytial virus [RSV]), parainfluenza, **influenza** viruses, and adenovirus).
- Adults are more frequently infected with bacteria (such as *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Staphylococcus aureus*), but the numbers of both adults and children are increasing globally, and both groups are being infected with *Pneumococcus*, a common bacterium.
- Pneumonia in older children and young adults is often caused by the bacteria-like *Mycoplasma pneumoniae*, the cause of what is often referred to as “walking” pneumonia.
- *Pneumocystis carinii* is an extremely important cause of pneumonia in patients with immune problems (such as patients being treated for **cancer** with **chemotherapy**, or patients with AIDS). Classically considered a parasite, *Pneumocystis* appears to be more related to fungi.
- People who come into contact with bird droppings, such as poultry workers, are at risk for pneumonia caused by the organism *Chlamydia psittaci*.
- A very large serious outbreak of pneumonia occurred in 1976, when many people attending an American Legion convention were infected by a previously unknown organism. Subsequently named *Legionella*

pneumophila, it causes what is now called “Legionnaire’s Disease.” The organism was traced to air conditioning units in the convention’s hotel.

Pneumonia is suspected in the patient who is febrile, has a cough, chest pain, SOB, and an increased rate of respiration (number of breaths per minute). Fever with a shaking chill is even more suspicious. Many patients cough up clumps of sputum—commonly known as “spit.” These secretions are produced in the alveoli during an infection or other inflammatory condition. They may appear streaked with pus or blood.

Severe pneumonia results in the signs of oxygen deprivation. These include a blue appearance of the nail beds or lips (cyanosis). The invading organism causes symptoms in part by provoking an overly strong **immune response** in the lungs. Thus, the immune system, which should help fight off infections, kicks into such high gear and damages the lung tissue, making it more susceptible to infection. The small **blood vessels** in the lungs (capillaries) become leaky, and protein-rich fluid seeps into the alveoli. This seepage results in less functional area for oxygen-carbon dioxide exchange. The patient becomes relatively oxygen-deprived while retaining potentially damaging carbon dioxide. The patient breathes faster and faster in an effort to inhale more oxygen and exhale more carbon dioxide.

Mucus production is increased, and the leaky capillaries may tinge the mucus with blood. Mucus plugs actually further decrease the efficiency of **gas exchange** in the lung. The alveoli fill further with fluid and debris from the large number of white blood cells (WBCs) being produced to fight the infection.

Consolidation, a feature of bacterial pneumonia, occurs when the alveoli—normally hollow air spaces within the lung—become solid due to quantities of fluid and debris.

Viral pneumonia and mycoplasma pneumonia do not result in consolidation. These types of pneumonia primarily infect the walls of the alveoli and the parenchyma of the lung.

X-ray examination of the chest may reveal certain abnormal changes associated with pneumonia. Localized shadows obscuring areas of the lung may indicate a bacterial pneumonia, while streaky- or patchy-appearing changes in the x-ray picture may indicate viral or mycoplasma pneumonia.

Diagnosis

Diagnosis is based on the patient’s symptoms and **physical examination** of the chest. When the physician listens with a **stethoscope**, abnormal sounds are

revealed. Tapping on the patient’s back, which should produce a resonant sound as a result of air filling the alveoli, may yield a dull thump if the alveoli are filled with fluid and debris.

Diagnosis of some bacterial pneumonias can be made with the results of specific laboratory tests. By staining sputum with special chemicals and examining it under a **microscope**, the technician can identify specific types of bacteria. Identification may require culturing the sputum, a procedure in which the sputum sample is used to grow greater numbers of itself (the bacteria) in a lab (petri) dish.

Treatment

Prior to the discovery of penicillin and other antibiotics, bacterial pneumonia was almost always fatal. As of 2001, when antibiotics are given early in the course of the disease, they are very effective against bacterial causes of pneumonia. Both erythromycin (E-Mycin, ERYC) and tetracycline (achromycin, sumycin) improve recovery time for symptoms of mycoplasma pneumonia. They do not, however, eradicate the organisms. Amantadine (Symmetrel) and acyclovir (Zovirax) may be helpful against certain viral pneumonias.

Prognosis

Prognosis varies according to the type of organism causing the infection. Recovery following pneumonia with *Mycoplasma pneumoniae* is nearly 100%. *Staphylococcus pneumoniae* has a death rate of 30–40%. Similarly, infections with a number of gram-negative bacteria (such as those in the gastrointestinal tract, which can cause infection following aspiration) have a high death rate—25–50%. *Streptococcus pneumoniae*, the most common organism causing pneumonia, produces a death rate of about 5%. More complications occur in the very young, or in elderly individuals who may have infections in multiple areas of the lung simultaneously. Individuals with other chronic illnesses—such as cirrhosis of the **liver**, congestive **heart** failure—or those without a functioning spleen or those who have other diseases that result in a weakened immune system—may experience complications. Patients with immune disorders, various types of cancer, transplanted organ(s) or tissue(s) transplants, or AIDS also may experience complications.

Health care team roles

In most cases, a diagnosis of pneumonia is made in a physician’s office, a general medical clinic, or emergency room by a primary care practitioner. Children and adolescents with pneumonia are most likely to be diagnosed by their primary care physician or pediatrician.

KEY TERMS

Alveoli—The little air sacs clustered at the ends of the bronchioles, in which oxygen-carbon dioxide exchange takes place.

Aspiration—A situation in which solids or liquids that should be swallowed into the stomach are instead breathed into the respiratory system.

Cilia—Hair-like projections from certain types of cells.

Cyanosis—A bluish tinge to the skin that can occur when the blood oxygen level drops too low.

Parenchyma—A term used to describe the supportive tissue surrounding a particular structure. An example is the tissue that surrounds and supports the actually functional lung tissue.

Sputum—Material produced within the alveoli in response to an infectious or inflammatory process.

Both registered nurses (RNs) and licensed practical nurses (LPNs) must complete a prescribed course in nursing and pass a state examination. RNs typically have a degree in nursing. Both RNs and LPNs are often the specialists who deal the most with pneumonia patients, both in general hospitals, homes, or other health care facilities. Good nursing care and observation are primary requirements. These include monitoring **vital signs**, including oxygen saturation (the amount of oxygen circulating in the blood), encouraging the patient to move, breathe deeply, cough, and get out of bed with assistance (if indicated) to facilitate good lung expansion. The nurse should also provide education to the patient about the importance of coughing, breathing deeply, and taking in adequate fluid.

Clinical laboratory scientists have specialized training and must pass a state examination. These are the staff who analyze blood samples or test urine/sputum specimens that reflect the presence of pneumonia at the outset, and as it resolves. These tests are typically ordered by physicians to diagnose and assess the progress of the infection.

Radiologic technologists have specialized training and must pass a state examination. Their responsibility is to take chest x rays to visualize and monitor the course of the pneumonia.

Prevention

Because many bacterial pneumonias occur in patients who are first infected with the influenza virus (the flu), yearly **vaccination** against influenza can

decrease the risk of pneumonia in certain patients. This is particularly true of the elderly and those afflicted with such chronic diseases as asthma, cystic fibrosis, other lung or heart diseases, **sickle cell disease**, diabetes, kidney disease, and some cancers.

A specific vaccine against *Streptococcus pneumoniae* and another vaccine developed in the early 2000s against *Pneumococcus* are very protective, and should also be administered to people over 65 years of age as well as to patients with chronic illnesses.

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Pneumonitis see **Pneumonia**

Podiatry see **Foot care**

Poisoning

Definition

Poisoning is the state produced by the introduction of toxic substances; that is, any substance that produces an injurious or fatal effect, into the body.

Description

Poisoning commonly involves the introduction of poisonous elements from outside the body. The term also can apply to noxious material produced within the body that, because of a disease condition such as kidney or **liver** failure, cannot be removed; or toxins produced by **bacteria**, as in the case of **food poisoning**. Poisons can enter the body from multiple external sources. They can be swallowed; inhaled, as in the case of carbon monoxide or aerosol compounds; or they can enter via the skin, as in snake or insect bites; and even via radiation from the sun that we call *sun poisoning*. Some question exists regarding whether electro-magnetic fields (EMFs) also produce damaging effects within the body.

Poisoning is a common occurrence. An estimated 10 million cases of poisoning occur in the United States each year. 2.24 million exposures to poisonous substances were reported to United States Poison Control Centers in 1998. In 50% of the cases, the victim is a child under the age of five. The most common toxic substances taken in are cosmetics and personal care products, followed by home cleaning products, medications and plants. Most poisonings, nearly 89%, occur in the home, and are accidental.

About 50 children die each year in the United States from poisoning. Curiosity, inability to read warning labels, a desire to imitate adults, and inadequate supervision lead to childhood poisonings. The elderly are the second most likely group to be poisoned. Mental confusion, poor eyesight, and the use of multiple drugs are the leading reasons why this group has a high rate of accidental poisoning. A substantial number—approximately eleven percent of all poisonings—also occur as suicide attempts.

Poisons taken internally are common in the home and workplace. There are basically two major types. One group consists of products that were never meant to be ingested or inhaled, such as shampoo, paint thinner, pesticides, houseplant leaves, and carbon monoxide. The other group contains products that can be safely ingested in small quantities, but which are harmful if taken in large amounts. These include pharmaceuticals, medicinal herbs, or alcohol. Other types of poisons include the bacterial toxins that cause food poisoning, such as *Escherichia coli*; heavy metals, such as the lead found in the paint on older houses; and the venom found in the **bites and stings** of some animals and insects. The staff at a poison control center and emergency room doctors have the most experience diagnosing and treating poisoning cases.

Causes and symptoms

The effects of poisons are as varied as the poisons themselves. The exact mechanisms of only a few are understood. Some poisons interfere with the **metabolism**. Others destroy the liver or **kidneys**, such as heavy metals and some **pain** relief medications, including acetaminophen (Tylenol) and **nonsteroidal anti-inflammatory drugs** (Advil, Ibuprofen). A poison may severely depress the **central nervous system**, leading to **coma** and eventual respiratory and circulatory failure. Potential poisons in this category include anesthetics (e.g. ether and chloroform); opiates (e.g. morphine and codeine); and barbiturates. Some poisons directly affect the respiratory and circulatory systems. Carbon monoxide causes death by binding with hemoglobin that would normally transport oxygen throughout the body. Certain corrosive vapors trigger the body to flood the **lungs** with fluids, effectively drowning the person. Cyanide interferes with respiration at the cellular level. Another group of poisons interferes with the electrochemical impulses that travel between **neurons** in the nervous system. Another group, including cocaine, ergot, strychnine, and some snake venoms, causes potentially fatal seizures.

Severity of poisoning symptoms can range from headache and nausea to convulsions and death. The type of poison; the amount and time of exposure; and the age, size, and health of the victim are all factors that determine the severity of symptoms and the chances for recovery.

Plant poisoning

There are more than 700 species of poisonous plants in the United States. Plants are second only to medicines in causing serious poisoning in children under age five. The appearance of a plant offers no determination of its poison. Some plants, such as the yew shrub, are almost entirely toxic: needles, bark, seeds, and berries. In other plants, only certain parts are poisonous. The bulb of the hyacinth and daffodil are toxic, but the flowers are not. It is the flowers of the jasmine plant that are the poisonous part. Some plants are confusing because portions of them are eaten as food while other parts are poisonous. For example, the fleshy stem (tuber) of the potato plant is nutritious; however, its roots, sprouts, and vines are poisonous. The leaves of tomatoes are poisonous, while the fruit is not. Rhubarb stalks are good to eat, but the leaves are poisonous. Apricots, cherries, peaches, and apples all produce healthful fruit, but their seeds contain a form of cyanide that can kill a child if chewed in sufficient quantities. One hundred milligrams (mg) of moist, crushed apricot seeds can produce 217 milligrams of cyanide.

Common houseplants that contain some poisonous parts include:

COMMON HOUSEHOLD, INDUSTRIAL, AND AGRICULTURAL PRODUCTS CONTAINING TOXIC SUBSTANCES

Alcohol (rubbing)	Fuel
Antifreeze	Floor/furniture polish
Arsenic	Gasoline
Art and craft supplies	Glues/adhesives
Automotive fluids	Hemlock
Batteries, automotive	Kerosene
Batteries, household	Mercury
Building products	Metal primers
Cleaning products	Metalworking materials
Cosmetics/personal care products	Mothballs
Cyanide	Oven cleaners
Daffodil bulbs	Paint strippers/thinners
<i>Dieffenbachia</i>	Paints, oil-based or alkyds
Disinfectants/air fresheners	Paints, water-based or latex
Drain openers	Pesticides, flea collars, insect repellents
English nightshade	Stains/finishes
Ethanol (found in alcoholic beverages)	Strychnine
Foxglove	Wood preservatives

(Illustration by Standley Publishing. Courtesy of Gale Group.)

- aloe
- amaryllis
- Boston ivy
- caladium
- cyclamen
- dumb cane (also called *Dieffenbachia*)
- philodendron

Common outdoor plants that contain some poisonous part include:

- azalea
- bird-of-paradise flower
- black cherry
- buttercup
- calla lilly
- castor bean
- chinaberry tree
- caffodil
- delphinium
- English ivy
- eucalyptus
- foxglove
- holly
- horse chestnut
- hydrangea
- iris
- jack-in-the-pulpit
- jimson weed (also called thornapple)
- larkspur
- lily-of-the-valley
- morning glory
- nightshade (several varieties)
- oleander
- potato
- rhododendron
- rhubarb
- sweet pea
- tomato
- wisteria
- yew

Symptoms of plant poisoning range from irritation of the skin or mucous membranes of the mouth and throat to nausea, vomiting, convulsions, irregular heartbeat, and even death. It is often difficult to tell if a person has eaten

a poisonous plant because there are no telltale empty containers and no unusual lesions or odors around the mouth.

Household chemicals

Many products used daily in the home are poisonous if swallowed. These products often contain strong acids or strong bases (alkalis). Toxic household cleaning products include:

- ammonia
- bleach
- dishwashing liquids
- drain openers
- floor waxes and furniture polishes
- laundry detergents, spot cleaners, and fabric softeners
- mildew removers
- oven cleaners
- toilet bowl cleaners

Personal care products found in the home can also be poisonous. These include:

- deodorant
- hair spray
- hair straighteners
- nail polish and polish remover
- perfume
- shampoo

Signs that a person has swallowed one of these substances include evidence of an empty container nearby, nausea or vomiting, and **burns** on the lips and skin around the mouth if the substance is a strong acid or alkali. The chemicals in some of these products may leave a distinctive odor on the breath.

Pharmaceuticals

Both over-the-counter and prescription medicines can help the body heal if taken as directed. When taken in large quantities, or with other drugs where there may be an adverse interaction, they can subsequently act as poisons. Drug overdoses, both accidental and intentional, are the leading cause of poisoning in adults. Medicinal herbs should be treated like pharmaceuticals and taken only in designated quantities under the supervision of a knowledgeable person. Herbs that have healing qualities when taken in small doses can be toxic in larger doses.

Diagnosis

Initially, poisoning is suspected if the victim shows changes in behavior and the signs or symptoms previously described. Evidence of an empty container or information from the victim are helpful in determining exactly what substance has caused the poisoning. Some acids and alkalis leave burns on the mouth. Petroleum products, such as lighter fluid or kerosene, leave a distinctive odor on the breath. Vomitus may be tested to determine the exact composition of the poison. Once hospitalized, **blood** and urine tests may be done on the patient to determine his metabolic condition.

Treatment

Treatment for poisoning depends on the poison swallowed or inhaled. Contacting a poison control center or hospital emergency room is the first step in getting proper treatment. The poison control center's telephone number is often listed with emergency numbers on the inside cover of the telephone book, or can be reached by dialing 911 or the operator. The poison control center will ask for specific information about the victim and the poison, then give appropriate **first aid** instructions. If the patient is to be taken to a hospital, a sample of vomitus and the poison container should be taken along, if they are available.

Most cases of plant poisoning are treated by inducing vomiting, if the person is fully conscious. Vomiting can be induced by taking syrup of **ipecac**, an over-the-counter product available at any pharmacy.

For acid, alkali, or petroleum product poisonings, the patient should not be made to vomit. Acids and alkalis can burn the esophagus if they are vomited, and petroleum products can be inhaled into the lungs during vomiting, resulting in aspiration **pneumonia**.

Once under medical care, doctors have the option of treating the patient with a specific remedy to counteract the poison (antidote) or with activated charcoal to absorb the substance inside the patient's **digestive system**. In some instances, pumping the **stomach** may be required. Medical personnel will also provide supportive care as needed, such as intravenous fluids or mechanical ventilation.

Prognosis

The outcome of poisoning varies from complete recovery to death, and depends on the type and amount of the poison, the health of the victim, and the speed with which medical care is obtained.

KEY TERMS

Acid—A chemical substance that contains the element hydrogen and has a pH above seven, which is considered neutral. Acids are generally described as sour or biting in character.

Alkali—A chemical substance that has the ability to neutralize acid. It has a pH below seven, which is considered neutral, and is generally described as caustic in nature.

Aspiration pneumonia—Fluid entering the lungs through choking or vomiting, and leading to infection of the lung.

Gastric lavage—Insertion of a tube into the stomach for the purpose of washing out and removing toxic material.

Ipecac—A medication made from the dried root of a plant native to Brazil, often used to induce vomiting.

Health care team roles

In most cases, a poisoning victim will initially be discovered by a family member or friend. Once the health care staff has been engaged at the request of those involved, it can include:

- Staff at local poison control centers. These are people specially trained regarding the properties and treatment of poisons. Staff may include physicians and nurses who are especially skilled at obtaining necessary information regarding the poison and providing the needed facts in regard to treatment.
- **Emergency medical technicians (EMTs)**, are specially trained in providing emergency care to people outside of hospitals. Often under the supervision of an emergency room physician, EMTs are frequently the first to provide medical intervention. They work from ambulances, providing the initial care often in the home, or place where the poisoning took place.
- If the poisoning victim is transported to a hospital emergency room, a licensed physician trained in emergency medicine will either begin or take further measures to negate the effect of the poison.
- Both registered nurses (RNs), and licensed practical nurses (LPNs) work in hospital emergency rooms, and are often located in poison control centers. In emergency rooms, both RNs and LPNs will be responsible for monitoring **vital signs**, obtaining specimens of vomitus, administering such medications as activated

charcoal or ipecac, or providing assistance in carrying out such procedures as gastric lavage (pumping the stomach). Providing reassurance to frightened patients and families, and offering information regarding poisons, especially to the families of children that have been poisoned, are both critical elements of care.

- Clinical laboratory scientists have specialized training and must pass a state examination. They draw blood samples or test urine to do toxic screens for various drugs, or other tests that determine what toxic substance has been ingested.
- Radiologic technologists have specialized training and must pass a state examination. They may be called upon to take a **chest x ray** to ensure that the person has not aspirated (had foreign material such as vomit enter the lungs), causing aspiration pneumonia.

Prevention

Most accidental poisonings are preventable. The number of deaths of children from poisoning in the United States has declined from about 450 per year in the 1960s to about 50 each year in the 1990s. This decline has occurred primarily due to better packaging of toxic materials, and to better public education.

Actions to prevent poisonings include:

- removing plants that are poisonous
- keeping medicines and household chemicals locked and in a place inaccessible to children
- keeping medications in child-resistant containers
- never referring to medicine as “candy”
- keeping cleaners and other poisons in their original containers
- disposing of outdated prescription medicines

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Polyneuropathies

Definition

Polyneuropathies encompass a wide range of disorders in which the nerves outside of the **brain** and spinal cord—peripheral to the central nervous system—have been damaged. Polyneuropathy is also referred to as peripheral neuritis or polyneuritis.

Description

Polyneuropathy is a common disorder with many underlying causes. Some of these causes occur frequently, such as diabetes, and others are extremely rare, such as acrylamide **poisoning** and certain inherited disorders. The most common worldwide cause of polyneuropathy is leprosy. Leprosy is caused by the bacterium *Mycobacterium leprae*, which attacks the peripheral nerves. According to statistical data from the World Health Organization, an estimated 1.15 million people suffer from leprosy worldwide.

Leprosy is extremely rare in the United States, where diabetes is the most commonly known cause of polyneuropathy. It has been estimated that more than 17 million people in the United States and Europe suffer from diabetes-related polyneuropathy. Many neuropathies are idiopathic, meaning that no known cause can be found. The most common inherited polyneuropathy in the United States is Charcot-Marie-Tooth disease, which affects approximately 125,000 persons.

Another of the better known polyneuropathies is Guillain-Barré syndrome (GBS, acute idiopathic demyelinating polyneuropathy); it is a complication of such viral illnesses, as cytomegalovirus, Epstein-Barr

virus, and human **immunodeficiency** virus (HIV) or bacterial **infection**, including *Campylobacter jejuni* and Lyme disease. The worldwide incidence rate is approximately 1.7 cases per 100,000 people annually. Other well-known causes of polyneuropathies include chronic **alcoholism**, infection, varicella-zoster virus, botulism, and poliomyelitis. Polyneuropathy may develop as a primary symptom, or it may be due to another disease. For example, polyneuropathy is only one symptom of such diseases as amyloid neuropathy, certain cancers, or inherited neurologic disorders. Such diseases may affect the peripheral nervous system (PNS) and the **central nervous system** (CNS), as well as other body tissues.

To understand polyneuropathy and its underlying causes, it may be helpful to review the structures and arrangement of the PNS.

Nerve cells and nerves

Nerve cells are the basic building block of the nervous system. In the PNS, nerve cells can be threadlike—their width is microscopic, but their length may be measured in feet. The long, spidery extensions of nerve cells are called axons. When a nerve cell is stimulated—by touch or **pain**, for example—the message is carried along the axon, and neurotransmitters are released within the cells. Neurotransmitters are chemicals within the nervous system that direct nerve-cell communication.

Certain nerve cell axons, such as those in the PNS, are covered with a substance called myelin. This myelin sheath may be compared to the plastic insulation coating electrical wires—it both protects the cells and prevents interference with the signals being transmitted. Protection is also given by Schwann cells, special cells within the nervous system that wrap around both myelinated and unmyelinated axons.

Nerve cell axons leading to the same areas of the body may be bundled together into nerves. Continuing the comparison to electrical wires, nerves may be compared to an electrical cord—the individual components being coated in their own sheaths and then encased together inside a larger protective sheath.

The nervous system is classified into two parts: the CNS and the PNS. The CNS is the brain and the **spinal cord**, and the PNS is composed of the nerves that lead to or branch off from the CNS.

Peripheral nervous system

The peripheral nerves handle a diverse array of functions in the body. This diversity is reflected in the major divisions of the PNS—the afferent and the efferent divisions. The afferent division conveys sensory information



Chronic alcoholism may lead to such signs as alcoholic neuropathy and ulcers on the feet. (Ansary/Custom Medical Stock Photo. Reproduced by permission.)

from the body to the CNS. When afferent nerve cell endings, called receptors, are stimulated, they release neurotransmitters. These neurotransmitters relay a signal to the brain, which interprets it and reacts by releasing other neurotransmitters.

Some of the neurotransmitters released by the brain are directed at the efferent division of the PNS. The efferent nerves control voluntary movements, such as moving the arms and legs; and involuntary movements, such as making the **heart pump blood**. The nerves controlling voluntary movements are called motor nerves, and the nerves controlling involuntary actions are referred to as autonomic nerves. The afferent and efferent divisions continually interact with one another.

Neuropathy

NERVE DAMAGE. When a patient suffers from a polyneuropathy, nerves of the PNS have been damaged. Nerve damage can arise from a number of causes, such as disease, physical injury, poisoning, or malnutrition. These agents may affect either afferent or efferent nerves. Depending upon the cause of damage, the nerve cell axon, its protective myelin sheath, or both may be injured or destroyed.

CLASSIFICATION. There are hundreds of polyneuropathies. Reflecting the scope of PNS activity, symptoms may involve sensory, motor, or autonomic functions. To aid in diagnosis and treatment, symptoms are classified into principal neuropathic syndromes, based on the type of affected nerves and how long symptoms have been developing. Acute development refers to symptoms that have appeared within days, and subacute refers to those that have evolved over a number of weeks. Early chronic symptoms are those that take from months to a

few years to develop, and late chronic symptoms are those that have been present for several years.

The classification system is composed of six principal neuropathic syndromes, which are subdivided into more specific categories. By narrowing the possible diagnoses in this way, specific medical tests can be used more efficiently and effectively. The six syndromes and a few associated causes are:

- Acute motor **paralysis** accompanied by variable problems with sensory and autonomic functions: Neuropathies associated with this syndrome are mainly accompanied by motor nerve problems, but the sensory and autonomic nerves may also be involved. Associated disorders include Guillain-Barré syndrome, diphtheritic polyneuropathy, and porphyritic neuropathy.
- Subacute sensorimotor paralysis: The term sensorimotor refers to neuropathies that are mainly characterized by sensory symptoms but also have a minor component of motor nerve problems. Poisoning with heavy metals (e.g., lead, mercury, and arsenic), chemicals, or drugs are linked to this syndrome. Diabetes, Lyme disease, and malnutrition are also possible causes.
- Chronic sensorimotor paralysis: Physical symptoms may resemble those in the above syndrome but the time frame for symptom development is prolonged. This syndrome encompasses neuropathies arising from cancers, diabetes, leprosy, inherited neurologic and metabolic disorders, and hypothyroidism.
- Neuropathy associated with mitochondrial diseases: Mitochondria are organelles (structures within cells) responsible for handling a cell's energy requirements. When mitochondria are damaged or destroyed, the cell's energy requirements are not met and it can die.
- Recurrent or relapsing polyneuropathy: This syndrome covers neuropathies that affect several nerves and may come and go, such as Guillain-Barré syndrome, porphyria, and chronic inflammatory demyelinating polyneuropathy.
- Mononeuropathy or plexopathy: Nerve damage associated with this syndrome is limited to a single nerve or a few closely associated nerves. Neuropathies related to physical injury to the nerve, such as **carpal tunnel syndrome** and **sciatica**, are included in this syndrome.

Causes and symptoms

Typical symptoms of neuropathy relate to the type of affected nerve. If a sensory nerve is damaged, common symptoms include numbness, tingling in the area, a prickling sensation, or pain. Pain associated with neuropathy can be quite intense and may be described as cut-

ting, stabbing, crushing, or burning. In some cases a normally nonpainful stimulus may be perceived as excruciating, or pain may be felt even in the absence of a stimulus. Damage to a motor nerve is usually indicated by weakness in the affected area. If the problem with the motor nerve has persisted, then atrophy (muscle wasting) or lack of muscle tone may be noticeable. Autonomic nerve damage is most noticeable when a patient stands upright and experiences such problems as light-headedness or changes in **blood pressure**. Other indicators of autonomic nerve damage are lack of sweat, tears, and saliva; constipation; urinary retention; and impotence. In some cases heart rhythm irregularities and respiratory problems may develop.

Symptoms may appear over days, weeks, months, or years. Their duration and the ultimate outcome of the neuropathy are linked to the cause of the nerve damage. Potential causes include diseases, physical injuries, poisoning, and malnutrition or alcohol abuse. In some cases neuropathy is not the primary disorder but a symptom of an underlying disease.

Disease

Diseases that cause polyneuropathies may be acquired or inherited; in some cases it is difficult to make the distinction. The diabetes-polyneuropathy link has been well established. A typical pattern of diabetes-associated neuropathic symptoms includes sensory effects that first begin in the feet. The associated pain or pins-and-needles, burning, crawling, or prickling sensations, form a typical “stocking” distribution in the feet and lower legs. Other diabetic neuropathies affect the autonomic nerves and have potentially fatal cardiovascular complications.

Several other metabolic diseases have a strong association with polyneuropathy. Uremia (**chronic kidney failure**) carries a 10%-90% risk of eventually developing neuropathy, and there may be an association between **liver** failure and polyneuropathy. Atherosclerosis (accumulation of **lipids** inside **blood vessels**) can impair blood supply to certain peripheral nerves. Without oxygen and nutrients the nerves slowly die. Mild polyneuropathy may develop in patients with hypothyroidism (low thyroid hormone levels). Individuals with acromegaly (abnormally enlarged skeletal extremities caused by an excess of growth hormone) may also develop mild polyneuropathy.

Neuropathy can also result from vasculitis, a group of disorders in which blood vessels are inflamed. When the blood vessels are inflamed or damaged, blood supply to the nerve can be affected, injuring the nerve.

Both viral and bacterial infections have been implicated in polyneuropathy. Leprosy is caused by the **bacterium** *M. leprae*, which directly attacks sensory nerves. Other bacterial illnesses may set the stage for an immune-mediated attack on the nerves. For example, one theory about Guillain-Barré syndrome involves complications following infection with *Campylobacter jejuni*, a bacterium commonly associated with **food poisoning**. This bacterium carries a protein that closely resembles components of myelin. The **immune system** launches an attack against the bacteria; but, according to the theory, the immune system confuses the myelin with the bacteria in some cases and attacks the myelin sheath as well. The underlying cause of neuropathy associated with Lyme disease is unknown; the bacteria may either precipitate an immune-mediated attack on the nerve or inflict damage directly.

Infection with certain **viruses** is associated with extremely painful sensory neuropathies. Shingles is an example of such a neuropathy. After a case of chickenpox the causative virus, varicella-zoster virus, becomes inactive or latent in sensory nerves. Years later the virus may be reactivated and, once reactivated, attacks and destroys axons. Infection with HIV is also associated with polyneuropathy, but the type of neuropathy that develops can vary. Some HIV-linked neuropathies are noted for myelin destruction rather than axonal degradation. Also, HIV infection is frequently accompanied by other infections, both bacterial and viral, that are associated with neuropathy.

Several types of polyneuropathies are associated with inherited disorders. These inherited disorders may primarily involve the nervous system, or the effects on the nervous system may be secondary to an inherited metabolic disorder. Inherited neuropathies fall into several of the principal syndromes because symptoms may be sensory, motor, or autonomic. The inheritance patterns also vary depending upon the specific disorder. The development of inherited disorders is typically prolonged over several years and may herald a degenerative condition—that is, a condition that becomes progressively worse over time. Even among specific disorders there may be a degree of variability in inheritance patterns and symptoms. For example, Charcot-Marie-Tooth disease is usually inherited as an autosomal dominant disorder; however, it can be autosomal recessive or, in rare cases, linked to the X chromosome. Its estimated frequency is approximately one in 2,500 people. Age of onset and sensory nerve involvement can vary between cases. The main symptom is a degeneration of the motor nerves in legs and arms with resultant muscle atrophy. Other inherited neuropathies have a distinctly metabolic component. For example, in familial amyloid polyneuropathies, pro-

tein components that make up the myelin are constructed and deposited incorrectly.

Physical injury

Accidental injuries during sports and recreational activities are common causes of polyneuropathy. The common types of injuries in these situations occur from placing too much pressure on the nerve, exceeding the nerve's capacity to stretch, blocking adequate blood supply of oxygen and nutrients to the nerve, and tearing the nerve. Pain may not always be immediately noticeable, and obvious signs of damage may take a while to develop.

These injuries usually affect one nerve or a group of closely associated nerves. For example, a common injury encountered in contact sports such as football is the "burner," or "stinger," syndrome. Typically, a stinger is caused by overstretching the main nerves that span from the neck into the arm. Immediate symptoms are numbness, tingling, and pain that travels down the arm, lasting only a minute or two. A single incident of a stinger is not dangerous, but recurrences can eventually cause permanent motor and sensory loss.

Poisoning

The poisons, or toxins, that cause polyneuropathy include drugs, industrial chemicals, and environmental toxins. Neuropathy that is caused by drugs usually involves sensory nerves on both sides of the body, particularly in the hands and feet; and pain is a common symptom. Neuropathy is a rare side effect of prescription medications. A few drugs that have been linked with polyneuropathy include metronidazole, an antibiotic; phenytoin, an anticonvulsant; and simvastatin, a cholesterol-lowering medication.

Certain industrial chemicals are neurotoxic (poisonous to nerves) following work-related exposures. Such chemicals as acrylamide, allyl chloride, and carbon disulfide have been strongly linked to development of polyneuropathy. Organic compounds, such as N-hexane and toluene, are also encountered in work-related settings, as well as in glue-sniffing and solvent abuse. Either route of exposure can produce severe sensorimotor neuropathy that develops rapidly.

Heavy metals are the third group of toxins that cause polyneuropathy. Lead, arsenic, thallium, and mercury usually are not toxic in their elemental form, but rather as components in organic or inorganic compounds. The types of metal-induced neuropathies vary widely. Arsenic poisoning may mimic Guillain-Barré syndrome; lead affects motor nerves more than sensory nerves; thallium produces painful sensorimotor neuropathy; and the effects of mercury are seen in both the CNS and PNS.

Malnutrition and alcohol abuse

Burning, stabbing pains and numbness in the feet, and sometimes in the hands, are distinguishing features of alcoholic neuropathy. The level of alcohol consumption associated with this variety of polyneuropathy has been estimated as approximately 3 liters of beer or 300 milliliters of liquor daily for three years. However, it is unclear whether alcohol alone is responsible for the neuropathic symptoms, because chronic alcoholism is strongly associated with malnutrition.

Malnutrition refers to an extreme lack of nutrients in the diet. It is unknown precisely which nutrient deficiencies cause polyneuropathies in alcoholics and famine and starvation victims, but it is suspected that the **B vitamins** have a significant role. For example, **thiamine** (vitamin B₁) deficiency is the cause of beriberi, a neuropathic disease characterized by **heart failure** and painful polyneuropathy of sensory nerves. **Vitamin E** deficiency seems to have a role in both CNS and PNS neuropathy.

Diagnosis

Clinical symptoms can indicate polyneuropathy, but an exact diagnosis requires a combination of medical history, medical tests, and possibly a process of exclusion. Certain symptoms may suggest a diagnosis, but more information is commonly needed. For example, painful, burning feet may be a symptom of alcohol abuse, diabetes, HIV infection, or an underlying malignant tumor, among other causes. Without further details effective treatment would be difficult.

During the history and **physical examination**, the physician obtains detailed information about the location, nature, and duration of symptoms to exclude some causes or even pinpoint the actual problem. The patient's medical history may also provide clues as to the cause, because certain diseases and medications are linked to specific polyneuropathies. A medical history should also include information about diseases that run in the family, because some polyneuropathies are genetically linked. Information about hobbies, recreational activities, alcohol consumption, and workplace activities can uncover possible injuries or exposures to poisonous substances.

The evaluation of a patient with polyneuropathy also includes laboratory tests, such as blood levels of glucose and creatinine, to detect diabetes and kidney problems, respectively. A **complete blood count** (CBC) is also done to determine levels of different blood cell types. **Iron, vitamin B₁₂, folic acid**, and other factors may be measured to rule out malnutrition. More specific tests, such as an assay for heavy metals or poisonous substances, or tests to detect vasculitis, are not typically per-

KEY TERMS

Afferent—Refers to peripheral nerves that transmit signals to the spinal cord and the brain. These nerves carry out sensory function.

Autonomic—Refers to peripheral nerves that carry signals from the brain and control such involuntary actions in the body as the beating of the heart.

Autosomal dominant or autosomal recessive—Refers to the inheritance pattern of a gene on a chromosome other than X or Y. Genes are inherited in pairs—one gene from each parent. However, the inheritance may not be equal, and one gene may overshadow the other in determining the final form of the encoded characteristic. The gene that overshadows the other is called the dominant gene; the overshadowed gene is the recessive one.

Axon—A long, threadlike projection that is part of a nerve cell.

Central nervous system (CNS)—The part of the nervous system that includes the brain and the spinal cord.

Efferent—Refers to peripheral nerves that carry signals away from the brain and spinal cord. These nerves carry out motor and autonomic functions.

Electromyography—A medical test that assesses nerve signals and muscle reactions. It can deter-

mine if there is a disorder with the nerve or if the muscle is not capable of responding.

Inheritance pattern—Refers to dominant or recessive inheritance.

Motor—Refers to peripheral nerves that control such voluntary movements as moving the arms and legs.

Myelin—The protective coating on axons.

Nerve biopsy—A medical test in which a small portion of a damaged nerve is surgically removed and examined under a microscope.

Nerve conduction—The speed and strength of a signal being transmitted by nerve cells. Testing these factors can reveal the nature of nerve injury, such as damage to nerve cells or to the protective myelin sheath.

Neurotransmitter—Chemicals within the nervous system that transmit information from or between nerve cells.

Peripheral nervous system (PNS)—Nerves that are outside of the brain and spinal cord.

Sensory—Refers to peripheral nerves that transmit information from the senses to the brain.

formed unless there is reason to suspect a particular cause. Routine and specialized blood tests are generally performed by a laboratory technologist.

An individual with neuropathy may be referred to a neurologist (physician specializing in nervous system disorders). By considering the results of the physical examination and observing information supplied by the referring primary care physician, the neurologist may be able to narrow down the possible diagnoses. Additional tests, such as nerve conduction studies and **electromyography**, which tests muscle reactions, can confirm that nerve damage has occurred and may also be able to indicate the nature of the damage. For example, if the neuropathy is caused by destruction of the myelin, damage is shown by slowed nerve conduction. If the axon itself has suffered damage, the nerve conduction may be slowed but will also be diminished in strength. Electromyography (performed by technologists often known as electromyographers or EMG technicians) adds further information by measuring nerve conduction and muscle response, which

determine whether the symptoms are due to a neuropathy or a muscle disorder.

In approximately 10% of polyneuropathy cases a nerve biopsy may be helpful. In this test the physician surgically removes a small part of the nerve for examination under a **microscope**. This procedure is usually performed to confirm a suspected diagnosis rather than as an initial diagnostic procedure.

Treatment

Treat the cause

Attacking the underlying cause of the neuropathy can prevent further nerve damage and may allow for better recovery. For example, in cases of such bacterial infections as leprosy or Lyme disease, **antibiotics** may be given to destroy the infectious bacteria. Viral infections are more difficult to treat because antibiotics are not effective against them. Neuropathies associated with drugs, chemicals, and toxins are treated in part by stop-

ping exposure to the damaging agent. Such chemicals as ethylenediaminetetraacetic acid (EDTA) are used to help the body concentrate and excrete some toxins. Diabetic neuropathies may be treated by gaining better control of blood sugar levels, but chronic kidney failure may require dialysis or even kidney transplant to prevent or reduce nerve damage. In some cases, such as compression injury or tumors, surgery may be considered to relieve pressure on a nerve.

In a crisis situation, as in the onset of Guillain-Barré syndrome, plasma exchange, intravenous immunoglobulin, and steroids may be prescribed. Intubation and mechanical ventilation may be required to support the **respiratory system**. Treatment may focus more on symptom management than on combating the underlying cause, at least until a definitive diagnosis has been made.

Supportive care and long-term therapy

Some polyneuropathies cannot be resolved; or may require considerable time for resolution. In these cases long-term monitoring and supportive care are necessary. Medical tests may be repeated to chart the progress of the neuropathy. If autonomic nerve involvement is a concern, regular monitoring of the **cardiovascular system** may be performed.

Because pain is associated with many neuropathies, **pain management** is an important aspect of treatment, especially if the pain becomes chronic. As in any chronic disease, narcotics are best avoided. Agents that may relieve neuropathic pain include amitriptyline, carbamazepine, and capsaicin cream. **Physical therapy** and physician-directed exercises can help maintain or improve function. When motor nerves are affected, braces and other supportive equipment can aid patients' ability to move about.

Prognosis

The outcome for polyneuropathy depends heavily upon the underlying cause. Polyneuropathy ranges from a reversible problem to a potentially fatal complication. In the best cases a damaged nerve regenerates. Though nerve cells cannot be replaced if they are killed, they are capable of recovering from damage. The extent of recovery depends upon the extent of the damage and the patient's age and general health status. Recovery can take weeks to years because **neurons** grow very slowly. Full recovery may not be possible, and it may not be possible to determine the prognosis at the outset.

If the neuropathy is a degenerative condition, such as Charcot-Marie-Tooth disease, then the patient's condition will worsen although there may be periods when the

disease seems to plateau. Cures have not yet been discovered for many degenerative diseases. For patients with incurable neuropathies, continued symptoms with a potential to worsening to disabilities, are to be expected.

A few polyneuropathies are eventually fatal. Fatalities from polyneuropathies have been associated with some cases of diphtheria, botulism, and other causes. Some diseases associated with neuropathy may also be fatal, but the ultimate cause of death is not necessarily related to the neuropathy—such as with **cancer**.

Health care team roles

The composition of the health care team treating patients with polyneuropathies will necessarily vary depending upon the underlying cause of the condition. For example, patients suffering from diabetes may be managed by physicians specializing in internal medicine and/or endocrinology. Cancer patients are often managed by oncologists, and patients with degenerative neurological disorders are treated by neurologists. Nearly all patients will also be cared for by laboratory technologists, radiological technologists, and nurses—the latter providing education about the disorder and management of the patient at home, and home safety assessments.

Patients requiring rehabilitation services may be seen by physiatrists (physician specialists in physical medicine), as well as physical and occupational therapists. Patients with diabetes and other metabolic or endocrine disorders also may receive counseling from registered dietitians and nutritionists to assist them to better manage these chronic diseases.

Prevention

Polyneuropathies are preventable only to the extent that the underlying causes are preventable. Primary prevention includes vaccines against diseases that cause neuropathy, such as polio and diphtheria. Timely treatment for physical injuries may help prevent permanent or worsening damage to nerves. Precautions when using certain chemicals and drugs are well advised in order to prevent exposure to neurotoxic agents. Control of such chronic diseases as diabetes may also reduce the risk of developing polyneuropathy.

Although not a preventive measure, genetic screening can serve as an early warning for potential problems. Genetic screening is available for some inherited conditions, but not all. In some cases presence of a particular gene does not necessarily mean the person will develop the disease because environmental and other components may be involved.

Resources

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- Humes, H. David, ed. *Kelley's Textbook of Internal Medicine*. Philadelphia: Lippincott Williams & Wilkins, 2000, 2764-2765.

ORGANIZATIONS

- American Diabetes Association. 1660 Duke St., Alexandria, VA 22314. (800) DIABETES. <<http://www.diabetes.org>>.
- Charcot-Marie-Tooth Association. Crozer Mills Enterprise Center. 601 Upland Ave., Upland, PA 19015. (800) 606-2682. <<http://www.charcot-marie-tooth.org>>.
- Guillain-Barré Syndrome Foundation International. P.O. Box 262, Wynnewood, PA 19096. (610) 667-0131. <<http://www.webmast.com/gbs>>.
- The Myelin Project. 1747 Pennsylvania Ave., NW, Ste. 950, Washington, DC 20006. (202) 452-8994. <<http://www.myelin.org>>.
- The Neuropathy Association. 60 E. 42nd St., Suite 942, New York, NY 10165. (800) 247-6968. <<http://www.neuropathy.org/association.html>>.

Barbara Wexler

Polysomnography

Definition

Polysomnography is a set of tests performed while a patient sleeps. It is done to diagnose and evaluate **sleep disorders**, and examines at a minimum **brain** wave patterns, the movements of both eyes, and the tone of at least one skeletal muscle.

Purpose

Polysomnography is used to diagnose and evaluate many types of sleeping disorders, including disorders of initiating or maintaining sleep (dissomnias) and disorders during sleep (parasomnias), including medical, psychiatric, and dental disorders that have symptoms during sleep. A relatively common dissomnia is sleep apnea, a disorder most prevalent in middle-aged and elderly obese men, in which the muscles of the soft palate in the back of the throat relax and close off the airway during sleep. Sleep apnea may cause the patient to snore loudly and gasp for air at night, and to be excessively sleepy and doze off during the day.

Another dissomnia often evaluated by polysomnography is narcolepsy. Narcoleptics suffer from excessive daytime sleepiness, sudden attacks of muscle weakness (cataplexy), and hallucinations at sleep onset. Some parasomnias that can be detected using polysomnography include disorders of arousal or rapid-eye-movement (REM) sleep problems, such as nightmares. Medical conditions including sleep-related **asthma**, depression, and panic disorder can be evaluated. Teeth-grinding (**bruxism**) or such neurological problems as restless leg syndrome show up during polysomnography. Finally, the tests can also be used to detect or evaluate seizures of sleep-related epilepsy that occur in the middle of the night, when the patient and his or her family are unlikely to be aware of them.

Precautions

Polysomnography is completely safe, and no special precautions need to be taken.

Description

Polysomnography is done during an overnight stay in a sleep laboratory. While the patient sleeps, a wide variety of tests can be performed.

One form of monitoring is **electroencephalography** (EEG), in which electrodes are attached to the patient's scalp in order to record his or her brain wave activity. The electroencephalograph records brain wave activity from different parts of the brain and charts them on a graph. The EEG not only helps doctors establish what stage of sleep the patient is in, but may also detect seizures. Standard tests have at least one central electrode attached to the scalp and one reference electrode attached to the ear. Other electrodes can be added in order to pinpoint the area of the brain where abnormal activity is occurring.

Another form of monitoring is continuous electrooculography (EOG), which records eye movement and is useful in determining when the patient is going through a stage of REM sleep. Both EEG and EOG can be helpful in determining sleep latency (the time that transpires between lights out and the onset of sleep); total sleep time; the time spent in each sleep stage; and the number of arousals from sleep.

The air flow through the patient's nose and mouth is measured by heat-sensitive devices called thermistors. This measurement can help detect episodes of apnea (stopped breathing), or hypopnea (inadequate breathing). Another test, called pulse oximetry, measures the amount of oxygen in the **blood** and can be used to assess the



A polysomnograph collects data on the electrical activity of the heart and brain, and muscle activity in the face and neck of a sleeping subject. (Photograph by Philippe Plailly. Science Source/Photo Researchers. Reproduced by permission.)

degree of oxygen starvation during episodes of hypopnea or apnea.

The electrical activity of the patient's **heart** is also measured using **electrocardiography** (ECG or EKG). Electrodes are affixed to the patient's chest and pick up electrical activity from various areas of the heart. They help detect cardiac arrhythmias (abnormal heart rhythms), which may occur during periods of sleep apnea. **Blood pressure** is also measured as episodes of sleep apnea sometimes dangerously elevate blood pressure.

A final standard measurement is the tone of at least one skeletal muscle, often a muscle of the chin (mentalis or submental). This is done using **electromyography** (EMG), which involves placing an electrode on the muscle to record its contractions. If normal, measurements will indicate the general atonia present during REM sleep. Other EMG channels can be placed, particularly on the leg (anterior tibialis), to indicate movement during sleep.

Depending on the suspected disorder, polysomnography can also include sound monitoring to record snor-

ing; video monitoring to document body positions; core body temperature readings; incident light intensities; penile swelling (tumescence); and pressure and pH at various levels of the esophagus.

One test that is often performed in conjunction with polysomnography is a Multiple Sleep Latency Test (MSLT). This test is also performed in a sleep laboratory and involves the recording of the sleep of several naps during the day after the overnight test. The MSLT is particularly important for a complete diagnosis of narcolepsy.

Preparation

Patient preparation is necessary to ensure that the night or nights in the sleep laboratory are as close as possible to an unmediated night in the patient's own home. Patients should bring suitable sleepwear and make sure their hair is clean and free from gels or sprays that may interfere with electrode functioning. They should be advised to maintain usual awake-sleep cycles and avoid sleeping pills, alcohol, stimulants, and strenuous **exercise** before the test.

Aftercare

Once the test is over, the monitors are detached from the patient. No special measures need to be taken after polysomnography.

Complications

The greatest limitations to polysomnography are the differences between the recording conditions and those that are present in the patient's home. The differences between the sleep laboratory and home have the highest effect on the first night of testing. Detection and elimination of this "first night effect" can be accomplished by the rather costly step of recording for multiple nights. Multiple night recordings are also sometimes necessary to obtain information about problems that appear only sporadically.

Results

Standard analysis still involves the tedious and time-consuming review and scoring of either paper tracings or recordings projected on a computer monitor. However, automatic computer-based systems are becoming more and more common in clinical and research settings.

Results are interpreted in light of recorded overnight parameters such as the times of lights on/off, total time in bed, and total sleep time. The overnight recording is divided into time periods of approximately 30 seconds. The standard EEG, EMG, and EOG recordings are evaluated, and the predominant stage of sleep, according to the manual of Rechtschaffen and Kales, is assigned to the entire time period.

These data are used to calculate total time and relative proportion of the night spent in each of the six stages of sleep, including REM and non-REM. Latencies to REM and slow-wave sleep (SWS) are also recorded.

Special note is made of such neurophysiologic events as epileptic events, intrusion of alpha-type brain waves into sleep, or periodic activity of the tibialis anterior. Respiratory activities, including apneic or hypopneic episodes and oxygen saturation, are correlated with sleep stages. Other parameters that are being measured, such as body position, gastroesophageal reflux, bruxism, and penile tumescence, are recorded.

If a sleep apnea syndrome is diagnosed, primarily through a demonstration of periodic breathing stoppage and effects on the pulse and heart, a trial of continuous positive airway pressure or a trial of an oral appliance may be undertaken, either in a partial-night or second-night polysomnography recording.

KEY TERMS

Cataplexy—A condition characterized by sudden loss of muscle tone brought on by emotions, often associated with narcolepsy.

Electrocardiography (ECG)—Recording of the electrical activity from various regions of the heart muscle.

Electroencephalography (EEG)—Recording of the electrical activity from various regions of the brain.

Electrooculography (EOG)—Recording of the electrical activity of the muscles that control eye movement.

Narcolepsy—A sleep disorder characterized by attacks of sleep, cataplexy, sleep paralysis, or hallucinations with the onset of sleep.

Sleep apnea—A sleep disorder characterized by lapses in breathing during sleep.

Sleep latency—The time it takes to fall asleep once the lights are out.

Health care team roles

Polysomnography is often performed by a specially trained technician called a polysomnographic technologist. Training programs for this position can involve one- to two-year programs in training as an electrodiagnostic technologist, with additional time for the polysomnography courses. Some typical courses in this area include:

- fundamentals of polysomnography
- sleep disorders
- infant and pediatric polysomnography
- polysomnography instrumentation
- polysomnography recording and monitoring
- polysomnography record scoring

Registration in polysomnography is available from the Board of Registered Polysomnography Technologists. The certification requires passing a written test.

Resources

BOOKS

- Misulis, Karl E. "Polysomnography Basics." In *Essentials of Clinical Neurophysiology*. Boston, MA: Butterworth-Heinemann, 1997.

PERIODICALS

Grandjean, Cynthia and Susanne Gibbons. "Assessing Ambulatory Geriatric Sleep Complaints." *The Nurse Practitioner* (September 2000).

ORGANIZATIONS

Association of Polysomnographic Technologists. PO Box 14861, Lexena, KS, 66285. (913) 541-1991 ext. 477. <<http://www.aptweb.org>>.

National Sleep Foundation. 1522 K St. NW, Suite 500, Washington, DC 20005. (202) 347-3471. <<http://www.sleepfoundation.org>>.

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Porphyrias

Definition

The porphyrias are a group of rare disorders that affect heme biosynthesis. Heme is an essential component of hemoglobin as well as of many enzymes throughout the body.

Description

Biosynthesis of heme is a multistep process that starts with simple molecules and ends with a large, complex heme molecule. Each step of the biosynthesis pathway is directed by its own enzyme (a task-specific protein). As a heme precursor molecule moves through each step, an enzyme modifies it in some way. If the precursor is not modified, it cannot proceed to the next step.

The main characteristic of the porphyrias is a defect in one of the enzymes of the heme biosynthesis pathway. The defect prevents protoporphyrins or porphyrin (heme precursors) from proceeding further along the pathway. Symptoms may be debilitating or life-threatening in some cases. Porphyria is an inherited condition, but it may be acquired after exposure to poisonous substances.

Heme

Heme is primarily synthesized in the **liver** and bone marrow. Heme synthesis for immature red **blood** cells, namely the erythroblasts and the reticulocytes, occurs in the bone marrow.

Although production is concentrated in the liver and bone marrow, heme is used in various capacities in virtually every tissue in the body. In most cells, it is a key building block in the construction of factors that oversee **metabolism** as well as transport of oxygen and energy. In immature red blood cells, heme is a featured component of hemoglobin. Hemoglobin is the red pigment that gives red blood cells the ability to transport oxygen as well as their characteristic color.

Heme biosynthesis

The heme molecule is composed of porphyrin and an **iron** atom. Much of the heme biosynthesis pathway is dedicated to constructing the porphyrin molecule. Porphyrin is a large molecule shaped like a four-leaf clover. An iron atom is placed at its center during the last step of heme biosynthesis.

The production of heme may be compared to a factory assembly line. The heme "assembly line" is an eight-step process, requiring eight different—and properly functioning—enzymes:

- step 1: delta-aminolevulinic acid synthase
- step 2: delta-aminolevulinic acid dehydratase
- step 3: porphobilogen deaminase
- step 4: uroporphyrinogen III cosynthase
- step 5: uroporphyrinogen decarboxylase
- step 6: coproporphyrinogen oxidase
- step 7: protoporphyrinogen oxidase
- step 8: ferrochelatase

The control of heme biosynthesis is complex. There are various chemical signals that can trigger increased or decreased production. These signals can affect the enzymes themselves or their production, starting at the genetic level.

Porphyrias

Under normal circumstances, when heme concentrations are at an appropriate level, precursor production decreases. However, a malfunction in the biosynthesis pathway—represented by a defective enzyme—means that heme biosynthesis does not reach completion. Because heme levels remain low, the synthesis pathway continues to churn out precursor molecules in an attempt to make up the deficit.

The net effect of this continued production is an abnormal accumulation of precursor molecules and development of some type of porphyria. Each type of porphyria corresponds to a specific enzyme defect and an accumulation of the associated precursor. Although there

are eight steps in heme biosynthesis, there are only seven types of porphyrias; a defect in ALA synthase activity does not have a corresponding porphyria.

The porphyrias are divided into two general categories, depending on the location of the deficient enzyme. Porphyrias that affect heme biosynthesis in the liver are called hepatic porphyrias. The porphyrias that affect heme biosynthesis in immature red blood cells are called erythropoietic porphyrias (erythropoiesis is the process through which red blood cells are produced).

Incidence of porphyria varies widely between types and occasionally by geographic location. Although certain porphyrias are more common than others, their greater frequency is only relative to other types; all porphyrias are considered rare disorders.

The hepatic porphyrias, and the heme biosynthesis steps at which enzyme defects occur, are:

- ALA dehydratase deficiency porphyria (step 2). This porphyria type is extraordinarily rare; only six cases have ever been reported in the medical literature. The inheritance pattern seems to be autosomal recessive, which means a defective enzyme gene must be inherited from both parents for the disorder to occur.
- Acute intermittent porphyria (step 3). Acute intermittent porphyria (AIP) is also known as Swedish porphyria, pyrraloporphyria, and intermittent acute porphyria. AIP is inherited as an autosomal dominant trait, which means only one copy of the defective gene needs to be present for the disorder to occur. However, simply inheriting this gene does not necessarily mean that a person will develop the disease. Approximately five to 10 per 100,000 persons in the United States carry the gene, but only 10% of carriers ever develop AIP symptoms.
- Porphyria cutanea tarda (step 5). Porphyria cutanea tarda (PCT) is also called symptomatic porphyria, porphyria cutanea symptomatica, and idiosyncratic porphyria. PCT may be acquired, typically as a result of disease (especially hepatitis C), drug or alcohol abuse, or exposure to certain poisons. PCT may also be inherited as an autosomal dominant disorder, but most people with the inherited form remain latent—that is, symptoms never develop. It is the most common of the porphyrias, but the incidence is not well defined.
- Hereditary coproporphyrinemia (step 6). Hereditary coproporphyrinemia (HCP) is inherited in an autosomal dominant manner. As with all porphyrias, it is an uncommon ailment. By 1977, only 111 cases were recorded; in Denmark, the estimated incidence is two in 1 million people.

- Variegate porphyria (step 7). Variegate porphyria (VP) is also known as porphyria variegata, protocoproporphyrinemia, South African genetic porphyria, and royal malady (supposedly King George III of England and Mary, Queen of Scots, suffered from VP). VP is inherited in an autosomal dominant manner and is especially prominent in South Africans of Dutch descent. Among that population, the incidence is approximately three in 1,000 persons, and it is estimated that there are 10,000 cases of VP in South Africa. Interestingly, it seems that the affected South Africans are descendants of two Dutch settlers who came to South Africa in 1680. Elsewhere, the incidence is estimated to be one to two cases per 100,000 persons.

The erythropoietic porphyrias, and the steps of heme biosynthesis at which they occur, are:

- Congenital erythropoietic porphyria (step 4). Congenital erythropoietic porphyria (CEP) is also called Günther's disease, erythropoietic porphyria, congenital porphyria, congenital hematoporphyria, and erythropoietic uroporphyrinemia. CEP is inherited in an autosomal recessive manner and occurs very rarely. Onset of symptoms usually occurs in infancy, but may be delayed until adulthood.
- Erythropoietic protoporphyria (step 8). Also known as protoporphyria and erythrohepatic protoporphyria, erythropoietic protoporphyria (EPP) is more common than CEP; more than 300 cases have been reported. In these cases, the onset of symptoms typically occurred in childhood.

In addition to the above types of porphyria, there is a very rare type, called hepatoerythropoietic porphyria (HEP), that affects heme biosynthesis in both the liver and the bone marrow. HEP results from a defect in uroporphyrinogen decarboxylase activity (step 5), but strongly resembles congenital erythropoietic porphyria. Only 20 cases of HEP have been reported worldwide; it seems to be inherited in an autosomal recessive manner.

Causes and symptoms

General characteristics

The underlying cause of all porphyrias is a defective enzyme somewhere along the heme biosynthesis pathway. In virtually all cases, the defective enzyme is a genetically linked factor. Therefore, porphyrias are inheritable conditions. However, an environmental trigger—such as diet, drugs, or sun exposure—may be necessary before any symptoms develop. In many cases, symptoms do not develop, and individuals may be completely unaware that they have a gene for porphyria.

KEY TERMS

Autosomal dominant—An inheritance pattern in which a trait is determined by one gene in a pair (genes are inherited in pairs; one copy from each parent).

Autosomal recessive—An inheritance pattern in which a trait is expressed only if both genes in a pair code for that particular characteristic (genes are inherited in pairs; one copy from each parent).

Enzyme—A protein molecule that catalyzes a chemical reaction.

Erythropoiesis—The process through which new red blood cells are created; it begins in the bone marrow.

Erythropoietic—Referring to the creation of new red blood cells.

Gene—A portion of DNA (deoxyribonucleic acid) that codes for a specific product, such as an enzyme.

Hematin—A drug that is administered intravenously to halt an acute porphyria attack. It inhibits heme biosynthesis, preventing the further accumulation of heme precursors.

Heme—A large complex molecule contained in hemoglobin and a number of important enzymes throughout the body. Through these factors, it plays a vital role in metabolism and oxygen and energy transport. Heme is composed of porphyrin and an iron atom.

Hemoglobin—A molecule composed of heme and protein that enables red blood cells to transport oxygen throughout the body. Hemoglobin gives red blood cells their characteristic color.

Hepatic—Referring to the liver.

Neuropathy—A condition characterized by nerve damage. Major symptoms can include weakness, numbness, paralysis, or pain in the affected area.

Porphyrin—A large molecule shaped somewhat like a four-leaf clover. Combined with an iron atom, it forms a heme molecule.

Protoporphyrin—A precursor molecule to the porphyrin molecule.

All of the hepatic porphyrias—except porphyria cutanea tarda—follow a pattern of acute attacks interspersed with periods of complete symptom remission.

For this reason, they are often referred to as the acute porphyrias. The erythropoietic porphyrias and porphyria cutanea tarda do not follow the same pattern and are considered chronic conditions.

The specific symptoms of each porphyria depend on the affected enzyme and whether it occurs in the liver or in the bone marrow. The severity of symptoms can vary widely, even within the same porphyria type. When the porphyria becomes symptomatic, the common factor between all types is an abnormal accumulation of protoporphyrins or porphyrin.

ALA dehydratase porphyria (ADP)

ADP is characterized by a deficiency of ALA dehydratase. Of the few cases on record, the prominent symptoms were vomiting; **pain** in the abdomen, arms, and legs; and neuropathy. (Neuropathy refers to nerve damage that can cause pain, numbness, or paralysis.) As a result of neuropathy, the arms and legs may be weak or paralyzed and breathing can be impaired.

Acute intermittent porphyria (AIP)

AIP is caused by a deficiency in porphobilogen deaminase, but symptoms usually do not occur unless an individual with the deficiency encounters a biological trigger. Triggers can include hormones (for example oral contraceptives, menstruation, **pregnancy**), drugs, and dietary factors. However, most people with the deficiency never develop symptoms.

Attacks occur after **puberty** and commonly feature severe abdominal pain, nausea and vomiting, and constipation. Muscle weakness and pain in the back, arms, and legs are also typical symptoms. During an attack, the urine takes on a deep reddish color. The **central nervous system** may also be involved, as demonstrated by hallucinations, confusion, seizures, and mood changes.

Congenital erythropoietic porphyria (CEP)

CEP arises from a deficiency in uroporphyrinogen III cosynthase. Symptoms are often apparent in infancy and include reddish urine and possibly an enlarged spleen. The skin is unusually sensitive to light and blisters easily if exposed to sunlight. (Sunlight induces changes in protoporphyrins in the plasma and skin. These altered molecules can damage the skin.) Increased hair growth is common. Damage from recurrent blistering and associated skin infections can be severe; in some cases facial features and fingers are lost to recurrent damage and **infection**. Deposits of protoporphyrins sometimes occur in the teeth and bones.

Porphyria cutanea tarda (PCT)

PCT is caused by deficient uroporphyrinogen decarboxylase; it may be an acquired or inherited condition. The acquired form usually does not appear until adulthood. The inherited form may appear in childhood, but often demonstrates no symptoms. Early symptoms include blistering on the hands, face, and arms following minor injuries or exposure to sunlight. Lightening or darkening of the skin may occur along with increased hair growth or loss of hair. Liver function is abnormal but the signs are mild.

Hepatoerythropoietic porphyria (HEP)

HEP is linked to a deficiency of uroporphyrinogen decarboxylase in both the liver and the bone marrow. The symptoms resemble those of CEP.

Hereditary coproporphyria (HCP)

HCP is similar to AIP, but the symptoms are typically milder; the disorder is caused by a deficiency in coproporphyrinogen oxidase. The greatest difference between HCP and AIP is that people with HCP may have some skin sensitivity to sunlight. However, extensive damage to the skin is rarely seen.

Variegate porphyria (VP)

VP is caused by deficient protoporphyrinogen oxidase, and, like AIP, symptoms only occur during attacks. Major symptoms of this type of porphyria involve neurologic problems and sensitivity to light. Areas of the skin that are exposed to sunlight are susceptible to burning, blistering, and scarring.

Erythropoietic protoporphyria (EPP)

Owing to deficient ferrochelatase, the last step in the heme biosynthesis pathway—the insertion of an iron atom into a porphyrin molecule—cannot be completed. The major symptoms of this disorder are related to sensitivity to light—including both artificial and natural light sources. Following exposure to light, a patient with EPP experiences burning, itching, swelling, and reddening of the skin. Blistering and scarring may occur but are neither common nor severe. EPP may result in the formation of gallstones as well as liver complications. Symptoms can appear in childhood and tend to be more severe during the summer when exposure to sunlight is more likely.

Diagnosis

Depending on the array of symptoms presented, the possibility of porphyria may not immediately come to the

physician's mind. In the absence of a family history of porphyria, some symptoms of porphyria, such as abdominal pain and vomiting, may be attributed to other disorders. Neurological symptoms, including confusion and hallucinations, may lead to an initial suspicion of psychiatric illness rather than a physical disorder. Diagnosis may be aided in cases in which these symptoms appear in combination with neuropathy, sensitivity to sunlight, or other factors. Certain symptoms, such as urine the color of port wine, are hallmarks of porphyria.

A common initial test measures protoporphyrins in the urine. However, if skin sensitivity to light is a symptom, a blood plasma test is indicated. If these tests reveal abnormal levels of protoporphyrins, further tests are performed to measure heme precursor levels in the stool and in red blood cells. The presence and estimated quantity of porphyrin and protoporphyrins are easily detected in biological samples using spectrofluorometric testing. This procedure involves the use of a laboratory instrument called a spectrofluorometer, which directs light of a specific strength at a fluid sample. Certain molecules in the sample—such as heme precursors—absorb the light energy and fluoresce. When molecules fluoresce, they emit light at a different strength from the absorbed light. The fluorescence can be detected and quantified by the spectrofluorometer. Not all molecules fluoresce, but among those that do, the intensity and quality of the fluorescence is an identifying characteristic. Diagnostic laboratory work, including analysis of blood, urine and stool samples is performed by laboratory technologists.

Heme precursors in the blood, urine, or stool give some indication of the type of porphyria, but more detailed biochemical testing is required to determine their exact identity. Making this determination yields a strong indicator of which enzyme in the heme biosynthesis pathway is defective, which in turn allows a diagnosis of the particular type of porphyria.

Biochemical tests rely on the color, chemical properties, and other unique features of each heme precursor. For example, a screening test for acute intermittent porphyria (AIP) is the Watson-Schwartz test. In this test, a special dye is added to a urine sample. If one of two heme precursors—porphobilinogen or urobilinogen—is present, the sample turns pink or red. Further testing is necessary to determine whether the precursor is porphobilinogen or urobilinogen—only porphobilinogen is indicative of AIP.

Other biochemical tests rely on the fact that heme precursors become less water-soluble (able to be dissolved in water) as they progress further through the heme biosynthesis pathway. For example, to determine

whether the Watson-Schwartz urine test is positive for porphobilinogen or urobilinogen, a measure of chloroform is added to the test tube. Chloroform is a water-insoluble substance, and even after vigorous mixing, the water and chloroform separate into two distinct layers. Whether the chloroform layer or the water layer becomes pink indicates which heme precursor is present. Porphobilinogen tends to be water-soluble, and urobilinogen is slightly water-insoluble. Since like mixes with like, porphobilinogen mixes more readily in the water than chloroform; therefore, if the water layer is pink, an AIP diagnosis is probable.

As a final test, measuring specific enzymes and their activities may be done for some types of porphyrias; however, such tests are not done for screening purposes. Certain enzymes, such as porphobilinogen deaminase (the defective enzyme in AIP), can be easily extracted from red blood cells; however, other enzymes are less readily collected or tested. Basically, an enzyme test involves adding a measure of the enzyme to a test tube containing the precursor it is supposed to modify. Both the production of modified precursor and the rate at which it appears are measured in the laboratory. If a modified precursor is produced, the test indicates that the enzyme is doing its job. The rate at which the modified precursor is produced can be compared to a standard to measure the enzyme's efficiency.

Treatment

Treatment for porphyria revolves around avoiding acute attacks, limiting potential effects, and treating symptoms. However, treatment options vary depending on the type of porphyria that has been diagnosed. Given the rarity of ALA dehydratase porphyria (six reported cases), definitive treatment guidelines have not been developed.

Acute intermittent porphyria, hereditary coproporphyria, and variegata porphyria

Treatment for acute intermittent porphyria, hereditary coproporphyria, and variegata porphyria follows the same basic regime. A patient diagnosed with one of these porphyrias can prevent most attacks by avoiding precipitating factors, such as certain drugs that have been identified as triggers for acute porphyria attacks. Individuals must maintain adequate **nutrition**, particularly in respect to **carbohydrates**. In some cases, an attack can be stopped by increasing carbohydrate consumption or by receiving carbohydrates intravenously.

When an attack occurs, medical attention is needed. Pain is usually severe, and narcotic **analgesics** are the best option for relief. Phenothiazines can be used to

counter nausea, vomiting, and **anxiety**; and chloral hydrate or diazepam is useful for sedation or to induce sleep. Intravenously administered hematin may be used to curtail an attack. This drug seems to work by signaling the heme biosynthesis pathway to slow production of precursors. Women, who tend to develop symptoms more frequently than men in response to hormonal fluctuations, may find hormone therapy that inhibits ovulation to be helpful.

Congenital erythropoietic porphyria

The key points of congenital erythropoietic porphyria treatment are avoiding exposure to sunlight, and preventing trauma to, and infections of the skin. Liberal use of sunscreens and taking beta-carotene supplements can provide some protection from sun-induced damage. Such medical treatments as removing the spleen or administering red blood cell transfusions can have short-term benefits, but do not offer a cure. Oral doses of activated charcoal may offer the potential of remission.

Porphyria cutanea tarda

As with other porphyrias, the first line of defense is the avoidance of precipitating factors, especially alcohol. Regular blood withdrawal is a proven therapy for pushing symptoms into remission. For patients who are anemic or cannot have blood drawn for other reasons, chloroquine therapy may be used.

Erythropoietic protoporphyria

Avoiding sunlight, using sunscreens, and taking beta-carotene supplements are typical treatment options for erythropoietic protoporphyria. The drug cholestyramine may reduce the skin's sensitivity to sunlight as well as the accumulated heme precursors in the liver. Liver transplantation has been used in cases of liver failure, but it has not effected a long-term cure of the porphyria.

Prognosis

Even in the presence of a genetic inheritance for a porphyria, symptom development depends on a variety of factors. In the majority of cases, an individual remains asymptomatic throughout life. Porphyria symptoms are rarely fatal with proper medical treatment, but they may be associated with temporarily debilitating or permanently disfiguring consequences. Measures to avoid these consequences are not always successful, regardless of how diligently they are pursued. Although pregnancy has

been known to trigger porphyria attacks, it is not as great a danger as was once thought.

Health care team roles

Patients diagnosed with porphyrias are cared for by an interdisciplinary treatment team that may include primary care physicians, hematologists, and dermatologists. Laboratory technologists are involved during the diagnostic process; and nurses, health educators and genetic counselors provide instruction about how to recognize triggers and prevent attacks or flares of the condition.

Prevention

For the most part, the porphyrias are attributable to inherited genes; such an inheritance cannot be prevented. However, symptoms can be prevented or limited by avoiding factors that trigger development.

When there is a family history of porphyria, individuals should consider testing to determine whether they carry the associated gene. Even if symptoms are absent, it is useful to know about the presence of the gene to assess the risks of developing the associated porphyria. This knowledge also reveals whether the individual's offspring may be at risk. Theoretically, it is possible to perform prenatal tests. However, these tests would not indicate whether the child would develop porphyria symptoms; only that they might have the genetic predisposition to develop symptoms.

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American Porphyria Foundation. P.O. Box 22712, Houston, TX 77227. (713) 266-9617.
<<http://www.enterprise.net/apf/>>.

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Portable defibrillators see **Defibrillators, portable**

Positron emission tomography (PET)

Definition

Positron emission tomography (PET) is a non-invasive scanning technique that utilizes small amounts of radioactive positrons (positively charged particles) to visualize body function and **metabolism**.

Purpose

As of 2001, PET is the fastest growing nuclear medicine tool in terms of increasing acceptance and applications. It is useful in the diagnosis, staging, and treatment of **cancer** because it provides information that cannot be obtained by other techniques like computed tomography (CT) and **magnetic resonance imaging (MRI)**.

PET scans can be performed at medical centers equipped with a small cyclotron. Smaller cyclotrons and increasing availability of certain radiopharmaceuticals are making PET a more widely used imaging modality.

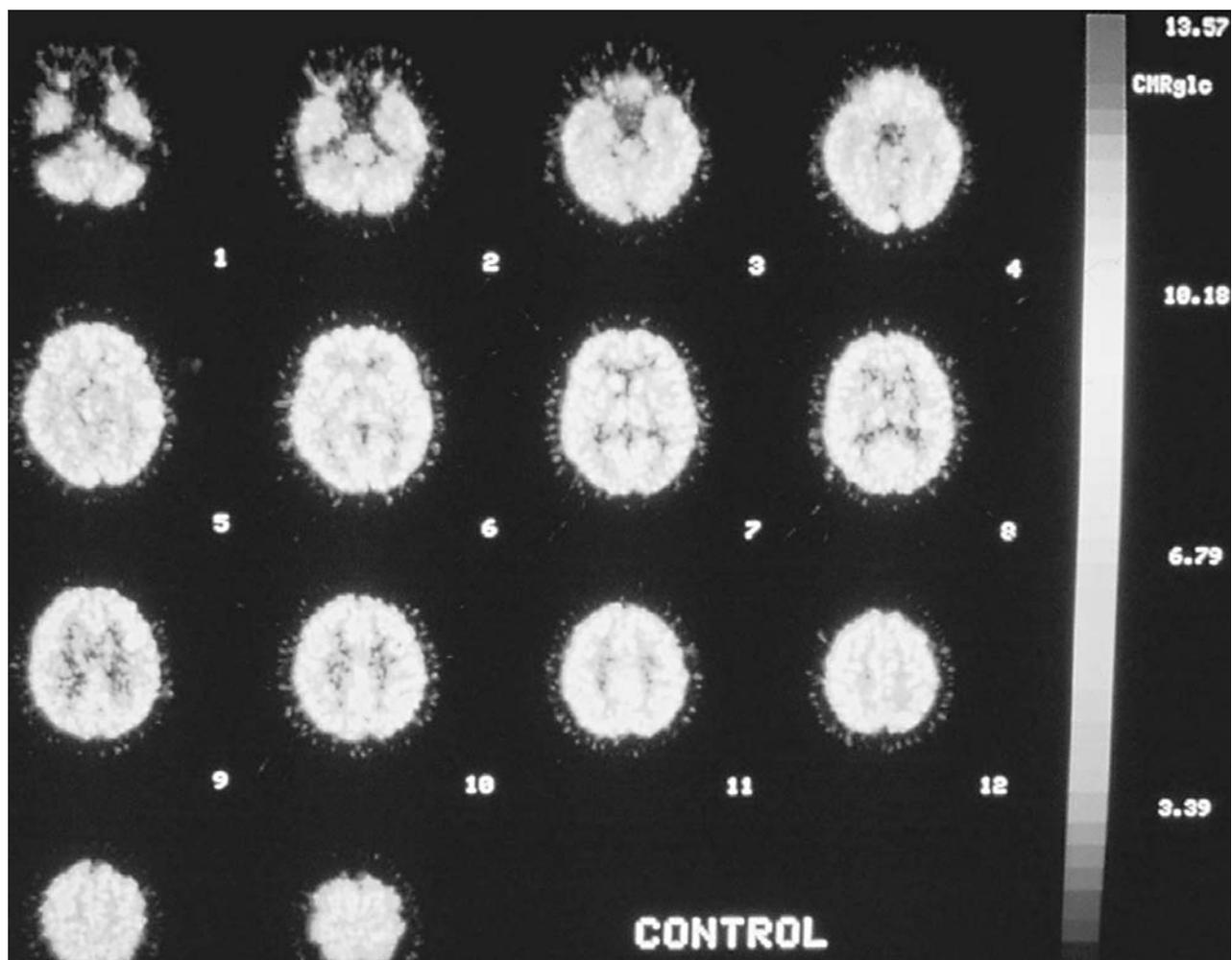
Physicians first used PET to obtain information about **brain** function and to study brain activity in various neurological diseases and disorders, including stroke, epilepsy, **Alzheimer's disease**, **Parkinson's disease**, and Huntington's disease; and in such psychiatric disorders as **schizophrenia**, depression, obsessive-compulsive disorder, attention-deficit/hyperactivity disorder, and Tourette syndrome. More and more, PET is being used to evaluate patients for head and neck, lymphoma, melanoma, lung, colorectal, and esophageal cancers. PET also is used to evaluate **heart** muscle function in patients with **coronary artery disease** or cardiomyopathy.

Precautions

There is always a slight risk when radioactive material is injected into the body. However, because the radioactive tracers used are short-lived and clear the body quickly, they are considered safe. The radiation dose received is only slightly more than that received in a **chest x ray**. Still, pregnant women should not have a PET scan.

Description

PET involves injecting a patient with a radiopharmaceutical similar to glucose. An hour after injection of this tracer, a PET scanner images a specific metabolic function by measuring the concentration and distribution of the tracer throughout the body.



Position emission tomography (PET) scan control study. (Photograph by Jon Meyer. Custom Medical Stock Photo. Reproduced by permission.)

When it enters the body, the tracer courses through the bloodstream to the target organ, where it emits positrons. The positively charged positrons collide with negatively charged electrons and gamma rays are produced. The gamma rays are detected by photomultiplier-scintillator combinations positioned on opposite sides of the patient. These signals are then processed by the computer and images are generated.

PET provides an advantage over CT and MRI because it can determine if a lesion is malignant. The two other modalities provide images of anatomical structures but often cannot provide a determination of malignancy. Recently, PET has been used in combination with CT and MRI to identify abnormalities with more precision and indicate areas of most active metabolism. This additional

information allows for more accurate evaluation of cancer treatment and management.

Health care team roles

Personnel for a PET facility should include a physicist for technical support, calibration, and software; a physician for medical interventions and reading; and administrative staff for scheduling, paperwork, and billing. A trained technologist performs the PET scans. A positron emission tomography technologist performs PET procedures on clinical and research subjects referred for neurologic, oncologic, cardiac, or other conditions. The technologist also ensures appropriate patient care, acquires data, and performs analysis according to protocols. A technologist needs training in nuclear medicine. State licensure is required as a nuclear medicine technologist.

KEY TERMS

Electron—One of the small particles that make up an atom. An electron has the same mass and amount of charge as a positron, but the electron has a negative charge.

Gamma ray—A high-energy photon emitted by radioactive substances.

Half-life—The time required for half of the atoms in a radioactive substance to disintegrate.

Photon—A light particle.

Positron—One of the small particles that make up an atom. A positron has the same mass and amount of charge as an electron, but the positron has a positive charge.

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Dan Harvey

Positron emission tomography (PET) unit

Definition

The **positron emission tomography (PET)** unit is a device used to produce images of the body that reflect biochemical changes taking place in the body. Among the body imaging technologies used in medicine, the PET unit is characterized by its use of positron-emitting tracer substances. Because of its use of short-lived positron-emitting tracers, the PET unit can provide images of biochemical processes. This feature of PET technology distinguishes it from computer tomography (CT) and **magnetic resonance imaging (MRI)** technologies, which can provide only images of the structure of the body.

Purpose

The purpose of the PET unit is to provide images reflecting biochemical changes occurring within the body. The PET unit can also, when used in conjunction with mathematical models of organ systems, quantify biochemical activity (e.g. **blood** flow, metabolic activity in tissue).

Because the PET unit can provide information on biochemical function, it is particularly helpful in assessing tissue viability and biological processes related to tissue health. The PET unit is used for these purposes most often in the fields of neurology (study of the **brain**), cardiology (study of the **heart**), and oncology (**cancer**).

In neurology, the PET unit is used to diagnose and differentiate among different types of epilepsy, **dementia**, and cerebrovascular disease. Because the regions of the brain that are affected by these abnormalities have blood flow and glucose utilization patterns that are different from healthy parts of the brain, the PET unit can—by using tracers that follow cerebral blood flow, glucose pathways, and oxygen metabolism—identify areas of the brain that are affected. During epileptic seizures, blood flow and glucose use increase in the area of the epileptogenic focus (site originating the seizure). PET scans are used to identify these foci in patients with drug-resistant epilepsy so that surgical intervention can target these

seizure-prone areas. In dementia, the PET unit is used to distinguish **Alzheimer's disease** from other types of dementia, because each type of dementia has a characteristic glucose utilization pattern in the brain. The PET unit is also used to evaluate and monitor treatments for stroke patients by measuring cerebral blood flow, glucose **metabolism**, and oxygen levels.

In cardiology, the PET unit is used to assess the metabolism and function of myocardial tissue. Blood flow and fatty acid metabolism are measured by the PET unit, and areas that are affected by **coronary artery disease** are easily identified. The state of the myocardial tissue, as reflected in the PET scan, also helps the cardiologist determine the best intervention, e.g. an angiogram rather than a heart bypass.

In oncology, the PET unit has had a long history of being used for the diagnosis and localization of brain tumors. Because tumors have greater blood flow directed to them than normal brain cells, the PET scan can identify where the tumor is localized by pinpointing the area with abnormally high blood flow. More broadly, the PET unit can be used in many parts of the body to grade the severity of tumors and identify metastatic processes. Moreover, because PET identifies variations in metabolic activity, the scans are particularly useful in assessing the effectiveness of radiological treatment of cancer; unlike other types of imaging, PET scans can distinguish between (non-viable) scar tissue caused by the radiological treatment of tumors, and viable tumor cells that might have been missed by the treatment.

Description

Standard components

The components of the PET unit are best understood in the context of the procedures required for positron emission tomography.

The first step in the PET process is the creation of the radioisotope (radioactive version of a chemical element) that is to be used in the tracer compound. The creation of the radioisotope takes place in a device called the cyclotron. The cyclotron is a particle accelerator that speeds up a particle so quickly that it strips electrons from the particle. In most PET units, the particle used is hydrogen, and the resulting stripped particle is a proton (represented as H⁺). A beam of protons created in this way is then used to bombard a stable isotope (non-radioactive version of a chemical element). The bombardment of the stable version of a chemical element with H⁺ produces a radioactive version of the element.

The most common radionuclides created by a PET cyclotron are C-11 (carbon), N-13 (nitrogen), O-15 (oxy-

gen), and F-18 (flourine). These elements are popular because many of the compounds in the human body are based on these elements or on analogs of these elements, so that a biochemical compound that the body naturally uses can be created from these radionuclides. Note that, because these positron-emitting radionuclides decay in a short amount of time (depending on the element, 2-110 minutes), the radionuclide must be produced by a cyclotron within a short distance from the location of the other PET procedures.

Once the radionuclide is generated by the cyclotron, it enters the biosynthesizer unit, where it is used to create radioactive biochemical compounds. Examples of compounds synthesized are 15-C (to measure blood volume), 13-N-glutamine (to measure myocardial metabolism), 15-O₂ (to measure oxygen metabolism), and 18-F-deoxyglucose (to measure glucose metabolism).

The patient is then injected with or inhales the radioactive labeled tracer and is positioned in the gantry of the PET scanner. The scanner consists of a ring of detectors designed to find the location of and quantify the photon emissions from positron-electron reactions. Note that although the decaying radioactive compounds emit positrons, the positrons do not leave the body. Instead, the positrons emitted by the compounds go a short distance within the body before colliding with electrons. In the annihilation reaction that results from this positron-electron collision, high-energy photons are released; and it is these photons that pass through the body and are detected by the PET scanner. The two released photons, in an annihilation reaction, go in exactly opposite directions (180 degrees from each other), so that the PET scanner is able to reconstruct the three-dimensional spatial distribution of the compound by reconstructing the paths of photons and pinpointing the reaction site.

Since the photons released are not detectable visually, the detector ring in the scanner uses scintillation compounds (compounds that detect the photon flashes from the reaction) that convert the detected photon energy into visible forms. The scanner then uses sophisticated mathematical programs to construct coherent PET images from the visible data. When quantitative information is needed, a tracer kinetic model (mathematical model of tracer behavior) is used in conjunction with the PET data to quantify metabolic and functional processes.

The PET scanner is controlled by a computer monitor that allows for entry of text and commands. The images are previewed on an image monitor, which can be separate from or on the same screen as the control monitor. Because clinicians are often reluctant to diagnose using solely the image monitor, many PET systems allow for the conversion of these images to sheet film that can

then be viewed on a standard lightbox. Many systems also have an archival system that saves image data for future retrieval.

Variations of equipment

Because PET facilities differ in their imaging needs and financial resources, there may be variations in the features of cyclotrons and scanners among facilities. For radiotracer production, two different systems are often seen—the remote semiautomated system and the remote automated system. The remote semiautomated system allows the operator to determine the order and timing of the reactions and visually monitor the radionuclide synthesis. The semiautomated system is less expensive than the automated system, and is popular in research settings that do not have a standard set of radiotracers to be routinely produced. In clinical settings, where there is a regular flow of patients, the more costly automated system is used because automated synthesis requires less personnel time and production time, and there is less variation in the radionuclides required.

Cyclotrons are available as “Proton Only” devices or “Dual Particle” devices. Although “Proton Only” machines are cheaper, they restrict the chemical synthesis options through which particular radionuclides can be produced. Large quantities of O-15 used for brain research, for example, would be infeasible with “Proton Only” machines because of the prohibitive costs of the source materials required to synthesize O-15 with this type of machine. In general, institutions that have both clinical and research groups using the PET unit (and thus a broad range of radionuclide needs) use “Dual Particle” devices.

Some cyclotrons have what is called dual irradiation capacity, which allows them to produce two different radioisotopes at the same time. These cyclotrons can also, if both ion beams are used to produce the same type of radioisotope, produce large amounts of a single isotope. Dual irradiation cyclotrons are more expensive than single irradiation cyclotrons and are generally found in institutions with both clinical and research demands.

Although many PET scanners are single-ring scanners, multiple-ring scanners are emerging at advanced research and clinical institutions. These multiple-ring scanners allow for the simultaneous imaging of contiguous cross-sections. These types of scanners allow for faster scanning and more dynamic visualization of body processes.

Settings

Because of the high cost of the PET devices, the PET unit is used primarily in research institutions and

advanced clinical (tertiary care) settings. In 1992, Michel Ter-Pergossian, a prominent researcher in PET technology, noted that there were 50-80 PET centers internationally.

Operation

Partly because of radiation safety regulations strictly governing the use and disposal of radioactive materials, radiotracer production and cyclotron operation is mostly automated. The nuclear medicine technologist, typically through a menu-driven computer control unit, designates the specific radiotracer to be synthesized and selects the chemical processes desired. Because the cyclotron is shielded, either in a protected room with concrete walls or behind a shield accompanying the cyclotron unit, the technologist is exposed to very little radiation.

After the radiotracer is produced, quality control (QC) testing is conducted daily. The technologist transfers the materials (in a lead container) from the biosynthesizer unit to the radiochemistry area for QC testing. The compounds are tested for radiochemical purity, radionuclidic purity, correct pH, and sterility. As the pharmacist performs the spectrometry and chromatography tests, he or she stands behind lead shielding. A monitor in the QC testing area indicates the level of radiation exposure in the area to allow the pharmacist to gauge his/her exposure. Staff periodically check their gloves for radioactive contamination; and contaminated items (such as gloves, shoe covers, and syringes) are immediately placed in protected radioactive waste containers.

The scanner operator brings the patient to the scanning room and aligns the patient in a relatively immobile position on the gantry. In the radiochemistry room, he or she or another technologist measures the appropriate patient dose for the radiotracer, and the radiotracer is placed into a Lucite-shielded syringe. The syringe is placed in a lead container, and the technologist carries the lead container to the scanning room, where he or she administers the radiotracer to the patient.

In the control room—an attached room with a window through which the patient can be viewed throughout the entire scan—the technologist controls the scanning and image processing at the control computer. He or she selects the appropriate scanning procedure for the area of interest and enters parameters related to image processing. When all parameters have been verified and entered, the technologist enters the commands to execute the scan. Depending on the nature of the question that the scan seeks to answer, the scan may take 10-90 minutes. The technologist assesses the quality of the images, and should be able to identify artifacts from problems arising in the PET detector or image processor. If the PET

KEY TERMS

Annihilation reaction—Reaction between electron and positron in which both are destroyed and each particle's mass is converted into photon energy.

Electron—Negatively charged particle of an atom.

Gantry—Frame in which patient is placed, over which the PET scanner moves.

Photon—High-energy light waves.

Positron—Negatively charged electrons, often symbolized as H⁺.

Proton—Positively charged particle of an atom.

Radionuclide—A radioactive element.

Radiotracer—A tracer compound with a radioactive element.

Tracer—Substance that can be followed through the course of a biochemical process.

images are acceptable, they are stored for the physician or researcher to review at a later date.

Health care team roles

A typical team directly involved with using the PET unit consists of a radiochemist, a pharmacist, two nuclear medicine technologists (a scanner operator and a cyclotron operator), and a medical physicist. The radiochemist oversees the radiochemistry facility and supervises all radiotracer production. He or she is the primary cyclotron operator. The pharmacist performs quality control on the radiotracers. He or she can also operate the cyclotron and administer radiotracers to patients. Both nuclear medicine technologists assist in preparing patients for the PET scan. In addition, the scanner operator and cyclotron operator perform quality control on their respective devices. The medical physicist is the radiation safety officer of the facility. He or she ensures that the facility meets the legal safety requirements for dealing with radioactive materials, and makes sure that personnel are properly trained and monitored.

Nurses and nuclear medicine radiologists are also involved with the PET process. Nurses prepare the patients for the PET scan, monitor patients through the process, and may take blood samples as needed. Nuclear medicine radiologists are the physicians reviewing and interpreting the PET images in the course of patient work-up.

Training

Nuclear medicine technologists, researchers, and physicians who will be using the PET computer stations typically take a week-long course, offered by the makers of the PET unit, to learn how to operate the control computers. Technologists also require a more advanced course in the physics and instrumentation of PET; in radiation safety; and in quality control during image processing. Clinicians who interpret the scans require nuclear medicine training through fellowships or continuing education.

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Genevieve Pham-Kanter

Post-traumatic stress disorder

Definition

Post-traumatic **stress** disorder (PTSD) is primarily caused by human reactions to events outside the realm of ordinary life experience. Domestic and criminal violence, natural disasters, and transportation accidents are major categories of incidents associated with PTSD. Once thought to be experienced primarily by war veterans, PTSD is now known to occur in survivors of sexual, physical or emotional abuse, and in persons who have witnessed a traumatic event.

PTSD may result from long-term experiences of trauma as well as from time-limited violent events. It is now recognized that repeated traumas or such traumas of long duration as **child abuse**, domestic violence, stalking, cult membership, and hostage situations may also produce the symptoms of PTSD in survivors.

Description

After a traumatic event, the person who suffered the trauma, as well as others who witnessed it or were

involved as emergency workers, may experience a range of symptoms. These may include physical **pain**; change in bowel function, such as **diarrhea** and/or constipation; change in sleep patterns, such as sleeping more or less than before the trauma; **heart** palpitations, sweating, being easily startled or becoming hypervigilant; becoming increasingly susceptible to illness.

As the individual struggles to cope with life after the event, ordinary events or situations that resemble the trauma in certain respects often trigger frightening, vivid memories or flashbacks. For example, one survivor of a plane crash would have flashbacks of the crash whenever he smelled something burning. A Vietnam veteran would have flashbacks whenever he heard a car backfire.

Causes and symptoms

Causes

While it is not clear why some people develop PTSD following a trauma and others do not, experts suspect that it may be influenced both by the severity of the event, by the person's personality and genetic make-up, and by whether or not the trauma was expected. In addition, occupational factors play a role; persons who work as fire fighters, police officers, emergency room staff, or in similar high-risk occupations have a higher rate of PTSD than the general population. Lastly, the nature of the trauma itself is a factor; as a rule, traumas resulting from intentional human behavior (rape, torture, genocide, domestic violence, etc.) are experienced as more stressful than traumas resulting from accidents, natural disasters, or animal attacks.

Symptoms

The *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV), specifies six diagnostic criteria for PTSD:

- **Traumatic stressor:** The patient has been exposed to a catastrophic event involving actual or threatened death or injury, or a threat to the physical integrity of the self or others. During exposure to the trauma, the person's emotional response was marked by intense fear, feelings of helplessness, or horror.
- **Intrusive symptoms:** The patient experiences flashbacks, traumatic daydreams, or nightmares, in which he or she relives the trauma as if it were recurring in the present. Intrusive symptoms result from an abnormal process of **memory** formation.
- **Avoidant symptoms:** The patient attempts to reduce the possibility of exposure to anything that might trigger memories of the trauma, and to minimize his or her reactions to such memories. This cluster of symptoms

includes dissociative symptoms (derealization and depersonalization), psychic numbing, and avoidance of places, persons, or things associated with the trauma. Patients with PTSD are at increased risk of substance abuse as a form of self-medication to numb painful memories.

- **Hyperarousal:** Hyperarousal is a condition in which the patient's nervous system is always on "red alert" for the return of danger. This symptom cluster includes hypervigilance, insomnia, difficulty concentrating, general irritability, and an extreme startle response.
- **Duration of symptoms:** The symptoms must persist for at least one month.
- **Significance:** The patient suffers from significant social, interpersonal, or work-related problems as a result of the PTSD symptoms. A common social symptom of PTSD is a feeling of disconnection from other people (including loved ones); from the larger society; and from God or other sources of meaning.

The symptoms of PTSD usually begin within three months of the trauma, although sometimes PTSD does not develop until years after the initial trauma occurred. Once the symptoms begin, they may fade away again within six months. Others suffer with the symptoms for far longer; and in some cases, the problem may become chronic.

PTSD in children

PTSD in children may trigger the onset of learning disabilities, self-mutilation or other destructive behaviors, sleep terrors, and a variety of conduct disorders. Children may also develop abnormally close attachments to their primary caretakers or other dependency behaviors in their attempts to cope with the traumatic experience.

Treatment

A diagnosis of PTSD does not indicate personal weakness or mental illness. It is a perfectly natural and normal reaction to one or more abnormal events. Just like a perfectly healthy bone will break if placed under enough stress, a perfectly healthy person placed under sufficient stress can develop PTSD.

It is important to understand that not every person who experiences a traumatic event will experience PTSD. There is some evidence that an approach known as critical incident stress debriefing, or CISD, may lower the incidence of PTSD in survivors of a large-scale civilian disaster or war zone trauma. CISD should be offered to survivors within 48 hours of the traumatic event. In general, persons who are experiencing some of the symp-

KEY TERMS

Benzodiazepines—A class of drugs that have a hypnotic and sedative action, used mainly as tranquilizers to control symptoms of anxiety.

Cognitive-behavioral therapy—A type of psychotherapy used to treat anxiety disorders (including PTSD) that emphasizes behavioral change as well as alteration of negative thought patterns.

Dissociation—The splitting off of certain mental processes from conscious awareness. Many PTSD patients have dissociative symptoms.

Flashback—An abnormally vivid, often recurrent, recollection of a traumatic event.

Hyperarousal—A condition of abnormally intense nervous excitement. Some symptoms of PTSD are classified as symptoms of hyperarousal.

Hypervigilance—A condition of abnormally intense watchfulness or wariness. Hypervigilance is one of the most common symptoms of PTSD.

Selective serotonin reuptake inhibitors (SSRIs)—A class of antidepressants that work by blocking the reabsorption of serotonin in the brain, raising the levels of serotonin. SSRIs include Prozac, Zoloft, and Paxil.

toms of PTSD should consult a mental health professional. He or she will diagnose the condition if the symptoms of stress last for more than a month after a traumatic event. While a formal diagnosis of PTSD is made only in the wake of a severe trauma, it is possible to have a mild PTSD-like reaction following less severe stress.

Medication

The most helpful treatment of PTSD appears to be a combination of medication along with supportive and cognitive-behavioral therapies. Effective medications include anxiety-reducing medications and antidepressants, especially the selective serotonin reuptake inhibitors (SSRIs) such as fluoxetine (Prozac). Sleep problems can be lessened with brief treatment with an anti-anxiety drug, such as a benzodiazepine like alprazolam (Xanax), but long-term usage can lead to such disturbing side effects as increased anger.

Psychotherapy

Therapy can help reduce negative thought patterns and self-talk, in that many PTSD patients blame them-

selves for the traumatic event, their reactions to it, or both. Cognitive-behavioral therapy focuses on changing specific actions and thoughts with the help of **relaxation** training and breathing techniques. Group therapy with other PTSD sufferers and family therapy can also be helpful.

Alternative and complementary approaches

Patients diagnosed with PTSD may benefit from such complementary approaches as **meditation** and mindfulness training, which appear to be useful in reducing the number of flashbacks. **Yoga**, bodywork, and **massage therapy** help to reduce the muscle soreness and tension associated with PTSD. Lastly, some patients find martial arts training useful in restoring a sense of personal competence and safety.

Prognosis

The severity of PTSD depends in part on the predictability of the trauma; its severity; its duration and chronicity; the role of human intention in inflicting the trauma; and the patient's personality style, overall state of health, and genetic predisposition.

With appropriate medication, emotional support, and counseling, most people show significant improvement. On the other hand, prolonged exposure to severe trauma—such as experienced by victims of prolonged physical or sexual abuse and survivors of the Holocaust—may cause permanent psychological scars.

Health care team roles

It is essential for all treatment team members to know their roles and execute them properly throughout the treatment and recovery phases of this disorder. Depending on whether outpatient or inpatient treatment is being provided, the team leaders may include psychiatrists, psychologists, nursing staff, behavior specialists and other medical/behavioral staff. In some cases it may be appropriate to include the patient's religious or spiritual advisor as a member of the team, in that increasing numbers of clergy have taken advanced training in trauma therapy.

Regular meetings are important so that all persons involved can provide input. Family members involved in patient care should be reaffirmed as to their need to provide consistency and adherence to the plan of care. Psychological evaluations will provide a base for the rest of the team to compose and/or update the treatment plan.

During treatment planning phases, needs and strengths are assessed, as well as progress from prior

plans. The treatment team leader, normally a behavior specialist, a psychologist or a psychiatrist, will then compose a plan of care that will describe goals for the next phase of care, interventions and other information needed to initiate or continue care.

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- National Alliance for the Mentally Ill. 2101 Wilson Blvd. No. 302, Arlington, VA 22201. (703) 524-7600.
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Jacqueline N. Martin, M.S.

Postmortem care

Definition

Postmortem care is the care provided to a patient immediately after death.

Purpose

Postmortem care serves several purposes, including:

- preparing the patient for viewing by family
- ensuring proper identification of the patient prior to transportation to the morgue or funeral home
- providing appropriate disposition of patient's belongings
- maintaining vital organs, if donation is planned

Precautions

Government regulations at both state and federal level require hospitals to establish policies and procedures to certify death; to identify potential donors; and to care for a body after death. If organ donation is anticipated, respiratory and circulatory support must be maintained until vital organs can be harvested. It must be clearly communicated to the family that the devices used to maintain organ perfusion no longer keep the patient alive, but are merely supporting the organs in anticipation of transplant.

Vital organs requiring support are:

- heart
- liver
- lungs
- kidneys
- pancreas

KEY TERMS

Algor mortis—Reduction of body temperature with loss of skin elasticity.

Livor mortis—Discoloration of skin in dependent areas.

Rigor mortis—Stiffening of the body, developing within two to four hours of death.

Such non-vital tissues as the cornea, skin, long bones, and middle ear bones do not require support after death.

If the patient had an infectious disease, the body must be labeled in accordance with established policy.

Before rigor mortis develops, the nurse should position the body in a normal alignment and close the eyelids and mouth, inserting dentures if necessary. Because of the reduction in body temperature and loss of skin tone (algor mortis) after death, it is important to gently remove all tape and dressings to prevent tissue damage. The skin or body parts should never be pulled on. The head of the bed should be elevated to prevent purplish discoloration (livor mortis) of the face. The body must be stored in a cool place to slow bacterial formation after death.

Description

Equipment

A commercial morgue pack, if available, will contain gauze or string ties, chin straps, a shroud, and three identification tags. In addition to these items, the nurse should gather the following:

- gloves
- ABD pads
- cotton balls
- adhesive bandages to cover **wounds** or punctures
- plastic bag for belongings
- bath basin with water
- soap
- towels
- washcloths
- clean sheets
- stretcher or morgue cart

Preparation

Before placing the body in a supine position with arms at sides and head on a pillow, the nurse should put on clean gloves. The head of the bed should be slightly elevated. At this time, the nurse can insert the patient's dentures, if worn, and then close the mouth. By placing a fingertip on each eye, the nurse should gently close the patient's eyes. If the eyes will not remain closed, moistened cotton balls can be placed on the eyelids for several minutes, and then a repeated attempt to close the eyes can be made. A folded towel should be placed under the chin to keep the mouth closed. All catheters, tubes, and tape can be removed, but adhesive bandages should be applied to puncture sites.

At the time of death, the patient's survivors become the focus of concern, and the nurse must then be able to offer comfort and support to the living. All the patient's belongings can be gathered for the family to take. If a ring cannot be removed, the nurse can cover the ring with gauze, tape it securely, and tie the gauze to the wrist to prevent loss.

Before the family views the patient, the body is cleansed, using soap, water, and washcloths. To absorb any rectal drainage, one or more ABD pads is placed between the buttocks. The body is covered up to the chin in a clean sheet, with the arms placed outside of the sheet if possible. Then the room must be prepared for receiving the family and friends by removing all trash and providing lower light in the room. If there are unpleasant odors present in the room, a room deodorizer can be used before allowing the family to return.

The nurse can then offer family members the opportunity to view the body, but not force them, letting them know that either viewing or not viewing is acceptable. This is the time to ask family members if they prefer that any jewelry be left on the body. The nurse should clearly document whether personal items are remaining with the body, or to whom the items were given. The nurse can allow survivors privacy in viewing the body, but not leave them alone until it is ascertained that they are comfortable remaining with the body. The nurse can encourage the family to touch and talk as a way to say goodbye to the deceased.

When the family has left, the towel can be removed from under the chin, placing an ABD pad under the chin and wrapping chin straps under the chin, with the straps tied loosely on top of the head. Padding the wrists with an ABD pad prevents bruising, and then the nurse ties the wrists together with gauze or soft string ties; the ankles should be padded and tied in the same manner. It will be necessary to fill out three identification tags with the deceased's name, room and bed number; date and time of

death; and the physician's name. One tag will be tied to the big toe, hand, or foot. Another identification tag must be attached to the shrouded body, and the third identification tag attached to the personal belongings. The nurse must ensure that the patient's identification bracelet is not removed.

Aftercare

A family member should take all the patient's personal belongings. The body will be transported to the morgue or funeral home.

Complications

If organ donation is planned, failure to maintain support for vital organs will mean that organs cannot be harvested.

Results

The patient's family will have the opportunity to view the body, if they wish, in order to begin the grief process. Emotional support of the survivors will be provided by trained staff members.

Health care team roles

Physicians must certify the death. If the death occurred in unusual circumstances, an **autopsy** may be requested. Staff members, pastoral care, or other personnel should remain with the family during preparation of the patient's body for viewing. Nursing is responsible for coordination of all postmortem care. Trained staff members will provide information to the family regarding organ donation.

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Postoperative care

Definition

Postoperative care is the management of a patient after surgery. This includes care given during the immediate postoperative period, both in the operating room and the postanesthesia care unit (PACU), as well as during the days following the surgery.

Purpose

The goal of postoperative care is to prevent such complications as **infection**, to promote healing of the surgical incision, and to return the patient to a state of health.

Precautions

Thorough postoperative care is crucial to ensuring positive outcomes for patients who have had surgery. There are no contraindications to providing this care. However, skill and careful monitoring are needed to prevent complications and to restore the patient to health as soon as possible.

Description

Postoperative care involves assessment, diagnosis, planning, intervention and outcome evaluation. The extent of postoperative care required by each patient depends on the original health status of the patient, type of surgery, and whether the surgery was performed in a day-surgery setting or in the hospital. Patients who have procedures done in a day-surgery center usually require only a few hours of care by health care professionals before they are discharged to go home. If postanesthesia or postoperative complications occur within these hours, the patient must be admitted to the hospital. Patients who are admitted to the hospital may require days or weeks of postoperative care by hospital staff before they are discharged.

Postanesthesia care unit (PACU)

After the surgical procedure, and anesthesia reversal and extubation if necessary, the patient is transferred to the PACU. The length of time the patient spends there depends on the length of surgery; the type of surgery; the status of regional anesthesia (for example, spinal anesthesia); and the patient's level of consciousness. Rather than being sent to the PACU, some patients may be transferred directly to the critical care unit instead. For example, patients who have had coronary artery bypass grafting (CABG) are sent directly to the critical care unit.

In the PACU, the anesthesiologist or the **nurse anesthetist** reports on the patient's condition; the type of surgery performed; the type of anesthesia given; estimated **blood** loss; and total input and output during the surgery. The receiving nurse should also be made aware of any complications during the surgery, including any variations in hemodynamic stability.

Assessment of the patient's airway patency, **vital signs**, and level of consciousness are the first priorities upon admission to the PACU. The following is a list of other assessment categories:

- surgical site (check that dressings are intact and there are no signs of overt bleeding)
- patency of drainage tubes/drains
- body temperature (hypothermia/hyperthermia)
- patency/rate of IV fluids
- circulation/sensation in extremities after vascular or orthopedic surgery
- level of sensation after regional anesthesia
- **pain** status
- nausea/vomiting

The patient is discharged from the PACU when they meet established criteria for discharge, as determined by use of a scale. An example is the Aldrete scale, which scores the patient on mobility, respiratory status, circulation, consciousness, and pulse oximetry. Depending on the type of surgery and the patient's condition, the patient may be admitted to either a general surgical floor or the intensive care unit. Since the patient may still be sedated from anesthesia, safety is a primary goal. The patient's call light should be in their hand and all side rails should be up. Patients in a day-surgery setting are either discharged from the PACU to the unit to their home, or are directly discharged home after they have voided, ambulated, and tolerated a small amount of oral intake.

First 24 hours

After the hospitalized patient transfers from the PACU, the receiving nurse should assess the patient again, using the same previously mentioned categories. If the patient reports "hearing" or feeling pain during surgery (under anesthesia) the observation should not be discounted. The anesthesiologist or nurse anesthetist should discuss the possibility of an episode of awareness under anesthesia with the patient. Vital signs, respiratory status, pain status, the incision, and any drainage tubes should be monitored every one to two hours for at least the first eight hours. Body temperature must be monitored, since patients are often hypothermic after surgery and may need a warming blanket or warmed IV fluids. Respiratory status should be assessed frequently, including auscultation of lung sounds, assessment of chest excursion, and presence of adequate cough. Fluid intake and urine output should be monitored every one to two hours. If the patient doesn't have a urinary catheter, the bladder should be assessed for distension and the patient monitored for inability to void. If they have not voided six to eight hours after surgery, the physician should be notified. If the patient had a vascular or neurological procedure performed, circulatory status or neurological status should be assessed as ordered by the surgeon, usually every one to two hours. The patient may require medication for nausea and/or vomiting, as well as for pain.

Patients with a patient-controlled analgesia (PCA) pump may need to be reminded how to use it. If the patient is too sedated immediately after the surgery, the nurse may push the button to deliver pain medication for them. The patient should be asked to rate their pain on a pain scale in order to determine their acceptable level of pain. Every attempt should be made by the nurse to keep the patient's pain under control. This often means that the nurse must offer pain medication every hour or two—many times before the patient requests it. Controlling pain is crucial so that the patient may perform coughing, deep breathing exercises, may be able to turn in bed, sit up, and, eventually, ambulate.

Effective preoperative teaching has a positive impact on the first 24 hours postoperatively. If patients understand that they must perform respiratory exercises to prevent **pneumonia**; and that movement is imperative for preventing blood clots, encouraging circulation to the extremities, and keeping the **lungs** clear; then they will be much more likely to perform these tasks. Understanding the need for movement and respiratory exercises also underscores the importance of keeping pain under control. Respiratory exercises (coughing, deep breathing and incentive spirometry) should be done

every two hours. The patient should be turned every two hours, and should at least be sitting on the edge of the bed by eight hours after surgery, unless contraindicated (for example, post-hip replacement). These patients will have sequential compression devices on their legs until they are able to ambulate. The sequential compression devices are stockings that inflate with air in order to simulate the effect of walking on the calf muscles and return blood to the **heart**. The patient should be encouraged to splint chest and abdominal incisions with a pillow to decrease the pain caused by coughing and moving. Patients should be kept NPO (nothing by mouth) if ordered by the surgeon, at least until their cough and gag **reflexes** have returned. Patients often have a dry mouth following surgery, which can be relieved with oral sponges dipped in ice water or by applying lemon ginger in mouth swabs.

Patients who are discharged home after a day-surgery procedure are given prescriptions for their pain medications and are responsible for their own pain control and respiratory exercises. Their families (or caregivers) should be included in preoperative teaching so that a caregiver can assist the patient at home. The patient should be reminded to call their physician if they have any complications or uncontrolled pain. These patients are often managed at home on a follow-up basis by a hospital-connected visiting nurse or **home care** service.

After 24 hours

After the initial 24 hours, vital signs can be monitored every four to eight hours if the patient is stable. The incision and dressing should be monitored for the amount of drainage and signs of infection; the surgeon may order the dressing to be changed during the first postoperative day. Postoperative dressing changes should be done using sterile technique. For home-care patients this technique must be emphasized. The hospitalized patient should be sitting up in a chair at the bedside and ambulating with assistance by this time period. Respiratory exercises should continue to be performed every two hours and incentive spirometry values should improve. Bowel sounds should be monitored and the patient's diet gradually increased as tolerated, depending on the type of surgery and the physician's orders.

The patient should be monitored for any evidence of potential complication, such as leg **edema**, redness, and pain (deep vein thrombosis); shortness of breath (pulmonary embolism); dehiscence (separation) of the incision; or ileus. If any of these occur, the surgeon should be notified immediately. If dehiscence occurs, sterile saline-soaked dressing packs should be placed on the wound. The patient and the family should be updated on the eval-

KEY TERMS

Deep vein thrombosis (DVT)—Potentially life-threatening blood clot in one of the deep veins of the body, and often in the legs secondary to immobility after surgery. Symptoms include pain, warmth, swelling, and redness.

Dehiscence—Separation of a surgical incision or rupture of a wound closure.

Ileus—Obstruction in or immobility of the intestines. Symptoms include nausea and vomiting, absent bowel sounds, abdominal pain, and abdominal distension.

Incentive spirometer—Device that is used postoperatively to prevent lung collapse and promote maximum inspiration. The patient inhales until a preset volume is reached, then sustains the volume by holding their breath for three to five seconds.

PACU—The post-anesthesia care unit, where the patient is cared for after surgery.

Patient-controlled analgesia pump (PCA pump)—A pump which the patient uses to self-administer medication to control pain.

Pulmonary embolism (PE)—Potentially life-threatening blockage of a pulmonary artery by fat, air, or a blood clot that originated elsewhere in the body. Symptoms include acute shortness of breath and sudden chest pain.

uation of the patient, the patient's condition, and any teaching as often as necessary.

Preparation

Postoperative care involves many procedures and teaching topics. Preparation for procedures includes having all needed supplies at the bedside. Pain medication should be offered prior to any procedure that is likely to cause discomfort. Preparation for teaching includes having resources available. Many hospitals have **patient education** materials such as handouts and video tapes that can be used to assist in teaching the patient what to expect during the postoperative time period.

Aftercare

Aftercare includes ensuring that patients are comfortable, either in bed or in a chair, and that they have their call lights accessible. After dressing changes, blood-

soaked dressings should be properly disposed of in a bio-hazard container. Again, pain medication should be offered before any procedure that might cause discomfort. After teaching a patient, or the caregiver, aftercare includes answering all of their questions; and, in some cases, having them demonstrate the techniques they will be using.

Complications

Postoperative care is indicated for all patients who have had an invasive procedure, regardless how minor. However, improper care can lead to complications. For example, changing a surgical dressing without sterile technique can lead to infection. Failure to monitor a patient closely, or failing to assist them with respiratory exercises and ambulation, can lead to pneumonia or deep vein thrombosis, and potentially pulmonary embolus. Patients who have not had thorough teaching on what to expect may resist attempts to assist them, leading to complications and anger on the part of the patient or family.

Results

The goal of postoperative care is to ensure that patients have good outcomes after surgical procedures. A good outcome includes recovery without complications and adequate **pain management**. Another objective of postoperative care is to assist patients in taking responsibility for regaining good health.

Health care team roles

Almost every member of the health care team has a role in postoperative care. The surgeon performs the surgery and manages the patient's postoperative care. The patient's primary care doctor often helps manage the care of hospitalized patients as well. Nurses are at the bedside 24 hours a day, so they monitor the patient for complications; assist the patient with respiratory exercises and regaining mobility; provide postoperative teaching; and generally care for the patient. Respiratory therapists also provide instruction and assistance with respiratory exercises, and monitor the patient's respiratory status. Radiology personnel take x-rays that are ordered by the physician, and laboratory personnel draw blood samples and perform blood tests. All team members must communicate with one another and with the patient to provide the best possible postoperative care.

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Postpartum care

Definition

Postpartum care encompasses management of the mother, newborn, and infant during the postpartal period. This period usually is considered to be the first few days after delivery, but technically it includes the six-week period after **childbirth** up to the mother's postpartum checkup with her health care provider.

Purpose

Immediately following childbirth, a new mother experiences profound physical and emotional changes. She may stay in the hospital or birthing center a very short time, even as little as 24–48 hours after delivery. The physical and emotional care a woman receives during the postpartum period can influence her for the remainder of her life.

Precautions

During the postpartum period the mother is at risk for such problems as **infection**, hemorrhage, pregnancy-induced **hypertension**, **blood** clot formation, the opening up of incisions, breast problems, and **postpartum depression**.

Description

Postpartum care in the hospital

The initial phase of the postpartum period encompasses the first one to two hours after delivery. It takes place most often in the birthing room or in a recovery

room. Once this initial phase is over, the woman has passed through the most dangerous part of childbirth. Assessments of **pain**, the condition of the uterus, vaginal discharge, the condition of the perineum, and the presence/absence of bladder distension (followed by appropriate interventions) are part of the initial postpartum evaluation; and should be done every 15 minutes for the first hour, then generally every 30 minutes for the second hour, and every four to eight hours thereafter depending on facility policy.

PAIN/DISCOMFORT. The degree of pain and discomfort from incisions, lacerations, and uterine cramping (afterbirth pains) is assessed by hospital staff. The woman may also complain of muscle pain after a prolonged labor. If the level of pain warrants it, analgesic medications are given, usually orally. Women who have undergone cesarean births may have more pain than women who have given birth vaginally, and may need injectable **analgesics**. If a woman complains of pain in her calf, she should be evaluated for thrombophlebitis. Also, if a woman complains of a headache, her **blood pressure** should be checked to rule out the presence of pregnancy-induced hypertension. A woman who received epidural anesthesia during delivery may develop a “spinal headache.” A spinal headache is due to the loss of cerebrospinal fluid from the subarachnoid space that may occur during the administration of the spinal anesthesia. Spinal headaches should be treated by the anesthesiologist or nurse-anesthetist. Treatment for this type of headache typically includes keeping the patient flat in bed, encouraging increased fluid intake, and administering pain medication.

Breast engorgement is characterized by low-grade **fever** and the absence of systemic symptoms. It is usually bilateral; the breasts feel warm to the touch and appear shiny. Pain from breast engorgement can be minimized for the breastfeeding mother by mild analgesics, the application of warm packs, and frequent nursing. For the mother who is not breastfeeding, this pain can be minimized by mild analgesics and the application of cold packs. A nursing mother may find that the use of a lanolin-based preparation or a nipple shield (although controversial) provides relief for sore or cracked nipples. Changing positions for the nursing baby also can help in reducing irritation and minimizing stress on sore spots.

A plugged duct can also cause breast pain. Breast pain caused by a plugged duct is distinguished from breast engorgement by the fact that it is usually confined to one breast and the breast is not warm to the touch. This pain may be relieved by heat packs, gentle massage of the breast toward the nipple, and changing positions for nursing the baby.

FUNDUS. The condition of the uterus is assessed by evaluating the height and consistency of the fundus (the part of the uterus that can be palpated abdominally). Immediately after delivery, uterine contractions begin triggering involution. Involution is the process whereby the uterus and other reproductive organs return to their state prior to **pregnancy**. To properly palpate the uterus, the woman is positioned flat on her back (supine). The health care provider places one hand at the base of the uterus above the symphysis pubis (the interpubic joint of the pelvis) in a cupping manner (to support the lower uterine ligaments). Then, she presses in and downward with the other hand at the umbilicus until she makes contact with a hard, globular mass. If the uterus is not firm, light massaging usually results in tightening. Massaging of the uterus should not be so vigorous as to cause the mother pain. A mother who has had a cesarean delivery should be medicated, if possible, prior to assessment of the fundus; and the health care provider should use the minimal amount of pressure necessary to locate her fundus. The height of the fundus after the first hour following delivery is at the umbilicus or above it. Every day the fundal height decreases by approximately the width of one finger (one cm).

The fundal height may be palpated off of midline because of a distended bladder. If possible, the woman should be encouraged to empty her bladder prior to assessment of the fundus. A full bladder can prevent uterine involution.

A woman sometimes receives the medication oxytocin (Pitocin) after the delivery of the placenta. Oxytocin causes the uterus to contract and can decrease the amount of postpartum bleeding. The health care provider should assess the condition of the uterus frequently, and may need to massage the uterus gently to encourage its clamping down on itself, especially when oxytocin has not been given. If the uterus does not firm to gentle massage, then a clot may be present inside. Gentle pressure on the uterus following massage, and while simultaneously supporting the base of the uterus, may expel the clot.

If massaging the uterus does not result in a firming of the fundus, then the physician or nurse-midwife should be contacted immediately. The existence of severe atony or a retained fragment of placenta may result in excessive loss of blood.

VAGINAL DISCHARGE (LOCHIA). The color and amount of vaginal discharge (lochia) is assessed by frequently removing the perineal pad and checking the flow of lochia after delivery. An excessive amount could be a sign of a complication such as clot formation or a retained portion of the placenta. The vaginal discharge is

red for one to three days following delivery and is called *lochia rubra*. Between days two and 10, the discharge changes to a pink or brownish color and is called *lochia serosa*. The last phase occurs when the vaginal discharge turns white. This vaginal discharge is referred to as *lochia alba* and may occur from 10–14 days postpartum. The spotting can continue for another six weeks. It is common in mothers who breastfeed their babies. A constant trickling of blood or the soaking through of a perineal pad in an hour or less is not normal and should be further evaluated.

PERINEUM. The condition of the perineal area is assessed for an episiotomy or laceration repair. An episiotomy is the surgical procedure whereby the physician or nurse-midwife extends the vaginal outlet immediately prior to delivery of the baby. The incision is repaired with sutures after delivery.

Generally an episiotomy will be 1–2 inches (2.5–5 cm) in length. By 24 hours postpartum the edges of the episiotomy should be fused together. An episiotomy may be covered over with edematous tissue and not easily visible, so the examination must be done carefully. If the laceration or episiotomy is infected it appears red and swollen, and discharges pus. Treatment depends on the severity of the infection and may include sitz baths; application of an antibiotic cream to the wound; oral **antibiotics**; or opening the wound, cleansing the site, and resuturing it.

When the perineal area is examined, the patient should also be checked for the presence of a hematoma (a round area filled with blood) that is caused by the rupturing of small **blood vessels** on the surface of the perineum. After observing the perineum, the rectal area also is evaluated for hemorrhoids, making note of their size, character, and number.

The following measures are effective in providing relief of perineal discomfort:

- Application of cold packs to the perineum for the first 24 hours after delivery.
- Application of warm packs to the perineum after the first 24 hours.
- Rinsing of the perineal area with warm water after every void and/or bowel movement. (This is also helpful in preventing infection and in promoting healing.)
- Use of anesthetic sprays and creams. Cleaning the area with witch hazel pads (Tucks) is also soothing.
- Sitting in a sitz bath—a small basin that fits on top of the toilet through which warm water flows—three or four times a day. After discharge a woman may use her bathtub at home for this purpose.

BLADDER DISTENTION. In the first 48 hours after delivery it is normal to have an increase in the formation and secretion of urine (postpartum diuresis). A full bladder can cause the uterus to shift upwards and not contract effectively. An overdistended bladder can even cause injury to the **urinary system**. A woman should be encouraged to void within her first hour postpartum; and her bladder should be checked after voiding, since urinary retention can be a problem. If the woman had a cesarean section and has a Foley catheter in place in her bladder, then the output is checked every hour during the initial postpartum period. The Foley catheter is likely to be removed approximately eight hours after surgery. The health care provider needs to assess for voiding after removal of the Foley catheter.

Postpartum care after hospital discharge

Ideal postpartum care would include several home visits by health care providers in the one to two weeks following delivery to assess the status of the mother and her family. This rarely happens in the United States, but follow-up phone calls by health care providers during the first week and a visit by the mother and baby to her physician or nurse-midwife one to two weeks after the birth are desirable.

Several problems that may arise during the postpartum period do not typically develop until after the new mother is discharged from the hospital. These include **mastitis**, endometritis, and postpartum depression.

MASTITIS. Mastitis is an inflammation of the breast, usually caused by streptococcal or staphylococcal infection. It can develop any time a woman is breastfeeding, but usually does not occur before the tenth postpartum day. Symptoms of mastitis often mimic those of the flu, and include body aches and a fever of 101°F (38.6°C) or more. Mastitis is treated with a course of antibiotics, and women should begin to feel better within 24 hours of beginning the antibiotics. If this does not happen, the woman may need to be hospitalized for intravenous antibiotics.

Other measures that may help the mother feel better include bed rest for at least 24 hours, moist heat on the infected breast every two to three hours (when awake), acetaminophen for pain and fever relief, increased fluid intake, and going without a bra for several days. Mastitis does not contaminate the breast milk and the baby should continue to nurse from both breasts. If nursing from the affected breast is too painful, use of a breast pump or manual expression of milk may be needed to prevent engorgement and facilitate continued milk production.

ENDOMETRITIS. Endometritis is an inflammation of the endometrium, the mucous membrane lining the

uterus. It is usually caused by a bacterial infection. Symptoms of this infection include fever, abdominal pain, and foul-smelling vaginal discharge. **Physical examination** of the patient reveals a tender uterus. Endometritis is treated with a course of antibiotics and other care, including bed rest, acetaminophen for pain and fever relief, and increased fluid intake. Severe cases may require hospitalization.

POSTPARTUM DEPRESSION. Postpartum depression may appear at any time during the first year after a baby's birth. It ranges in severity from mild, postpartum "blues" that last only a few days shortly after birth, to intense, suicidal, depressive psychosis. Not only does postpartum depression cause distress for the new mother and her partner, but it can also interfere with the new mother's ability to bond with her baby and to relate to any other children she may have.

Symptoms of severe postpartum depression or psychosis include insomnia, hallucinations, agitation, and bizarre feelings or behavior. Any new mother exhibiting signs of postpartum depression should be referred to mental health professionals, support groups, and/or new mother groups. Psychotropic medication is often helpful, as is **psychotherapy**. About 10% of cases of postpartum depression are caused by postpartum thyroiditis, a temporary inflammation of the **thyroid gland** that usually clears up spontaneously in one to four months. Whenever postpartum depression occurs, thyroid function should be tested to rule out hyperthyroidism or hypothyroidism as the cause of symptoms.

Six-week postpartum check-up

Although this postpartum check-up is traditionally scheduled six weeks after delivery, it may be done any time between four weeks and eight weeks after delivery. It usually includes a breast examination, a pelvic examination, any necessary laboratory tests, and a health education component covering such areas as breastfeeding, birth control, weight reduction, etc. This checkup is also an opportunity to review the pregnancy and birth experience, to discuss problems and assess for depression, to provide emotional support, to answer questions, and to consider if any further referrals are necessary for the new mother.

Health care team roles

The new mother is given instruction in how to hygienically care for her perineal area. She is encouraged to change her perineal pad frequently and to wash her hands afterwards. The presence of a wet pad against sutures is an excellent medium for the development of an infection that could potentially spread to the uterus. The

KEY TERMS

Perineum—The area between the rectum and the outlet of the vagina.

Pregnancy-induced hypertension—Vasospasm occurring during pregnancy resulting in such symptoms as hypertension, swelling, and protein in the urine. If not treated, it can sometimes result in a seizure.

Thrombophlebitis—Blood clot formation resulting in inflammation of the lining of a blood vessel.

Umbilicus—Navel; depression in the center of the abdomen where the umbilical cord was attached.

woman is also instructed not to use tampons for six weeks after delivery, since tampon use can cause infection or even toxic shock syndrome.

New mothers may be overwhelmed by the degree of discomfort after giving birth, and may be frustrated by their desire to interact with their new baby while at the same time being limited by pain, discomfort, and exhaustion. The health care team member can help the new mother by providing perineal care for her until she is able to get out of bed, and by administering pain medications as ordered.

Other important things health care providers can do for postpartum women include:

- Evaluate pulse, respiratory rate, and blood pressure every 15 minutes during the first hour postpartum, every 30 minutes for two hours, and then every eight hours. Evaluate the woman's temperature at the end of the first hour postpartum and then every four hours for the first 2–12 hours postpartum.
- Help the woman take a shower as soon as she is allowed to, while monitoring her for lightheadedness.
- Place a warm blanket over the mother after delivery if she experiences shaking and chills.
- Provide emotional support to the mother and family through explanations about childbirth and how it can be a highly emotional and psychologically overwhelming time.
- Promote adequate rest.
- Encourage a generous intake of nutrients and fluids.
- Ask if the woman has had a bowel movement prior to discharge and offer medication to soften stools if desired.

- Monitor the woman's voiding and ensure the woman is not having difficulty. Catheterization is sometimes required.
- Assist with ambulation until the woman is steady on her feet.
- Review laboratory tests for signs of anemia, infection, and electrolyte imbalance.
- Teach the woman muscle-strengthening exercises.
- Prepare the mother and family for discharge through discharge teaching.
- Arrange for a home visit if this is provided for through the facility and/or patient's insurance.

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Association of Women's Health, Obstetric, and Neonatal Nurses, 2000 L Street, NW, Suite 740, Washington, D. C. 20036. Phone (U.S.): (800) 673-8499. Phone (Canada): (800) 245-0231. <<http://www.awhonn.org/>>.

Nadine M. Jacobson

Postpartum depression

Definition

Postpartum depression (PPD) is a major depressive episode that occurs after **childbirth**. There are conflicting data regarding the time of onset. The *Diagnostic and Statistical Manual of Mental Disorders* (1995) supports the theory that PPD occurs within four weeks of childbirth. Other clinical investigations report its occurrence up to 12 weeks post-delivery; yet others state that PPD occurs from 6–12 months after delivery. It is reported that PPD may last longer than one month.

Description

The beginning of PPD tends to be gradual, and may persist for many months. It might develop into a second episode if there is a subsequent **pregnancy**. According to several controlled studies, PPD affects approximately 12–16% of childbearing women. In adolescent mothers,

the figure can be as high as 26%. Women who have a previous history of depression are predisposed to PPD; and up to 30% of women who have had a major depressive episode before they conceived might develop PPD. This rate can rise as high as 50–62% in women who have a history of depression in previous pregnancies or during the postpartum periods.

Mild cases of PPD are sometimes unrecognized by women themselves. Embarrassment about difficulty coping with their new circumstances is sometimes shared by new mothers—so much that they might conceal it. This is a serious problem that disrupts women's lives and can have negative effects on the baby, other children, the new mother's partner, and other significant relationships. Marital problems, inadequate social networks, ambivalence about the pregnancy, and disturbing life events can add to the risk of depression.

The father's risk of becoming depressed increases significantly during the postpartum period as well.

Postpartum depression is often divided into two types: early onset and late onset. An early-onset depression most often presents as “baby blues,” a brief experience during the first days or weeks following birth. During the first week after the birth of their child, up to 80% of mothers may experience the “baby blues.” This period of time is characterized by feelings of oversensitivity, uncontrollable teariness, irritability, **anxiety**, and mood changes. Symptoms tend to peak between three and five days after childbirth, and normally disappear within a few days.

In short, some depression, tiredness, and anxiety often fall within the normal range of reactions after giving birth.

A late-onset PPD appears several weeks after the birth. This may involve a growing feeling of sadness, grief, lack of energy, chronic fatigue, inability to sleep, changes in appetite, significant weight loss or gain, difficulty caring for the baby—and sometimes, thoughts of harming the baby.

Causes and symptoms

As of 2001, experts are not positive about the causes of PPD. It may be caused by factors that vary from person to person. Pregnancy and birth are accompanied by sudden hormonal shifts that can cause a range of emotions. Additionally, the 24-hour responsibilities involved in caring for a newborn present major psychological and lifestyle adjustments for most new mothers. These physical and emotional stresses are usually aggravated by not getting adequate rest until the baby's routine stabilizes.

Experiences of new mothers vary considerably, but may include the following.

Feelings:

- persistent low mood
- inadequacy, failure, hopelessness, helplessness
- exhaustion, emptiness, sadness, teariness
- guilt, shame, worthlessness
- confusion, anxiety, and panic
- fear for the baby and of the baby
- fear of being alone or going out

Behaviors:

- lack of interest or pleasure in usual activities
- insomnia or excessive sleep; nightmares
- changes in appetite
- decreased energy and motivation
- withdrawal from social contact
- poor self-care
- inability to cope with routine tasks

Thoughts:

- inability to think clearly and make decisions
- lack of concentration and poor memory
- inability to deal with stressful situations
- fear of being rejected by partner
- worry about harming herself, her partner, or her baby
- suicidal ideation

Some symptoms may not indicate a severe problem. However, persistent low mood or loss of interest or pleasure in activities, along with four other symptoms occurring at the same time, may signal a problem. If these symptoms persist for a period of at least two weeks, a clinical depression may be occurring, and professional intervention may be required.

There are several important risk factors for PPD, including:

- stress
- loss of pleasure or interest in living
- lack of sleep (sleep deprivation)
- poor nutrition
- lack of support from one's partner, family, or friends
- family history of clinical depression
- complications for mother or baby during labor and delivery
- premature or postmature delivery

- poor newborn health
- separation of mother and baby
- a difficult baby (i.e., problems with temperament, feeding, sleeping, or settling)
- preexisting neurosis or psychosis

Diagnosis

There is no specific diagnostic test for PPD. However, it is important to understand that PPD is a bona fide illness, and that it has specific symptoms, the same as a physical condition. **Blood** tests to measure thyroid hormone levels can rule out postpartum thyroiditis, which can mimic PPD.

It is important to note that a small percentage of women experience postpartum psychosis, a rare disorder. This is the most severe, but least common, postpartum condition. Occurring in only 1–2 births per 1,000, postpartum psychosis appears between 48–72 hours and several weeks after delivery. Symptoms may include elated mood, mood changeability, disorganized behavior, insomnia, religious preoccupation, agitation, suicide attempts or suicidal ideation, bizarre feelings or behavior, and hallucinations. Postpartum psychosis is a serious condition that requires immediate psychiatric intervention and possible hospitalization.

Other psychiatric conditions, such as panic disorder and obsessive-compulsive disorder (OCD), are possible manifestations of PPD.

Complications

If PPD is misdiagnosed or remains untreated, a severely depressed woman may attempt or complete suicide. On a lesser but significant level, untreated PPD can lead to severe depression, anxiety, or postpartum psychosis.

Treatment

Several treatment options exist for mild-to-moderate PPD; these are psychiatric therapies that include interpersonal therapy (IPT) and cognitive-behavior therapy (CBT). Under investigation at the time of this writing in 2001, bright-light therapy may be effective in treating PPD. Clinical studies have reported that pregnant depressed women and postpartum depressed women, respectively, experienced antidepressant effects when bright-light therapy was administered. Another effective treatment combines antidepressant medication with counseling. Antidepressants generally become effective several weeks after a patient has begun taking them.

Medication must be prescribed carefully if the mother is breastfeeding, as it can pass to the baby in the mother's breast milk. This is why the physician must be aware that the baby is being breast-fed. The results of several short-term studies point to relative safety (i.e., lack of toxicity, minimal exposure to the maternal dose, or few adverse effects) in the use of SSRIs (selective serotonin reuptake inhibitors) by nursing mothers.

Postpartum depression also may be treated with "talk" therapy and participation in a support group. The mother needs to feel cared for, and that her feelings are respected. Nursing staff and allied health professionals can positively affect the treatment course by providing the mother with supportive one-on-one therapy, whereby the therapist listens to the woman's specific concerns and fears.

Such alternative treatment measures as **homeopathy** may be helpful, since they are meant to address mental, physical, and spiritual states—all of which are affected by PPD. Acupuncture and Chinese and Western herbs may also help by balancing mood and hormone levels. However, caution is strongly advised when taking herbs; as of 2001, they are unregulated. Toxicity studies have not been conducted to evaluate the safety of these substances. Seeking help from a homeopathic practitioner, however, does provide the new mother with an opportunity to discuss specific nutritional needs or mood problems.

Fortunately, there are useful things that a new mother can do for herself, including:

- Making each day as simple as possible.
- Asking for help from supportive friends and family members whenever possible.
- Avoiding extra pressures or unnecessary tasks.
- Involving her partner more intensively in the care of the baby from the beginning.
- Discussing with her partner how both can share the household chores and responsibilities.
- Scheduling frequent outings, such as walks and short visits with friends.
- Having the baby sleep in a separate room so that she can sleep more restfully.
- Sharing her feelings with her partner or another good listener.
- Talking with other mothers to keep problems in perspective.
- Sleeping or resting when the baby is sleeping.
- Taking care of her health and well-being.
- Not losing her sense of humor or self-esteem.

Prognosis

With appropriate support from friends and family, many mild cases of PPD go away by themselves. If depression becomes severe, a patient should not attempt to care for herself or the baby; in some cases, psychiatric hospitalization may be necessary. However, a three-pronged approach consisting of supervised medication, psychiatric counseling, and support from family, friends, and others, may relieve even severe depression in three to six months.

Health care team roles

Nursing staff and allied health professionals can assist in the diagnosis of postpartum depression by observing the patient for symptoms. Since PPD can present as a mood disorder, anxiety state, or psychotic episode, it is critical that nursing staff and allied health professionals understand the warning signs.

During the treatment phase, nursing staff and allied health professionals can help a new mother by providing her with appropriate **patient education** materials, and referrals for ongoing supportive therapy or group **psychotherapy**, if applicable.

Prevention

Exercise can help enhance a new mother's emotional well-being. New mothers should also cultivate good sleeping habits and rest when physically or emotionally tired. It is important for the health professional to teach the patient how to recognize the signs of fatigue and to make time for herself.

Psychotherapy or the use of antidepressant medication can also help to prevent future episodes of postpartum or ongoing clinical depression.

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Bethanne Black

Postural drainage see **Chest physical therapy**

Postural evaluation

Definition

Posture can be defined as the position of the body in any environment or mode. Some examples of specific postures are sitting, standing, walking, or leaning forward. Posture is based on the position of the spine and all the joints in the musculoskeletal system. Postural evaluation or analysis consists of evaluating a patient’s posture through a series of appropriate tests and measurements. It is part of the branch of **physical therapy** called kinesi-ology, which includes the study of the anatomy and physiology of body movement.

Good or normal posture is defined as an imaginary straight line that connects the earlobe; cervical vertebrae; acromion (bony outgrowth on the shoulder blade); lumbar vertebrae; and a set of points behind the hip and slightly in front of the knee and ankle. In an actual postural evaluation, the patient may be asked to stand by a vertical plumb line so that the examiner can visualize any deviations from normal alignment.

Purpose

Good posture in humans is the end product of a complex combination of mechanical, neurological, and psychological factors, including muscular strength and flexibility, vision, touch, balance, self-esteem, kinesthetic (a sense of the location and movement of muscles and joints) awareness, and a properly functioning vestibular (inner ear) system. Because of the number of body parts and functions involved in good posture, a postural evaluation may serve a variety of purposes:

- As part of the musculoskeletal assessment of a balance evaluation. Postural abnormalities frequently affect an

KEY TERMS

Acromion—A bony prominence on the shoulder blade that articulates with the clavicle, forming the acromioclavicular (AC) joint.

Atrophy—The wasting away of muscle tissue from disuse.

Kinesiology—The branch of physical therapy that deals with the anatomy and physiology of body movement.

Osteoarthritis—A degenerative disorder of the cartilage and bone in the joints.

Osteoporosis—A condition characterized by decrease in bone mass and density, and enlargement of bone spaces.

elderly person’s sense of balance and his or her ability to react quickly to loss of balance.

- As a step in the differential diagnosis of chronic pain syndromes. Chronic neck and back **pain** in particular often result from poor posture, which causes muscles to contract, changes the amount of blood flow to the spine, and leads to deformation of the connective tissues in the spine and neck area.
- As part of a physical examination in sports medicine. Deviations from normal posture increase the risk of certain types of athletic injuries, and may interfere with athletic performance.
- In the evaluation of work-related postural problems and repetitive stress injuries (RSIs). Some physical therapists now visit work places in order to assess the physical demands of certain jobs—especially jobs that require sitting at desks in front of computers for long periods. These assessments are sometimes called ergonomic evaluations, which means that the design of equipment and other physical features of the workplace is coordinated with the physical requirements of the workers.

Precautions

Postural evaluation is noninvasive and should not cause the patient physical discomfort under normal circumstances. Care should be taken, however, to perform the evaluation in an appropriate examination room to protect the patient’s modesty. The room should be kept at a comfortable temperature.

Description

Postural evaluation typically begins with a visual assessment of the patient's posture while he or she is standing by a vertical plumb line. The person's posture is then scored according to check lists for the back view and the side view. Deviations from good posture are rated according to severity, in which a slight deviation is scored as 1 point, a moderate deviation as 2, and a severe deviation as 3 points. The total number of points from both back and side views is then calculated. A score of 12 points or higher is considered poor posture. Some therapists prefer to use posture photographs for a postural evaluation while other practitioners may order x-rays, on the grounds that these imaging modalities yield more accurate results than simple visual examination.

Visual assessment of posture also includes the clinician's careful visual observation of the patient's positioning during walking, sitting, and weight transfers.

Manual muscle testing is an important part of postural analysis. The clinician uses his or her hands to evaluate the various muscles for atrophy (wasting away from disuse), misalignment, overstretching, or constriction and shortening. Manual testing also allows the clinician to determine the extent as well as the presence of muscular imbalance.

Preparation

Accurate evaluation of patients with postural dysfunction requires careful history-taking. This includes family and social history as well as medical history. In most cases changes in posture are due to such anomalies as excessive weight gain, poor postural habits, traumatic injuries, uneven development of the musculature, or congenital defects. A family history may yield information about hereditary disorders that affect posture as well as family members' attitudes toward the patient. In some cases, people develop poor posture in response to physical or emotional abuse.

Results

An accurate postural evaluation provides the physical therapist with necessary information in devising a treatment plan. The goal of rehabilitation is to isolate the cause(s) of postural abnormalities and provide appropriate treatment through postural correction exercises and **patient education**. Other treatments can include such modalities as heat, ice, and massage; flexibility exercises; strengthening programs; and cardiovascular conditioning.

Health care team roles

Postural evaluations may be performed by physical therapists, physicians, nurses, and chiropractors. It is important that physicians—especially pediatricians—nurses, and other allied health professionals routinely evaluate patients' posture in an effort to minimize further complications of various diseases and disorders. Most health care facilities have screening clinics that offer postural assessment free of charge. It is also imperative that individuals with spinal **osteoarthritis**, **osteoporosis**, Marfan's syndrome, and other conditions that affect the spine be properly educated on the importance of good posture. The elderly and others who may have developed balance problems should have their posture evaluated as part of an overall balance evaluation.

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- National Rehabilitation Information Center and ABLEDATA (database). 8455 Colesville Road, Suite 935, Silver Spring, MD 20910. (800) 346-2742 or (800) 227-0216.

Mark Damian Rossi, Ph.D., P.T.

Posturography see **Balance and coordination tests**

Potassium hydroxide test see **KOH test**

Potassium test see **Electrolyte tests**

PPD skin test see **Tuberculin skin test**

Preconception counseling

Definition

Preconception counseling is **patient education** that helps a woman to make lifestyle changes before conception that will assist in promoting a healthy **pregnancy** and a healthy baby.

Purpose

Various health and environmental factors can increase the rate of abnormalities, referred to as birth defects, seen in babies at birth. Examples of these abnormalities are such conditions as cleft palate/lip, congenital **heart** disease, or spina bifida (opening of the spine). Some abnormalities are hereditary.

Pregnancy can worsen some chronic maternal diseases or increase the risk of poor neonatal outcome. In addition, some medications used by the pregnant woman may cause developmental problems in the fetus.

Precautions

Not all women visit a health care provider during the critical early weeks of pregnancy. Thus, as a part of patient education, health care professionals should provide preconception counseling in all encounters with women of childbearing age.

Description

Preconception counseling should address the following areas:

Nutrition

DIET. The importance of a well-balanced, nutritious diet should be emphasized in preconception counseling. A woman who is underweight when she conceives may have a small baby (small babies are more likely to have problems during labor and immediately after delivery). A woman who is overweight is at increased risk of developing elevated **blood pressure** and **gestational diabetes** during pregnancy. Women should be informed that trying to lose weight during pregnancy is not advised, as it could rob a developing baby of essential nutrients.

FOLIC ACID SUPPLEMENTATION. Even though many grains and other products are fortified with **folic acid** (a B vitamin), the level may not be high enough to increase the folic acid intake of most childbearing-age women to the recommended level of 400 micrograms (mcg) per day. Therefore, most women of childbearing age should consume 400 mcg (0.4 milligrams, or mg) of folic acid per day. Women with a previous child with a **neural tube defect** and women on antiseizure medication need extra folic acid. Folic acid is thought to help prevent certain birth abnormalities, including spina bifida, other neural-tube defects, and possibly heart abnormalities. Folic acid may also reduce the likelihood of getting colon **cancer** and coronary heart disease.

MULTIVITAMIN SUPPLEMENTATION. To ensure an adequate daily intake of **vitamins** and **minerals**, women

Obstetric history data

Pregnancies and births (term, preterm, abortions, living)
 Date of each birth (month and year)
 Outcome of each birth:
 Gestational age at birth
 Type of delivery
 Length of labor
 Birth weight
 Gender
 Complications during pregnancy, at delivery, postpartum
 Any depression during the year after birth
 Present health
 Names and location of children
 Feelings about previous pregnancies, birthing experiences, parenting
 Feelings about any perinatal loss or other losses in which children were involved.

SOURCE: Wheeler, L. *Nurse-Midwifery Handbook: A Practical Guide to Prenatal and Postpartum Care*. Philadelphia: Lippincott-Raven Pub., 1997.

of reproductive age should take a multivitamin supplement that contains folic acid. Women planning on a pregnancy should be cautious to avoid an excess intake of **vitamin A**, however. It has been chemically associated with a class of retinoids recognized to cause birth abnormalities. Vitamin A doses larger than 10,000 international units (IU) have been linked to a nearly five-fold increase in the occurrence of congenital heart malformations.

Immunizations

RUBELLA (GERMAN MEASLES). All women of childbearing age should be immunized against rubella. Contracting rubella during pregnancy can result in numerous severe birth abnormalities, including deafness, heart defects, **cataracts**, and mental retardation. Conception is not recommended for at least three months after receiving an immunization for rubella, and the immunization may not be given during pregnancy.

VARICELLA (CHICKEN POX). A woman who has not had varicella should be immunized for it prior to conception. Varicella **infection** can result in serious maternal and fetal complications. For example, 9 percent of women who contract varicella in pregnancy will develop varicella **pneumonia**. The varicella immunization may not be given during pregnancy.

Risk reduction

Women contemplating pregnancy should be counseled concerning the following lifestyle behaviors and their potential implications. A woman may not even be aware that she is pregnant for the first few weeks and may engage in dangerous lifestyle behaviors during a

KEY TERMS

Abruptio placentae—Premature separation of the placenta from the uterine wall. Occurs late in pregnancy and results in bleeding that may or may not establish an obstetrical emergency.

Placenta previa—The placenta usually touches or implants on the posterior aspect of the uterus, away from the cervix. In a placenta previa, the location of implantation of the placenta is low in the uterus and may totally or partially occlude the cervix. A placenta previa may cause complications at delivery, such as excessive bleeding.

Preeclampsia—Also called pregnancy-induced hypertension or toxemia of pregnancy. A condition unique to pregnancy, with symptoms of elevated blood pressure, protein in the urine (proteinuria), and edema. Exists in varying degrees of severity and can result in maternal seizure activity.

critical period of embryonic development. If conception is a possibility, women should try to maintain a healthy lifestyle so that their babies will have the best odds of a good outcome at birth and later on in life.

ALCOHOL. Consumption of alcohol during pregnancy can lead to **fetal alcohol syndrome**, a condition resulting in several physical and behavioral problems in affected children. Even intake of lower levels of alcohol can cause neurological and behavioral problems in children of women who drink during pregnancy. Studies have found that children of women who consumed alcohol during pregnancy had lower birth weights, were shorter, and had smaller head circumferences.

DRUGS. Infants of pregnant drug users are at risk for prematurity, low birth weight, and perinatal death. Women who abuse drugs should be offered support and referred to groups that can help with drug addiction.

TOBACCO. Women who smoke during pregnancy have an increased risk for abruptio placentae, **placenta previa**, and preeclampsia. Their babies may be born prematurely, be smaller, have congenital abnormalities, be at increased risk for sudden infant death syndrome (SIDS), and possibly have developmental delays.

Medical conditions and pregnancy

DIABETES MELLITUS. Women with **diabetes mellitus** should try to attain stability in their **blood** sugar levels prior to conception. Some oral medications for diabetes are contraindicated during pregnancy, so planning is nec-

essary for conception. Complications of diabetes mellitus include large or small babies.

OTHER COMPLICATIONS. Women with medical conditions who are contemplating pregnancy should be counseled as to pregnancy risks for themselves and their babies. For example, a woman who has epilepsy should consult with her physician or nurse practitioner about the toxicity of the current medication she is taking to control seizures; a less toxic medication may be recommended for the period of preconception and pregnancy.

REDUCTION IN EXPOSURE TO TERATOGENS. Exposure to various substances can be teratogenic (capable of causing birth defects). Teratogenic hazards include **anticancer drugs**, and perhaps such occupational substances as organic solvents and anesthetic gases.

Some teratogens can even cause birth defects when the exposure took place prior to conception. The father's exposure to occupational toxins can also cause miscarriages, preterm deliveries, and birth defects.

Genetic counseling

Couples may wish to have **genetic counseling** if there is a family history of a child with a genetic abnormality; because of ethnically associated genetic diseases; or for advanced maternal/paternal age (age 34 or 35 in women, unknown in men).

Other issues

Preconception counseling may include discussions of several other health-related issues:

- contraception
- domestic violence
- exercise
- gynecological screening
- use of prescription and over-the-counter medications
- general health
- safe sex
- sibling concerns

Preparation

Insertion of a form in the patient's chart addressing issues related to preconception counseling can guide the health care provider in performing a thorough assessment and providing appropriate interventions.

Results

Preconception counseling can result in healthier pregnancies, culminating in good birth outcomes.

Health care team roles

The opportunity to provide preconception counseling exists at any time a health care provider is assessing or educating a woman of childbearing age. (Such providers include nurses, nurse-practitioners, obstetricians, perinatologists, dieticians, substance-abuse counselors, social workers, geneticists, radiologists, and radiology technicians.) Health care professionals who are not trained to provide genetic counseling should be prepared to provide support related to **genetic testing**.

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National Clearinghouse for Maternal and Child Health. 2070 Chain Bridge Road, Suite 450, Vienna, VA 22182-2536. (888) 434-4624, (703) 356-1964. Fax (703) 821-2098. <<http://www.nmchc.org/>>.

National Society of Genetic Counselors. 233 Canterbury Drive, Wallingford, PA 19086-6617. (610) 872-7608. <http://www.nsgc.org/faq_consumers.asp/>.

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Nadine M. Jacobson, R.N.

Prednisone see **Corticosteroids**

Preeclampsia and eclampsia

Definition

Preeclampsia and eclampsia are hypertensive disorders of **pregnancy** that occur in 5%–10% of pregnancies. In developing countries, hypertensive disorders of preg-

nancy are the single most common cause of death in **childbirth**. Preeclampsia is defined by the presence of three elements: **hypertension**, proteinuria (protein in the urine), and **edema** (fluid retention). If seizures develop following the appearance of the first three factors, the condition is called eclampsia.

Description

The cause of preeclampsia is unknown, but is thought to be an immunologic disorder of some kind. Preeclampsia is more likely to develop in primigravidas (women in their first pregnancy); in women who have used barrier methods of **contraception**; in women who have new sexual partners; and in women whose birth parents have similar HLA antigens. Other risk factors include a family history of preeclampsia; age extremes in the mother (younger than 20 years or older than 40); pre-existing kidney disease or vascular disorder; diabetes; **multiple pregnancy**; five or more previous pregnancies; African American descent; and genetic abnormalities in the fetus. Since the 1980s, preeclampsia has been associated with poor **blood** supply to the placenta or placental dysfunction, but the stages in the development of the disorder between damage to the placenta and the appearance of hypertension are not yet fully understood.

Hypertensive disorders of pregnancy affect six major systems or sites in the body: the **central nervous system** (CNS); **kidneys**; **liver**; the blood; the **blood vessels**; and the fetus and placenta. In severe cases, the mother may suffer liver failure, rupture of the liver, or pulmonary edema (fluid in the **lungs**); the fetus may die.

Classification of hypertensive disorders of pregnancy

The most common classification used to define hypertensive disorders of pregnancy is the one recommended by the American College of Obstetricians and Gynecologists (ACOG) and endorsed by the NIH Working Group on High Blood Pressure:

- Chronic hypertension, defined as **blood pressure** greater than or equal to 140 mm Hg systolic or 90 mm Hg diastolic present prior to pregnancy or before the 20th week of pregnancy. During pregnancy the hypertension remains, but proteinuria does not occur. Women who develop hypertension during pregnancy, without proteinuria or seizures, and whose blood pressure remains elevated after pregnancy are also diagnosed with chronic hypertension.
- Gestational hypertension, defined as elevated blood pressure greater than or equal to 140 mm Hg systolic or 90 mm Hg diastolic that arises after midpregnancy with

no proteinuria. Blood pressure returns to normal by 12 weeks postpartum. Final diagnosis of this condition is delayed until the postpartum period. If the patient does not develop preeclampsia, and her blood pressure returns to normal, the final diagnosis is transient hypertension of pregnancy. If her blood pressure remains elevated, a diagnosis of chronic hypertension is given.

- Preeclampsia and eclampsia. Preeclampsia is characterized by blood pressure greater than or equal to 140 mm Hg systolic or 90 mm Hg diastolic occurring after mid-pregnancy (20 weeks gestation), and accompanied by proteinuria. Preeclampsia may be further categorized as mild or severe. A woman is considered to have severe preeclampsia when her blood pressure reading is 160+ mm Hg systolic or 110+ mm Hg diastolic; her proteinuria is equal to or greater than 5 mg of protein in the urine per 24 hours; or other organ systems are involved. She may have headache, visual disturbances, or other CNS symptoms; pulmonary edema, **cyanosis**, or other cardiovascular symptoms; and abdominal pain.
- Preeclampsia superimposed on chronic hypertension. Pregnant women with preexisting chronic hypertension may develop preeclampsia. Superimposed preeclampsia is suspected when proteinuria develops or increases suddenly; when previously controlled hypertension exhibits a sudden increase; or when the patient develops thrombocytopenia or elevated liver enzyme levels. Women with preeclampsia superimposed on chronic hypertension have a poorer prognosis than women with either condition alone.

Measurement of blood pressure

For purposes of accuracy and standardization, health professionals should take blood pressure measurements in pregnant women with the patient seated rather than lying on her side, because substantial differences exist between the blood pressures in the upper and lower arms when the patient is lying on her side. In addition, the National Institutes of Health (NIH) recommends that the diastolic pressure reading should be taken at Korotkoff 5, with the disappearance of sound—not at Korotkoff 4, when sound becomes muffled. To meet strict criteria for hypertension, the patient's readings must be elevated on at least two separate occasions at least six hours apart.

Causes and symptoms

As previously mentioned, the initial cause of preeclampsia/eclampsia is not known but is thought to be immunologic. The relationship among the three factors that define preeclampsia appears to be as follows. First, the normal increase in blood plasma volume and decrease in peripheral vascular resistance that occur dur-

ing an uncomplicated pregnancy are absent. The patient's blood vessels allow fluid to leak from the vessels into the surrounding tissue, which results in edema. The seizures that characterize eclampsia result from edema of the **brain**. The patient's kidneys are under stress because of diminished blood flow through the kidneys and decreased filtration. This process allows protein molecules to spill over into the urine. Damage to the kidneys lowers urine output and increases the levels of sodium in body tissues. Higher concentrations of sodium result in increased fluid retention. Protein lost through the urine also affects the movement of fluid into the tissues, further increasing fluid retention.

The HELLP syndrome

A liver condition related to hypertension in pregnancy is called the HELLP syndrome, which occurs in about 1:150 births. HELLP stands for *hemolysis, elevated liver enzymes, and low platelet count*. Normal liver functioning is altered in the HELLP syndrome as a result of vascular damage related to preeclampsia. Researchers believe that the fetus and mother share a defect in processing fatty acids that leads to destruction of red blood cells, inflammation of the liver, and decreased platelet count. HELLP syndrome is associated with disseminated intravascular coagulation (DIC); **placental abruption** (sudden tearing); acute renal failure; and pulmonary edema. About 30% of pregnancy-related cases of HELLP develop in the postpartum period.

Disseminated intravascular coagulation

Preeclampsia and eclampsia may also be associated with the serious condition known as disseminated intravascular coagulation, or DIC. DIC is a disorder characterized by both bleeding and thrombosis (the formation of intravascular clots). Maternal hemorrhage is a risk in patients with preeclampsia who develop DIC. About 15% of hypertension-related deaths in pregnancy are associated with DIC.

Diagnosis

The diagnosis of preeclampsia is complicated by the fact that the signs of hypertension in pregnancy can be easily confused with the symptoms of chronic hypertension, **gallbladder** and pancreatic diseases, and other disorders. Since prevention of maternal and fetal morbidity and mortality is of the utmost priority, however, the NIH recommends overdiagnosis of preeclampsia rather than underdiagnosis to ensure careful management. Pregnant women should have their weight, blood pressure, and

urine checked at every prenatal visit. Regular prenatal visits are extremely important, as the early symptoms of preeclampsia cause no discomfort. The NIH guidelines suggest that women who develop an increase of 30 mmHg systolic or 15 mmHg diastolic over their prenatal baseline measurements should be closely monitored, especially if their protein or uric acid levels are elevated. Early detection of preeclampsia allows for proper management of the condition.

Treatment

Pre-delivery management

Delivery is the definitive treatment of preeclampsia. Even mild preeclampsia that develops at 36 weeks of gestation or later is managed by delivery. Prior to 36 weeks, severe preeclampsia requires delivery of the fetus. Mild to moderate preeclampsia between 20 and 36 weeks is treated with bed rest. Rest increases central blood flow to the patient's **heart**, kidneys, placenta, and other organs. Bed rest at home is an option for some patients with mild preeclampsia and stable home situations. Patients with severe eclampsia or unstable family situations require hospitalization. Monitoring of fetal heart rate and lung maturity is an important part of the management of preeclampsia.

Medications

Medication for preeclampsia is usually directed toward preventing convulsions rather than controlling blood pressure. Magnesium sulfate is the drug of choice for controlling seizures during pregnancy. Prophylactic magnesium sulfate administration may continue into the postpartum period.

Emergency care

The primary concern in emergency treatment of convulsions is to assure the patient's safety. The patient is placed on her side to allow any secretions in the mouth to drain, thus decreasing the risk of aspiration. In addition, this position improves blood flow to the placenta and fetus. Delivery of the fetus usually follows as soon as possible after the convulsion to minimize the risk of placental abruption.

Vaginal delivery is preferred to caesarean delivery in order to avoid the additional stress of surgery on the patient's organ systems. The NIH recommends a trial of labor induction, regardless of the condition of the patient's cervix. Magnesium sulfate may be given as an anticonvulsant. Antihypertensive medication is restricted

KEY TERMS

Cyanosis—A bluish color to the skin that indicates poor circulation and poor oxygenation of the blood and tissues.

Disseminated intravascular coagulation (DIC)—A disorder of blood coagulation characterized by both bleeding and thrombosis (intravascular clotting).

Edema—Abnormal accumulation of fluid in the tissues, cavities, or joint capsules of the body. It is one of three important indications of preeclampsia.

HELLP—A syndrome related to liver dysfunction that develops in some patients with preeclampsia. The letters stand for Hemolysis, Elevated Liver enzyme levels, and Low Platelet count.

Oliguria—Minimal urine output, usually defined as 500 ml or less over a 24-hour period.

Placental abruption—Sudden rupture or tearing of the placenta. The convulsions that characterize eclampsia increase the risk of placental abruption.

Proteinuria—A significant amount of protein in the urine. It is also sometimes called albuminuria.

Thrombocytopenia—A blood platelet count below 100,000 cells/mm³.

to use for sudden elevations of blood pressure, or if the patient's diastolic pressure reaches 105 to 110 mm Hg.

Prognosis

Risks to the fetus from preeclampsia include intrauterine growth retardation and low birth weight, placental abruption, and stillbirth. The fetus may be delivered prematurely if the condition of the mother deteriorates. Risks to the mother include vascular organ damage; the additional risks of eclampsia include convulsions and accompanying oxygen deprivation, hemorrhage in the brain, temporary blindness, permanent neurological damage, liver or kidney damage, cerebrovascular and cardiovascular complications, and even death. The prognoses for both the fetus and mother are excellent in mild preeclampsia. If blood pressure readings are within normal limits after several weeks postpartum, the mother may still be at increased risk of hypertension later in life, and should have her blood pressure checked yearly.

The long-term prognosis for children born to preeclamptic mothers is not yet known. These individu-

als do, however, appear to be at increased risk of chronic disease in adult life.

Health care team roles

The responsibilities of nursing staff in the management of preeclampsia and eclampsia include **patient education** and monitoring of patient compliance with the physician's instructions as well as assisting with emergency care. Patients resting at home should be visited and assessed periodically by a home health nurse. These functions are essential to good management of high-risk patients. Providing emotional support to patients with complications during pregnancy is also a critical function. If the patient requires hospitalization, a calm and quiet environment can help decrease the risk of seizure.

Prevention

Since the cause of preeclampsia is unclear, prevention focuses on early detection and management to avoid progression. Bed rest improves blood flow to the placenta and to maternal organs. Lying on the side increases sodium excretion and decreases fluid retention through increased diuresis. Magnesium sulfate may be given to lessen the risk of convulsions.

Recent clinical trials appear to indicate that some preventive strategies do not benefit most patients at risk for preeclampsia. These strategies include the prophylactic administration of heparin, **calcium**, or aspirin; and supplemental doses of fatty acids.

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American College of Obstetricians and Gynecologists. 409 12th St., S.W., PO Box 96920, Washington, D.C. 20090-6920. <<http://www.acog.com>>.

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Pregnancy-induced hypertension see
Preeclampsia and eclampsia

Pregnancy

Definition

Pregnancy is the condition of having a developing embryo or fetus in the body. The union of an egg (ovum) with sperm is called fertilization, or conception, and it is this union that produces the embryo. Pregnancy includes the period from conception to birth of the fetus, and usually lasts 10 lunar months (40 weeks/280 days), or nine calendar months—as measured from the first day of the last menstrual period (LMP). It is also referred to as a gestation period that consists of three trimesters. The trimesters are not equal, but are defined by different stages of a baby's development. The first trimester includes the first 13 weeks of pregnancy, or the first 12 weeks of life. The second trimester consists of weeks 14–26, and the third trimester is weeks 27–40.

Description

At the time of sexual intercourse, a man ejects millions of sperm into the woman's vagina. The sperm travel in all directions, propelled by their whiplike tails, and many swim through the cervix toward the uterus. A very small number of them may survive as long as 48 hours, but only one has to make it to the fallopian tube to meet the egg that has been released from an ovary. It takes approximately 30 minutes following intercourse for the sperm to meet the egg. One sperm penetrates the egg and its tail is shed, while the remainder of the sperm provides one-half of the genetic material of the future fetus—the other half provided by the egg. The fertilized egg then travels along the fallopian tube, arriving in the uterus four to five days later. Fluid secreted by the tube lining provides it with **nutrition** during its travels. After two to three days in the uterine cavity, the fertilized egg implants into the thick lining of the uterus. Implantation

occurs at about day 22 of a normal menstrual cycle. If the fertilized egg were visible to the naked eye, it would appear to be covered with fine hairs, called villi. These villi become the densest where the **blood** supply is richest, and eventually form the placenta. The mother's blood moves slowly around these villi, permitting them to absorb food and oxygen, and to eliminate waste products. The placenta is completely formed and functioning by 10 weeks after fertilization. Between 12 and 20 weeks' gestation, the placenta weighs more than the fetus, because the fetal organs are not sufficiently developed to deal with the processes needed for nutrition.

First month

At week four of pregnancy, the embryo is about one-eighth of an inch (0.275 cm) long, and weighs about 1/32 of an ounce (3 g). A formed yolk sac is present.

Second month

During the next four weeks, the embryo will grow to be about one inch long (2.5 cm) and weigh about 5/16 of an ounce (8.7 g). The umbilical cord will form, and the pulsation of the **heart** can be noted. The head and tail of the embryo are formed, and sex glands are determined, although the external genitals cannot be visibly identified as male or female. Limbs are well formed, and toes and fingers are present. The development of a skeleton and the formation of bone cells begin. Facial features begin to form, as does the external portion of the ear. The eyelids are fused throughout this period. By this stage, the fetus has a distinctly human appearance and the beginnings of all the main organ systems are established. Since the structures of the **brain**, heart, **liver**, limbs, ears, nose and eyes develop by the end of eight weeks, this is considered the most critical period of development. Any exposure to medications, alcohol, or illicit drugs during this time may cause defects, or anomalies, in the fetus.

Third month

Approximately nine weeks after conception, the baby has developed the features of a human being, and is called a fetus, not an embryo. Limb movements first occur at the end of the embryo stage, although they are not coordinated and cannot be felt. At 12 weeks of pregnancy, the fetus is 1–3 inches (7.5 cm) long from head to heel, and weighs about one ounce (28 g). The formation of red blood cells has already occurred in the liver, but now the spleen takes over making them. Urine formation begins between the ninth and twelfth weeks, and is discharged into the amniotic fluid. The fetus can reabsorb some of this fluid after swallowing it. Waste products are

now transferred to the mother's circulatory system by crossing the placenta.

Fourth month

Growth is very rapid during this period, and limb movements become coordinated, although it is difficult for the mother to feel them. An ultrasound reveals the bones of the fetal skeleton, which are clearly visible. Their development continues as the limbs lengthen. Scalp hair patterning is also determined during this period, and slow eye movements can occur at about 14 weeks. External genitals can be recognized by 14 weeks, and the external ears stand out from the head. The fetus is now about 6 inches (15 cm) long, and weighs about 4 ounces (112 g).

Fifth month

“Quickening” is the mother's feeling the baby move for the first time; it usually occurs during this period. The average time between a mother's first detection of fetal movements and delivery is 147 days, with a deviation between plus or minus 15 days. The baby's skin is now covered with a greasy, cheese-like material called “vernix caseosa,” and it protects the delicate fetal skin from cuts, chapping, and hardening, all of which could occur from exposure to the amniotic fluid. Eyebrows and head hair are also visible at 20 weeks, and the fetus is usually completely covered with fine, downy hair (the lanugo), which helps to hold the vernix on the skin. Brown fat forms during this period to prepare for heat production when the baby is born. By 18 weeks, a female fetus has a formed uterus, and the opening for the vagina has begun. Many egg-forming follicles are also forming in the ovaries. By 20 weeks in a male fetus, the testes have begun to descend, but they are still located inside the abdominal wall. The fetus now weighs about one pound (454 g) and is 10 inches (25 cm) long.

Sixth month

There is a substantial weight gain this month. The skin, usually wrinkled, appears clear, and is pink to red because blood is visible in the capillaries. At 21 weeks, rapid eye movements (REMs) begin, and blink-startle responses are visible on ultrasound following a loud noise. Fingernails are present by 24 weeks, and the cells in the lung have begun to secrete a substance necessary to develop the alveoli of the **lungs**. In most medical practices, a fetus born before 24 weeks is not considered viable or capable of living, but if born at 24 weeks, attempts will be made for survival. The chances of a good outcome are, however, very poor. The fetus now weighs



Chloasma may appear on a woman's face during the last trimester of pregnancy. The brown pigmentation disappears sometime after delivery. (NMSB/Custom Medical Stock Photo. Reproduced by permission.)

about 1.5 pounds (730 g), and is about 13 inches (32 cm) long.

Seventh month

By 26 weeks, the eyes are partially open and eyelashes are present. At 28 weeks, the eyes are wide open and a good head of hair is often present. At this age, a fetus can often survive even if born prematurely, presuming it is given intensive care. The lungs and blood circulation are developed, and can provide a better exchange of oxygen. Also, the **central nervous system** is now more mature, and can manage rhythmic breathing movements as well as assist in controlling body temperature. Toenails are present and more fat is deposited, smoothing the wrinkly skin. At 28 weeks, the bone marrow takes over the red blood cell-making work of the spleen, becoming the major site of this process. At 30 weeks, a light reflex of the eyes can be obtained. The skin is pink and smooth, and the limbs have a chubby appearance. The fetus might weigh as much as 3 lbs (1.3 kg), and is about 14–15 inches (35–37.5 cm) long. The fetus can be observed on ultrasound; it is sucking its thumb and practicing breathing movements. The mother may experience hiccoughs as rhythmic movements when the baby is practicing its breathing.

Eighth month

Fetuses 32 weeks and older usually survive if born prematurely. At 32 weeks, the fingernails reach the fingertips. At 35 weeks, fetuses have a firm grasp and show a spontaneous orientation to light. Growth continues, but slows as the baby begins to take up most of the room in the uterus. Now weighing between 3.5–4.5 lbs (1.7–2.3 kg), and measuring 16–18 inches (40–45 cm) long, the

fetus may prepare for delivery by moving into the head-down position.

Ninth month

At 36 weeks, the body appears plump. The hair covering the body is almost gone. Toenails reach toe tips and the limbs are flexed. A full-term baby is one born anywhere from 37–40 weeks' gestation. A baby born after 41 weeks is considered postdate. Adding 0.5 lb (227 g) a week as the due date approaches, the fetus drops lower into the mother's abdomen and prepares for the onset of labor, which may begin any time between the 37th and 41st week of gestation. The expected date of delivery (EDD) of a fetus is 266 days, or 38 weeks after fertilization (i.e., 280 days or 40 weeks after the LMP). Prolongation of pregnancy occurs in 5–6% of women. If the pregnancy continues past 41–42 weeks, the physician will order fetal monitoring to determine the status of the baby. Since the mortality rate increases significantly after two to three weeks postdate, labor is often induced. Most healthy babies will weigh 6–8 lbs (2.7–3.6 kg) at birth, and will be about 19–21 inches (47–52 cm) long.

Causes and symptoms

The first sign of pregnancy is usually a missed menstrual period. A little bleeding or spotting may occur, due to implantation of the fertilized egg. Some women experience no early symptoms of pregnancy during the first few weeks, while others may experience all of them. A woman's breasts usually seem larger and feel tender as the mammary glands prepare for eventual breastfeeding. Nipples begin to enlarge and the veins over the surface of the breasts become more noticeable. Morning sickness (i.e., nausea and vomiting) is somewhat common, and can happen at any time—day or night. Extreme sensitivity to **smell** may worsen nausea. It is normal to feel bloated and more tired than usual. Frequent urination is common, and the pregnant woman may find herself getting up during the night to urinate. There may be a creamy white discharge from the vagina; that is normal. Food cravings may occur. Most women gain about 2–4 pounds (0.7–1.8 kg) by the end of the first trimester (0–13 weeks), and their clothes begin to feel tight.

In the second trimester (14–26 weeks), morning sickness usually ends and a woman's appetite may increase. There is a weight gain of about 12–15 pounds (5.4–6.75 kg) during this trimester. Most women begin to look pregnant and feel more energetic. Heart rate increases, as does the volume of blood in the body. This increase may cause a woman to feel flushed and warm at times. Some women experience constipation, heartburn and indigestion, backache, sleeplessness, or swollen feet dur-

ing the second trimester. Physical activity, such as swimming and walking, will help constipation as well as drinking plenty of fluids (i.e., at least eight glasses of water a day) and eating high-fiber foods (i.e., fruits, vegetables, and whole grains). For backaches, it is important to maintain good posture, avoid lifting very heavy objects, and wear low-heeled shoes. Eating smaller amounts of food more frequently and avoiding fried or spicy food will help to relieve heartburn or indigestion. When the woman sits down to rest, her feet should be elevated to prevent swelling of the ankles. Pregnant women should not try to stand for long periods of time.

By the third trimester (27–40 weeks), many women begin to experience a range of common symptoms. As the baby grows larger and begins to press against internal organs, a woman may feel somewhat breathless at times. Lying on her left or right side, not on her back, and using pillows to lean on in a semi-propped position can relieve this. Leaking of urine may occur with coughing or sneezing, and frequent urination begins again. As the pelvis widens and the joints become looser, discomfort may be felt in the pelvic joints. Some women feel as if their legs cannot support their weight. This is the body's way of preparing for birth. The joints are loosening so that the baby can fit through the pelvis. Stretch marks may develop on the abdomen, breasts and thighs, and a dark line may appear from the navel to the pubic hair. A thin fluid called "colostrum" may be expressed from the nipples. Hemorrhoids may develop. Gums may become sensitive and bleed more easily, and eyes may dry out, making **contact lenses** uncomfortable to wear. Pica (a craving to eat substances other than food) may occur. **Varicose veins** may be a problem in the second half of pregnancy. This can be alleviated to a certain degree by wearing support hose, not standing for long periods of time, and resting with the feet up. Chloasma (a brown pigment) may appear on the face. This is due to the hormones of pregnancy and will disappear some time after delivery. Weak, irregular, painless tightenings of the uterus become more intense as the body practices for labor. These are called Braxton-Hicks contractions, and feel as if the baby is balling up. In most women, genuine labor consists of regular contractions that increase in intensity. Kicks from an active baby may cause sharp pains, and lower backaches are common. It is important for women in the third trimester to rest often and avoid straining themselves. When resting or sleeping, it may be more comfortable to lie on the left or right side with one leg bent, placing pillows under the **stomach** and between the knees. Weight gain will continue as it did in the second trimester.

In a woman's first pregnancy (later in repeat pregnancies), the baby's head drops down low into the pelvis by the last four weeks. This change may relieve pressure

FDA categories for drugs during pregnancy

Category A	No risk to fetus in first trimester demonstrated in controlled studies, and no evidence of risk in other trimesters.
Category B	No fetal risk shown in animal studies but no controlled studies in pregnant women are available; or animal studies showed an adverse effect not confirmed in controlled studies with pregnant women in the first trimester.
Category C	Adverse effects on fetus found in animal studies but no controlled studies in women; or studies in women and animals are not available. Give drug only if benefit justifies the possible risk to the fetus.
Category D	Positive evidence of fetal risk exists but the benefits may be acceptable despite the risk, as in life-threatening situations or serious disease.
Category X	Fetal abnormalities have been demonstrated or evidence for fetal risk exists, and the risk involved by using the drug outweighs any benefit.

SOURCE: U.S. Food and Drug Administration.

on the upper abdomen and the lungs, allowing a woman to breathe more easily. This new position, however, does place more pressure on the bladder.

Total weight gain recommended in pregnancy is 25–35 pounds (12–16 kg) for women of normal weight for their height. Underweight women should possibly gain up to 40 pounds (18 kg), and overweight women should limit weight gain to 15–25 pounds (7–11 kg). Increased fluid volume makes up 2–3 pounds (0.9–1.4 kg); breast enlargement provides 1–2 pounds (0.45–0.9 kg); 2 pounds (0.9 kg) comes from enlargement of the uterus; and amniotic fluid is about 2 pounds (0.9 kg). At term, an infant weighs about 6–8 pounds (2.7–3.6 kg), and the placenta weighs 1–2 pounds (0.45–0.9 kg). Usually 4–6 pounds (1.8–2.7 kg) are due to maternal stores of fat and protein that are important for breastfeeding.

While many of the symptoms mentioned are considered normal, there are others that may indicate the presence of complications. A pregnant woman experiencing any of the following should contact her doctor or midwife *immediately*:

- abdominal pain
- rupture of the amniotic sac or fluid leaking from the vagina
- bleeding from the vagina
- no fetal movement for 24 hours (after the sixth month)
- continuous headaches
- marked, sudden swelling of eyelids, hands, or face
- dim or blurry vision

KEY TERMS

Alpha-fetoprotein—A substance produced by a fetus' liver that can be found in the amniotic fluid and in the mother's blood. Abnormally high levels of this substance suggests there may be defects in the fetal neural tube, a structure that will include the brain and spinal cord when completely developed. Abnormally low levels suggest the possibility of Down syndrome.

Alveolus/Alveoli—A little hollow space in the thin-walled chambers of the lungs which is surrounded by capillaries for the exchange of carbon dioxide and oxygen.

Amniotic fluid—The fluid or 'bag of waters' that the fetus floats in and maintains a constant body temperature. It is normally clear.

Anomaly—A marked deviation from normal.

Braxton-Hick contractions—Short, fairly painless uterine contractions during pregnancy that may be mistaken for labor pains. They allow the uterus to grow and help circulate blood through the uterine blood vessels.

Cervix—The narrow lower end of the uterus.

Chloasma—A skin discoloration common during pregnancy, also known as the "mask of pregnancy." The blotches may appear on the forehead, cheeks, and nose, and may merge into one dark mask. Chloasma usually fades after pregnancy, but it may become permanent or recur with subsequent pregnancies.

Diffusion—The process of being widely spread.

Embryo—An unborn child during the first nine weeks of development following conception (fertilization with sperm). For the rest of pregnancy, the embryo is known as a fetus.

Fallopian tube—Either of two slender tubes, one on each side of the uterus, where fertilization takes place.

Fetus—An unborn child from the end of the ninth week after fertilization until birth.

Gestation—The period of development of an embryo and fetus or the duration of a pregnancy in a human.

Human chorionic gonadotropin (hCG)—A hormone produced by the placenta during pregnancy.

Osmosis—The diffusion of a substance across a membrane.

Placenta—The organ that develops in the uterus during pregnancy that links the blood supplies of the mother and baby.

Rhythm method—The oldest method of contraception, with a very high failure rate, in which partners periodically refrain from having sex during ovulation. Ovulation is predicted on the basis of a woman's previous menstrual cycle.

Uterus—The hollow muscular organ in females in which the fertilized egg becomes embedded and develops into an embryo and then a fetus.

Villus/Villi—A small protrusion or projection from the surface of a membrane.

- persistent heartburn (unrelieved by **antacids**) or a burning sensation in the chest area
- persistent vomiting

Diagnosis

Many women discover they are pregnant after a positive home **pregnancy test**. Urine tests check for the presence of human chorionic gonadotropin (hCG), which is produced by the placenta. The newest home tests can detect pregnancy six to nine days after a missed menstrual period—sometimes earlier. The manufacturers of these tests claim an accuracy rate of 96–99%; but some factors, such as taking medications, sunlight, heat, and medical conditions can affect the test. A negative result followed by no menstrual period within a week indicates the need

to repeat the pregnancy test. While home tests are very accurate, they are less accurate than a pregnancy test performed in a lab. For this reason, women may want to consider having a second test at their doctor's or midwife's office to verify the accuracy of the result.

Blood tests to determine pregnancy are generally used when a very early diagnosis of pregnancy is needed. This more expensive test, which also looks for hCG, can produce a result within nine to 12 days after conception.

Approximately 3% of live-born infants have a major defect. There are tests that can be performed to determine many of these. As of 2001, there is a prenatal diagnostic screening test for determining the risk of neural tube defects, abdominal wall defects, **Down syndrome**, and trisomy 18. The triple-marker screening test measures

levels of alpha fetoprotein (AFP), human chorionic gonadotropin (hCG), and unconjugated estriol. AFP is a protein produced in the fetal yolk sac during the first trimester and later by the fetal liver. Abnormally high levels of this protein are associated with severe neural tube defects. Human chorionic gonadotropin (hCG) is a hormone produced and secreted by the placenta. During early normal pregnancy, the level of this hormone rises rapidly, then begins to decline between the 10th and 20th week of gestation. High levels of hCG during the second trimester are associated with Down syndrome. Unconjugated estriol is produced by the placenta, the fetal **adrenal glands**, and the liver. It rises as normal pregnancy progresses, and its values are often lower with Down syndrome. A woman must have her blood sample drawn between the 15th and 20th week of gestation in order for this test to be accurate.

Other tests are recommended for women who are at higher risk for having a child with a birth defect. This includes women who have previously given birth to a child with a defect, or who have a family history of birth defects; women who have been exposed to certain drugs or high levels of radiation; and women 35 years of age or older. The presence of any of these risk factors warrants not only **genetic counseling**, but consideration of an ultrasound by a specialist, chorionic villi sampling (CVS), and/or **amniocentesis**.

First prenatal visit

During a woman's first prenatal visit, the following diagnostic tests are usually performed:

- complete blood count (CBC), for anemia
- blood type, Rh, and antibody screen
- syphilis (VDRL)
- rubella titer (German measles)
- hepatitis B virus (HBV)
- urinalysis and culture
- Pap smear
- cervical cultures for gonorrhea and chlamydia
- recommendation of HIV antibody test, with counseling

A screening test for **gestational diabetes** is performed between 24 and 28 weeks' gestation by giving the woman a 50 g glucose drink, then drawing a blood sample one hour later to check the glucose level. A normal value is less than 130-140 mg/dL. A woman with a family history of diabetes, however, should be tested on her first visit to the obstetrician/gynecologist or nurse-midwife.

Treatment

Women with heart disease, diabetes, lupus, and some hereditary conditions should consult a health professional before getting pregnant, as these conditions increase the risk of morbidity and mortality for both the mother and child.

Prenatal care is vitally important for the health of the unborn baby. During the first trimester, the woman should receive 0.4 to 0.8 µg (micrograms) of **folic acid** daily to reduce the chance of neural tube defects. Ideally, this daily dose of folic acid should begin at least one month prior to conception. Generally, requirements for all **vitamins** are increased during pregnancy. Prenatal vitamins prescribed by a physician or midwife usually contain the recommended amount of folic acid, and some contain a stool softener to offset the constipating effects of **iron**. Following delivery, vitamins are also recommended for the breast-feeding woman. Most pregnant women need at least 2,300 calories a day; these should come from good sources of protein, green leafy vegetables, fresh fruit, and breads and cereals. Small meals may be eaten frequently throughout the day.

Since most medications can pass from the mother to the baby, no medication (not even a nonprescription drug) should be taken except under medical supervision. No drug should be considered completely safe (especially during early pregnancy), although many physicians and nurse-midwives approve their patients' use of some drugs, including acetaminophen. Drugs taken during the first three months of a pregnancy may interfere with the normal formation of a baby's organs, leading to birth defects. Drugs taken later on in pregnancy may slow the baby's growth rate, or they may damage specific fetal tissue (such as developing teeth).

To increase the chance of having a healthy baby, a pregnant woman should avoid the following:

- smoking
- alcohol
- street drugs
- large amounts of **caffeine** (more than a cup or two of coffee per day)
- artificial sweeteners (although clinicians debate this)
- more than 5,000 U of vitamin A

Prognosis

Pregnancy is a natural condition and not a disease. If a woman takes good care of herself, plans her pregnancy with medical counseling, maintains optimal health, and obtains good prenatal care, the pregnancy and birth expe-

rience will be joyful events. In choosing a caregiver, the pregnant woman must consider what she wants for herself and her baby. The standard hospital experience, despite the homey decorations and presence of family members, frequently demands that the woman in labor remain in bed attached to a fetal monitor. Bed rest and hydration by IV slow down labor, even when normal. The ability to walk and change position during labor alleviates discomfort felt during contractions.

Many health care facilities are now utilizing nurse-midwives to attend births; their approach permits fewer interventions. Nurse-midwives are nurses who have received additional training in order to care for women having normal pregnancies and birth. If any complications should arise, they are well trained to detect them early, and they will call in the physician with whom they work. The pregnant woman and her partner should make a birth plan for their experience and present it to their caregiver early in the pregnancy to determine if the individual meets their expectations. The American College of Nurse-Midwives, (202) 728-9860, can provide the pregnant woman with a list of midwives in her area.

Childbirth education classes for the woman and her partner are extremely important in helping a couple prepare for labor and delivery. Pregnant women should be made aware of the options for the location and circumstances for birth. Increasing numbers of women are having their babies in their own homes or in birthing centers, as opposed to a traditional hospital setting.

Prevention

There are many methods of **contraception** available to prevent pregnancy. In order of least to most effective, these include:

- spermicide alone
- natural (rhythm) method
- diaphragm or cervical cap
- condom alone
- diaphragm with spermicide
- condom with spermicide
- intrauterine device (IUD)
- contraceptive pill
- sterilization (either man or woman)
- abstinence

Resources

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Starr, Winifred L., Shannon, Maureen T., Lommel, Lisa L., Gutierrez, Yolanda M. *Ambulatory Obstetrics*. San Francisco, CA: UCSF Nursing Press, 1999.

ORGANIZATIONS

The Couple to Couple League. P.O. Box 111184, Cincinnati, OH 45211-1184. (513) 471-2000. www.ccli.org.

Doulas of North America. 13513 North Grove Drive, Alpine, UT 84004. www.dona.com (801) 756-7331.

Healthy Mothers, Healthy Babies National Coalition. 121 North Washington St., Suite 300, Alexandria, VA 22314. (703) 836-6110. www.hmhb.org.

National Institute of Child Health and Human Development. Bldg 31, Room 2A32, MSC 2425, 31 Center Drive, Bethesda, MD 20892-2425. www.nichd.nih.gov.

OTHER

"The Art and Science of Birth." *Midwifery Today*. <<http://www.midwiferytoday.com>>.

Planned Parenthood. <<http://www.plannedparenthood.org>>.

"Pregnancy Information." <<http://www.childbirth.org>>.

Linda K. Bennington

Pregnancy massage

Definition

Pregnancy massage is the prenatal use of **massage therapy** to support the physiologic, structural, and emotional well-being of both mother and fetus. Various forms of massage therapy, including Swedish, deep tissue, neuromuscular, movement, and Oriental-based therapies, may be applied throughout pregnancy as well as during labor and the postpartum period.

Origins

Cultural and anthropological studies indicate that massage and movement during the childbearing experience were and continue to be a prominent part of many

cultures' health care. Indian Ayurvedic medical manuals detail therapists' instructions for rubbing specially formulated oils into pregnant patients' stretched abdominal skin. Traditional sculptures depict Eskimo fathers supporting and lovingly stroking their laboring wives' backs. In certain Irish hospitals laboring women are held and touched by a doula (labor assistant) or midwife through most of their notably short, uncomplicated labors. For billions of women, over thousand of years, midwives' highly developed hands-on skills have provided loving support and eased childbearing discomforts. As massage therapy resumes its place within Western health care methods, pregnancy massage is becoming one of its fastest-growing specialized applications.

Benefits

Profound physiologic, functional, emotional, relational, and lifestyle changes occur during gestation and labor, often creating high **stress** levels. Too much stress can negatively affect maternal and infant health, resulting in reduced uterine **blood** supply and higher incidence of **miscarriage**, prematurity, and other complications. Massage therapy can help a woman approach her due date with less **anxiety** as well as less physical discomfort. Even apart from easing specific aches, massage can act as an overall tonic and increase the expectant mother's body awareness.

Massage therapy can address the various physical challenges of pregnancy: **edema**; foot, leg, or hand discomforts; and **pain** in the lower back, pelvis, or hips. Swedish massage may facilitate gestation by supporting cardiac function, placental and mammary development, and increasing cellular respiration. It can also reduce edema and high **blood pressure** as well as contribute to sympathetic nervous system sedation. Deep tissue, trigger point, and both active and passive movements alleviate stress on weight-bearing joints, muscles, and fascial tissues to reduce neck and back pain caused by poor posture and strain on the uterine ligaments. During labor, women whose partners use basic massage strokes on their backs and legs have shorter, less complicated labors. After the baby's birth, massage therapy can gently facilitate the body's return to its pre-pregnancy state, alleviate pain, foster a renewed sense of body and self, and help maintain flexibility despite the physical stresses of infant care. For post-Caesarean mothers, specific therapeutic techniques can also reduce scar tissue formation and facilitate the healing of the incision and related soft tissue areas.



Pregnancy massage increases blood flow, relaxes muscles, reduces water retention, and makes the skin more supple. It is particularly useful in relieving the back pain of late pregnancy. (Photo Researchers, Inc. Reproduced by permission.)

Description

When nestled with pillows or other specialty cushions into a side-lying or semi-reclining position, most women are more comfortable for the 30–60 minutes of a typical massage session. A pregnant woman can expect to enjoy many of the same techniques, draping, and professional demeanor offered all massage therapy clients. The lower back, hips, and neck benefit from sensitively applied deep tissue, neuromuscular, and **movement therapy**. Edema in the legs and arms may be relieved with the gliding and kneading strokes of Swedish or lymphatic drainage massage. Pregnant women should expect a thorough health and prenatal intake interview with their therapists. Cost, procedures, and insurance coverage are similar to those for other massage client populations.

Preparations

In addition to the preparations listed in the massage therapy entry, some expectant women will be asked to secure a release from their maternity health care provider, especially those with complications or high-risk factors.

KEY TERMS

Doula—A woman who assists an expectant mother with physical and emotional support during labor.

Edema—An abnormal accumulation of fluid in specific parts of the body, causing swelling of the area. Many women experience edema of the wrists and ankles during pregnancy.

Precautions

In addition to those listed in the massage therapy entry, the following other precautions are prudent:

- The abdomen should be touched only superficially with a flat, gentle hand.
- Any pressure applied to the inner leg should also be superficial.
- Women who must be on bed rest for any complication are at higher risk of blood clots forming in their legs; therefore, most massage of the legs should be avoided.
- Massage is safest when a woman is either lying on the side or propped semi-sitting at a 45–70-degree angle rather than lying on her back or belly.
- Because there are many other specific body areas and types of techniques that must be avoided or modified according to an individual woman's health condition, advanced specialized training of the therapist and consultation with the expectant mother's physician or midwife are highly recommended. It is better to avoid massage if the woman has vaginal bleeding, abdominal pain, or diarrhea.

Side effects

There are no known side effects to receiving appropriate prenatal massage therapy.

Research and general acceptance

Current research on the benefits of touch is providing a contemporary basis for its reintroduction into maternity care. Scientists have found that rats restricted from cutaneous self-stimulation had poorly developed placentas and 50% less mammary gland development. Their litters were often ill, stillborn, or died shortly after birth due to poor mothering skills. Women who are nauseated and/or vomiting prenatally experienced a decrease in these discomforts when they applied finger pressure to a specific acupuncture point (**acupressure**) on their fore-

arm several times each day. Pregnant women massaged twice weekly for five weeks experienced less anxiety, leg, and back pain. When compared with control groups who practiced **relaxation** exercises only, the women who had had massage reported better sleep and improved moods; and their labors had fewer complications, including fewer premature births. Studies show that when women receive nurturing touch during later pregnancy, they touch their babies more frequently and lovingly. During labor the presence of a doula, a woman providing physical and emotional support, including extensive touching and massage, reduces the length of labor and number of complications, interventions, medications, and cesarean sections.

Training and certification

Some massage therapy schools include comprehensive courses in pregnancy massage therapy. More often, however, therapists receive only introductory guidance in maternity applications during their 500–1000 hours of basic training. They pursue specialization certification in pre- and perinatal massage therapy. Several nationwide programs offer such advanced training in 24–34-hour workshop programs.

Resources

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ORGANIZATIONS

- National Association of Pregnancy Massage Therapy.
(888) 451-4945.

Carole Osborne-Sheets

Pregnancy test

Definition

Pregnancy is detected by measuring the concentration of human chorionic gonadotropin (hCG) in serum or urine. Human chorionic gonadotropin is a hormone produced by the placenta that supports the corpus luteum after fertilization of the ovum. Production of hCG begins at the time of implantation, and hCG can usually be detected in serum and urine within 10 days after fertilization. The level of hCG in serum and urine is usually above 25 mIU/mL, the cutoff for a positive pregnancy test, before the next expected period. Therefore, pregnancy can be detected reliably within two to three days following the first missed menses using a qualitative hCG test. In addition to diagnosis of pregnancy, the test is used in emergency departments to rule out pregnancy in circumstances in which x ray and other procedures are contraindicated by pregnancy. The test is also used to rule out pregnancy in females with acute abdominal **pain** that suggests the possibility of ectopic pregnancy (i.e., pregnancy outside the uterus).

Quantitative measurements of hCG are used as an aid to the diagnosis of ectopic pregnancy and trophoblastic tumors. Serial measurements may be used to monitor treatment and recurrence of tumors that secrete hCG. Measurement of hCG is also part of the triple marker screening procedure performed on maternal serum between weeks 15 to 20 to assess the fetal risk of **Down syndrome**.

Description

Chorionic gonadotropin is a hormone consisting of two polypeptide chains or subunits designated alpha and beta. The alpha chain is identical to the alpha chain of luteinizing hormone (LH), follicle stimulating hormone (FSH), and thyroid stimulating hormone (TSH). The beta chain is identical to that of LH except for the C-terminal end, which contains an additional 24 amino acids. Antibodies made against the alpha subunit will cross-react with LH, FSH, and TSH, but antibodies can be made to the beta subunit that are hCG-specific. All tests for pregnancy utilize antibodies to both subunits, which makes the pregnancy test highly specific for hCG. Chorionic gonadotropin is produced at an exponential rate through week 12 of gestation, often reaching in excess of 100,000 mIU/mL. In a normal pregnancy, the production of hCG doubles approximately every two days during this period. The level falls off sharply after the first trimester to approximately 20,000 mIU/mL, and is maintained at this level throughout a normal pregnan-

cy. Following a normal delivery, the hCG can be detected in serum and urine for three to four weeks. This period may be longer following an aborted pregnancy, especially if a trophoblastic tumor was present.

All pregnancy tests are double antibody sandwich immunoassays. The most commonly used platform, called immunochromatography, consists of a disposable device containing a membrane on which an antibody to one hCG subunit is immobilized. The membrane also contains an antibody to the other hCG subunit that is mobile. The mobile antibody is conjugated to an enzyme, dyed latex particle, or colloidal gold particle. Sample is added to the device and is drawn by capillary action onto the membrane, where it mixes with the mobile antibody. If hCG molecules are present, they bind to the mobile antibodies, forming antibody-antigen complexes. These migrate along the membrane to the region containing the immobilized antibody. The immobilized antibody binds to the other hCG subunit, forming an antibody-hCG-antibody sandwich that remains fixed to the membrane in the reaction zone region. At this point, the dye or gold particles are focused in the reaction zone and produce color, usually in the form of a plus sign or other visible indicator of a positive test. If an enzyme-conjugated antibody is used, a substrate solution is added, which is hydrolyzed by the enzyme to produce a colored product at the reaction zone.

Precautions

In order to achieve accurate results for home pregnancy tests, the manufacturer's instructions must be followed precisely. A significantly higher error rate has been observed with home pregnancy tests than with laboratory tests for pregnancy, which typically have an error rate below 1%. Diluted urine may cause a false-negative result. False-positive results may be caused by heterophile antibodies, medications containing mouse monoclonal antibodies, autoantibodies, and hyperlipemia. In very early pregnancy, the color reaction may be difficult to interpret. In such cases, the test should be repeated after waiting at least 48 hours. If serum is to be used, standard precautions for the prevention of transmission of bloodborne pathogens should be followed.

Preparation

No preparation is generally required for a pregnancy test. However, if urine is used, the first morning urine is the specimen of choice because the urine will be more concentrated after an overnight fast.

KEY TERMS

Ectopic pregnancy—A pregnancy that develops outside the mother's uterus. Ectopic pregnancies often cause severe pain in the lower abdomen and are potentially life-threatening because of the massive blood loss that may occur as the developing embryo/fetus ruptures and damages the tissues in which it has implanted.

Embryo—In humans, the developing individual from the time of implantation to about the end of the second month after conception. From the third month to the point of delivery, the individual is called a fetus.

Hormone—A chemical produced by a specific organ or tissue of the body that is released into the bloodstream in order to exert an effect in another part of the body.

Human chorionic gonadotropin (hCG)—A hormone produced by the placenta of a developing pregnancy.

Hydatidiform mole—A rare, generally benign grape-like mass that grows in the uterus from the remains of an abnormally developed embryo and surrounding tissue. In extremely rare cases, the mole develops into a choriocarcinoma, a malignant tumor that can invade the wall of the uterus.

Implantation—The attachment of the fertilized egg or embryo to the wall of the uterus.

Menstrual cycle—A hormonally regulated series of monthly events that occur during the reproductive years of the human female to ensure that the proper internal environment exists for fertilization, implantation, and development of a baby. Each month, a mature egg is released from the follicle of an ovary. If an egg is released, fertilized, and implanted, the expanded lining of the uterus is maintained. If fertilization and/or implantation does not occur, the egg and all of the excess uterine lining are shed from the body during menstruation.

Miscarriage—Loss of the embryo or fetus and other products of pregnancy before the middle of the second trimester. Often, early in a pregnancy, if the condition of the baby and/or the mother's uterus are not compatible with sustaining life, the pregnancy stops, and the contents of the uterus are expelled. For this reason, miscarriage is also referred to as spontaneous abortion.

Placenta—The organ that unites the fetus to the mother's uterus. The placenta produces hCG, among other hormones, to help maintain the pregnancy. It transfers nutrients and antibodies to the fetus, and waste products from the fetus. After delivery, the placenta, known at this point as the afterbirth, is expelled.

Aftercare

No special care is required after a urine test for hCG. If **blood** is drawn, discomfort or bruising may occur at the puncture site or the person may feel dizzy or faint. Pressure to the puncture site until the bleeding stops reduces bruising; warm packs relieve discomfort. Women who feel faint should be observed until the condition goes away.

Complications

Tests for hCG levels pose no direct risk to a woman's health. The main risk with a home pregnancy test is a false-negative result, which may be lessened by following the manufacturer's instructions carefully and waiting at least several days after the expected menstrual period before performing the test. A false-negative result can cause a delay in seeking **prenatal care**, which can pose a risk to both the woman and her fetus.

Results

HCG levels below 25 mIU/mL will give a negative pregnancy test result for all pregnancy test methods. Home test kits use a cutoff of 50 mIU/mL and will be negative below this level. Following **miscarriage** or abortion, the pregnancy test may remain positive for four weeks or longer. An hCG test performed during this time may be positive in the absence of pregnancy.

The upper limit of normal for a quantitative hCG test is approximately 5 mIU/mL. In rare circumstances, such as pelvic inflammatory disease, the hCG level in non-pregnancy may be greater than 5 mIU/mL. Persons with trophoblastic tumors, molar pregnancies, and choriocarcinoma will have greatly elevated levels of hCG. HCG may be found in persons with testicular **cancer** and other malignancies that secrete hCG or alpha and/or beta subunits. Quantitative hCG measurement is useful in detect-

ing hCG-secreting tumors. Periodic measurements are useful in evaluating treatment and monitoring patients for recurrence. Maternal serum hCG levels are increased by approximately 25% above normal for the gestational age in Down syndrome pregnancies and in some other trisomy syndromes. In ectopic pregnancy, hCG levels are lower than normal, and the hCG doubling time is less than expected. Minimum hCG increases between timed hCG measurements in the first trimester are:

- two measurements one day apart: 29% increase
- two measurements two days apart: 66% increase
- two measurements three days apart: 114% increase
- two measurements four days apart: 175% increase
- two measurements five days apart: 255% increase

Recovery of a lower than expected increase is evidence of ectopic pregnancy. Decreases in hCG are seen in spontaneous abortion.

Health care team roles

If serum is used, a phlebotomist or nurse collects the blood specimen. A laboratory scientist, nurse, physician assistant, or physician can perform the pregnancy test. The result should be reported to the physician who orders the test. Quantitative hCG tests are ordered and interpreted by a physician and performed by a clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) or clinical laboratory technician CLT(NCA)/medical laboratory technician MLT(ASCP).

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Victoria DeMoranville

Premature infants

Definition

A premature infant is defined as one born before 37 weeks of gestation (**pregnancy**) without regard to birth weight. The length of a full-term pregnancy ranges from 37 to 42 weeks, measuring from the first day of the last menstrual period. "Preterm" is a word that is sometimes used instead of "premature." Extremely premature infants are defined as those born between 22 and 28 weeks of gestation. As of 2001, babies born at 21 weeks of gestation or less have little chance of survival.

In the United States, about 10% of all infants are born prematurely. African American babies are more likely to be premature (14%) than Caucasian or Hispanic babies (7%). The rates of survival of premature infants, however, have increased dramatically over the last three decades. At one teaching hospital in the Midwest, the survival rate of infants weighing less than 1 lb 12 oz (800 grams) at birth rose from 20% in 1977 to 49% in 1990. In spite of advances in medical technology, these children remain at higher risk of birth defects, weakened immune systems, and a variety of chronic medical and developmental disorders. Many require long-term follow-up care.

Description

Chances for survival

The most important factor affecting survival in extremely premature infants is gestational age at the time of birth, which is defined as the estimated time elapsed since conception. Another term for gestational age is postconceptional age. The likelihood of a preterm infant's survival at specific gestational ages in the United States in the late 1990s is as follows:

- 21 weeks or less: 0% survival rate
- 22 weeks: 0–10% survival rate
- 23 weeks: 10–35% survival rate
- 24 weeks: 40–70% survival rate
- 25 weeks: 50–80% survival rate
- 26 weeks: 80–90% survival rate
- 27 weeks: greater than 90% survival rate

The baby's chances of survival increase 3–4% per day between 23 and 24 weeks of gestation, and 2–3% per day between 24 and 26 weeks.

In addition to gestational age, the baby's weight at birth, the presence of breathing problems, the presence of birth defects, and the presence of severe **infection** are



Premature infants often must stay in an incubator for some time. (NLM. Reproduced by permission.)

important factors influencing survival. Birth weight in premature infants is categorized as follows: birth weight below 5 lb 8 oz (2500 g) is defined as low birth weight (LBW); weight below 3 lb 5 oz (1500 g) is very low birth weight (VLBW); and weight below 2 lb 3 oz (1000 g) is extremely low birth weight (ELBW).

Other factors affecting survival

Other factors that influence the rate of organ development or the fetal oxygen supply also influence a premature infant's chances for survival. These factors include:

- rupture of the amniotic sac with loss of amniotic fluid before 24 weeks of gestation
- male sex (male infants are slower to mature)
- race (African American infants have slightly better chances of survival than Caucasian infants of the same birth weight)
- uncontrolled diabetes in the mother (slows organ development in the fetus)
- severe **hypertension** before the eighth month of pregnancy (slows delivery of nutrients and oxygen to the fetus)

Causes and symptoms

Causes of preterm labor

Labor that begins before the 37th week of pregnancy is called premature or **preterm labor**. It is responsi-

ble for about 85% of illnesses and deaths in newborns in the United States. Premature labor is sometimes induced because of the mother's or the infant's condition. Preeclampsia/eclampsia is the most common reason for inducing labor; other reasons include fetal distress or bleeding. Common causes of spontaneous premature labor include:

- abruptio placentae, or detachment of the placenta from the uterine wall
- premature rupture of the amniotic sac
- incompetent (too easily dilated) cervix
- multiple pregnancy
- abdominal or cervical surgery during the current pregnancy
- placenta previa (the placenta lies between the baby and the birth canal)

Factors that increase the mother's risk of preterm labor include:

- history of preterm delivery
- history of abortions or miscarriages
- heavy smoking (more than 10 cigarettes per day)
- history of drug abuse
- exposure to diethylstilbestrol (DES), a synthetic estrogen given to treat estrogen deficiency conditions
- urinary tract infection
- malnutrition
- height below 5 ft (1.5 m)
- weight below 100 lb (45 kg)
- age below 18

Common medical problems in premature infants

The most common problems in premature infants include **jaundice**, apnea (a pause in breathing lasting longer than 15–20 seconds), and inability to breast-feed or bottle-feed. Apnea in premature infants is accompanied by the baby's turning pale or bluish, and by a slowing-down of its **heart** rate (bradycardia). These problems are particularly likely to affect infants born more than four to six weeks early.

More serious medical problems that are relatively frequent in premature infants are described in the next four subsections.

RESPIRATORY DISTRESS SYNDROME (RDS). **Respiratory distress syndrome** (RDS) is the most common lung disorder in preterm infants. It is caused by a lack of surfactant in the **lungs**. Surfactant is a surface-active substance produced by the body that coats the

lungs and keeps them from collapsing. Babies with RDS typically breathe rapidly, with flaring nostrils and grunting sounds. RDS is usually treated by giving the baby extra oxygen under pressure. Sometimes the baby is also given additional surfactant by intubation.

TRANSIENT TACHYPNEA OF THE NEWBORN (TTNB). Transient tachypnea of the newborn is a disorder lasting for several hours or a few days characterized by rapid, grunting breathing. TTNB is thought to be caused by slow reabsorption of fetal lung fluid. It is also treated with supplemental oxygen.

PATENT DUCTUS ARTERIOSUS (PDA). A patent ductus arteriosus refers to an opening in the **blood** vessel that connects the aorta and the pulmonary artery. In full-term infants, this blood vessel closes in the first few days after birth. In preterm infants, it may remain open, thus allowing too much blood to flow into the baby's lungs. PDAs are treated with indomethacin or ibuprofen to close the blood vessel, or diuretics to decrease the amount of fluid that collects in the baby's lungs. If the medications do not close the ductus, it can be closed surgically.

RETINOPATHY OF PREMATURITY (ROP). Retinopathy of prematurity, or ROP, is the abnormal growth of **blood vessels** in the eyes. ROP is most common in infants who are more than 12 weeks premature. It often resolves on its own, but sometimes requires treatment. Treatment consists of killing the inner lining of the eye at the ends of the abnormal blood vessels to prevent further growth.

Less common but severe medical conditions

The next five subsections briefly describe serious disorders that may affect premature infants.

AIR LEAKS. Air leaks refer to several conditions in preterm infants, all characterized by air leaking from the air sacs in the lungs. The air may be trapped between the chest wall and the lung, trapped in the middle part of the chest, leaked into the abdomen, or leaked into the spaces between the tiny air sacs. Premature infants are vulnerable to air leaks because their lungs are not yet fully developed. In milder cases, the air is gradually reabsorbed by the baby's body. In severe cases, the baby may be treated by placement of a chest tube, or be placed on a ventilator.

NECROTIZING ENTEROCOLITIS (NEC). Necrotizing enterocolitis (NEC) is an inflammatory disorder in which part of the bowel lining or part of the bowel itself is destroyed. It is not always clear why a specific infant may develop NEC. The baby may vomit, have a swollen or abnormally reddish abdomen, or pass blood in the stool. NEC is usually treated with **antibiotics**. If a section of the bowel itself has been destroyed, surgery may be necessary.

BRONCHOPULMONARY DYSPLASIA (BPD). Bronchopulmonary dysplasia, or BPD, is a long-term lung disease that is most likely to develop in infants who were extremely premature, had severe RDS, or developed infections of the lungs. BPD is diagnosed if the baby's chest x-rays remain abnormal and the baby still needs oxygen by the time it is 36 weeks of gestational age (a month before its full-term due date). Babies with BPD are treated with supplemental oxygen, sometimes for as long as a year after they develop BPD. They may also be given steroids or diuretics.

INTRAVENTRICULAR HEMORRHAGE (IVH). Intra-ventricular hemorrhage (IVH) is a **brain** disorder in which blood seeps into the ventricles (a series of connecting cavities) of the brain. IVH develops because the blood vessels in the brain of a premature infant are fragile and break open easily. The preterm babies at highest risk for IVH are those weighing less than 2 lb 4 oz (1000 g). There is no specific treatment for IVH, but the condition can be monitored by ultrasound. In mild cases of IVH, the blood in the ventricles is slowly reabsorbed by the body. Babies with hydrocephalus (abnormal amounts of cerebrospinal fluid collecting in the ventricles of the brain), which is a possible complication of IVH, are at risk for permanent brain injury.

PERIVENTRICULAR LEUKOMALACIA (PVL). Periventricular leukomalacia (PVL) refers to a softening of the white matter of the brain surrounding the ventricles, caused by the death of brain tissue in these areas. The precise causes of PVL are still not fully understood. PVL often develops in babies with IVH. There is no specific treatment for PVL; moreover, infants with this disorder are at very high risk for motor (movement) and developmental disabilities as they mature.

Diagnosis

Many of the problems associated with prematurity depend on the degree of prematurity and the baby's birth weight. The gestational age of the fetus may be calculated from the date of the mother's last menstrual period or by using ultrasound imaging to observe **fetal development**. After the baby is born, such physical assessment scales as the Dubowitz Maturity Scale may be used to estimate gestational age. The Dubowitz scale bases its determination on the infant's physical and neuromuscular maturity.

Once the baby's gestational age and weight are determined, further tests and electronic monitoring may need to be used to diagnose problems or to track the baby's condition. A heart monitor or cardiorespiratory monitor may be attached to the baby's chest, abdomen, arms, or legs with adhesive patches to monitor breathing

KEY TERMS

Apnea—A pause in breathing of more than 15–20 seconds. In premature infants, apnea usually causes a change in the baby's color and a slowing of the heartbeat.

Bronchopulmonary dysplasia (BPD)—A chronic lung disorder that sometimes develops in premature infants who have had severe respiratory distress syndrome or lung infections.

Chronologic or birth age—The infant's age as measured by the time elapsed since birth.

Gestational age—The infant's age as measured by the estimated time since conception; sometimes called postconceptional age.

Hydrocephalus—An abnormal buildup of cerebrospinal fluid in the ventricles of the brain. In premature infants, it is often a complication of IVH.

Intraventricular hemorrhage (IVH)—A condition in which fragile blood vessels within the brain burst and bleed into the hollow chambers (ventricles) of the brain and into the tissue surrounding them.

Kangaroo care—A form of skin-to-skin contact in which either parent of a premature infant holds the baby under the blouse or shirt, against the skin. It is thought to help the infant's development as well as its bonding with the parents.

Necrotizing enterocolitis (NEC)—A condition that sometimes occurs in premature infants in which the lining of the bowel or a section of the bowel itself dies.

Neonatology—The study of the development and

disorders of newborn children. A physician who specializes in this field is called a neonatologist.

Patent ductus arteriosus (PDA)—An opening in the blood vessel that connects the aorta and the pulmonary artery. In full-term infants, this opening closes shortly after birth, but in premature infants, it may remain open and allow blood to collect in the infant's lungs.

Periventricular leukomalacia (PVL)—A brain disorder in which some of the white matter of the brain near the ventricles is softened because of the death of tissue in these areas.

Preeclampsia/eclampsia—Complications of pregnancy related to high blood pressure in a woman whose blood pressure was normal before pregnancy. Preeclampsia and eclampsia are common reasons for inducing premature labor.

Preterm—Another word for premature.

Respiratory distress syndrome (RDS)—A condition in which a premature infant lacks a sufficient amount of surfactant, a protective film that helps air sacs in the lungs to stay open.

Retinopathy of prematurity (ROP)—A condition in which the blood vessels in the retina of the eye display abnormal growth.

Surfactant—A protective film that helps air sacs in the lungs to stay open.

Tachypnea—Rapid breathing. Some premature infants develop rapid breathing for a few hours or days. This condition is known as transient tachypnea of the newborn (TTNB).

and heart rate. A **thermometer** probe may be taped on the skin to monitor body temperature. Blood samples may be taken from a vein or artery. A radiologic technologist may perform x rays or ultrasound imaging to examine the heart, lungs, and other internal organs.

Treatment

Treatment depends on the types of complications that are present. The infant may be placed in a heat-controlled unit (an incubator) to maintain body temperature. Infants that are having trouble breathing on their own may need oxygen either pumped into the incubator, administered through small tubes placed in their nostrils (nasal cannula), or through a respirator or ventilator that

pumps air through an endotracheal tube inserted into the airway. Oxygen may be delivered under pressure by continuous positive airway pressure (CPAP) or positive end expiratory pressure (PEEP).

Medications and surgery

The infant may require fluids and nutrients to be administered through an intravenous line inserted into a vein in the hand, foot, arm, leg, or scalp. If the baby needs medications to treat infections, to close a patent ductus, or to increase urinary output, they may also be administered through the intravenous line. Surgery may be required in the treatment of PDA, NEC, or IVH. If hydrocephalus develops as a complication of IVH, it may

be treated by surgical placement of a shunt, which is a tube connecting one of the ventricles in the brain to a longer tube under the skin that allows the excess cerebrospinal fluid to be absorbed in the abdomen.

Environmental considerations

Premature infants require special attention to their physical and social environment as well as to the symptoms of any disorders they may have. Some modifications are necessary because the nervous systems of preterm infants are not as fully developed as those of full-term infants.

PHYSICAL ENVIRONMENT. Premature infants experience loud noises and bright lights as stressful. In addition, they are more disturbed by frequent handling than full-term infants. Parents and other care givers should be advised to position the infant on its side in a flexed position; because premature infants do not have the muscle strength to move against gravity, they tend to lie with arms and legs in an extended position. Over a period of time, this extended position can delay the baby's motor development.

SOCIAL ENVIRONMENT. Neonatal intensive care units, or NICUs, complicate the premature infant's social environment by exposing him or her to many more clinical staff members than the full-term infant, and at the same time keeping him or her away from the parents more than the full-term infant. For this reason, skin-to-skin contact with parents, sometimes called kangaroo care, and gentle massage are encouraged as promoting infant and parent well-being. Parents should be encouraged to have early contact with the premature baby to facilitate parent-infant bonding.

Prognosis

The prognoses of premature infants vary widely, depending on gestational age, birth weight, the reasons for premature delivery, and the many other factors discussed above.

Health care team roles

Premature infants receive routine care and monitoring in the NICU from nurses. A neonatologist, who is a physician specializing in care of the newborn, may be consulted if a medical intervention seems necessary. A radiologist may be consulted for radiographic or ultrasound studies, and a surgeon may be called in if an operation is required.

Other health professionals involved in the premature infant's care are the respiratory therapist, who monitors

the care of infants requiring supplemental oxygen or **ventilators**; the social worker, who helps families adjust emotionally and provides referrals to hospital and community resources; and the occupational therapist, who evaluates the baby's progress and plans a program of developmental therapy if necessary.

After discharge from the hospital, the infant's growth and development will be monitored by a pediatrician or family physician. This doctor will reinforce the parents' education about caring for their baby, review the hospital records, and give the baby its first immunizations (most can be given at the usual chronological age). Most doctors recommend office visits every one or two weeks until the infant has adapted satisfactorily to the home environment and is gaining an appropriate amount of weight.

Prevention

Some of the risks and complications of premature delivery can be reduced if the mother receives good **pre-natal care**, follows a healthy diet, avoids alcohol consumption, and refrains from cigarette smoking. In some cases of premature labor, the mother may be placed on bed rest or given drugs that can postpone labor for days or weeks, giving the fetus more time to develop before delivery. The physician or nurse-midwife may prescribe a steroid medication to be given to the mother if a premature birth is expected, to assist the baby's lung development.

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Premature labor *see* **Preterm labor**

Prenatal nutrition

Definition

Maternal **nutrition** during **pregnancy** affects both the health of the mother and the growing fetus. Requirements for calories and specific nutrients are increased for the baby's growth and proper development. These needs can be met by increasing healthful food consumption and specific nutrient supplementation.

Purpose

Proper prenatal nutrition helps ensure a healthy start for a new baby and promotes the mother's well-being during and after pregnancy. Nurses and other allied health professionals can play a role in educating pregnant women about sufficient weight gain, the importance of a healthy diet, and the following recommendations for supplementation.

Precautions

Maternal weight gain during pregnancy is an important predictor of a baby's birth weight. The height and weight of the mother before pregnancy should be taken into account when assessing maternal nutrient needs. Both underweight and excessively overweight women need special attention. Underweight women are more likely to give birth to premature or low birth-weight infants, while overweight women have an increased risk of developing pregnancy-related complications. Other high-risk groups for low birth-weight babies include women younger than 15 and those older than 35. Women whose pregnancies are fewer than 12 months apart are also at higher risk.

Description

Maternal weight gain is a measure often used to assess how well a pregnancy is progressing. Normal weight gain is considered to be 25 to 35 pounds, although individual needs should also be taken into account.

Women who are underweight to start with may benefit from gaining more (28-40 pounds), while overweight women may try to gain less (15-25 pounds). Even for overweight women, however, weight gain is important to allow for proper growth of the fetus.

Nutrient needs during pregnancy depend on physical activity and **metabolism** of the mother. For most women, energy needs increase to about 300 extra calories per day during the second and third trimesters. Protein needs increase to allow for new tissue growth and maintenance; deficiency can result in lower a birth weight. An extra 10 to 12 grams of protein per day is recommended during the last half of pregnancy.

Vitamin and mineral requirements are also increased during pregnancy. To meet those needs, most women in the United States are advised to take a multivitamin supplement with **minerals** while they are pregnant. Eating a well-balanced diet with plenty of fruits, vegetables, and whole grains will also help provide the needed **vitamins**. **Iron** and **calcium** are two minerals of special concern. The fetus acquires most of these minerals during the last trimester of the pregnancy. Doctors recommend daily supplementation of 30 mg of iron in the form of ferrous sulfate to avoid **iron deficiency anemia**, which can cause excessive tiredness in the mother. Calcium intake should be 1,200 to 1,500 mg per day, which can be obtained through diet or supplementation. Adequate calcium is important so that the mother does not lose bone mass during pregnancy. There is also some evidence that calcium supplementation reduces the risk of pregnancy-induced **hypertension**, also known as preeclampsia, for women who are at high risk for this condition.

Folate (**folic acid**) is an extremely important vitamin, not only during pregnancy, but before pregnancy as well. Folate is crucial to the development of new cells, and deficiency during pregnancy has been associated with the development of congenital malformations known as neural tube defects (NTDs). The most serious NTDs include spina bifida and anencephaly. Spina bifida is characterized by gaps in the spine, typically resulting in serious lifelong disability. An infant with anencephaly lacks **brain** formation and dies shortly after birth. Because NTDs arise early in pregnancy, before most women know they are pregnant, the U.S. Public Health Service recommends that all women of childbearing age consume 0.4 mg (400 micrograms) of folic acid daily. Adequate amounts of folate can be obtained from the diet, but in practice most women do not consume enough. To help address this problem, in 1996 the U.S. Food and Drug Administration (FDA) approved folate fortification of flour, breads, cereal, and rice.

Complications

Good nutrition is especially important for certain conditions during pregnancy. Diabetes, a disease of poor **blood** sugar regulation, is one common problem requiring special attention to diet. Some women develop it only during pregnancy, when it is termed **gestational diabetes**. It can lead to multiple complications, including abnormally enhanced growth of the fetus, a condition called macrosomia. Such babies need special care at birth until blood sugar levels can be brought under control. Control of gestational diabetes includes careful attention to diet so that maternal blood sugar levels are kept as normal as possible throughout pregnancy. Women should eat frequent small meals; select foods high in fiber and complex **carbohydrates**; and avoid highly refined foods and simple sugars.

Another common problem is nausea and vomiting in early pregnancy. Because hunger seems to exacerbate the problem, suggestions to alleviate nausea include eating small, frequent meals of easily digestible foods, and having dry crackers near the bed to eat immediately upon awakening. Some women have severe enough symptoms that they are in danger of weight loss, **dehydration**, and electrolyte disturbances. This condition, termed hyperemesis gravidarum, may require hospitalization or medications to treat it if simple nutritional measures cannot control it.

Phenylketonuria (PKU) is a more unusual condition, but it is one in which the importance of maternal nutrition is paramount. PKU and the related condition, hyperphenylalanemia (HPA), are genetic disorders involving the impairment of the ability to digest phenylalanine, an essential amino acid found in protein. Before the disease was recognized, people with PKU developed severe mental retardation in childhood. Since routine screening and early dietary treatment has been instituted, people with PKU now can develop normally. However, women with these conditions may be advised not to become pregnant because of the high risk of mental retardation and congenital defects in the developing fetus. Women who desire pregnancy should discuss their plans with health personnel in a clinic that specializes in the treatment of these disorders well before becoming pregnant, so that strict dietary measures can be taken before conception and throughout pregnancy.

An abnormal food behavior that sometimes occurs in pregnant women is pica, which involves the consumption of such nonfood items as cornstarch, dirt, hair, cigarette ashes, or coffee grounds. Pica is sometimes associated with iron deficiency; and some think that the consumption of these substances may relieve the nausea and vomiting associated with pregnancy. Although many of these

KEY TERMS

Congenital malformations—Deformities that occur at birth.

Gestational diabetes—A disorder occurring in pregnancy involving insensitivity to insulin, causing poor blood sugar regulation.

Hyperemesis gravidarum—Excessive vomiting during pregnancy.

Macrosomia—An abnormally large body. Macrosomia of the newborn is a common complication of gestational diabetes.

Phenylketonuria (PKU)—A congenital deficiency of an enzyme that aids in the breakdown of an amino acid, leading to the development of severe mental retardation. PKU can be controlled with a strict diet, which is especially critical during pregnancy of a mother with PKU to avoid physical and mental defects in the fetus.

Pica—A desire that sometimes arises in pregnancy to eat such non-food substances as dirt or clay.

Preeclampsia—A syndrome of high blood pressure that develops during pregnancy. The chief danger of preeclampsia is that it will progress to eclampsia, which is a life-threatening condition characterized by seizures.

substances are not inherently harmful, there is a concern that such habits may displace the intake of nutritious foods during pregnancy.

Alcohol consumption during pregnancy can result in **fetal alcohol syndrome (FAS)**, characterized by varying degrees of numerous physical and mental problems, including mental retardation, facial abnormalities, and **heart** and skeletal defects. Because of the unpredictable effects of even small amounts of alcohol, women are advised to drink no alcohol at any time during pregnancy.

Quitting smoking and avoiding secondhand smoke is especially important during pregnancy. Exposure to tobacco smoke increases the risk of a low birth-weight infant.

The effect of food additives is controversial, but doctors recommend that sugar substitutes, including saccharin and aspartame, be used in moderation if at all. **Caffeine** consumption during pregnancy is another debatable issue, although too much caffeine may have negative effects.

Especially for teenagers and young women, eating disorders may be of concern. Anorexia, bulimia nervosa (characterized by episodes of binge eating and vomiting), use of **laxatives**, or excessive exercising pose a serious risk to the mother and the fetus. Poor weight gain during pregnancy may indicate the presence of a eating disorder.

Results

Good nutrition and adequate weight gain in pregnancy increase the likelihood that the mother will feel her best during pregnancy and that a healthy baby will be born with a normal birth weight. Specific nutrient deficiencies can lead to birth defects, as is well documented for folic acid; or health consequences to the mother (e.g., calcium deficiency's possible role in preeclampsia). In addition, nutritional intervention is the treatment of choice for several conditions, including gestational diabetes, nausea and vomiting in pregnancy, and maternal PKU.

Health care team roles

Dietetic professionals, nurse practitioners, nurse midwives, and physicians play an important role in the **prenatal care** of pregnant women. Dietitians can provide the nutrition counseling and education necessary to ensure the normal growth and development of the fetus. They can warn women about the dangers of improper food intake and the outcome it may have on pregnancy. Physicians are primarily responsible for determining that the fetus is growing properly and for detecting and monitoring medical conditions. In uncomplicated pregnancies, nurse practitioners and nurse midwives may play a more prominent role in prenatal care.

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Lisa M. Gourley

Prenatal care

Definition

Prenatal care is that health care given to a pregnant woman and to the developing fetus until the time of delivery.

Purpose

The purpose of prenatal care is to:

- Establish a baseline for **vital signs** and current health status.
- Identify women at risk for pregnancy-related complications.
- Minimize pregnancy-related complications through prevention techniques, anticipatory action, and intervention as soon as a complication is recognized.
- Offer education to the woman about possible lifestyle and work-related dangers to her and the developing fetus.
- Provide routine evaluation of the growth and development of the fetus.
- Educate the pregnant woman about normal and abnormal conditions in **pregnancy**.
- Teach the woman to recognize the signs of impending labor.
- Assist in connecting the pregnant woman to childbirth- and or parenting-education classes.

Precautions

Practitioners of prenatal care need to be aware of the possibility of domestic abuse, since such violence may begin with a pregnancy. About half of the women who are abused prior to becoming pregnant will continue to be abused during the pregnancy. Questions about abuse should be included at the first prenatal visit, and periodically thereafter if suspicion of it arises.

Description

The prenatal period lasts about 38 weeks from conception to delivery, or 40 weeks from the last menstrual period (LMP). It may also be referred to as the *antenatal* period. While some women come for their first prenatal visit shortly after missing a menstrual period, others may not come for prenatal care until later.

The first prenatal visit is usually the longest, as it includes a complete **health history**, **physical examination** (including pelvic and bimanual exams), and **blood**

and urine testing. A recommended schedule for prenatal visits is:

- Once a month until 28 weeks' gestation.
- Every two weeks from week 28 to week 36.
- Every week from week 36 until delivery.

The pregnancy is confirmed at the first prenatal visit. A urine or blood test may be done as well as a physical examination. A woman may have taken a home **pregnancy test** after a missed period and may already be experiencing some nausea, vomiting, or breast tenderness. Practitioners should assess the woman's feelings about the pregnancy and assist in appropriate referrals if she needs further counseling.

The complete health history should record the following information:

- The first day of the woman's last menstrual period. The LMP date will be used to calculate the estimated date of delivery, referred to as the due date. Calculation of the due date uses a formula called Naegele's rule: subtract three months from the date of the woman's LMP. Then add one week and one year. Most women deliver within two weeks before or after their due date.
- Previous gynecologic and obstetric history. Practitioners should not assume that this is the woman's first pregnancy. A woman may not divulge her complete history if her partner is present and there are aspects of her history that she has not yet shared. This history should include contraceptive choices and prior exposure to sexually transmitted diseases. If she is Rh-negative, did she receive RHOgam with a previous pregnancy, even if it was terminated early?
- Personal medical history. This should include childhood diseases, **allergies**, side effects or allergies to medications, such chronic diseases as high **blood pressure** and diabetes, medications currently being taken, vaccinations, surgeries, and eating disorders. Past conditions may become reactivated during a pregnancy. Women with prior eating disorders may have difficulty gaining weight during a pregnancy. Women should be asked about medication taken before the pregnancy was suspected, as well as any unprotected exposure to x rays. The form of **contraception** at the time of conception needs to be established, and women should be asked if an intrauterine device (IUD) is in place.
- Family medical history, including ethnicity. Women may need screening if there is a family history of sickle-cell anemia, Tay-Sachs, **cystic fibrosis**, or thalassemia. Sometimes there is no family history but testing is still important if suggested by ethnic heritage. Women should be asked if there is a family history of

Prenatal visit schedule recommended by the U.S. Public Health Service

First pregnancy	Second or later pregnancy
First visit: 6–8 weeks	First visit: 6–8 weeks
Second visit: Within 4 wks of first	Second visit: 14–16 weeks
Third visit: 14–16 weeks	Third visit: 24–28 weeks
Fourth visit: 24–28 weeks	Fourth visit: 32 weeks
Fifth visit: 32 weeks	Fifth visit: 35 weeks
Sixth visit: 36 weeks	Sixth visit: 39 weeks
Seventh visit: 38 weeks	Seventh visit: 41 weeks
Eighth visit: 40 weeks	
Ninth visit: 41 weeks	

SOURCE: Public Health Service Expert Panel on the Content of Prenatal Care, Dept. of Health and Human Services, 1989.

retardation, developmental delay, reproductive loss, or other issues.

- Information about work, lifestyle, and hobbies. This information can be helpful in understanding potential risks for the pregnancy, such as alcohol, tobacco, or drug use, work- and hobby-related risks of chemical exposure or physical hazards, **exercise** patterns, possible exposure to Lyme disease, and nutritional intake. Does the woman's work require heavy lifting or continually standing in one place? Could she be exposed to chemicals that could be teratogenic to the fetus? Exercise during pregnancy helps with **stress** and **anxiety**, and most women can maintain their prepregnancy exercise routines during pregnancy. However, they need to avoid overheating, as this is harmful to the fetus. Overheating includes the use of saunas, hot tubs, and tanning beds. Exercise with potential trauma to the abdomen should be avoided. Exercise may be contraindicated in the case of intrauterine growth retardation, once the membranes have ruptured, vaginal bleeding, or for women at increased risk for **preterm labor**. The extent of the woman's support network should also be assessed. Does she have other children? Is she the primary caregiver for an ailing parent? Does the woman have cats or work in a veterinary office? (Toxoplasmosis is spread through soil, undercooked meat, and cat stool. Pregnant women should avoid contact with used cat litter, sand, or soil.)
- A verbal review of body systems, from head to toe. These questions may prompt a woman to remember or include information that she otherwise may have discounted as unimportant. It also establishes a baseline of her medical condition, especially if she develops symptoms later on in the pregnancy.
- Physical exam. The physical exam on the first visit will include a head-to-toe assessment in order to establish

Important points in prenatal care

	Objective data	Emotional assessment	Laboratory
First visit	Accurate blood pressure (BP) Cervical length and dilation Size/dates Body Mass Index (BMI) Genetic problems	Feelings about this pregnancy/previous birth/losses Stressors Support system Need for referral: counseling, food, shelter, genetics, etc.	Consider: HIV, PPD, sonogram, glucose screen
16 to 19 weeks			Amniocentesis
20 weeks	Fetal heart tones with fetoscope Weight gain	Stressors and body image	
24 to 26 weeks	Cervix check if history of pre-term labor or if first baby	Recurrent or vivid dreams; fears	
28 weeks	Weight gain Review dating	Stressors and body image	Glu screen Rh immune globulin
36 weeks	Presentation	Fears about labor	Consider repeating: Hct., GC and chlamydia, RPR, HIV, HbsAg Schedule version if breech

SOURCE: Wheeler, L. *Nurse-Midwifery Handbook: A Practical Guide to Prenatal and Postpartum Care*. Philadelphia: Lippincott-Raven Pub., 1997.

the presence of any abnormal or unusual findings, along with height, weight, and blood pressure. Women might be encouraged to continue, or begin, monthly breast self-exams for signs of lumps, and to report any physical changes such as thyroid enlargement or the development of varicose veins.

- Pelvic exam. The pelvic exam begins with an assessment of the external genitalia for any signs of redness, **infection**, vaginal discharge, or lesions. It will include a Pap smear for cervical **cancer**, as well as an assessment of the vaginal walls and cervix, checking for any growths, lesions, or signs of infection. The pregnancy will be confirmed by checking for changes in the uterine size. A bimanual exam allows the practitioner to check the uterus as well as the ovaries. A rectal exam checks for any rectal masses. The presence of hemorrhoids will also be noted. Cultures may be taken to check for infection or an undiagnosed sexually transmitted disease (STD), such as gonorrhea or chlamydia. Left untreated, these infections can be harmful to the mother and fetus. During the first visit the practitioner may also evaluate the adequacy of the pelvic size and shape for vaginal delivery.
- Fetal **heart** tones can be heard by 10 to 12 weeks' gestation. The normal fetal heart rate is 120 to 160 beats per minute. The fundal height will be measured at each visit to chart the growth pattern of the uterus.
- Laboratory work may include a **urinalysis**, **complete blood count**, rubella antibody titer, and blood type with **Rh factor**. Testing for hepatitis B is common. Women should be offered the option of HIV screening, as early detection can provide the opportunity of using medication to decrease the risk of transmission to the

fetus. Additional screening may be done for toxoplasmosis, cytomegalovirus, herpes simplex, or group B streptococci.

Normal physical changes to expect during pregnancy should be discussed. The pregnant woman should also be given the emergency number to call when the health facility is closed, along with guidelines about when it is appropriate to call. Teaching about the use of over-the-counter medications should be done, as many people are not aware that nonprescription drugs can be harmful to the developing fetus. Before leaving from the first prenatal visit, the next appointment should be scheduled, to encourage ongoing care.

Subsequent prenatal visits are considerably shorter, unless complications arise. A routine visit includes a urine check for protein, glucose, and possibly ketones; a weight and blood-pressure check; and measurement of fundal height. At each visit the woman should be asked if she is experiencing any of the common discomforts of pregnancy, such as ankle **edema** (swelling), leg cramps, Braxton-Hicks contractions, fatigue, backache, nausea or vomiting, constipation, or shortness of breath. In the first trimester, and again toward the end of pregnancy, the uterus applies pressure on the bladder, possibly resulting in the need for frequent urination. If frequency is accompanied by burning or **pain** with urination, a urinary tract infection should be ruled out.

While nausea and vomiting are common until the fourth or fifth month of pregnancy, excessive vomiting can result in **dehydration** and electrolyte imbalance. Sometimes hospitalization is required. The new mother should also be educated about signs that might indicate a developing problem, such as abdominal pain (perhaps

indicative of an ectopic pregnancy), edema in the face (preeclampsia), headaches, blurred **vision**, vaginal bleeding, continual vomiting, decrease in fetal movement, or presence of vaginal fluid (rupture of the amniotic membranes).

An opportunity should be provided to answer any questions the woman might have. Attendance at **child-birth** and/or parenting classes, and access to classes for older siblings, should be discussed. The pregnant woman should also be assessed for signs of depression. As the pregnancy progresses, lying supine can cause the uterus to compress the vena cava, impeding blood flow to the heart. This may be experienced as an irregular heart rate or a feeling of anxiety. Lying on the left side resolves this problem.

Pregnant women should be encouraged to eat a wide variety of nutritious foods. Women whose prepregnancy weight is within an appropriate range for height should expect to gain about 25 to 35 pounds over the course of the pregnancy. Those who are overweight should gain less, but not try to diet while pregnant. Pica, or the desire to eat nonfood substances, may not cause harm to the fetus if the substances themselves are not harmful and the woman is otherwise eating a balanced diet. Questions to assess for pica should be part of routine visits. A woman's financial situation can affect her ability to purchase nutritious foods. This need should be assessed at the first visit so that an appropriate referral can be made for food stamps or other assistance programs. The use of megavitamins should be evaluated, as high doses of fat-soluble **vitamins** can be harmful. Intake of high doses of **vitamin A** is associated with birth defects.

At 10 to 18 weeks, **genetic counseling** may be provided for women with a family history of congenital, chromosomal, or neural-tube anomalies, or for women above age 35. Chorionic villi sampling (CVS) may be done between 10 and 12 weeks, while **amniocentesis** may be performed between 14 and 18 weeks. Ultrasound may be done between 12 and 24 weeks to confirm dating of the pregnancy or to check fetal anatomy.

A **triple marker screen test** that evaluates maternal serum alpha-fetoprotein, human chorionic gonadotropin (hCG), and unconjugated estriol levels is usually run on a blood sample between 16 and 20 weeks to screen for neural-tube defects. Inadequate intake of **follic acid** is associated with such neural-tube defects as spina bifida. Elevated levels of alpha fetoprotein may indicate a neural-tube defect, but can also be due to a **multiple pregnancy**, inaccurate dates, or fetal death. The test can also indicate if the fetus has Down's syndrome. As with other laboratory tests, false positives can occur.

At 20 to 22 weeks, women should be aware of the danger of premature rupture of the membranes and preterm labor. Fundal height should be at the umbilicus.

Screening for **gestational diabetes** is done around 26 to 28 weeks. The first screening test does not require fasting, and blood is drawn once, an hour after a drink containing 50 gm of glucose is ingested. If the result is abnormal in any way, a three-hour glucose tolerance test (GTT) will be administered. This test is usually done in the morning, after the woman has fasted for eight hours. A sample for the FBS (fasting blood sugar) test is drawn, glucose is given, and blood is then drawn hourly over the next three hours. Babies of mothers with gestational diabetes are at risk of excessive intrauterine growth, and blood sugar abnormalities after birth. While gestational diabetes (GDM) usually resolves when the pregnancy terminates, women with GDM are at increased risk—about 60%—of developing diabetes within the next 16 years.

From 28 weeks to 34 weeks onward, fetal presentation (position) will be checked at each visit.

After 36 weeks the physician may choose to conduct a sterile internal exam to evaluate the condition of the cervix for labor and delivery.

From 40 to 42 weeks fetal well-being and the amount of amniotic fluid may be monitored more closely. Too little or too much may indicate problems. Induction of labor will be considered.

Preparation

In coming to the first prenatal visit, it is helpful for the woman to bring in:

- Medical records from a previous pregnancy not easily accessible by the current practitioner or facility, especially if complications arose.
- Information on family medical history as well as personal medical history.
- Date of last menstrual period.
- Names and dosages of any medications currently being taken (both prescription and over-the-counter products, including any herbal remedies).
- A list of any questions she may have.

At the first visit, a physical exam will be performed. In preparation, the woman will need to undress, put on a gown, and empty her bladder. (The pelvic exam puts pressure on the bladder, creating discomfort if full.) This may be the first pelvic exam for some women; they should be told what to expect before anything is done. Proper draping can help ease discomfort. For the pelvic

KEY TERMS

Braxton-Hicks contractions—Irregular tightening of the uterus that begins in the first trimester of pregnancy. The contractions increase in frequency and strength as the pregnancy progresses and may be confused for labor contractions toward the end of the pregnancy. They are sometimes referred to as “false labor pains.”

Fundal height—Measured by a tape measure from the top of the symphysis pubis, over the arch of the growing uterus, to the top of the fundus.

Gestation—The length of the pregnancy, from fertilization until birth.

Sickle-cell anemia—A form of anemia characterized by crescent-shaped red blood cells containing an abnormal form of hemoglobin. Physical symptoms of crisis include fever, joint pain, and weakness. It is most common in people of African American, Mediterranean, Latin American, and Native American descent.

Tay-Sachs disease—A genetic disorder resulting in the progressive degeneration of the central nervous system. It is found primarily in individuals of Eastern European Ashkenazi Jewish descent.

Thalassemia—A genetic-based anemia in which the red blood cells are easily destroyed and release iron into the blood system, which then deposits it in the skin and internal organs. Thalassemia is most commonly found in individuals of Mediterranean, Middle Eastern, and Asian descent.

exam the woman will need to lie on her back with her feet in stirrups. Warming the speculum prevents the woman from tensing as the speculum is inserted.

If an ultrasound is to be done, the woman will need to drink about a quart of water one to two hours prior to the test, without voiding, in order to better visualize the fetal structures. Later in the pregnancy, when there is more amniotic fluid, this will not be necessary. While the ultrasound is painless, having a full bladder can become quite uncomfortable. The nurse or radiology technician should ensure that the test can begin on time whenever possible.

If a woman is considering an amniocentesis or chorionic villi sampling, she should understand the risks accompanying these procedures (which include a slightly increased chance of **miscarriage**), the information that

can be expected, and the options available if abnormal results are found.

Aftercare

After a woman has an internal exam, she should be given a tissue to remove lubricant used for the exam. A sanitary pad may be offered if spotting occurred. If abnormal results have been reported, the woman or her partner may need additional time to ask questions, receive appropriate referral information, or be consoled.

Complications

At each visit, weight, blood pressure, and urine are checked. A rapid weight gain, increased blood pressure, and proteinuria signal the development of preeclampsia. Vaginal bleeding at any time during pregnancy needs evaluation. Third-trimester bleeding may indicate **placenta previa** or **placental abruption**, two conditions that put the fetus at risk. Sharp abdominal pain may indicate an ectopic pregnancy; the woman needs to be evaluated right away should such pain occur. An ectopic pregnancy can result in rupture of the fallopian tube and internal bleeding. A gush of fluid from the vagina can signal the rupture of the amniotic membranes. If this sign occurs at the end of pregnancy, it may indicate that labor is about to begin. However, once the membranes have ruptured, the uterus is more easily exposed to infection. Without adequate amniotic fluid, the umbilical cord can prolapse, reducing the oxygen flow to the fetus. Loss of fluid needs to be evaluated to determine if it was due to ruptured membranes or stress incontinence.

Results

The goal of prenatal care is the delivery of a healthy baby at term, from a healthy mother prepared to handle the challenges of parenthood.

Health care team roles

Nurses, dieticians, social workers, childbirth educators, midwives, nurse practitioners, obstetricians, and perinatologists play important roles in prenatal care, through careful listening both to what is said and what may be omitted, thorough assessment and documentation, and education and referral. Radiology technicians will see the woman during ultrasound, amniocentesis, and chorionic villi sampling, at a time when she may be anxious about the test being performed. Laboratory technicians may see the woman at the end of a difficult visit, perhaps after she has received bad news or is anxious about an upcoming test. If the pregnant woman is dehy-

drated, venous access is more challenging to obtain. Providing an understanding, reassuring, and calm environment, and utilizing one's experience to perform the task at hand with the greatest of skill, can minimize any further sense of trauma.

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March of Dimes. <<http://www.modimes.org>>.

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Beachwood Library, links to sites on several genetic diseases. <<http://www.beachwood.k12.oh.us/bhslmc/CURRICUL/science/bio/genedis.htm>>.

The Sickle Cell Information Center. P. O. Box 109; Grady Memorial Hospital; 80 Butler Street SE, Atlanta, GA 30303. (404) 616-3572. <<http://www.emory.edu/PEDS/SICKLE/>>.

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Preoperative care

Definition

Preoperative care is the preparation and management of a patient prior to surgery. This care includes physical and psychological preparation.

Purpose

Patients who are physically and psychologically prepared for surgery tend to have better outcomes after surgery. Preoperative teaching meets the patient's need for information regarding the surgical experience, which in turn may alleviate most fears the patient has. Knowing what to expect after the surgery, and enlisting the patient's input about goals and expectations, often helps the patient cope better with postoperative **pain** and decreased mobility. Preoperative care is extremely important prior to any invasive procedure, regardless of whether the procedure is minimally invasive or major surgery.

Precautions

There are no contraindications to preoperative care. Even in an emergent situation, the patient must be physically prepared and should be prepared psychologically to the degree possible, as indicated by the patient's physical status. If the patient is unresponsive, emotional and psychological preparation should be focused on the family.

Preoperative teaching must be individualized for each patient, since some people want as much information as possible while others want only the minimum. For some patients, receiving too much information increases their **anxiety**. Patients have different capabilities in understanding medical procedures; if printed materials are used for teaching, the nurse must ascertain the patient's literacy level in order to provide appropriate material. The health care professional must maintain a balance between relaying essential information and meeting the patient's information needs.

Description

Preoperative care involves many components and may be done the day before surgery, in the hospital, or during the weeks before surgery on an outpatient basis. Many surgical procedures are now performed in a day-surgery setting and the patient is never admitted to the hospital.

Physical preparation

Physical preparation should include obtaining a complete history and physical, including the patient's surgical and anesthesia history. It should be determined if the patient has ever had an adverse reaction to anesthesia (such as anaphylactic **shock**), or if there is a family history of malignant hyperthermia. Such laboratory tests as CBC, electrolytes, prothrombin time, activated partial thromboplastin time, or **urinalysis** may be done. An EKG should be done if the patient has a history of cardiac disease or is over 50 years of age. A chest X-ray should be taken if the patient has a history of respiratory disease. The patient should be assessed for risk factors that might impair healing, such as nutritional deficits, steroid use, radiation or **chemotherapy**, drug or alcohol abuse, or such metabolic diseases as diabetes. The patient should also provide a list of all medications, **vitamins**, and herbal or food supplements that they use. Supplements are often overlooked, but some can cause adverse effects when used with general anesthetics (e.g. St John's wort, valerian root) and others can prolong bleeding time (e.g. garlic, ginkgo biloba).

Latex allergy merits mention because it is becoming a **public health** concern. Latex is found in most sterile

KEY TERMS

Activated partial thromboplastin time (APTT)—A lab test that detects coagulation defects in the intrinsic clotting cascade. Used to regulate heparin dosing.

Complete blood count (CBC)—A lab test that determines the number of red and white blood cells per cubic millimeter of blood.

Electrocardiogram (EKG)—A graphic record showing the electrical activity of the heart.

Incentive spirometer—Device that is used postoperatively to prevent lung collapse and promote maximum inspiration. The patient inhales until a preset volume is reached, then sustains the volume by holding the breath for three to five seconds.

Prothrombin time (PT)—A lab test that detects coagulation defects in the extrinsic clotting cascade. Used to regulate coumadin dosing.

surgical gloves and is a common component in other medical supplies, including **general anesthesia** masks, tubing, and multi-dose medication vials. It is estimated that one percent to six percent of the general population and eight to seventeen percent of healthcare workers have this allergy. At least 50% of children with spina bifida are latex-sensitive as a result of early frequent surgical exposure. There is currently no cure available for latex allergy, and research has found that up to 19% of all anaphylactic reactions during surgery may be a result of latex allergy. The best treatment is prevention, but immediate symptomatic treatment is required if the allergic response occurs. Every patient should be assessed for a potential latex reaction. Patients with latex sensitivity should have their chart flagged with a caution label. Latex-free gloves and supplies must be used for anyone with a documented latex allergy.

Bowel clearance may be ordered if the patient is having surgery of the lower gastrointestinal (GI) tract. The patient should start the bowel preparation early in the evening to prevent interrupted sleep during the night. Some patients may benefit from a sleeping pill the night before surgery.

Often skin preparation is ordered for the night before surgery. Skin preparation can take the form of scrubbing with a special soap (i.e., Hibiclens), or hair removal from the surgical area. However, as of this printing (in 2001), shaving hair is no longer recommended because studies

show that shaving the area may increase the chance of **infection**. Instead, adhesive barrier drapes can contain hair growth on the skin around the incision.

Psychological preparation

Patients are often fearful or anxious about having surgery. Health care workers can help decrease anxiety by listening to the patient's concerns, validating their legitimacy, and answering the patient's questions honestly. This responsiveness can be especially beneficial for patients who are critically ill or who are having a high-risk procedure. The family needs to be included in psychological preoperative care as much as the patient. In the hospital, pastoral care can be offered. If the patient expresses a fear of dying during surgery, this concern should not be discounted. The surgeon should be notified. In some cases, the procedure may be postponed until the patient feels more secure.

Children may be especially fearful. They should be allowed to have a parent with them as much as possible, as long as the parent is not demonstrably fearful and contributing to the child's apprehension. Children should also be encouraged to bring a favorite toy or blanket with them on the day of surgery.

Preparing the patient and family psychologically helps them to cope better with the patient's postoperative course. Preparation leads to superior outcomes, since the goals of recovery are known ahead of time and the patient is able to manage postoperative pain more effectively.

Informed consent

Obtaining the patient's or guardian's written consent for the surgery is a vital portion of preoperative care. By law, the physician who will perform the procedure must explain the risks and benefits of the surgery, along with other treatment options. However, the nurse is often the person who actually witnesses the patient's signature on the consent form. The nurse should verify that the patient understands everything the physician told them by asking the patient to explain what they have been told.

Patients who are mentally impaired, heavily sedated, or critically ill are not considered legally able to give consent. In this situation, the next of kin (spouse, adult child, adult sibling, or person with medical power of attorney) may act as a surrogate and sign the consent form. Children under age 18 must have a parent or guardian sign.

Preoperative teaching

Preoperative teaching includes teaching about the preoperative period, the surgery itself, and the postoperative period.

Instruction about the preoperative period deals primarily with where the patient should go on the day of surgery, the time they should arrive, and how they should prepare for surgery. For example, they should be told how long they should be NPO (nothing by mouth); which medications to take prior to surgery; and the medications that should be brought with them (such as inhalers for patients with **asthma**).

Instruction about the surgery itself includes informing the patient about what will be done during the surgery and how long it is expected to take. The patient should be told where the incision would be. Children having surgery should be allowed to “practice” on a doll or stuffed animal. It may be helpful to demonstrate procedures on the doll prior to doing them on the child. It is also important to tell the family (or other concerned parties) where they can wait during the surgery; when they can expect progress information (and from whom); and how long it will be before they can see the patient.

Informing the patient about what to expect during the postoperative period is one of the best ways to improve the patient’s outcome. Instruction about expected activities can also increase compliance and help prevent complications. This includes the opportunity for the patient to practice coughing and deep breathing exercises, use an incentive spirometer, and practice splinting the incision. Additionally, the patient should be informed about early ambulation. The patient should also be taught that the respiratory interventions decrease the occurrence of **pneumonia** and that early leg exercises and ambulation decrease the risk of **blood** clots.

Patients hospitalized postoperatively should be informed about the tubes and equipment that they will have. These may include multiple IV lines, drainage tubes, dressings, and monitoring devices. In addition, they may have sequential compression stockings on their legs to prevent blood clots until they start ambulating.

Pain management is the primary concern for many patients having surgery. Preoperative instruction should include information about the pain management method that they will utilize postoperatively. Patients should be encouraged to ask for or take pain medication before the pain becomes unbearable, and should be taught how to rate their pain on a pain scale. This instruction allows the patients, and others who may be assessing them, to evaluate the pain consistently. If they will be using a patient-controlled analgesia (PCA) pump, they should be taught

how to use it during the preoperative period. Use of alternative methods of pain control (distraction, imagery, positioning, mindfulness meditation, music therapy) may also be presented.

Finally, long-term goals should be discussed, such as when the patient will be able to eat solid food, when they will be discharged if they are hospitalized, and when they will be able to drive a car or return to work.

Preparation

Preparation for preoperative care involves ensuring that all supplies for physical preparation are accessible. To prepare for teaching, any applicable patient handouts or videos should be gathered and offered to the patient. The consent form should be ready for the patient to sign, with the name of the physician and the procedure filled in. A sufficient amount of time should be scheduled so that the patient does not feel rushed, and the patient should understand that they have the right to add or strike out items on the generic consent form that they do not wish to agree to. For example, a patient who is about to undergo a tonsillectomy might choose to strike out (and initial) an item that indicates sterility might be a complication of the operation.

Aftercare

The only aftercare required is to ensure that the patient understands the surgery and that all of their questions are answered.

Complications

Complications can result from improper preoperative care. For example, surgery may be done on the wrong side of the body if the incorrect body part is marked during physical preparation. Hospitalized patients may be given the wrong preoperative medications; or sedatives may be inadvertently given before **informed consent** is obtained.

Results

The anticipated outcome of preoperative care is a patient who is informed about their surgical course and able to cope with it successfully. The goal is to decrease complications and promote recovery.

Health care team roles

As mentioned above, the physician is legally responsible for discussing the risks and benefits of the procedure and for obtaining the patient’s informed consent.

However, the nurse is often the one who witnesses the patient's signature. If the nurses were not present for the physicians' discussions with the patients, the nurses must ensure that the patients understand the risks and benefits of the surgery by having the patients relate what they were told by their physician. The nurse is usually responsible for preoperative instruction, although a respiratory therapist often teaches about the postoperative respiratory exercises, especially in a hospital setting. Laboratory personnel may draw blood samples and perform laboratory tests. Radiology personnel perform the chest x-ray if one is ordered.

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Presbyopia

Definition

The term presbyopia means "older eye," and is a **vision** condition involving the loss of the eye's ability to focus on close objects.

Description

Presbyopia is a condition that occurs as a part of normal aging. The condition develops gradually over a number of years. Symptoms are usually noticeable by age 40 to 45, and continue to develop until the process stabilizes some 10 or 20 years later. Presbyopia occurs without regard to other eye conditions.

Causes and symptoms

In the eye, the crystalline lens is located just behind the iris and the pupil. Tiny ciliary muscles pull and push the lens, adjusting its curvature, and thereby adjusting the eye's power to bring objects into focus. As individuals age, the lens becomes less flexible and elastic, and the muscles become less powerful. Because these changes result in inadequate adjustment of the lens of the eye for various distances, objects that are close will appear blurry. The major cause of presbyopia is loss of elasticity of the lens of the eye. Loss of ciliary muscle power and loss of elasticity of the zonules that connect the ciliary muscle to the lens, however, are also believed to contribute to the problem.

Symptoms of presbyopia result in the inability to focus on objects close at hand. As the lens hardens, it is unable to focus the rays of light that come from near objects. Individuals typically have difficulty reading small print, such as that in telephone directories and newspaper advertisements, and may need to hold reading materials at arm's length. Symptoms include headache and eyestrain when doing close work; blurry vision; and eye fatigue. Symptoms may be worse early in the morning or when individuals are fatigued. Dim lighting may also aggravate the problem.

Diagnosis

Presbyopia is officially diagnosed during an **eye examination** conducted by optometrists (O.D.s) or ophthalmologists (M.D.s).

O.D.s or M.D.s, with the help of ophthalmic assistants, should perform a comprehensive eye exam to diagnose the condition. The assistant should take a detailed patient history prior to the exam. This is especially important when diagnosing premature presbyopia.

The optometrist or ophthalmologist, or in some cases a highly trained assistant, will begin the ocular examination by testing visual acuity and refraction. During the exam the clinician will also determine ocular motility and alignment, nearpoint of convergence, near fusional vergence amplitudes, relative accommodation measurements, accommodative amplitude and facility of accommodation.

To further determine presbyopia, the clinician should perform near retinoscopy and intermediate distance testing, which can be performed with a phoropter or trial lens.

There are five different types of presbyopia:

- Incipient presbyopia is the earliest stage in which symptoms are documented. Usually the patient has trouble

reading small print, but may perform well on testing and may actually reject a near vision prescription.

- Functional presbyopia is the point at which patients usually notice the difficulties with near vision. The age when this occurs varies and depends on environment, task requirements, **nutrition**, or general health.
- Absolute presbyopia is the result of continuous gradual decline in accommodation, and is the next phase after functional presbyopia. At this stage, little accommodative ability remains.
- Premature presbyopia is the appearance of the disease at an earlier age than expected because of nutritional, environmental, or disease-related causes. Pharmaceuticals may also be a cause of premature presbyopia.
- Nocturnal presbyopia occurs when accommodation decreases in low-light conditions.

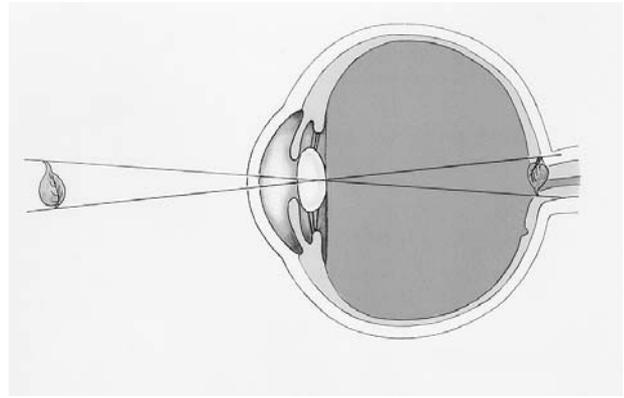
Treatment

Presbyopia cannot be cured, but physicians can help patients compensate for it by prescribing reading, bifocal, or trifocal eyeglasses. A convex lens is used to make up for the lost automatic focusing power of the eye. Half-glasses can be worn, which leave the top open and uncorrected for distance vision. Bifocals achieve the same goal by allowing correction of other refractive errors (improper focusing of images on the retina of the eye).

In addition to glasses, **contact lenses** can be useful in the treatment of presbyopia. Contact lens technicians need to take the patient's medical history to ensure the patient is a good candidate for contact lenses. Some lenses require a greater care commitment, so each patient's expectations need to be discussed before any lens is prescribed.

The two common types of contact lenses prescribed for presbyopia are bifocal and monovision contact lenses.

Bifocal lenses come in two designs, simultaneous vision and alternating vision. Soft and rigid lenses are available in the simultaneous vision design, but only RGP lenses are available in the alternating vision design. Alternating vision lenses behave more like bifocal eyeglasses than the simultaneous design. This alternating lens allows patients to look through two distinct visual zones and adjust their gaze for distance vision or for reading. To prevent rotation while in the eye, bifocal contact lenses use a specially manufactured type of lens. Good candidates for bifocal lenses are those patients who have a good tear film (moist eyes); good binocular vision (ability to focus both eyes together) and visual acuity in each eye; and no disease or abnormalities of the eyelids.



Changes in the elasticity of the lens cause people with presbyopia to lose the ability to focus on close objects.
(June Hill Pedigo/Custom Medical Stock Photo. Reproduced by permission.)

The bifocal contact lens wearer must be motivated to invest the time it requires to maintain contact lenses, and be involved in occupations that do not impose high visual demands. Further, bifocal contact lenses may limit binocular vision. Bifocal contact lenses are relatively expensive, in part due to the time it takes the patient to be accurately fitted.

An alternative to wearing eyeglasses or bifocal contact lenses is monovision contact lenses. Monovision fitting provides one contact lens that corrects for near vision and a second contact lens for the alternate eye that corrects for distance vision. If distance vision is normal, the individual wears only a single contact lens for near vision. Monovision works by having one eye focus for distant objects while the other eye becomes the reading eye. The **brain** learns to adapt to this and will automatically use the correct eye depending on the location of material in view. Advantages of monovision lenses are patient acceptability, convenience, and lower cost.

Several problems exist with the use of contact lenses in the treatment of presbyopia. Physicians need to ask patients to report any headache and fatigue or decrease in visual acuity during the adjustment period. Monovision contact lenses usually result in a small reduction in high-contrast visual acuity and reduced depth perception as compared with bifocal contact lenses. In addition, since monovision corrects one eye for distance and one for eye for near vision, objects at intermediate distances are often out of focus, especially in absolute presbyopia.

Some ophthalmologists are performing laser thermal keratoplasty (LTK) on presbyopic patients. The LTK procedure was approved to treat **hyperopia** in mid-2000, but some surgeons are treating presbyopia as an “off-label” procedure. The LTK procedure takes three seconds per eye and involves no cutting or removal of corneal eye tis-

KEY TERMS

Accommodation—The ability of the eye to change its focus from near to distant objects.

Binocular vision—Using both eyes at the same time to see an image.

Ciliary muscles—The small muscles that permit the lens to change its shape in order to focus on near or distant objects.

Lens (or crystalline lens)—The eye structure behind the iris and pupil that helps focus light on the retina.

Visual acuity—Sharpness or clearness of vision.

sue. Instead, the surgeon uses a holmium:YAG laser to direct eight simultaneous spots of laser energy to the periphery of the cornea to shrink the corneal collagen. The laser heats the corneal collagen and steepens its shape, improving its refractive (focusing) power. Presbyopes receiving this treatment should be advised of regression after possibly just a few years.

Laser-assisted in-situ keratomileusis (LASIK) is another option for presbyopes. Surgeons correct one of the patient's eyes to achieve a monovision effect. This technique allows for good intermediate vision that facilitates reading menus or putting on makeup, but it can cause reduction in binocular distance vision and depth perception.

In preparatory interviews with patients, physicians and ophthalmic assistants should stress that with whatever surgical treatment the patient chooses, there will be regression. The aging process continues and therefore advancing presbyopia is unavoidable.

Prognosis

The changes in vision due to aging usually start in a person's early 40s and continue for several decades. At some point, there is no further development of presbyopia, as the ability to accommodate is virtually gone.

Health care team roles

Nurses, ophthalmic assistants, and well-trained technicians can perform a number of tasks previously required of an ophthalmologist or optometrist. Technicians can assist in diagnosing presbyopia by per-

forming the first-level testing of refraction, as well as taking medical and lifestyle history, retinal photography, automated refractometry, automated keratometry and corneal topography.

Allied health professionals also play an important role in performing the contact lens examination. Before prescribing contact lenses, technicians take a written and oral interview of the patient to determine if the patient is a suitable contact lens candidate. The technician must assess the technical aspects of the patient's ocular status. Next, the technician must discuss the patient's needs and expectations and evaluate all the information to make the correct lens choice. This is especially important for presbyopic patients choosing monovision, as this modality requires a larger commitment from patients.

The physician, or sometimes a contact lens technician, selects the lens material and design, then determines which trial lens is needed. A technician determines the lens parameters by using the results from the trial lens insertion. The patient's palpebral aperture and visual iris diameter are measured to determine the appropriate diameter for the contact lens. The technician will review the findings and make the recommendation to the prescribing physician for the proper contact lenses.

Before the patient is sent home with the lenses, the technician will give a detailed demonstration of inserting, removing, and cleaning the lenses.

Nurses and assistants also prepare patients for surgery by taking history, **blood pressure** and inserting eye-drops. They also may be involved in preparing the surgical areas, especially if surgery is performed in an ambulatory surgery center. Ophthalmic nurses are specially trained to assist in ocular surgeries.

Patient education

Doctors should emphasize with patients the challenges of choosing monovision and bifocal contact lenses to treat presbyopia. Doctors also should stress that surgical procedures are not permanent, and that patients may have to be retreated if regression occurs.

Prevention

There is no known way to prevent presbyopia.

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American Optometric Association. 243 N. Lindbergh Boulevard, St. Louis, MO 63141. (314) 991-4100. AmOptNEWS@aol.com.

Contact Lens Association of Ophthalmologists. 721 Papworth Avenue, Suite 206, Metairie, LA 70005, (504) 835-3937, <<http://www.claao.org>>.

Lighthouse National Center for Vision and Aging. 111 E. 59th Street, New York, NY 10022. (800) 334-5497. <<http://www.lighthouse.org>>.

National Eye Institute. 2020 Vision Place, Bethesda, MD 20892-3655. (301) 496-5248; Publications: (800) 869-5248. <<http://www.nei.nih.gov>>.

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Mary Bekker

Presenile dementia *see* **Alzheimer's disease**

Pressure ulcer

Definition

Pressure ulcers, also commonly known as bedsores, decubitus ulcers, and pressure sores, are among the most serious skin injuries. These tender or inflamed patches

develop when skin covering a weight-bearing part of the body is squeezed between bone and another body part or some other hard object. The ulceration results from the loss of **blood** flow and oxygen (ischemic hypoxia) to the tissues owing to prolonged pressure on a body part.

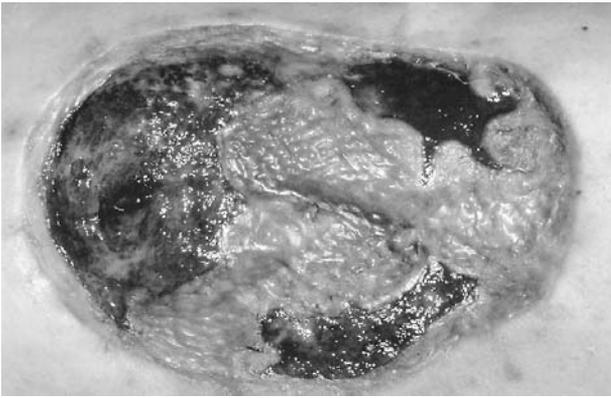
Description

Pressure ulcers are most likely to occur in people who have decreased mobility, including the frail, elderly, or seriously ill. People who have atherosclerosis (artery disease), diabetes, **heart** disease, incontinence, malnutrition, **obesity**, **paralysis**, and **spinal cord** injuries are all at high risk for developing pressure ulcers. This often-painful condition usually begins with shiny red skin that quickly blisters and deteriorates into open sores that can harbor life-threatening infections. These ulcerations are most likely to develop on the:

- ankles
- back of the head
- heels
- hips
- knees
- spine
- shoulder blades

Pressure ulcers usually develop over bony prominences and are graded, or staged, to classify the amount of tissue damage that is observed. These stages are:

- Stage I. The skin is reddened, and the damage may be superficial. The first sign of skin ulceration occurs when pressure squeezes the tiny **blood vessels** that supply the skin with nutrients and oxygen. The area does not return to its normal appearance after the source of pressure is removed.
- Stage II. There is partial-thickness skin loss involving the epidermis (outer layer), the dermis (inner layer), or both. The skin is blistered, peeling, or has a shallow crater, though the damage is still minor.
- Stage III. There is full-thickness skin loss involving damage to, or necrosis (death) of, the subcutaneous (under the skin) tissue. It may extend down to, but not through, the underlying fascia (connective tissue). This type of ulcer usually appears as a deeper crater. Drainage may be seen.
- Stage IV. Full-thickness skin loss is present, with extensive tissue destruction and damage to muscle, bone, or the supporting structures such as tendons. This stage of ulceration is associated with high morbidity.



Bed sore. (Photograph by Michael English, M.D., Custom Medical Stock Photo. Reproduced by permission.)

Causes and symptoms

The primary risk factors leading to the formation of a pressure ulcer include all of the following:

- **Pressure.** Very intense pressure, even if it occurs for a short time, may cause a pressure ulcer. Less intense pressure that lasts over a long period of time may also cause ulceration.
- **Friction.** This phenomenon occurs when two forces move against each other. When a patient's skin is dragged or pulled over bed sheets, friction occurs, with possible tissue injury resulting. This friction injury often happens when a patient is pulled, instead of lifted, up in bed.
- **Shear.** Deeper than a friction injury, shear happens when the skin located over a bony prominence slides over a hard surface. The skin and surrounding structures remain in one position because pressure keeps the skin stuck to a surface such as bed sheets. The shearing literally tears at the skin, the subcutaneous layer, and the muscle as well. Deep tissue injury and vascular damage may occur.
- **Tissue maceration.** Prolonged moisture on the skin can decrease the skin's resiliency and alter its pH (the measure of acidity and alkalinity).

Pressure ulcers usually develop in six stages:

- erythema
- erythema, swelling of tissue, and possible peeling of the outer layer of skin
- dead skin, draining wound, and an exposed layer of subcutaneous tissue
- tissue necrosis through the skin and subcutaneous layers, into the muscle
- inner fat and muscle necrosis

- destruction of bone, local infections, and potential for sepsis

Diagnosis

Physical examination, medical and nursing history, and patient and caregiver observation are the basis of diagnosis. Special attention must be paid to any physical or mental impairment such as incontinence or confusion that could complicate a patient's recovery. Staging is done based on the wound's characteristics and depth of soft tissue damage. Correct staging can only be done after all necrotic (dead) tissue has been removed, allowing for complete inspection of the wound bed (area). According to the National Pressure Ulcer Advisory Panel, once a particular stage (I, II, III, or IV) has been assigned to a pressure ulcer, it will always remain at that stage. Although pressure ulcers will heal to progressively more shallow depths, they do not replace the lost muscle, fat, or dermis. Instead, the ulcer is filled in with scar tissue. Therefore, when a Stage IV ulcer has healed, it should be classified as a healed Stage IV ulcer, not a Stage 0 ulcer.

Treatment

The desired outcomes of pressure ulcer treatment are to protect the remaining healthy cells, heal the ulcer completely, and prevent the formation of other pressure ulcers. If addressed promptly, surface pressure ulcers can be prevented from developing into more serious **wounds.**

Pressure ulcer management contains four basic components:

- **Debridement.** This is a procedure that involves the removal of dead tissue or other debris from the wound. Debridement can be done by a sharp method, where the tissue is actually cut out with a scalpel or other sharp instrument; and is usually performed by a physician, physician's assistant, or an advanced practice nurse. Another method is mechanical debridement, which utilizes wet-to-dry dressings, wound irrigation, and dextranomers (beads placed into the wound bed to absorb drainage). Enzymatic debridement utilizes certain topical debriding agents to help remove the dead tissue. Autolytic debridement uses synthetic dressings that help the involved tissue self-digest from enzymes that are contained in wound fluids. This last-mentioned method should not be used for infected pressure ulcers.
- **Cleansing.** Normal saline is the recommended solution for cleansing wounds because it does not harm the wound bed, and it adequately cleanses the majority of wounds. Such solutions as hydrogen peroxide, povi-

done iodine, iodophor, and acetic acid are cytotoxic (toxic to cells), and should not be used. There are several commercially prepared wound cleansers containing surfactants (surface-active substances) and other ingredients, but these may also have some toxic effects on the cells. In order to minimize wound damage during cleansing, appropriate irrigation methods should be used. Too little pressure, such as that produced with a bulb syringe, yields poor results; while too much pressure will cause damage to healthy tissue. Irrigating the ulcer using a 35-ml syringe with a 19-gauge angiocatheter will usually provide enough pressure to get rid of eschar (scabs), **bacteria**, and other debris. In addition, the use of daily whirlpool treatments may help facilitate the removal of necrotic tissue.

- **Infection** management. Because of the various factors that may affect a patient's resistance to infection, the patient should be closely monitored for any signs of infection in the wound so that **antibiotics** can be initiated promptly. These signs include a sudden deterioration of the ulcer; changes in the color or texture of the granulation (new capillaries formed on the surface of a wound in healing) tissue; or alterations in the amount or appearance of the wound drainage. In addition, any increase in redness, **edema**, or tenderness of the ulcerated area should be reported to the physician.
- **Dressings**. When selecting a dressing for a pressure ulcer, the most important factor is the ability of the dressing to keep the wound bed moist and the surrounding healthy, intact skin dry. There are numerous types of dressings available; and selecting one should be a determination based on the preference of the physician and nurse, the time available to perform **wound care**, and the specific conditions of each wound.

Other adjunctive treatments that promote healing include electrical stimulation, ultrasound, hyperbaric (high pressure) oxygen, and laser irradiation. If there is extensive tissue necrosis, or if there are signs of infection, the physician may order topical and/or systemic antibiotic treatment. Very deep ulcers that do not respond to treatment may require skin grafts or plastic surgery.

Many patients are interested in complementary or alternative treatments, and several have been suggested in the treatment of pressure ulcers. **Zinc** and **vitamins A, C, E, and B** complex help skin repair injuries and stay healthy, but large doses of vitamins or **minerals** should not be used without consulting a physician. Various herbal remedies, including a tea tree oil rinse and an herbal tea made from the calendula plant, may act as anti-septic agents. Again, the physician or health care profes-

KEY TERMS

Cytotoxic—The characteristic of being destructive to cells.

Ischemia—The temporary deficiency of blood flow to a tissue or organ.

Necrotic—Relating to the death of a portion of tissue.

sional should be consulted when considering any of these treatments.

Prognosis

With prompt, appropriate treatment, pressure ulcers should begin to heal in two to four weeks. If the ulcer exhibits no signs of progress in three weeks, the treatment plan should be reevaluated. The National Pressure Ulcer Advisory Panel recommends that if a non-healing wound is clean, then the ulcer should be treated with topical antibiotics. If the bedsore still does not respond within two weeks, then other factors need to be explored.

Health care team roles

Several members of the health care team are important when treating the patient with a pressure ulcer. The physician orders treatment and performs any necessary surgical interventions. The nurse plays a primary role in assessing the wound and administering treatment; consulting with the physician on wound care decisions; and providing **patient education**. Physical therapists may also participate in pressure ulcer care by providing whirlpool treatments.

Prevention

It is usually possible to prevent pressure ulcers from forming and/or worsening. A variety of measures can be taken to accomplish this goal. At-risk individuals should be identified. These individuals include those with a history of previous pressure ulcers, since healed full-thickness pressure ulcers have only 80% of the strength of non-injured skin. A systematic skin assessment should be performed daily on all patients at risk for ulcer formation. Because a health care professional may not be available to assess homebound patients, the family or other caregivers should be educated on the symptoms of early skin breakdown and on when to notify their health care professional.

Other methods of pressure ulcer prevention are:

- Always cleanse the skin of incontinent patients at the time of soiling.
- Moisturize dry skin to keep it well hydrated.
- Turn and reposition the patient at least every two hours. Keep a turning schedule posted at the bedside.
- Utilize proper patient positioning, lifting, and transferring methods to avoid friction and shear. Use a lift sheet when moving the patient.
- Use pillows or cushions to pad bony prominences and support limbs.
- Consider using an alternating pressure mattress or other support surface designed to reduce pressure on the skin.
- Do not massage bony prominences, as this practice could cause deep tissue damage.
- Encourage adequate consumption of protein, calories and fluids.
- Maintain or improve the patient's activity level. Perform range of motion exercises, if possible.
- Instruct the patient, family, and any other caregivers regarding appropriate preventative care.

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ORGANIZATIONS

National Pressure Ulcer Advisory Panel. 11250 Roger Bacon Drive, Suite 8, Reston, Virginia 20190-5202. (703) 464-4849. <<http://www.npuap.org>>.

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Preterm labor

Definition

Preterm labor is characterized by contractions or irritability of the uterus between weeks 20-36 of gestation that cause effacement and/or dilatation of the cervix.

Description

The usual length of a human **pregnancy** is from 37 to 42 weeks after the first day of the last menstrual period. The baby is more likely to survive and be healthy if it remains in the uterus for the full term of the pregnancy. Between eight to ten percent of births in the United States are preterm births. Preterm labor is the greatest cause of newborn illness and death in the United States.

Causes and symptoms

The causes of preterm labor are often not identifiable. Women with a previous history of preterm labor have the highest risk of developing it again, between 17 and 37%. Other risk factors are: low socioeconomic status, minority race, maternal age less than 18 or greater than 40, premature rupture of membranes (bag of waters), multiple gestation (twins, triplets, etc.), harmful maternal behaviors (smoking, drug use, alcohol use, no **prenatal care**), uterine abnormalities (fibroid tumor, abnormally shaped uterus, incompetent cervix, exposure to diethylstilbestrol—their mothers took DES when they carried them), infectious causes (**infection** of the uterus, kidney infection), fetal causes (intrauterine fetal death, intrauterine growth retardation, birth defects), and abnormal implantation of the placenta.

The symptoms of preterm labor can include contractions of the uterus or tightening of the abdomen occurring every 10 minutes or more often. The uterine contractions of preterm labor, sometimes painful, will usually increase in frequency, duration, and intensity. Other symptoms associated with preterm labor can include menstrual-like cramps; abdominal cramping with or without **diarrhea**; pressure or **pain** in the pelvic region; low backache; or a change in the color or amount of vaginal discharge. As labor progresses the cervix, the opening of the uterus, will open (dilate) and the tissue around it will become thinner (efface). Premature rupture of membranes (when the water breaks) may also occur.

An occasional contraction can occur anytime during pregnancy and does not necessarily indicate that labor is starting. Premature contractions are sometimes confused with Braxton-Hicks contractions, which can occur throughout the pregnancy. Braxton-Hicks contractions do not cause the cervix to open or efface and are considered "false labor."

Diagnosis

The health care provider will conduct a pelvic examination and ask about the timing and intensity of the contractions. A physician or nurse will conduct a vaginal examination and determine if the cervix has started to

dilate or efface. An ultrasound technician may proceed with a transvaginal ultrasound (ultrasound of the vagina by use of a probe that is inserted into the vagina), to measure cervical length. A cervical length of < 0.98-1.18 in (2.5-3.0 cm) is associated with preterm labor.

Urine may be collected to screen for infection. A cervical culture or a wet smear may also be done to look for infection. Presence of fetal fibronectin in vaginal and cervical secretions, between 24 and 24 weeks gestation, may indicate impending preterm labor. Fibronectin is a substance that functions as an adhesive between the fetal membranes and the underlying decidua.

A fetal **heart** monitor is placed on the mother's abdomen to record the heartbeat of the fetus and to time the contractions. Occasionally the woman will have home monitoring of contractions and fetal activity.

A fetal ultrasound may be performed to determine the age and weight of the fetus, the condition of the placenta, and to see if there is more than one fetus present. Another test, **amniocentesis**, may be done to determine if the baby's **lungs** are mature. During an amniocentesis, a needle-like tube is inserted through the mother's abdomen into the uterus to draw out some of the fluid surrounding the fetus (amniotic fluid). Analysis of the amniotic fluid can determine if the baby's lungs are mature. A baby with mature lungs is much more likely to survive outside the uterus.

Treatment

The goal of treatment is to stop preterm labor and to prevent the fetus from being delivered prior to term. A first recommendation may be for the woman with premature contractions to lie down and to drink water or other fluids. If contractions continue or increase, medical attention should be sought. In addition to bed rest, medical care may include intravenous fluids. Sometimes, this extra fluid is enough to stop contractions.

In some cases, oral or injectable drugs, like terbutaline sulfate (Bricanyl), ritodrine (Yutopar), magnesium sulfate, nifedipine (Procardia), or indomethacin (Indocin) are administered to delay delivery. When used to treat preterm labor, these medications are called tocolytic agents. Unfortunately, no study has conclusively demonstrated that the use of tocolytic drugs has significantly improved neonatal outcome. Medications used to treat preterm labor can have maternal and fetal side effects. Magnesium sulfate can lead to pulmonary **edema**, profound muscular **paralysis**, and respiratory depression. Terbutaline and Ritodrine can cause arrhythmias and hypoglycemia as well as pulmonary edema. Pregnant

women who are treated with these medications need to be monitored closely in a hospital environment.

An advantage of tocolysis is in delaying delivery so that drugs that will enhance fetal lung maturity can be administered. A delay in delivery also allows for transfer to a tertiary facility that is equipped to care for premature babies. The preferred drugs to stimulate lung maturity are dexamethasone and betamethasone, **corticosteroids** that promote the fetal production of surfactant after 24 hours of administration. The benefit of these corticosteroids will last up to seven days, at which time the medications can be readministered.

If a vaginal or urinary tract infection is detected, antibiotic therapy is usually indicated. **Antibiotics** may briefly prolong the pregnancies of women who have ruptured their membranes.

Prognosis

Once symptoms of preterm labor occur during the pregnancy, the mother and fetus need to be monitored regularly. If the preterm labor cannot be stopped or controlled, the infant will be delivered prematurely. These infants that are born prematurely have an increased risk of health problems, including birth defects, lung problems, mental retardation, blindness, deafness, and developmental disabilities. If the infant is born too early, its body systems may not be mature enough for it to survive. Evaluating the infant's lung maturity is one of the keys to determining its chances of survival.

Health care team roles

Prior to initiating tocolytic medications, it is important to obtain such baseline laboratory test results as **hematocrit**, serum glucose, potassium, sodium chloride, and carbon dioxide levels. An electrocardiogram is frequently ordered because tocolytic drugs can cause an increased heart rate (tachycardia) and sometimes arrhythmias. An external uterine and fetal monitor should be put in place, and often monitors of maternal **vital signs** are also applied. Accurate fluid intake and output measurements are important in detecting the development of pulmonary edema (fluid in the lungs).

Other potentially serious complications of tocolytic therapy include: low **blood pressure** (hypotension), cardiac arrest, respiratory depression, low potassium, high **blood** sugar, maternal death, kidney failure, hepatitis, and gastrointestinal bleeding.

Ritodrine is a drug that is sometimes used in the management of preterm labor. To administer the medication accurately, it should be delivered as a piggyback to a main intravenous solution that goes through an infusion

KEY TERMS

Braxton-Hicks contractions—Tightening of the uterus or abdomen that can occur throughout pregnancy. These contractions do not cause changes to the cervix and are sometimes called false labor or practice contractions.

Cervix—The opening at the bottom of the uterus, which dilates or opens in order for the fetus to pass into the vagina or birth canal during the delivery process.

Contraction—A tightening of the uterus during pregnancy. Contractions may or may not be painful and may or may not indicate labor.

Decidua—The part of the lining of the uterus that sloughs off during menstruation.

pump and a microdrip tubing set. To avoid hyperglycemia, a potential side effect, the woman should receive few IV solutions containing dextrose. The ritodrine drip is increased gradually, usually every 10 minutes until uterine contractions cease, the maximum dose is reached, and/or side effects become too intense. The nurse should assess the patient's vital signs every 15 minutes during titration, and then every 30 minutes until uterine contractions stop. Ask the patient to inform the health care provider if she starts to experience any chest pain or shortness of breath. The health care provider should listen to the lungs for any abnormal breath sounds that could indicate the development of pulmonary edema. A heart rate greater than 120 beats per minute (bpm), a blood pressure lower than 90/60, and any cardiac arrhythmias should be reported immediately. Continue to monitor laboratory values every four hours. The fetal response to contractions and medication administration should be monitored continuously. Closely monitor daily weights to assess for possible pulmonary edema resulting from fluid retention. If therapy with ritodrine is successful in halting uterine contractions, then oral administration of ritodrine or terbutaline will often be ordered. Other tocolytic medications that are delivered in a similar manner are magnesium sulfate, subcutaneous terbutaline, nifedipine, and indomethacin.

Patient education

Health care professionals should educate all pregnant women about the signs and symptoms of preterm labor, ensuring an understanding of even the more subtle symptoms. Pregnant women should be alert for symptoms that

could be indicative of preterm labor, such as constant, dull, low back pain; vaginal spotting; pelvic pressure and/or tightening of the abdomen; increased vaginal discharge; and intestinal-like cramping.

Pregnant women who are at home on bed rest should be given the following instructions:

- Stay on bed rest except to get up to use the bathroom.
- Drink eight to ten glasses of liquids a day.
- Do not engage in such activities as nipple stimulation that could trigger contractions.
- Do not engage in sexual activities, including masturbation.
- Promptly inform the health care provider if the membranes rupture (sudden gush of vaginal fluid) or if there is any vaginal bleeding.
- Communicate to the health care provider any symptoms of a urinary tract infection (burning on urination and frequent urination) or of a vaginal infection (vaginal burning, itching or discomfort).

Prevention

Smoking, poor **nutrition**, and drug or alcohol abuse can increase the risk of premature labor and early delivery. Smoking, drug and alcohol use should be stopped. A healthy diet and prenatal vitamin supplements (prescribed by the health care provider) are important for the growth of the fetus and the health of the mother. Pregnant women are advised to see a health care provider early in the pregnancy and to receive regular prenatal examinations throughout the pregnancy. The health care provider should be informed of any medications that the mother is receiving and any maternal health conditions.

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Nadine M. Jacobson, R.N.

Preventive dentistry

Definition

Preventive dentistry is the area of dentistry that focuses on those procedures and life practices that help people to prevent the beginning or progression of oral disease. It includes at-home dental care performed by patients, as well as dental care and education by professional dental staff in the office or clinic.

Purpose

Preventive dentistry includes two aspects of dental care, both performed to help patients avoid dental disease or to catch it in its early, more treatable stages. In part, it is the **oral hygiene** care performed by the patient at home. Preventive dentistry also encompasses what is done by the dental staff in their offices to help patients maintain healthy teeth and gums. In either case, the objective is to stop the development of oral disease or to find it at an early stage. Dental health professionals most often look for early signs of periodontal disease, dental decay, and other changes in the soft tissue of the mouth that could lead to **oral cancer**.

Precautions

Preventive dentistry should always be prescribed and not harm patients when done correctly. At times, dentists do need to take precautions when someone has a medical condition that would be affected by some of the procedures. Dentists need to be aware of certain medical conditions, such as mitral valve prolapse, which need to be treated with prophylactic **antibiotics**. **Allergies** to any of the medications or materials used in preventive dentistry are rare.

Description

Preventive care in a dental office includes prophylaxis, or the cleaning of the teeth, which removes accumulations of calculus. It includes examination of the teeth and soft tissue, using visual and tactile exams, radiographic examination, such as x rays, and oral **cancer** screening. Newer techniques to diagnose periodontal, or gum disease, include computerized measurement devices that measure the bacterial content in the mouth. Sometimes, dentists prescribe medications to help prevent dental disease. These include anti-inflammatory mouthwashes to prevent periodontal problems.

Preventive procedures often performed by dentists for children include the use of fluoride supplements and applications. Dentists apply dental sealants to children's

teeth, forming a barrier between tooth crevasses and **bacteria** to help ward off dental decay. Dental health professionals also look for malocclusions, and might refer patients to a dental specialist, such as an orthodontist, to correct a patient's bad bite. Experts state that children should be evaluated by an orthodontist by age seven.

An important part of preventive dentistry performed by dental professionals is educating patients about at-home care, **nutrition**, and smoking cessation. At-home procedures performed by patients that help ward off dental disease include regular and proper brushing, flossing and sometimes use of mouth rinses and at-home fluoride applications. Dentists and their staff explain proper brushing and flossing techniques. Proper brushing includes use of a soft nylon toothbrush with round-ended bristles. Patients should place the bristles along the gum line at a 45-degree angle to cover the tooth surface and gum line. The brushing technique should be gentle and in a rolling back-and-forth motion, with two to three teeth being brushed at a time. Patients should brush the inner surfaces of their teeth and tilt the brush vertically to brush the front teeth. Ideally, patients should use a back-and-forth motion to brush the biting surface of the teeth and the tongue. Flossing removes plaque from between teeth and at the gum line. It should be done with an 18-inch strip of floss wrapped around the middle fingers of each hand. The remaining one to two inches of floss that is inserted between the teeth should be directed by the thumbs. By keeping the floss taut, patients can use their index fingers to guide the floss between the lower teeth with a gentle zig-zag motion, while contouring the floss around the sides of the teeth. They should floss each tooth with a clean section of the floss and ensure that the floss goes under the gum line.

Preventive dental care should begin in infancy, within the first year of life before teeth first appear, and continue throughout life. Even before teeth erupt, parents can clean infants' gums after feeding. Preventive care in adolescence includes brushing and flossing, as well as wearing custom-made mouth guards to protect the teeth during contact sports. Considering that 75% of Americans have some form of dental disease, regular dental visits are particularly important for adults. Seniors often benefit from training in proper techniques of **denture care** and cleaning, which include brushing the replacement teeth. Those who have problems moving their hands because of arthritis, for example, also benefit from tips for adapting toothbrushes for easier handling.

KEY TERMS

Calculus—A hard deposit formed when teeth are not brushed properly.

Dental decay—The destruction of the tooth enamel.

Fluoride—A naturally occurring mineral in all water sources, which effectively prevents and reverses the early signs of tooth decay.

Malocclusion—Bad bite.

Periodontal disease—Gum disease, which is an infection of the soft tissues supporting the teeth.

Plaque—The thin, sticky film of bacteria that grows on teeth.

Prophylaxis—Dental cleaning.

Results

The results of good preventive dental care are healthy teeth and gums throughout one's life and the early detection of oral disease. Preventive procedures, such as fluoride applications and sealants, can prevent tooth decay. Regular dental checkups and oral cancer screenings can catch oral cancer at its most treatable stages. Dental checkups and consistent at-home preventive dental care can stave off caries (tooth decay) and periodontal disease, which can lead to tooth loss. An estimated 75% of adults have periodontal disease. Regular dental checkups can reduce the risk of permanent tooth and gum damage, and expensive treatment in the future. As a result of preventive dental care, people tend to keep their original teeth throughout life and don't need as much restorative dental work. Preventive dental examinations also ensure that a dentist will notice any oral signs of systemic disease. A dental checkup might reveal a lesion in the mouth that could lead to a referral to a physician for further investigation.

Treatments resulting from preventive dental procedures are designed to stop the process of the disease. Restorative dentistry, including the placement of fillings, crowns, and dental work, addresses tooth decay and tooth loss that can result from periodontal disease. Periodontal treatments help restore healthy gums and can prevent tooth loss.

Health care team roles

The dentist oversees the process of examination, diagnosis, treatment planning, and education. The allied

dental personnel include the dental hygienist and dental assistant. Dental hygienists sometimes perform preventive techniques, including cleaning, fluoride and sealant application, and **patient education**. The dental assistant in some states, depending on state licensing, can perform many of the same procedures as the hygienist, assist the dentist during checkups, and provide patient guidance and education.

Resources

ORGANIZATIONS

American Dental Association. 211 E. Chicago Ave., Chicago, IL 60611. (312) 440-2806. <<http://www.ada.org>>.

American Dental Hygienists' Association. 444 North Michigan Avenue, Suite 3400, Chicago, IL 60611. (312) 440-8900. <<http://adha.org>>.

OTHER

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Office address: 40 Central Park. New York, N.Y. 10019-1413. (212) 246-2398.

Lisette Hilton

Primary tooth development see **Tooth development, primary**

Private insurance plans

Definition

Private insurance plans include all forms of health insurance that are not funded by the government. These plans are intended to protect their beneficiaries from the high costs that may be incurred for health care. Most private insurance plans in the United States are employment-based; of the 194 million Americans who were covered by private health insurance in 1999, 172 million, or 89%, were enrolled in employment-based plans.

Description

Private health insurance plans may be purchased on an individual or a group basis. Most group plans are offered by large employers, although some are offered by voluntary associations. Individual policies are usually more expensive than group policies; they may also have additional coverage restrictions.

There are several major categories of private health insurance in the United States.

Indemnity plans

Indemnity plans are private insurance plans that allow beneficiaries to choose any physician or hospital when they need medical care. Most indemnity plans have a deductible, or amount that the policyholder must pay before the plan will pay any benefits. After the deductible, indemnity plans pay a co-insurance percentage, most often 70%–90% of the charges. The beneficiary pays the remainder of the bill.

Preferred Provider Organization (PPO) plans

PPO plans are like indemnity plans in that they usually have both a deductible and a co-insurance percentage. Unlike indemnity plans, however, PPOs offer beneficiaries a list of physicians and hospitals from which they must select in order to receive the plan's maximum benefit. PPOs tend to be less expensive than indemnity plans because health care providers are often willing to reduce their fees in order to participate in these plans. Many large companies have moved their insured employees into PPOs because of their cost effectiveness.

A person enrolled in a PPO can choose to go “out of network” and continue under the care of their present physician. They may also propose their physician for membership in the PPO so that continuity of service can be provided.

Health Maintenance Organization (HMO) plans

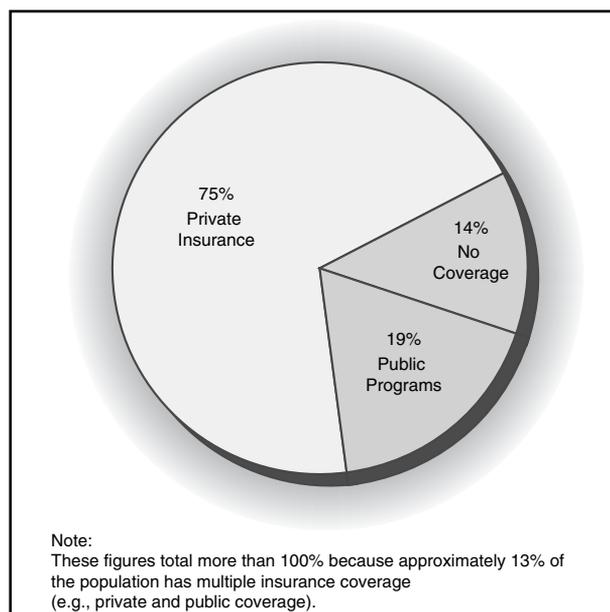
HMOs usually have no deductibles; the beneficiary is charged a small co-payment, typically \$5 or \$10, per visit, and the plan covers all other charges. Beneficiaries are, however, usually offered a much smaller list of health care providers from which to choose. In most HMOs, each beneficiary selects a primary care doctor who is responsible for all health care needs. Referrals to specialists must be made through the primary care doctor. Like PPOs, HMOs are usually able to charge lower premiums because their health care providers agree to substantially reduced fees.

Long-term care (LTC) insurance

Long-term care insurance, or LTC, is a type of private health insurance intended to cover the cost of custodial or nursing **home care**. It can be very expensive, and persons considering this form of insurance should not purchase it if the premiums would cause financial hardship in the present.

Medigap insurance plans

Medigap insurance plans are private plans intended to supplement **Medicare** coverage, because Medicare



Insurance coverage in the United States. (Delmar Publishers, Inc. Reproduced by permission.)

does not offer complete health insurance protection. There are ten standard Medigap benefit “packages,” identified by the letters A through J, that are available in most states, United States territories, and the District of Columbia. Medigap policies pay most or all of the co-insurance amounts charged by Medicare, and some Medigap policies cover Medicare deductibles.

Medical savings accounts

Medical savings accounts (MSAs) are not health insurance plans in the strict sense, but offer a partial alternative to expensive individual private insurance plans. MSAs are similar to Individual Retirement Accounts (IRAs) and have been considered a significant tax break for self-employed individuals. They were created as a four-year pilot project by the Health Insurance Portability and Accountability Act (HIPAA) of 1996. The federal government issued an extension on these accounts for two years, effective December 31, 2000. The government will not revoke these accounts once they have been opened.

An MSA must be combined with a qualified high-deductible private health plan. Without an MSA, a self-employed individual can deduct qualified medical expenses only under the itemized deductions of a 1040 tax form; and the expenses must exceed 7.5% of the adjusted gross income.

KEY TERMS

Co-insurance—The percentage of health care charges that an insurance company pays after the beneficiary pays the deductible. Most co-insurance percentages are between 70% and 90%.

Deductible—An amount of money that an insured person is required to pay on each claim made on an insurance policy.

Indemnity plans—Private health insurance plans that allow the policyholder to choose any physician or hospital when health care is needed.

Long-term care (LTC) insurance—A type of private health insurance intended to cover the cost of long-term nursing home care or home health care.

Medigap—A group of ten standardized private health insurance policies intended to cover the coinsurance and deductible costs that Medicare does not cover.

Portability—A feature that allows employees to transfer health insurance coverage or other benefits from one employer to another when they change jobs.

Preferred provider organizations (PPOs)—Private health insurance plans that require beneficiaries to select their health care providers from a list approved by the insurance company.

Premium—The amount paid by an insurance policyholder for insurance coverage. Most health insurance policy premiums are payable on a monthly basis.

Viewpoints

The high cost of health insurance

The cost of private health insurance has risen steadily over the past two decades, largely because of the rising cost of health care in the United States. Between 1980 and 1995, the total amount spent on health care in the United States rose from \$247.2 billion to \$1.04 trillion, more than a 400% increase. The reasons for the escalating costs include the following:

- Increased longevity. The life expectancy of most Americans is around 75 years. When older people join an insured group, the whole group's health care risks and costs rise.
- Advances in medical technology. New technology is often expensive.

- Increased use of health care. Between 1991 and 1996, the average number of visits to doctors' offices rose from 2.7 per person to 3.4.

The rising costs of health insurance over the past thirty years have caused many employers to curtail or drop health insurance as an employee benefit. The cost of health insurance premiums increased from \$16.8 billion in 1970 to \$310 billion in 1995. Some employers have increased the amount of money that employees are expected to contribute toward their health care. Others, particularly smaller businesses, do not offer insurance at all. A 1997 study found that only 34% of workers in smaller businesses were covered through their employers, whereas 82% of employees in the largest companies were covered. Workers in large-employer health insurance plans are also more likely to have policies that cover more health services, policies with lower deductibles, and more opportunities to enroll in HMOs.

The uninsured

The U. S. Census Bureau reported in 1997 that 43.4 million people in the United States, or 16.1% of the population, had no health insurance coverage. Between 1998 and 1999, both the number and the proportion of uninsured Americans declined slightly, to 42.6 million and 15.5% respectively.

Some workers do not have health insurance because they cannot afford it. In the 1950s, employer-based health insurance served most American families reasonably well because many workers were employed by large firms and remained with them for life. Over the past two decades, however, more and more people are employed by small firms that do not offer health insurance as a benefit, and more workers move from company to company every few years. Most uninsured workers are either self-employed, work only part-time, or work in low-wage jobs that do not give them access to lower-cost employer-sponsored group plans. At the same time, workers in these three categories do not qualify for coverage by government programs for low-income people.

The other major category of uninsured people includes those who cannot purchase private insurance at affordable rates because they are likely to need expensive medical services. Those who have a high risk of developing **cancer** or are HIV-positive may not be able to obtain coverage from any insurance company. Some insurance companies began introducing so-called "preexisting condition" clauses in their policies as early as the 1980s that denied private insurance to anyone already diagnosed with a serious medical condition. The Health Insurance Portability and Accountability Act of 1996 was intended to help workers who could not change their jobs

because they had family members with serious health problems. They would be denied health insurance by the preexisting condition clauses in the plan offered by their new employer. HIPAA requires employer-sponsored insurance plans to accept transfers from other plans without imposing preexisting condition clauses.

An individual private health insurance plan can be expensive and restrictive. It may, however, be the only choice for a consumer who is not employed; is self-employed; or is a new hire at a company and must wait for several months or more before the company's coverage takes effect.

Tax credit proposals

One approach to the rising costs of private health insurance that is gaining bipartisan political support is to offer tax credits that would allow more Americans to purchase health insurance. The present federal tax code favors workers who already have employer-sponsored health insurance. Supporters of the tax credit approach maintain that it would give workers a wider choice of health plans; create greater portability of health insurance; and encourage groups other than employment-based populations (e.g., church groups, unions, fraternal organizations, etc.) to sponsor insurance plans for their members.

Resources

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Jacqueline Martin

PRK see **Refractive eye surgeries**

Proctosigmoidoscopy see **Sigmoidoscopy**

Professional-patient relationship

Definition

The professional-patient relationship is a bond of trust between the patient and the medical professional who is performing treatment.

Description

The relationship established between patients and health care providers is fiduciary in nature, which means that it is based on trust. In this respect it is similar to the relationships between lawyers and clients or between clergy and their congregations. The professional trusts the patient or client to disclose all the information that may be relevant to his or her condition or illness, and to be truthful while disclosing it. In return, the patient or client trusts the health care professional to maintain high standards of competence; to protect the confidentiality of private information; and to carry out his or her work in the best interests of the patient rather than taking advantage of the patient's vulnerability.

Ethical principles

Health care professionals are obligated to act according to ethical and legal standards. Ethical guidelines refer to the moral standards that are considered to govern health care. The fundamental ethical principles underlying Western medical practice have not changed since they were first enunciated by Hippocrates (460-377 BC). These principles include:

- **Honesty:** The professional does not withhold necessary information from the patient or lie to the patient about the nature or seriousness of his or her condition.
- **Beneficence (doing good):** The professional uses his or her knowledge and skills to balance good results and potential harms, and act in the patient's best interests.

- Justice. The professional does not refuse treatment on the basis of a patient's race, religion, nationality, income, or other personal characteristic.
- Avoiding conflicts of interest. This principle means that the professional must not benefit personally from his or her professional actions or influence. For example, a physician should prescribe a particular medication because it is the best choice for the patient, not because the professional owns stock in the company that manufactures the drug.
- Pledging to do no harm. This principle means that the professional must avoid actions detrimental to the patient.

All major organizations of health care providers, including the American Hospital Association, the American Medical Association, the American Dental Association, and the American Nurses Association have formal ethical guidelines for professional-patient relationships. These ethical policy statements are based on the ancient Hippocratic oath.

Legal obligations

In the United States and Canada, the legal obligations of health care providers are based on and presuppose the traditional ethical standards of good medical practice. These legal obligations include accepting federal and state examination and licensure standards; government regulation of **medical records**; court orders regarding reporting or disclosure of a patient's medical records; and a number of other obligations.

The legal obligations and liabilities of health care professionals have become increasingly complex over the last 30 years. This development is partly the result of technological advances that pose new questions to the legal system. For example, the safe operation of **medical lasers** depends on proper engineering and maintenance procedures as well as on the surgeon's skill and training in using the laser. A patient injured by a malfunctioning laser might decide to sue the manufacturer and the **hospital administration** as well as the surgeon. In addition, however, the growing complexity of health care legislation is part of a larger trend toward resolving social issues through litigation rather than through public debate or other means.

Viewpoints

Historical background

Prior to the second half of the twentieth century, the patient-physician relationship was strictly hierarchical. The physician was assumed to know what was best for the patient, and the patient was expected to follow "doc-

tor's orders." After World War II, however, patients in the developed countries began to take a more active role in their health care. This change was related to the larger proportion of high-school students going on to college, and to the rapid spread of medical information via television and health care books written for the general public. Patients who were employed in other fields requiring specialized training, or who read widely, were less impressed by the physician's educational credentials and more likely to question his or her advice.

The social context of contemporary health care

In addition to the rise in education level among the general population in Europe and North America, several other factors have helped to reshape patient-professional relationships. The most important factors are the following:

- The loss of a social consensus regarding moral issues. At one time, health care professionals could be fairly sure that they and their patients agreed on the major moral issues that were likely to arise in health care situations. Today, however, there is widespread disagreement within the professions as well as in the general population about such questions as abortion, **euthanasia**, organ donation, limitations on medical research, and others. A patient who disagrees with his or her health care provider on the moral implications of a procedure is now generally allowed to refuse the procedure.
- The high-pressure education of health care professionals. Over the past thirty years, the training of physicians, nurses, dentists, pharmacists, and other health care professionals has become much more demanding. One factor is the sheer accumulation of scientific knowledge; today's medical, dental, or nursing student must master a much larger body of information than students of previous generations. Another factor is the increased tendency toward professional specialization, which makes it more difficult for health care providers to see patients as whole human beings.
- Managed care. Managed care has changed physician-patient relationships by requiring patients to choose their doctor from a list of providers approved by the managed care organization. In many instances patients have left physicians who were trusted and who had cared for them for years. In other instances managed care organizations have terminated physicians on short notice, thus disrupting continuity of patient care. Some observers have remarked that patients' attitudes toward physicians have become increasingly adversarial because they think doctors are more concerned with

pleasing insurance companies than to provide good care.

- Changes in communications technology. The widespread use of computers in managed care and health insurance organizations to store databases of patient information has raised questions about preserving confidentiality. In addition, the increasing popularity of e-mail for communication between patients and professionals opens up concerns about the security and privacy of electronic files.
- Multicultural issues. Hospitals and medical or dental offices have been increasingly confronted with the complications that can arise in cross-cultural professional-patient relationships. Different ethnic and racial groups in the United States have widely varying customs and attitudes toward such matters as expressing physical **pain** or grief; undressing in front of a professional of the opposite sex; asking questions about their diagnosis and treatment; and other issues that arise in medical settings.

Professional implications

Now, at the beginning of the twenty-first century, the major emphasis of the professional-patient relationship is on the medical professional and the patient as partners making a joint decision about the patient's treatment. Patients have requested and been given more rights concerning their medical treatment. Medical professionals should encourage patients to learn about their medical problems, weigh the benefits of different treatments, and make choices based on their own beliefs and values.

Some specific issues

Recent changes in professional-patient relationships have tended to cluster around several specific issues.

INVOLVEMENT OF FAMILY MEMBERS IN PROFESSIONAL/PATIENT RELATIONSHIPS. Although discussions of professional-patient relationships often proceed as if the relationship concerns only two people, the care provider and the patient, in many cases family members are also involved. In the cases of children and elderly patients, family members may be needed to describe the patient's symptoms or provide care at home. With regard to the elderly, different family members may have sharp disagreements about the level of health care that is necessary, which can complicate the professional's work.

CONFIDENTIALITY. The computerization of patient information, combined with the increasing involvement of federal and state governments in health care, has led some observers to ask whether present security measures

KEY TERMS

Boundaries—The limits that define a human being's personal space. Boundaries may be physical, psychological, emotional, or spiritual.

Confidentiality—The protection and maintenance of strict privacy and secrecy in relationships between professionals and their patients or clients.

Ethics—The rules of conduct recognized as governing a particular group, as medical professionals.

Hippocratic Oath—The ethical pledge attributed to Hippocrates that is used as a standard for care by physicians worldwide.

Rapport—The relation between professional and patient, particularly one that is harmonious and empathic.

are adequate. Both trends—the use of computers and the expansion of government regulation—increase the number of people who have access to patient records and private information.

In the United States and Canada, the courts generally recognize two limitations on the professional's obligation to preserve confidentiality. The first is a court order that requires the physician to deliver confidential information about a patient. The second limitation concerns situations in which a patient is endangering his or her own life or the lives of others.

SEXUAL MISCONDUCT. The most explosive issue in recent years has been the rise in the number of reported incidents of sexual harassment or abuse of patients on the part of health professionals. The two specialties that have studied the issue most carefully are psychiatry and obstetrics-gynecology. Most such incidents (about 85%) involve male professionals and female patients; another 12% involve male professionals and male patients. The remaining 3% involve female professionals.

Studies of sexual misconduct on the part of professionals have reported the following findings:

- The greater degree of patient participation in medical decision-making does not do away with a basic inequality in professional-patient relationships. The patient is dependent on the professional's knowledge and authority, and the professional is obligated not to exploit that advantage.

- People who are seriously ill are emotionally vulnerable. They are less able to protect themselves against violation of their physical or psychological boundaries. Thus they cannot be regarded as “consenting” to a sexual relationship with a health care provider.
- Many adult patients were abused as children and find it difficult to protect themselves in adult life even apart from health crises. In particular, many women have been trained in childhood to be passive and compliant in the face of aggressive or exploitative behavior from men. These patients should not be accused of inviting or “asking for” sexual abuse.
- Some medical procedures appear to be fertile ground for poor communication or misunderstanding between the professional and patient.

Most medical, dental, and nursing schools in the United States and Canada now include courses in professional ethics, communication skills, and understanding of the social context of professional-patient relationships. Students are taught that mutual respect and clear communication between professionals and patients are the most effective safeguards against abuse.

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- American Medical Association. 515 N. State Street, Chicago, IL, 60610. (312) 464-5000. <<http://www.ama-assn.org>>.
- American Nurses Association. 600 Maryland Avenue, SW, Suite 100 West, Washington, DC 20024. (202) 651-7000. <<http://www.ana.org>>.
- Canadian Medical Association. 1867 Alta Vista Drive, Ottawa ON K1G 3Y6. (613) 731-8610x2307 or (888) 855-2555. Fax (613) 236-8864. cmamsc@cma.ca.

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Peggy Elaine Browning

Progesterone assay see **Sex hormones tests**

Prolactin test see **Pituitary hormone tests**

Prolapsed disk see **Herniated disk**

Prophylactic antibiotic premedication

Definition

Prophylactic antibiotic premedication is the practice of prescribing limited antibiotic therapy to dental patients who are at risk of contracting microbial disease as a result of invasive dental procedures.

Purpose

Oral **bacteria** can enter the bloodstream during dental procedures and are normally destroyed by the body’s **immune system**. In certain cases, however, bacteria may settle on abnormal **heart** valves or tissue that has been weakened by surgery or an existing heart problem. Infective **endocarditis**, an **infection** of the endocardium or heart valves, can be the result. Prophylactic premedication with approved **antibiotics** manages and reduces the risk of infection.

A study published in November 2000 has called into question whether antibiotic prophylaxis is necessary for dental treatment. Such treatment, the study concluded, does not seem to be a risk factor for infective endocarditis. The American Dental Association (ADA) and American Heart Association have stated that their current recommendations are valid, although further research is warranted. The ADA’s Council on Scientific Affairs continues to monitor, analyze, and assess research in prophylactic premedication with antibiotics.

The use of prophylactic premedication in oral health care has undergone many changes since its inception. Dosages have been decreased, and the conditions requiring premedication have changed. Premedication for

patients who are recipients of large joint prostheses is no longer universally recommended. Some associations of orthopedists, for instance, state that routine antibiotic coverage is not necessary for patients who have joint prostheses and are undergoing dental procedures. It is recognized, however, that decisions regarding premedication should be made on an individual basis.

Precautions

According to the American Heart Association, endocarditis rarely occurs in people with normal hearts. Certain preexisting heart conditions are susceptible to bacteremia, however. These include:

- an artificial (prosthetic) heart valve
- a history of previous endocarditis
- heart valves damaged (scarred) by such conditions as rheumatic fever
- congenital heart or heart valve defects
- mitral valve prolapse with a murmur
- hypertrophic cardiomyopathy

Description

Procedures affected

Dental procedures for which antibiotic premedication is indicated include those in which bleeding is likely. They include:

- dental extractions
- periodontal procedures, including surgery, scaling and root planing, probing, and periodontal maintenance
- dental implant placement and reimplantation of avulsed (torn out) teeth
- endodontic (root canal) instrumentation or surgery—only beyond the apex
- subgingival placement of antibiotic strips
- initial placement of orthodontic fibers
- intraligamentary local anesthetic injections
- prophylactic cleaning of teeth or implants where bleeding is anticipated
- restorative dentistry with or without retraction cord
- local anesthetic injections
- intracanal endodontic treatment, post-placement and buildup
- placement of rubber dams
- postoperative suture removal

KEY TERMS

Bacteremia—Presence of bacteria in the blood.

Cardiomyopathy—Chronic disorder of the heart muscle that may involve hypertrophy and obstructive damage to the heart.

Endocardium—Membrane lining the chambers of the heart and covering the cusps of the various valves.

Infective endocarditis—A systemic disease characterized by focal bacterial infection of the heart valves, with formation of bacteria-laden vegetation.

Mitral valve prolapse—Downward displacement of the valve between the left atrium and ventricle of the heart.

- placement of removable prosthodontic/orthodontic appliances
- taking of oral impressions, fluoride treatments
- taking of oral radiographs, orthodontic appliance adjustment
- shedding of primary teeth

Dosages recommended

The American Heart Association recommends the following standard regimens for dental treatment in patients at risk of bacterial endocarditis.

- General adult patients: 2 grams amoxicillin (children, 50 mg/kg) given orally one hour before procedure.
- Adult patients unable to take oral medications: 2 grams ampicillin (children, 50 mg/kg) given intramuscularly or intravenously within 30 minutes before procedure.
- Adult patients allergic to amoxicillin, ampicillin, or penicillin: 600 mg clindamycin (children, 20 mg/kg) given orally one hour before procedure. Alternatively, use 2 grams cephalexin or cefadroxil (children, 50 mg/kg) given orally one hour before procedure. Cephalosporins should not be used in patients with immediate-type hypersensitivity reaction to penicillins. Another alternative is 500 mg azithromycin or clarithromycin (children, 14 mg/kg) given orally one hour before procedure.
- Adult patients allergic to amoxicillin, ampicillin, or penicillin who are unable to take oral medications: 600 mg clindamycin (children, 20 mg/kg) intravenously within 30 minutes before procedure. Alternatively, use

1 gram cefazolin (children, 25 mg/kg) intramuscularly or intravenously within 30 minutes before procedure.

Preparation

Antibiotic premedication is given to the patient either one hour (oral) or 30 minutes (intramuscular and intravenous) prior to the procedure.

Complications

When prophylactic premedication is prescribed for dental treatment, prior use of antibiotics should be considered. Resistant organisms may develop, especially if the proposed dental treatment closely follows prior antibiotic exposure. In that case, it is recommended that dentists consult with the patient's physician on the drug chosen and its dosage.

Possible allergic reactions to antibiotics must also be considered. Careful attention to the patient's **health history** is indicated to determine any prior allergy.

Patients who have difficulty swallowing may be given antibiotics intravenously or intramuscularly.

Results

Prophylactic antibiotic premedication manages and reduces the risk of infective endocarditis as a result of dental treatment.

Health care team roles

Dentists prescribing prophylactic antibiotic premedication should consult with the patient's physicians, both general and specialty. When treating a patient with heart problems, for instance, the dentist would contact the patient's cardiologist. In determining whether a patient with a large joint prosthesis should be premedicated, the dentist should confer with the patient's orthopedic specialist.

Every member of the dental team must be aware of the risks of infective endocarditis to their patients. Health questionnaires should be scrutinized at the initial visit to identify patients at risk. On follow-up visits, health histories should be updated.

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Proprioceptive neuromuscular facilitation

Definition

Proprioceptive neuromuscular facilitation (PNF) is a rehabilitation technique that was initiated over 50 years ago. It is used to stimulate the neuromuscular system in an effort to excite proprioceptors (sensory organs in muscles, tendons, bones and joints) in order to produce a desired movement.

Purpose

An individual with a neuromuscular disorder may have dyscoordinated movement; that is, movement that is jerky or unsteady. PNF is a specific treatment approach that attempts to make movement more efficient and to improve function during activities of daily living.

Precautions

When using PNF, care must be taken during the movements. Injuries to tendons, muscles, or ligaments can occur if movement is not indicated or is too aggressive.

Description

PNF involves many combinations of motions. The goal is to incorporate postural and righting **reflexes**, which are important for maintaining balance. Usually during PNF motions or patterns, resistance is given, first during the stronger part of the range and followed by the weakest part of the range. Other techniques in PNF have the patient isometrically contract the involved muscle or muscle group (agonist), followed by immediately contracting the muscle or muscle group opposite the involved group (antagonist). This technique is called rhythmic stabilization. Another technique incorporates rhythmic stabilization alternately. Contraction of agonist and antagonist in an alternating fashion is called slow reversal.

PNF is based on flexion and extension, but is performed in diagonal patterns. This practice maximizes neuromuscular facilitation by lengthening the muscle or muscle group as much as possible, thus incorporating the stretch reflex.

There are various types of movement patterns in PNF, including unilateral and bilateral patterns. Unilateral patterns are usually based on one limb, either upper or lower, and can incorporate head and trunk movement. Bilateral patterns are done on either both upper or lower limbs at the same time. There are other techniques within the scope of PNF that are used to facilitate. Facilitatory techniques used to stimulate the neuromuscular system include stretch, traction, approximation, and maximal resistance. Other techniques that require significant participation by the patient are rhythmic stabilization, contract-relax, hold-relax, slow reversal, and repeated contractions.

Complications

Which PNF technique is used in therapy depends on a patient's needs. For example, it would not be advisable to apply a stretch technique to an area of known muscle tearing or around a fracture area. Overstretching a limb with known hypertonicity may cause significant muscle or tendon damage. Care must be taken to minimize stresses placed on muscle, tendon, or joints when known pathology is present.

KEY TERMS

Agonist—The muscle that contracts to create movement or tension. For example, the quadriceps muscles are the agonists in knee extension.

Antagonist—The muscle that opposes the movement being completed. The hamstrings are antagonists to the quadriceps during knee extension.

Dyscoordinated—Movement that is asynchronous, jerky, and unsteady.

Extension—The act of straightening a joint to bring the bones more in line, e.g., straightening the knee or elbow.

Flexion—Bending of a joint, such as bending or flexing the knee.

Postural—Pertaining to the position of the head, neck, trunk and lower limbs in relation to the ground and the vertical.

Proprioceptors—Sensory organs in muscle, tendon, bone, and joint that provide information to the brain about the surrounding environment, such as position.

Righting—The ability to maintain one's head and center of gravity within one's base of support. For example, while standing on a moving bus, an individual adjusts to maintain an upright posture as the bus comes to a stop.

Results

The goal of PNF is to restore neuromuscular function to an individual who presents with impairment to the neuromuscular system. By restoring neuromuscular function, the individual can improve gait, mobility, and self-care. Thus, the goal of PNF is to restore movement, control posture and body awareness, improve coordination, and improve muscle function.

Health care team roles

PNF techniques are typically used by physical and occupational therapists. Nurses and other allied health care professionals must realize that PNF alone does not restore neuromuscular function. Activities of daily living (ADL) must be integrated within the total construct of rehabilitation; that is, during self-care, recreation, and socialization. Nurses and other allied health care professionals must provide an environment that facilitates this integration of rehabilitation with other activities.

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Mark Damian Rossi, Ph.D, P.T., C.S.C.S.

Prostaglandins see **Uterine stimulants**

Prostate-specific antigen test see **Tumor marker tests**

Prostate biopsy

Definition

Prostate biopsy is a surgical procedure to remove small samples of prostate tissue for microscopic examination. The prostate gland lies just below the urinary bladder and surrounds the urethra. The gland produces enzyme-rich secretions that contribute to the seminal fluid via ducts that enter the urethra.

Purpose

A prostate biopsy is usually performed to determine whether the patient has **prostate cancer**. Occasionally, it may also be used to diagnose a condition called benign prostatic hypertrophy (BPH), a progressive enlargement of the prostate that may cause obstruction of urine flow in older males.

A prostate biopsy is ordered when other tests have indicated a need to visualize samples of prostate tissue for abnormalities. These tests are the digital rectal examination (DRE) and the prostate-specific antigen (PSA) **blood** test. The DRE is a routine screening test performed by the physician to feel for any enlargement or nodular growth of the patient's prostate. Higher than normal levels of the protein marker PSA can be an indicator of prostate **cancer**. If either the DRE or PSA results are abnormal, the physician may order additional tests, including a prostate biopsy. Computed tomography scans, **magnetic resonance imaging**, and ultrasonograms provide detailed pictures of the prostate and can

also be used to determine the extent and spread of prostate disease. However, a prostate biopsy (examination of the cells of the gland under a **microscope**) remains the most definitive test for diagnosing and staging prostate cancer.

Precautions

A prostate biopsy is ordered only when the physician has used prior diagnostic tools that indicate an abnormal prostate. Prostate biopsies are usually performed by a urogenital system specialist (urologist). Special precautions will be required before the biopsy if the patient has a history of abnormal bleeding or is currently taking a blood-thinning medication.

Description

According to the American Cancer Society, next to skin cancer, prostate cancer continues to be the most commonly diagnosed cancer in American men. Prostate biopsies are usually performed in one of two ways. They can be performed by inserting a needle through the wall of the rectum or by inserting a needle through the perineum (the area between the base of the penis and the rectum). The patient may be given a sedative to help him relax. In preparation for the biopsy the patient will have an enema, and will begin antibiotic therapy to prevent an **infection**.

Needle biopsy via the rectum

This procedure, called a transrectal ultrasound-guided biopsy, is the most commonly performed type of prostate biopsy, and can usually be performed in the physician's office without **general anesthesia**. The patient is asked to lie on his side or on his back with his legs in stirrups. Local anesthetic is administered, and the urologist uses a thin needle attached to a spring-loaded gun directed by ultrasound to collect samples from the prostate. The gun is able to insert and remove the needle into the prostate tissue rapidly, creating less discomfort and trauma for the patient. The procedure can often be completed within 30 minutes. Usually the tissue samples are obtained by fine-needle aspiration, as opposed to larger core tissue samples that create more discomfort for the patient.

Needle biopsy via the perineum

If the chances of a complication for the patient are too great for the transrectal ultrasound-guided biopsy, the urologist may choose another route through the perineum for access to the prostate. The skin of the perineum is thoroughly cleansed and a local anesthetic is injected at

the site where the biopsy is to be performed. Once the area is numb, the physician makes a small (1 in/2.5 cm) incision in the perineum. The physician places one finger in the rectum to guide the placement of the biopsy needle, and the needle is then inserted into the prostate. A small amount of tissue is collected and the needle is withdrawn. The needle is then reinserted into another part of the prostate and another sample of tissue is collected. In this manner, samples are collected from several areas. After the procedure, pressure is applied at the biopsy site to stop bleeding. The patient usually experiences only slight discomfort and the procedure can often be completed within 30 minutes.

Preparation

Before scheduling the biopsy, the physician, nurse, or physician assistant completes a thorough medical history of the patient to include all medications that the patient is taking; a list of any medications to which the patient is allergic; and a history of any bleeding problems. The patient may be given an antibiotic shortly before the test to reduce the risk of infection. Usually an enema is required prior to the biopsy procedure, and the patient will be given instructions on administering the enema.

Aftercare

The physician, nurse, or physician assistant should monitor the patient for any complications, excessive bleeding, or **pain** from the procedure. After the procedure, the patient commonly experiences minor rectal bleeding, blood in urine or feces, and sometimes blood in the semen. These side effects usually last for only a few days. Often, the physician will prescribe **antibiotics** to guard against potential infection. The patient should drink fluids to help reduce any burning sensation and the chances of a urinary tract infection.

Complications

Prostate biopsy performed with a bioptic gun is a low-risk procedure. The possible complications include abnormal bleeding, urinary tract infection, or an inability to urinate. These complications are treatable, and the patient should notify the physician promptly if symptoms occur. If the patient develops a high **fever**, chills, or unusual pain or bleeding after the procedure, he should notify the physician immediately.

Results

The prostate tissue is fixed, stained, and prepared on glass slides for microscopic analysis by a pathologist

KEY TERMS

Benign prostatic hypertrophy (BPH)—A non-cancerous condition of the prostate that causes growth of the prostate tissue, thus enlarging the prostate and obstructing urination.

Biopsy—The surgical removal and microscopic examination of living tissue for diagnostic purposes.

Computed tomography (CT) scan—A medical procedure in which a series of x rays is taken at different angles and reconstructed by a computer in order to form detailed pictures of areas inside the body.

Digital rectal examination—A routine screening test that is used by physicians to detect any enlargement in the prostate gland or any hardening or other abnormality of the prostate tissue. The doctor inserts a gloved and lubricated finger (digit) into the patient's rectum, which lies just behind the prostate. Typically, since a majority of tumors develop in the posterior region of the prostate, they can be detected through the rectum.

Magnetic resonance imaging (MRI)—An imaging procedure that creates a detailed computer-constructed image of the target tissue based upon its deflection of a magnetic field produced by a powerful magnet. The magnetic field deflection is measured using radio waves (not x rays).

Pathologist—A doctor who specializes in the diagnosis of diseases by studying cells and tissues removed by biopsy.

Ultrasonogram—An image produced by high-frequency sound waves that cannot be heard by human ears. The sound waves are deflected by internal organs and tissues. These sound waves produce a pattern of echoes that are then used by the computer to create pictures of areas inside the body.

who will examine the samples for the presence of cancerous cells. If the prostate tissue samples show no sign of inflammation, and if no cancerous cells are detected, the results are normal. If malignant cells are present, the pathologist grades them, in order to estimate the aggressiveness of the tumor. The most commonly used grading system is called the Gleason system; the higher the Gleason score, the more likely it is that the cancer is fast-growing and may have already spread to other areas (metastasized).

Health care team roles

Training

The urologist and several non-physician health care providers are involved in the biopsy process. The urologist has received specialized training in ultrasound-guided biopsy procedures. The additional health care team members have obtained specialized training to assist the urologist by preparing the patient for the procedure and monitoring the patient during the procedure. They also ensure that the urologist has all of the instruments and equipment required before, during, and after the procedure. A health care provider properly packages and labels the specimens for transport to the pathology laboratory.

Patient education

The health care provider can be an important resource for patients who require a prostate biopsy. Health care professionals should make men aware of certain risk factors that can increase their chances of developing prostate cancer. Three important risk factors are age greater than 50; family history of prostate cancer; and African American descent. A health care provider should explain in detail the procedure to be performed and the possible complications associated with the biopsy.

The health care provider will instruct the patient in self-administering an enema. Following a needle biopsy, the health care providers should tell the patient that he may experience some minor discomfort, and that he should avoid strenuous activities for the remainder of the day. The health care provider should also inform that patient that he may notice a small amount of blood in his urine or minor bleeding from his rectum for two or three days after the test. The provider should emphasize to the patient that he should call the physician immediately if he experiences unusual bleeding, pain, fever, or an inability to urinate for 24 hours. The health care provider should provide the patient with the results of the test as soon as they are available.

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<<http://www.cancer.org>>.
- American Urological Association. 1120 N. Charles Street, Baltimore, MD 21201. (410) 727-1100.
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Prostate cancer

Definition

Prostate **cancer** is a disease in which the cells of the prostate (a gland found in the **male reproductive system**) become abnormal and start to grow uncontrollably, forming tumors. Tumors that can spread to other parts of the body are called malignant tumors or cancers. Tumors that are not capable of spreading in this way are said to be benign.

Description

The prostate is a gland that produces the fluid (semen), which contains sperm. The prostate is about the size of a walnut and lies just beneath the urinary bladder. Usually prostate cancer is slow-growing, but it can grow faster in some instances. As a prostate cancer grows, some of the cells may break off and spread to other parts of the body through the lymphatic or the **blood** systems. This process is known as metastasis. The most common sites of spreading are the lymph nodes and various bones in the spine and the pelvic region.

The **lymphatic system** is composed of ducts that transport extracellular fluid from distant areas of the body to the **heart**. Fluid enters lymph ducts and travels toward the heart. Any fluid collected is mixed with the blood. Any excess fluid is eliminated from the blood by the **kidneys**. Along the lymph system are clusters of specialized tissue called lymph nodes. These nodes act as strainers and retain cellular debris to prevent it from entering the blood stream. Lymph nodes also retain cancer cells that escape from tumors. For this reason, surgeons often remove some lymph nodes for analysis to determine the extent that a cancer may have spread beyond its original (primary) site.

The cause of prostate cancer is not clear; however, several risk factors are known. The average age at diag-

nosis of prostate cancer is approximately 72 years. In fact, 80% of prostate cancer cases occur in men over the age of 65. As men grow older, the likelihood of developing prostate cancer increases. Hence, age appears to be a risk factor for prostate cancer. Race may be another contributing factor. African Americans have the highest rate of prostate cancer in the world while the rate in Asians is one of the lowest. However, although the rate of prostate cancer in native Japanese men is low, the rate in Japanese Americans is closer to that of white American men. This finding suggests that environmental factors also play a role in prostate cancer.

There is some evidence to suggest that a diet high in fat increases the risk of prostate cancer. Studies also suggest that such nutrients as soy isoflavones, **vitamin E**, selenium, **vitamin D** and carotenoids (including lycopene, the red color agent in tomatoes and beets) may decrease prostate cancer risk. These substances contain particularly high levels of molecules called antioxidants, which seem to oppose the formation of cancer cells. Vasectomy may be linked to increased prostate cancer rates as well. Workers in such industries as welding, with exposure to the metal cadmium, appear to have a higher than average risk of prostate cancer. Male sex hormone levels also may be linked to the rate of prostate cancer. In addition, some studies have linked increased prostate cancer risk to smoking.

Genetic profile

An estimated 5-10% of prostate cancer is due to hereditary causes. Among men with early prostate cancer, a hereditary cause is likely in up to a third of cases before age 60 and in almost half of men diagnosed with prostate cancer at age 55 or less. Studies have found around a two- to three-fold increased rate of prostate cancer in close relatives of men with the disease. Hereditary prostate cancer is likely in a family if there are three cases of prostate cancer in close relatives; or three affected generations (on either mother's or father's side); or two relatives with prostate cancer before age 55.

Studies suggest that hereditary prostate cancer is likely to be caused by several different genes instead of a single gene. At least four other genes have been reported, including one thought to increase the risk of both prostate and **brain** tumors. Other genes known to increase the risk of other cancers, such as **breast cancer**, also may be linked to increased prostate cancer risk. Common variations in certain genes also may increase susceptibility to prostate cancer, including one gene linked to male sex hormones. Since no clear cause has been identified for the majority of hereditary prostate cancer, **genetic testing**, as of 2001, is typically done through research studies.

Demographics

Prostate cancer is the most common cancer among men in the United States, and is the second leading cause of cancer deaths. The American Cancer Society estimates that in 2001, 198,100 new cases of prostate cancer will be diagnosed, and it will cause 31,500 deaths. One in six men in the United States will be diagnosed with prostate cancer. Prostate cancer affects black men about twice as often as it does white men, and the mortality rate among African Americans is also higher. African Americans have the highest rate of prostate cancer in the world. The prostate cancer rate varies considerably around the world. The highest rates are in North America and Western Europe, whereas the rates are moderate in Africa and lowest in Asia. It is unclear what roles genetics, diet, economics, and health care access play in these rates.

Causes and symptoms

Frequently, prostate cancer has no symptoms, and the disease is diagnosed when a man goes for a routine screening examination. However, when the tumor is larger or the cancer has spread to nearby tissues, the following symptoms may be seen:

- weak or interrupted flow of urine
- frequent urination (especially at night)
- difficulty starting urination
- inability to urinate
- **pain** or burning sensation when urinating
- blood in the urine (hematuria)
- persistent pain in the lower back, hips, or thighs (bone pain)
- difficulty having or keeping an erection (impotence)

Diagnosis

Although prostate cancer may be very slow-growing, it can be quite aggressive, especially in younger men. When the disease is slow-growing, it may often go undetected. Because it may take many years for the cancer to develop, many men with the disease are likely to die of other causes rather than from the cancer.

Prostate cancer is frequently curable when detected early. However, because the early stages of prostate cancer may not have any symptoms, it often goes undetected until a man goes for a routine **physical examination**. Diagnosis of the disease is made using some or all of the following tests.



This patient's prostate cancer has metastasized, swelling the lymph nodes in the left groin. (Photograph by Dr. P. Marazzi. Photo Researchers, Inc. Reproduced by permission.)

Digital rectal examination (DRE)

In order to perform this test, a physician puts a lubricated, gloved finger (digit) into the rectum to feel for any lumps in the prostate. The rectum lies just behind the prostate gland, and a majority of prostate tumors begin in the posterior region of the prostate. The posterior portion of the prostate is most accessible to a physician's examining finger. If the physician does detect an abnormality, additional tests may be ordered to confirm these findings.

Blood tests

Blood tests are used to measure the amounts of certain protein markers, such as prostate-specific antigen (PSA), found circulating in the blood. The cells lining the prostate generally make this protein and a small amount can normally be detected in the bloodstream. However, prostate cancers typically produce large amounts of this protein, and it can be easily detected in the blood. Hence, when PSA is found in the blood in higher than normal amounts (for a man's age group), cancer may be present. Occasionally, other blood tests also are used to help with the diagnosis.

Transrectal ultrasound

A small sound-producing device (transducer) is placed in the rectum and sound waves are released from it. These sound waves bounce off the prostate tissue and an image is created by a computer using the reflected sound waves. Since normal prostate tissue and prostate tumors reflect the sound waves differently, the test can be used to detect tumors. Though the insertion of the transducer into the rectum may be slightly uncomfortable, the procedure is generally painless and takes only about 20 minutes.

PROSTATE BIOPSY. If cancer is suspected from the results of any of the above tests, a physician will remove

a small piece of prostate tissue with a hollow needle. This sample is then analyzed under a **microscope** for the presence of cancerous cells. **Prostate biopsy** is the most definitive diagnostic tool for prostate cancer.

If cancer is detected during the microscopic examination of the prostate tissue, a pathologist will grade the tumor. This means that the tumor will be scored on a scale of two to 10 to indicate how aggressive it is. Tumors with a lower score are less likely to grow and spread than are tumors with higher scores. This method of grading tumors is called the Gleason system. This is different from staging of the cancer. When a physician stages a cancer, a number is assigned. The number indicates whether it has spread and the extent of spread of the disease. In Stage I, the cancer is localized in the prostate in a single area; while in the last stage, Stage IV, the cancer cells have spread to other parts of the body.

X rays and imaging techniques

X-ray studies may be ordered to determine whether the cancer has spread to other areas. Imaging techniques (such as computed tomography [CT] scans and **magnetic resonance imaging** [MRI]), in which a computer is used to generate a detailed picture of the prostate and adjacent areas, may be undertaken to get a clearer view of the internal organs. A bone scan may be used to check whether the cancer has spread to bones.

The American Cancer Society and other organizations recommend that PSA blood testing and digital rectal examinations be offered to men with at least a 10-year life expectancy beginning at age 50. Men at higher risk for prostate cancer, such as those with a family history of the disease or African American men, may wish to consider screening at an earlier age, such as 45. A low-fat diet may slow the progression of prostate cancer. Hence, the American Cancer Society recommends a diet rich in fruits, vegetables and dietary fiber; and low in red meat and saturated **fats**, in order to reduce the risk of prostate cancer.

Treatment

A physician and an affected man will decide on a treatment after considering many factors. For example, the man's age, the stage of the tumor, his general health, and the presence of any coexisting illnesses have to be considered. In addition, a man's personal preferences and the risks and benefits of each treatment method are also taken into account before any decision is made.

Surgery

For early-stage prostate cancer, surgery is frequently considered. Radical prostatectomy involves complete

removal of the prostate. During the surgery, some of the lymph nodes near the prostate are removed to determine whether the cancer has spread beyond the prostate gland. Because the seminal vesicles (the glands where seminal fluid is made) are removed along with the prostate, **infertility** is often a side effect of this type of surgery. In order to minimize the risk of impotence (inability to have an erection) and incontinence (inability to control urine flow), a procedure known as a nerve-sparing prostatectomy is used.

In a different surgical method, known as the transurethral resection procedure or TURP, only the cancerous portion of the prostate is removed, by using a small wire loop that is introduced into the prostate through the urethra. This technique is most often used in men who cannot have a radical prostatectomy due to age or other illness, and it is infrequently recommended.

Radiation therapy

Radiation therapy involves the use of high-energy x-rays to kill cancer cells or to shrink tumors. It can be used instead of surgery for early-stage cancer. The radiation can be administered either from a machine outside the body (external beam radiation), or from small radioactive pellets implanted in the prostate gland in the area surrounding a tumor.

Hormone therapy

Hormone therapy is commonly used when the cancer is in an advanced stage and has spread to other parts of the body. Prostate cells need the male hormone testosterone to grow. Decreasing the levels of this hormone or inhibiting its activity may cause the cancer to shrink or stop growing. Hormone levels can be decreased in several ways. Orchiectomy is a surgical procedure that involves complete removal of the testicles, leading to a decrease in the levels of testosterone. Alternatively, drugs (such as LHRH agonists or anti-androgens) that bind to the male hormone testosterone and block its activity can be given. Luteinizing hormone releasing hormone (LHRH) agonists stimulate the **pituitary gland** in the brain to release luteinizing hormone. This release results in a decreased level of testosterone. Another approach involves administering the female hormone estrogen. When estrogen is given, the body senses the presence of a sex hormone and stops making the male hormone testosterone. However, there are some side effects to hormone therapy. Men may have “hot flashes,” enlargement and tenderness of the breasts, or impotence and loss of sexual desire—as well as blood clots, heart attacks, and strokes, depending on the dose of estrogen.

Chemotherapy

Chemotherapy is the use of drugs to kill cancer cells. The drugs can either be taken in pill form or injected into the body through a needle that is inserted into a blood vein. This type of treatment is called systemic treatment because the drug enters the blood stream, travels through the whole body, and kills cancer cells that are outside the prostate. Chemotherapy is sometimes used to treat prostate cancer that has recurred after other treatment. Research is ongoing to find more drugs that are effective for the treatment of prostate cancer.

Watchful waiting

Watchful waiting means that no immediate treatment is recommended, but physicians keep the man suspected of having prostate cancer under careful observation. This option is generally used among older men when the tumor is not very aggressive and they have other, more life-threatening illnesses. Prostate cancer in older men tends to be slow-growing. Therefore, the risk of a man dying from prostate cancer, rather than from other causes, is relatively small.

Prognosis

According to the American Cancer Society, the survival rate for all stages of prostate cancer combined has increased from 50% to 87% over the last 30 years. Due to early detection and better screening methods, nearly 60% of the tumors are diagnosed while they are still confined to the prostate gland. The five-year survival rate for early-stage cancers is almost 99%. Sixty-three percent of the men survive after 10 years, and 51% survive 15 years after initial diagnosis. Studies on the prognosis of hereditary prostate cancer are ongoing.

Health care team roles

A family physician or internist often makes an initial diagnosis of prostate cancer. A urologist often confirms the diagnosis and supervises treatment. A cancer oncologist may administer radiation or chemotherapy treatments. A surgeon may excise a tumor of the prostate. Nurses provide care throughout hospitalization. Nurses also provide education to the patient and family according to the physician’s orders, as well as **home care**.

Prevention

There is no known way to prevent prostate cancer. Some experts feel that dietary modifications may delay the onset of prostate cancer. This view is not universally shared.

KEY TERMS

Anti-androgen drugs—Drugs that block the activity of male hormones.

Benign—A term for a tumor that does not metastasize and is not life-threatening.

Benign prostatic hyperplasia (BPH)—A non-cancerous condition of the prostate that causes growth of prostatic tissue, thus enlarging the prostate and blocking urination.

Biopsy—The surgical removal and microscopic examination of living tissue for diagnostic purposes.

Chemotherapy—Treatment of the cancer with synthetic drugs that destroy the tumor either by inhibiting the growth of the cancerous cells or by killing the cancer cells.

Estrogen—A female sex hormone.

Hematuria—Blood in the urine.

Hormone therapy—A treatment for prostate cancer that involves reducing the levels of the male hormone testosterone so that the growth of the prostate cancer cells is inhibited.

Lymph nodes—Small, bean-shaped structures that are scattered along the lymphatic vessels. These nodes serve as filters and retain any bacteria or cancer cells that are traveling through the system.

Malignant—A tumor that is capable of spreading to

other organs and poses a serious threat to a person's life.

Metastasis—The spreading of cancer from the original site to other locations in the body.

Prostatectomy—The surgical removal of the prostate gland.

Radiation therapy—Treatment using high-energy radiation from x-ray machines, cobalt, radium, or other sources.

Rectum—The last 5-6 inches of the large intestine that leads to the anus.

Semen—A whitish, opaque fluid released at ejaculation.

Seminal vesicles—Tubes above the prostate that make seminal fluid.

Testicles—Two egg-shaped glands that produce male sperm and sex hormones.

Testosterone—A male sex hormone produced mainly by the testicles.

Transrectal ultrasound—A procedure in which a probe is placed in the rectum. High-frequency sound waves that cannot be heard by humans are sent out from the probe and reflected by the prostate. These sound waves produce a pattern of echoes that are then used by the computer to create sonograms or pictures of areas inside the body.

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- American Foundation for Urologic Disease, 1128 North Charles Street, Baltimore, MD 21201. (800) 242-2383 or (410) 468-1800. <<http://www.afud.org>>. admin@afud.org.
- American Urological Association, 1120 North Charles Street, Baltimore, MD 21201. (410) 727-1100. Fax: (410) 223-4370. <http://www.auanet.org/index_hi.cfm>. aua@auanet.org.
- College of American Pathologists. 325 Waukegan Road, Northfield, IL 60093. (800) 323-4040. <<http://www.cap.org/>>.
- National Cancer Institute. Building 31, Room 10A31, 31 Center Drive, MSC 2580, Bethesda, MD 20892-2580. (800) 422-6237 or (301) 435-3848. <<http://www.nci.nih.gov/>>.

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L. Fleming Fallon, Jr., MD, DrPH

Prostate ultrasound

Definition

A prostate ultrasound is a diagnostic test used to detect potential problems with a man's prostate. An ultrasound test involves very high-frequency sound waves that pass through the body. The pattern of reflected sound waves, or

“echoes,” shows the outline of the prostate. This test can show whether the prostate is enlarged, and whether an abnormal growth that might be **cancer** is present.

Purpose

The prostate is a chestnut-shaped organ surrounding the beginning of the urethra in men. It produces a milky fluid that is part of the seminal fluid discharged during ejaculation. Prostate disorders are common in men over 50. In cases of **prostate cancer**, ultrasound is often crucial, since early detection, when the lesion is localized and curable, can lead to effective therapy.

A doctor may decide to do a prostate ultrasound following a digital rectal examination (DRE) that reveals any prostate abnormalities such as lumps or an enlarged prostate; or following a **blood** test that reveals abnormal levels of a substance called prostate-specific antigen (PSA), a normal protease produced by the prostate epithelium. Currently, testing for PSA is the best available tumor marker. Abnormal levels of PSA may indicate the presence of cancer. However, the PSA test is non-specific, and PSA can be elevated without the presence of prostate cancer.

The ultrasound procedure involves a special probe inserted into the rectum that sends sound waves to the prostate gland. The waves bounce off the prostate surface and are translated by computer as an image on a screen.

If cancer is suspected, the doctor will want to take a tissue sample (**prostate biopsy**) to test it to see if it is cancerous. An ultrasound can show the location on the prostate from which the sample should be taken. It can also reveal if the cancer has begun to spread to other locations.

Ultrasound is also used in treatment of prostate cancer. If a doctor decides to treat the cancer with a surgical freezing procedure, ultrasound is used as an aid in the procedure. Doctors are also experimenting with a procedure that uses heat to kill cancerous prostate tissue. During this procedure, called high-intensity focused ultrasound (HIFUS), an ultrasound probe first creates an image of the prostate; then high-energy ultrasound beams target specific areas, generating heat that destroys cancerous tissue.

Ultrasound also can reveal such other types of prostate disease as prostatitis.

Precautions

A prostate ultrasound study is generally not performed on men who have recently had surgery on their lower bowel. This is because the test requires placing an ultrasound probe about the size of a finger into the rectum.

KEY TERMS

Benign prostatic hypertrophy (BPH)—An enlargement of the prostate that is not cancerous. However, BPH may cause problems with urinating or other symptoms.

Doppler—In ultrasound, a technique used to detect and evaluate moving structures that is usually applied to the evaluation of blood flowing in vessels.

Prostate-specific antigen (PSA) test—A blood test to detect PSA, a substance that is often produced by cancers of the prostate.

Urethra—The tube through which urine passes from the bladder and is excreted outside the body.

Description

The prostate ultrasound technique performed is called transrectal ultrasonography. This technique not only allows for visualization of the prostate; it is used to position the needle if a biopsy is performed. During the procedure, the cylinder-shaped ultrasound probe, or transducer, is gently placed in the rectum as the patient lies on his left side with the knees bent. This position allows for more comfort and easier insertion. The probe is rocked back and forth to obtain images of the entire prostate. Pictures of the prostate are produced and measurements are taken. The procedure takes about 15-25 minutes to perform. After the test, the patient's doctor can be notified right away, and usually he or she will have a written report within 36 hours.

During a biopsy, a small needle is inserted very rapidly into the prostate gland. Sample tissue is taken and sent to a pathology lab for preparation. Transrectal ultrasound-guided core biopsy of the prostate is regarded as the most effective determinant of the grade, volume, and localization of a tumor and of its distribution within the prostate. Usually, six to eight biopsies are taken.

Recently, in an effort to improve prostate cancer diagnosis, physicians have performed experiments with ultrasound contrast-agent enhanced color Doppler imaging. By revealing increased vascularity associated with prostate cancer, the procedure can allow for more targeted biopsies, thus reducing the number of biopsies needed.

Preparation

Patients are instructed to have an enema two to four hours before an exam. Feces or gas could impede the

progress of the rectal probe. Patients also are instructed not to urinate for one hour before the test. If biopsies may be done, the doctor will prescribe an antibiotic that usually is taken in four doses, starting the night before the biopsy; the morning of the test; the evening after the test; and the following morning.

Aftercare

For the most part, transrectal ultrasound is a painless procedure. The patient may be warned that there could be some discomfort as the probe is inserted. Generally, the patient is allowed to leave after a radiologist or urologist has reviewed the results. There may be some mucus or a small amount of bleeding from the rectum after the ultrasound. Some patients notice a small amount of blood in the urine for up to two days after the test. Blood may also be present in the semen. As long as the amount of blood is small and resolves after one to two days, there is no cause for concern.

Complications

There are no serious risks from a prostate ultrasound study. **Infection** is rare and is probably a result of biopsy rather than the sonogram itself. If the ultrasound probe is moved too vigorously, some bleeding may continue for a few days.

Results

Modern ultrasound techniques can display both the smooth-surfaced outer shell of the prostate and the core tissues surrounding the urethra. The entire volume of the prostate should be less than 20 milliliters, and its outline should appear as a smooth echo-reflecting (echogenic) rim. Some irregularities within the substance of the gland and **calcium** deposits are normal findings.

An enlarged prostate with dimmed echoes may indicate either prostatitis or benign enlargement of the gland, called benign prostatic hypertrophy (BPH). A distinct focal lump of tissue more likely means cancer. Cancer also often appears as an irregular area within the gland that distorts the normal pattern of echoes. In either case, a biopsy should clarify the diagnosis.

Health care team roles

The procedure is performed by a specially trained diagnostic medical sonographer. The sonographer assists the physician and radiologist in gathering sonographic data necessary to diagnose prostate cancer. Sonographers can have extensive, direct patient contact that may include performing some invasive procedures. The sono-

grapher obtains and records patient history; performs diagnostic procedures and obtains diagnostic images; analyzes technical information; and provides an oral and written summary of technical findings to the physician for medical diagnosis. A urologist or radiologist performs the biopsy.

Training

Medical sonography programs vary in length from one to four years depending on the program design and degree or certificate awarded. Program entry requirements vary as well, and range from a high-school diploma to specific qualifications in a clinically related health profession. Graduation from an accredited program is followed by a qualifying exam administered by the American Registry of Diagnostic Medical Sonographers (ARDMS). Continuing education is required.

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Daniel J. Harvey

Prostheses, lower limb see **Lower limb prostheses**

Prostheses, upper limb see **Upper limb prostheses**

Prosthetics

Definition

Prosthetics is the branch of surgery concerned with the replacement of missing body parts with artificial substitutes.



Artificial knee joint attached to human bones. (Photograph by Mike Devlin. National Audubon Society Collection/Photo Researchers, Inc. Reproduced by permission.)

Description

While prosthetics is defined as a branch of surgery, those involved in this profession include the surgeon, nurse, prosthetist, and physical therapist. Others involved in treatment can include a prosthetics technician, prosthetics assistant, rehabilitation counselor, and social worker.

The goal of prosthetics is to replace all or part of a missing limb so that a patient can function. This replacement can involve fitting a man with an artificial leg so that he can walk, or equipping a woman with an artificial hand so that she can hold objects. An artificial appliance is often called a "prosthetic" or a "prosthesis." Prosthesis can also refer to the replacement of a missing part with a prosthetic.

Historical perspective

The practice of prosthesis dates back to ancient times. During the sixteenth century, a German knight was

Guide for preprosthetic evaluation

Item to be evaluated	Observe for:
Activities of daily living	Transfers; ambulatory status; home (including hazards and barriers); self-care
Medical status	Cause of amputation; associated diseases/symptoms; medications
Neurologic	Sensation; neuroma; phantom pain; mental status
Psychological	Emotional status; family and work situations; prosthetic goals
Range of motion	Hips; knee; ankle
Residuum length	Bone length; soft-tissue, redundant-tissue length
Residuum shape	Cylindrical, conical, hourglass, "dog-ears," bulbous, above-knee adductor roll
Skin	Scar; open lesions; sensation; grafts
Vascularity (both limbs if vascular disease is cause of amputation)	Pulses; color; temperature; edema; pain; trophic changes

SOURCE: Sanders, G.T. *Lower Limb Amputation: A Guide to Rehabilitation*. Philadelphia: F.A. Davis Co., 1986.

known as Gutz of the Iron Hand because of his prosthetic. The appliance's movable fingers enabled the knight to hold a sword.

Wood, however, served as the primary material for prosthetics until the twentieth century. In the aftermath of two world wars, research led to the development of prosthetics made of aluminum alloys, metals, and fiber material.

Throughout the centuries, prosthetics were made with mechanical devices and rubber band-type material to allow their wearers to grip objects and move more easily. Movement devices in prosthetics now include hydraulic knees and computer-programmable hands that sense muscle movement.

Legs, arms, feet, and hands are the most commonly known artificial appliances. Other prosthetics include artificial eyes, hip joints, breasts, and **heart** valves. Prosthodontics is the branch of dentistry concerned with the replacement of teeth.

Contemporary prosthetic care

Patients requiring prosthetic care range from children born with missing limbs to elderly adults requiring hip joint replacement surgery. Such trauma as an automobile accident may cause the loss of a limb, and such conditions as diabetes may lead to the amputation of a limb.

Health care roles

Patients are seen by a prosthetics health care team, which can include a surgeon, nurse, prosthetist, pro-

sthetics technician, prosthetics assistant, and physical therapist.

Prosthetics is sometimes also grouped with orthotics in allied professions. Orthotics is concerned with producing and fitting braces (orthoses) for patients' limbs and spines.

Work settings

Members of the prosthetics health care team work in hospitals, rehabilitation facilities, medical centers, medical schools, colleges, and universities. Prosthetics technicians may work in those settings or in labs and facilities that manufacture prostheses.

The prosthetist designs and fits prostheses. When surgery is planned, the prosthetist consults with the surgeon about where a limb is to be amputated. The prosthetist's input includes recommendations about fitting the prosthesis after surgery.

Pre-operative preparation

For some members of the health care team, patient contact begins before surgery. The doctor examines the patient to determine if more treatment is needed. If amputation is required, those who counsel the patient may include the doctor, nurse, and social worker. They will try to help the patient prepare emotionally and physically for surgery and rehabilitation.

The prosthetics health care team

Prosthetists may supervise several staff members. In some workplaces, the prosthetics assistant assists the prosthetist and may fabricate, repair, and maintain artificial appliances. However, prosthetics may be made by the prosthetics technician, an allied health worker who takes direction from the prosthetist and the prosthetics assistant. The technician also repairs and maintains prostheses. In some settings, the technician may have no contact with patients.

After surgery, the patient may be seen by the surgeon or primary care doctor. During the rehabilitation phase, the prosthetist and therapist will help the patient adjust to the prosthetic. The nurse and social worker may provide **patient education** and support. If needed, the patient may be referred to a rehabilitation counselor or a vocational counselor.

In addition, the patient will see the prosthetist, prosthetics assistant, or prosthetics technician if the prosthetic needs adjusting.

The early stages of all prosthetic treatment usually involves the prosthetist working with the physical thera-

pist. The therapist can evaluate such factors as the patient's strength and ability to wear a prosthetic.

Education and training

Members of the health care team, such as surgeons, nurses, physical therapists, and social workers, may receive training in the use of prosthetics while studying for their respective professions. Prosthetists earn a four-year bachelor of science degree that includes specialized prosthetic training. They also serve a clinical residency. Programs for prosthetics assistants and technicians range from six months to two years. In addition, people working in these allied health professions can receive certification through the American Academy of Orthotics and Prosthetics. Board certification is based on education, employment, completion of certification of program modules (continuing education courses), and membership in the academy.

Advanced education and training

The name of the American Academy of Orthotics and Prosthetics reflects the relationship between the fields of orthotics and prosthetics. While orthotics usually focuses on temporary treatment with a brace, prosthetics involves permanent replacement of a body part with an artificial appliance. However, some patients require both prosthetics and orthotics, so schools offer degrees and certificates in both disciplines. Allied health professionals with education and experience in both disciplines will be twice as employable as those with degrees or certificates in only one of the professions.

Education is the key to career advancement for an allied health employee with only one specialty. A prosthetics technician can advance to assistant and then prosthetist by completing more classes.

The American Academy of Orthotics and Prosthetics offers continuing education courses and forums so that allied health workers remain knowledgeable about new developments in their professions.

Future outlook

The need for prosthetists, prosthetics assistants, and prosthetics technicians is expected to increase with the aging of the baby boomer generation. The existence of a rapidly growing senior population is a global trend, and prosthetics care should be in increasing demand worldwide. Among the needs for older populations are hip replacement and replacement of limbs amputated because of diabetes and other conditions.

Resources

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ORGANIZATIONS

American Academy of Orthotists and Prosthetists. 526 King Street, Suite 201, Alexandria, VA 22314. (703) 836-0788. <<http://www.oandp.org>>.

American Board for Certification of Orthotics and Prosthetics. 330 John Carlyle Street, Suite 200, Alexandria, VA 22314. (703) 836-7114. <<http://www.opoffice.org>>.

Liz Swain

Prosthodontics *see* **Dental specialties**

Protein-modified diet *see* **Diet therapy**

Protein C test *see* **Thrombosis risk tests**

Protein components test *see*

Hypercoagulability tests

Protein electrophoresis test

Definition

Electrophoresis is a technique used to separate the different components (fractions) of a mixture, such as **proteins** in a biological sample. Separation is based on differences in the charge (and sometimes size) of the molecules, which determines their rate of movement in an electric field. Serum protein electrophoresis is a screening test that measures the major **blood** proteins. Protein electrophoresis testing can also be performed on urine and cerebrospinal fluid (CSF) samples.

Purpose

Protein electrophoresis testing is used to evaluate, diagnose, and monitor a variety of diseases and conditions through examination of the amounts and types of protein in a blood, urine, or CSF specimen.

Precautions

Certain other diagnostic tests or prescription medications can affect the results of protein electrophoresis

Protein electrophoresis	
Electrophoresis results	Disease
Total protein: 6.4–8.3 g/dl (64.0–83.0 g/L)	Normal results
Albumin: 3.5–5.0 g/dl (35–50 g/L)	
Alpha ₁ globulin: 0.1–0.3 g/dl (1–3 g/L)	
Alpha ₂ globulin: 0.6–1.0 g/dl (6–10 g/L)	
Beta globulin: 0.7–1.1 g/dl (7–11 g/L)	
Decreased albumin	Acute infections, tissue necrosis, burns, surgery, stress, myocardial infarction
Increased alpha ₂ globulin	
Slightly decreased albumin	Chronic infection, granulomatous diseases, cirrhosis, rheumatoid-collagen diseases
Slightly increased gamma globulin	
Normal alpha ₂ globulin	
Greatly decreased albumin	Nephrotic syndrome
Greatly increased alpha ₂ globulin	
Normal increase in beta globulin	
Decreased albumin	Far-advanced cirrhosis
Increased gamma globulin	
Incorporation of beta and gamma peaks	
Greatly increased gamma globulin	Cirrhosis, chronic infection, globulin with a broad peaksarcoidosis, tuberculosis, endocarditis, rheumatoid-collagen disease
Decreased gamma globulin with normal other globulin levels	Light-chain multiple myeloma
Thin spikes in gamma globulin	Myeloma, macroglobulinemia, gammopathies

SOURCE: Pagana, K.D., and T.J. Pagana. *Mosby's Diagnostic and Laboratory Test Reference*, 3rd ed. St. Louis: Mosby, 1997.

tests. The administration of a contrast dye used in some other tests may falsely elevate apparent protein levels. Drugs that can alter results include aspirin, bicarbonates, chlorpromazine (Thorazine), **corticosteroids**, isoniazid (INH), and neomycin (Mycifradin). The total serum protein concentration may also be affected by changes in the patient's posture or by the use of a tourniquet during venipuncture.

Protein is less concentrated in urine and CSF than in blood. Urinary and CSF proteins must be concentrated before analysis, and the added sample handling can lead to contamination and erroneous results. In the collection of a CSF specimen, it is important that the sample not be contaminated with blood proteins that would invalidate the CSF protein measurements.

Description

Proteins are biologically important organic molecules—polymers of amino acids—that contain the ele-

ments carbon, hydrogen, nitrogen, and oxygen. Certain proteins may also contain sulfur, **phosphorus**, **iron**, iodine, selenium, or other trace elements. There are twenty-two amino acids commonly found in all proteins. The human body is capable of producing fourteen of these amino acids; the remaining eight so-called essential amino acids must be obtained from food. Proteins are found in muscles, blood, skin, hair, nails, and the internal organs and tissues. Enzymes, hemoglobin, and antibodies are proteins, as are many hormones.

Protein mixtures can be fractionated into individual component proteins by a variety of techniques, including precipitation, chromatography, ultracentrifugation, or electrophoresis.

A serum protein electrophoresis test is used to determine the percentage of each protein in the blood by separating them into five distinct classes: albumin, alpha₁-globulin, alpha₂-globulin, beta-globulin, and gamma-globulins (immunoglobulins). High-resolution protein electrophoresis uses a higher current to separate the major proteins comprising the alpha₁-globulin, alpha₂-globulin, and beta-globulin fractions. This procedure produces nine or more bands, including alpha₁ anti-trypsin, alpha₂ macroglobulin, haptoglobulin, transferrin, and complement proteins.

In addition to standard protein electrophoresis, the immunofixation electrophoresis test (IFE) may be used to assess the blood levels of specific immunoglobulins. An IFE test is usually ordered if a serum protein electrophoresis test shows an unusually high amount of protein in the gamma-globulin fraction. The IFE tests determine whether the increase in the gamma-globulin fraction is caused by excess immunoglobulins (antibodies), and whether it is polyclonal or monoclonal in nature. Polyclonal increases are caused by infections, **allergies**, and inflammatory diseases, while monoclonal increases are caused by malignant or benign proliferations of the antibody-producing cells (plasma cells).

Serum proteins

The total serum protein concentration may be used to assess a patient's hydration state: **dehydration** leads to high total serum protein concentration. Further, the levels of different blood proteins rise or fall in response to such disorders as **cancer**, intestinal or kidney protein-wasting syndromes, disorders of the **immune system**, **liver** dysfunction, impaired **nutrition**, and chronic fluid-retaining conditions.

ALBUMIN. Albumin, which is produced in the liver, is the most abundant blood protein. It makes a major contribution to the osmotic pressure that regulates the movement of water between the tissues and the bloodstream.

Albumin binds **calcium**, thyroid hormones, fatty acids, and many drugs, maintaining them in the circulation and preventing filtration in the **kidneys**. Low serum albumin levels can be indicative of pathology, and can increase free therapeutic drug levels and decrease total calcium levels. Albumin levels can play a role in the efficacy and toxicity of therapeutic drugs, and in **drug interactions**.

GLOBULINS. Serum globulins are present in protein electropherograms as four main fractions: alpha₁-, alpha₂-, beta-, and gamma-globulins.

- The major alpha₁-globulin is the “acute-phase” protein alpha₁-antitrypsin, a protease inhibitor produced by the **lungs** and liver. Alpha₁-antitrypsin deficiency is a marker of an inherited disorder characterized by an increased risk of **emphysema**.
- Alpha₂-globulins include serum haptoglobin, alpha₂-macroglobulin, and ceruloplasmin. Haptoglobin is an acute-phase protein that binds free hemoglobin released from red blood cells during hemolysis. Haptoglobin binding prevents excretion of free hemoglobin by the kidneys. In addition to hemolysis, low haptoglobin levels can indicate chronic liver disease, tumor metastasis, or severe sepsis. Alpha₂-macroglobulin, a broad-spectrum protease inhibitor, accounts for about one-third of the alpha₂-globulin fraction: its concentration is increased during nephrosis. Ceruloplasmin is an acute-phase protein involved in the storage and transport of **copper** and iron: its concentration is increased during **pregnancy** and decreased in Wilson’s disease.
- Beta-globulins include transferrin, low-density lipoproteins (LDL), and complement components. Transferrin transports dietary iron to the liver, spleen, and bone marrow. LDL (also referred to as beta lipoprotein) is the major carrier of cholesterol in the blood: high levels are associated with atherosclerosis. Complement is a system of blood proteins required for antibody-mediated cell lysis and involved in the inflammatory response.
- The gamma-globulin fraction contains the immunoglobulins, a family of proteins that function as antibodies. Antibodies, produced in response to **infection**, allergic reactions, and organ transplants, recognize and bind antigens to facilitate destruction by the immune system. The **immune response** is regulated by a large number of antigen-specific gamma-globulins that fall into five main classes called IgG, IgA, IgM, IgO, and IgE. Immunoglobulin deficiency due to inherited disorders can range from partial or complete loss of a single immunoglobulin class to complete absence of all immunoglobulins. An abnormally high level of immunoglobulins is generally found in acute and chronic infections, and is an indicator of autoimmune disease.

When the serum protein electrophoresis test demonstrates a significant deviation from the normal gamma-globulin levels, an IFE test should be ordered to determine the polyclonal or monoclonal nature of the specific globulin(s) involved.

Quantification of each immunoglobulin class and each of the proteins mentioned above may be performed by a procedure called immunonephelometry. This technique uses an antibody specific for the protein to be measured. When the antibody binds to the protein, an immune complex is formed that increases the amount of light scattered by the sample.

Deviations in serum proteins levels from reference levels are considered in conjunction with symptoms and results from other diagnostic procedures.

Urinary proteins

Protein electrophoresis is performed on urine samples to classify disorders that cause protein loss via the kidneys. Hemoglobin and myoglobin are found in the urine of trauma and burn victims, and in patients with infection or hemolysis. Protein electrophoresis of urine is most often performed in order to detect the presence of light chain fragments of immunoglobulins. These protein fragments are sufficiently small to filter through the kidneys and are excreted in the urine. They are called Bence-Jones proteins, and are found in patients who have multiple myeloma, a malignant proliferation of antibody-producing cells. Bence-Jones proteins may also be found in other variants of multiple myeloma, such as light chain disease, and in patients with systemic autoimmune diseases that result from degradation of immune complexes.

Cerebrospinal fluid (CSF) proteins

An increase in total protein concentration in the CSF is often found in bacterial and fungal **meningitis** and with **central nervous system** (CNS) tumors. The main use of CSF protein electrophoresis testing is in the diagnosis of **multiple sclerosis**.

The protein electrophoresis test method

In a clinical protein electrophoresis test, proteins are separated on the basis of how fast they move on a medium in an electrical field. In a standard electrophoresis test, a small amount of sample is applied to a cellulose acetate strip or gel made of agarose or polyacrylamide. The strip or gel is positioned between the apparatus electrodes, and a voltage is applied across it. Under the conditions of the test, the proteins in the sample are negatively charged and migrate toward the positive electrode at different rates. The migration rate is mainly dependent

KEY TERMS

Acute-phase proteins—Proteins produced during the acute-phase response, a set of physiological changes that occur in response to trauma conditions.

Albumin—A blood protein produced in the liver that helps to regulate water distribution in the body.

Antibodies—Immunoglobulin protein molecules produced by B cells and plasma cells during the immune response. Each antibody-binding site can bind part of an antigen to trigger immune defenses.

Antigen—Foreign body that triggers immune response.

Bence-Jones protein—The Ig light chain, part of an immunoglobulin, that is detected by urine protein electrophoresis in the case of multiple myeloma.

Complement—A group of complex proteins of the beta-globulin type in the blood that bind to antibodies during anaphylaxis. In the complement cascade, each complement component interacts with another in a cascade that causes cell membrane damage, leading to lysis.

Electropherogram—The pattern of stained proteins on an electrophoresis gel, or a graph showing peaks of proteins separated by electrophoresis.

Electrophoresis—A technique used to separate the proteins in a biological sample on the basis of charge and size as they migrate under the influence of an applied electric field.

Globulins—Plasma or serum proteins other than albumin, so named because of their globular shape. Four globulin fractions can be measured by electrophoresis in order to diagnose or monitor a variety of serious illnesses.

Paraprotein—An immunoglobulin produced by a clone of identical B-cells. Also called monoclonal protein.

Protein—Proteins, such as enzymes and antibodies, are biologically important polymers of amino acids that contain the elements carbon, hydrogen, nitrogen, and oxygen. Certain proteins may also contain sulfur, phosphorus, iron, iodine, selenium, or other trace elements.

on the charge of the protein molecules; however, on polyacrylamide gel it is also dependent on size. When electrophoresis is complete, the gel is treated with a dye to stain the proteins, and the intensity of stain in the bands is measured and recorded by a densitometer. In a capillary electrophoresis test, samples are automatically transferred from the collection tubes to the head of a fluid-filled glass capillary tube: the electrophoretic separation occurs during the transport of the proteins through the capillary, and the individual proteins are detected and quantified on-line by absorption of ultraviolet light. Both gel and capillary electrophoresis procedures produce a recording of each protein fraction as a peak. The area under the peak is used to calculate the percentage of the fraction. This is multiplied by the total protein concentration (determined by chemical analysis) to give the concentration of each fraction. The levels of proteins thus determined are compared with reference levels to ascertain whether a disease state is present.

Standard electrophoresis systems

High-throughput and semi-automated protein electrophoresis testing is available in most laboratories through the use of integrated systems of gels, reagent kits, and densitometers.

Capillary electrophoresis systems

In 1998, the introduction of fully automated clinical capillary electrophoresis instruments was introduced. The advantages of the capillary electrophoresis methodology include direct sampling of a minimal volume from the primary collection tube; automated detection of proteins without staining; rapid sample throughput; and improved accuracy and reproducibility. Agarose and capillary systems are also used to separate DNA, an increasingly important technology.

Preparation

The sample for the serum protein electrophoresis test is obtained by venipuncture. No anticoagulant should be used. It is usually not necessary for the patient to restrict food or fluids before the test; a 12-hour fast is requested before drawing blood for lipoprotein testing. The urine protein electrophoresis test requires either an early morning urine sample or a 24-hour urine sample according to the physician's request. CSF is collected by lumbar puncture performed in a hospital setting; because of risks associated with the procedure, the patient must sign a consent form. Any factors that might affect test results,

such as whether the patient is taking any medications, should be noted.

Complications

Risks posed by the venous puncture are minimal but may include slight bleeding from the puncture site; fainting or lightheadedness after the sample is drawn; or the development of a small bruise at the puncture site.

Lumbar puncture can lead to leakage of cerebrospinal fluid from the puncture site, headache, infection, symptoms of meningitis, nausea, vomiting, or difficulty urinating. Rarely, pre-existing intracranial pressure can lead to **brain** herniation resulting in brain damage and/or death. The patient must be kept lying flat in the hospital under observation for at least 6 to 8 hours after the procedure.

Results

The following serum protein electrophoresis reference values are representative; some variation among laboratories and specific methods is to be expected. The values were obtained by standard electrophoresis on agarose gels.

- total protein: 6.4 to 8.3 g/dL (about 0.5 g/dL lower in nonambulatory patients)
- albumin: 3.5 to 5.0 g/dL
- alpha₁-globulin: 0.1 to 0.3 g/dL
- alpha₂-globulin: 0.6 to 1.0 g/dL
- beta-globulin: 0.7 to 1.2 g/dL
- gamma-globulin: 0.7 to 1.6 g/dL

Albumin levels are increased in dehydration and decreased in malnutrition, pregnancy, liver disease, inflammatory diseases, and such protein-losing states as **malabsorption syndrome** and certain kidney disorders.

Alpha₁-globulins are increased in inflammatory diseases and decreased or absent in juvenile pulmonary emphysema, a hereditary disease.

Alpha₂-globulins are increased in acute and chronic inflammation and nephrotic syndrome; decreased values may indicate hemolysis.

Beta-globulin levels are increased in conditions of high cholesterol (hypercholesterolemia), in multiple myeloma, and in **iron deficiency anemia**; and decreased in disorders associated with complement depletion.

Gamma-globulin levels are increased in chronic inflammatory disease and such autoimmune conditions as rheumatoid arthritis and systemic lupus erythemato-

sus; cirrhosis; in acute and chronic infection; and in multiple myeloma. The gamma-globulins are decreased in a variety of genetic immune disorders; in secondary immune deficiency related to steroid use; leukemia; or severe infection.

Detection of a discrete (monoclonal) band in the gamma region of the electropherogram indicates the presence of a paraprotein. Type IgG or IgA paraproteins associated with multiple myeloma may be found by serum protein electrophoresis testing; however, the tumor may produce only Ig light chains that are removed from the blood by the kidneys. The Ig light chain (Bence-Jones protein) can be detected by urine protein electrophoresis.

In CSF, the total protein concentration is normally 0.015 to 0.045 g/dL, with gamma-globulin accounting for 3–12%. Increased gamma-globulin indicates multiple sclerosis, bacterial or fungal meningitis, neurosyphilis, or Guillain-Barré syndrome. Detection of monoclonal bands in CSF plays an important role in the diagnosis of multiple sclerosis.

In urine, normally no globulins and less than 0.050 g/dL albumin are present. Abnormal results indicate disruption of kidney function or acute inflammation. The presence of the Bence-Jones protein indicates multiple myeloma.

Health care team roles

Nurses are involved in the collection of blood samples by venipuncture, in patient support during and after lumbar puncture, and in instructing patients in the procedure for midstream collection of urine samples. A lumbar puncture is generally performed by a physician. Medical laboratory workers are responsible for preparation of samples for electrophoresis testing.

Training

The preparation of urine and CSF samples for electrophoresis testing often involves concentration and, in the case of urine samples and some CSF samples, centrifugation. Electrophoresis is classified as a high-complexity test and is performed by laboratory personnel with special training, most often by a clinical laboratory scientist (CLS) or medical technologist (MT).

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Patricia L. Bounds

Protein S test see **Thrombosis risk tests**

Proteins

Definition

Proteins are linear chains of amino acids connected by chemical bonds between the carboxyl group of each amino acid and the amine group of the one following. These bonds are called peptide bonds, and chains of only a few amino acids are referred to as polypeptides rather than proteins.

Description

Proteins are all around us. Much of the body's dry weight is protein; even bones are about one-quarter protein. The animals we eat and the microbes that attack us are likewise largely protein. The leather, wool, and silk clothing that we wear are nearly pure protein. The insulin that keeps diabetics alive and the "clot-busting" enzymes that may save **heart** attack patients are also proteins. Proteins can even be found working at industrial sites—protein enzymes produce not only the high-fructose corn syrup that sweetens most soft drinks, but also fuel-grade ethanol (alcohol) and other gasoline additives.

Within our bodies and those of other living things, proteins serve many functions. They digest foods and turn them into energy; they move our bodies and move molecules about within our cells; they let some substances pass through **cell membranes** while keeping others out; they turn light into chemical energy, making both **vision** and photosynthesis possible; they allow cells

to detect and react to hormones and toxins in their surroundings; and, as antibodies, they protect our bodies against foreign invaders. There are simply too many proteins—possibly more than 100,000—to even consider mentioning them all.

Proteins are made up of separate compounds called amino acids. It is these amino acids that our bodies actually need, not the entire protein molecule. Some amino acids are essential—they must be obtained from diet because they cannot be synthesized by humans in adequate amounts. There are nine essential amino acids. Others are nonessential, because they can be made in the body from precursors (components) of other amino acids. There are eleven nonessential amino acids.

Protein structure

Many proteins have components other than amino acids. For example, some may have sugar molecules chemically attached. Exactly which types of sugars are involved and where on the protein chain attachment occurs will vary with the specific protein. In a few cases, it may also vary among different people. The A, B, and O **blood** types, for example, differ in precisely which types of sugar are or are not added to a specific protein on the surface of red blood cells.

Other proteins may have fat-like (lipid) molecules chemically bonded to them. These sugar and lipid molecules are always added after synthesis of the protein's amino acid chain is complete. Such molecules can significantly affect the protein's properties.

Many other types of molecules may also be associated with proteins. Some proteins, for example, have specific metal ions associated with them. Others carry small molecules that are essential to their activity. Still others associate with nucleic acids in chromosomal or ribosomal structures.

Scientists have traditionally addressed protein structure at four levels: primary, secondary, tertiary, and quaternary. Primary structure is simply the linear sequence of amino acids in the peptide chain. It determines the protein's shape. Secondary and tertiary structure both refer to the three-dimensional shape into which a protein chain folds. The distinction is partly historical: secondary structure refers to certain highly regular arrangements of amino acids that scientists could detect as long ago as the 1950s, while tertiary structure refers to the complete three-dimensional shape. Tertiary structure determines the function of the protein. Determining a protein's tertiary structure can be difficult even today, although researchers have made major strides within the past decades.

The tertiary structure of many proteins shows a “string of beads” organization. The protein includes several compact regions known as domains, separated by short stretches in which the protein chain assumes an extended, essentially random configuration. Some scientists believe that domains were originally separate proteins that, over the course of evolution, have come together to perform their functions more efficiently.

Quaternary structure refers to the way in which protein chains—either identical or different—associate with each other. For example, a complete molecule of the oxygen-carrying protein hemoglobin includes four protein chains of two slightly different types. Simple laboratory tests usually allow scientists to determine how many chains make up a complete protein molecule.

PRIMARY PROTEIN STRUCTURE: PEPTIDE-CHAIN SYNTHESIS. Proteins are made (synthesized) in living things according to “directions” given by DNA and carried out by RNA and proteins. The synthesized protein’s linear sequence of amino acids is ultimately determined by the linear sequence of DNA bases—or of base triplets known as codons—in the gene that codes for it. Each cell possesses elaborate machinery for producing proteins from these blueprints.

The first step is copying the DNA blueprint, essentially fixed within the cell nucleus, into a more mobile form. This form is messenger ribonucleic acid (mRNA), a single-stranded nucleic acid carrying essentially the same sequence of bases as the DNA gene. The mRNA is free to move into the main part of the cell, the cytoplasm, where protein synthesis takes place.

Besides mRNA, protein synthesis requires ribosomes and transfer ribonucleic acid (tRNA). Ribosomes are the actual “factories” where synthesis takes place, while tRNA molecules are the “trucks” that bring amino acids to the ribosome and ensure that they are incorporated at the right spot in the growing chain.

Ribosomes are extremely complex assemblages. They comprise almost 70 different proteins and at least three different types of RNA, all organized into two different-sized subunits. As protein synthesis begins, the previously separate subunits come together at the beginning of the mRNA chain; all three components are essential for the synthetic process.

Transfer RNA molecules are rather small, only about 80 nucleotides long. (Nucleotides are the fundamental building blocks of nucleic acids, as amino acids are of proteins.) Each type of amino acid has at least one corresponding type of tRNA (sometimes more). This correspondence is enforced by the enzymes that attach amino acids to tRNA molecules, which “recognize” both the

amino acid and the tRNA type and do not act unless both are correct.

Transfer RNA molecules are not only trucks but translators. As the synthetic process adds one amino acid after another, they “read” the mRNA to determine which amino acid belongs next. They then bring the proper amino acid to the spot where synthesis is taking place, and the ribosome couples it to the growing chain. The tRNA is then released and the ribosome then moves along the mRNA to the next codon; that is, the next base triplet specifying an amino acid. The process repeats until the “stop” signal on the mRNA is reached, upon which the ribosome releases both the mRNA and the completed protein chain and its subunits separate to seek out other mRNAs.

SECONDARY STRUCTURE. The two major types of secondary structure are the alpha helix and the beta sheet, both discovered by Linus Pauling and R. B. Corey in 1951.

In an alpha helix, the backbone atoms of the peptide chain—the carboxyl carbon atom, the α -carbon atom (to which the side chain is attached), and the amino nitrogen atom—take the form of a three-dimensional spiral. The helix is held together by hydrogen bonds between each nitrogen atom and the oxygen atom of the carboxyl group belonging to the fourth amino acid up the chain.

Beta sheets feature several peptide chains lying next to each other in the same plane. The stabilizing hydrogen bonds are between nitrogen atoms on one chain and carboxyl-group oxygen atoms on the adjacent chain. Since each amino acid has its amino group hydrogen-bonded to the chain on one side and its carboxyl group to the chain on the other side, sheets can grow indefinitely.

TERTIARY STRUCTURE. Within seconds to minutes of their synthesis on ribosomes, proteins fold up into an essentially compact three-dimensional shape—their tertiary structure. Ordinary chemical forces fully determine both the steps in the folding pathway and the stability of the final shape. Some of these forces are hydrogen bonds between side chains of specific amino acids. Others involve electrical attraction between positively and negatively charged side chains. Perhaps most important, however, are what are called hydrophobic interactions—a scientific restatement of the observation that oil and water do not mix.

Some amino acid side chains are essentially oil-like (hydrophobic—literally, “water-fearing”). They accordingly stabilize tertiary structures that place them in the interior, largely surrounded by other oil-like side chains. Conversely, some side chains are charged or can form hydrogen bonds. These are hydrophilic, or “water-loving,” side chains. Unless they form hydrogen or electro-

static bonds with other specific side chains, they will stabilize structures in which they are on the exterior, interacting with water.

The forces that govern a protein's tertiary structure are simple. With thousands or even tens of thousands of atoms involved, however, the interactions can be extremely complex. Today's scientists are only beginning to discover ways to predict the shape a protein will assume and the folding process it will go through to reach that shape.

Digestion, metabolism, and elimination

Food in the human diet consists of proteins, **carbohydrates**, **fats**, **vitamins**, and **minerals**. The majority of minerals and vitamins pass through to the bloodstream without the need for further digestive changes, but other nutrient molecules must be broken down to simpler substances before they can be absorbed and used. Foods in the **stomach** are broken down by the action of the gastric juice containing hydrochloric acid and a protein-digesting enzyme called pepsin. Gastric juice is needed mainly for the digestion of protein by pepsin. If a hamburger and bun reach the stomach, there is no need for extra gastric juice for the bun (carbohydrate), but the hamburger (protein) will require a much greater supply of gastric juice. The gastric juice already present will begin the breakdown of the large protein molecules of the hamburger into smaller molecules: polypeptides and peptides.

From the time a protein-containing food is eaten, to its breakdown and subsequent use or excretion, many complicated processes and steps take place in the body. These processes are part of **metabolism**, in which a series of metabolic pathways are involved in the breakdown of the foods. Proteins are initially degraded into constituent amino acids, which may be converted to compounds called pyruvic acid or acetyl-CoA before being passed into the metabolic pathway known as the Krebs cycle; or they may enter the Krebs cycle directly after being converted into one of the metabolites of this metabolic pathway.

Proteins contain substantial amounts of nitrogen. When dietary protein is broken down into amino acids, nitrogen is produced and is eliminated in the urine in the form of urea, and in smaller amounts as uric acid, ammonia, and creatinine. Unabsorbed protein is excreted in the feces, but only about 10 grams per day because protein is used very efficiently in the body. Amino acids may be recycled many times for different functions. There are minute losses of protein as skin, or in menstrual blood, semen, and hair.

Function

After water, protein makes up the greatest percentage of human body weight. This key nutrient provides the building blocks children and adults need for growing, maintaining, and repairing worn-out cells. Without protein, human bodies could not regulate fluids and immune systems would shut down. In fact, if not for protein there would be no hormones or enzymes—the protein compounds that take part in every single physical function. The role of protein in the diet is mainly as a source of amino acids, some of which are essential because they cannot be produced in the body. Others are referred to as nonessential because they can be made in the body from simple precursors. Amino acids are central to every human bodily function with every chemical reaction that occurs. Some of the uses of amino acids are:

- Synthesis of substances called purines and pyrimidines, important for deoxyribonucleic acid (DNA).
- Producing creatine in skeletal muscle; creatine is needed for subsequent production of creatinine.
- Building and maintaining muscle and tissues.
- Maintaining proper cellular function.
- Controlling chemical reactions through enzymes.

There are also circulating proteins in the plasma of the blood that vary depending on the levels in the diet. Some examples of plasma proteins with important functions in the body are: serum albumin, retinal binding protein, fibrinogen, etc. If the protein intake is low, these proteins will be reduced in the blood and therefore their functions in the body may be affected.

Approximately 300 grams of protein is produced per day in the body with a dietary intake of about 100 grams. Some of the protein needed is acquired from endogenous sources (in the body from protein breakdown) and is released into the intestinal lumen; it is estimated at about 70 grams per day.

Role in human health

The human body, minus water, is mostly composed of amino acids. Almost all of the hormones are amino acids. Regulation of protein metabolism is necessary to maintain proper bodily function; therefore, it is important to eat protein-rich foods. Protein is also important for building body tissue and synthesizing enzymes. Twenty amino acids are used for protein synthesis. Animals and plants are quick and available sources of what are termed “essential” amino acids; they are called essential because the body cannot internally build them. Normal growth and health are dependent upon these essential amino acids. These essential amino acids are histidine, trypto-

phan, lysine, methionine, phenylalanine, threonine, valine, leucine, isoleucine and possibly arginine. Tyrosine and cysteine are produced in the body from phenylalanine and methionine respectively. The “nonessential” amino acids include alanine, glycine, serine, glutamic acid, aspartic acid, asparagine, glutamine, proline. They are considered nonessential because the body can produce them with simple precursors.

Protein requirements

On a per kilogram basis, protein requirements in humans are highest in infancy and gradually decline throughout one’s life, except in such circumstances as **pregnancy**, **lactation**, and illness. The Recommended Daily Allowance (RDA) suggests protein requirements based on age incrementally. The amount of protein needed also depends on body weight, but it is not a linear relationship. A person who weighs 400 lbs (181.43 kg) does not need four times as much protein as a person weighing 100 lbs (45.35 kg). From birth to three months, protein needs are at their highest (2.2 grams per kilogram of body weight). The requirement for adult males and females is 0.8 g/kg. This amount is equal to about 63 grams of dietary protein for a male aged 25-50 years who weighs 174 lbs. (79 kg), and 50 grams for a female aged 25-50 years who weighs 139 lbs. (63 kg). The average Western diet contains ample amounts of protein. In fact, most people in industrialized countries eat more protein than they need. In the United States, true protein deficiency is rare except when excess protein is lost and protein requirements are increased, as in cases of:

- **burns**
- **fever**
- fractures
- surgery
- wasting and/or cachexia associated with **cancer** (Approximately half of all cancer patients experience cachexia, a wasting syndrome that induces metabolic changes leading to a loss of muscle and fat.)
- chronic renal failure, when the patient is undergoing hemodialysis or peritoneal dialysis

Protein requirements may also be increased in training athletes because of greater muscle mass during training season.

In general, consequences of inadequate protein intake may include a faster loss of muscle mass from the body; higher risks of **infection**; and reduced protein reserves for use during periods of trauma or infection. In

addition, protein breakdown is rapid when a person is fasting or bedridden.

Dietary sources of protein

Meat, milk, eggs, poultry, and seafood are considered high-quality, “complete” proteins because they have all the essential amino acids (protein’s building blocks) in just the right proportion. Those sources are considered more complete than vegetable protein, such as beans, peas, and grains, also considered a good—even if not complete—source of amino acids. Except for soy, plant sources—nuts, beans, seeds, and grains—are deficient in one or more of the essential amino acids. But plant foods contain other vital nutrients (such as phytochemicals and fiber) not found in animal foods. Dietitians recommend that a healthy diet should consist of foods from a variety of sources and should include 10–20% of daily calories from protein (poultry, fish, dairy, soy protein, nuts, legumes, eggs, peanut butter, and vegetable sources).

Dietary guidelines

The food pyramid, developed by nutritionists, provides a visual guide to healthy eating. At its base are those foods that should be eaten numerous times each day, while at its apex are those foods that should be used sparingly. The pyramid suggests a range of servings in each group so that the number of servings can be adjusted to suit each individual’s caloric requirements. The daily recommendations (from bottom to top) of the food pyramid include:

- Bread, cereal, rice, and pasta: 6–11 servings.
- Vegetables: 3–5 servings.
- Fruits: 2–4 servings.
- Milk, yogurt, and cheese: 2–3 servings.
- Meat, poultry, fish, dried beans, eggs, and nuts: 2–3 servings.
- Fats, oils, and sweets: use sparingly.

Protein-modified diets

High-protein diets are designed to provide about 1.5 g of protein for each kilogram of a person’s body weight. Complex proteins, such as milk and meats, should make up one-half to two-thirds of the daily protein requirement. High-protein diets are recommended for people who:

- Have an increased need for protein due to protein-calorie malnutrition; severe **stress**; or such conditions as **AIDS**, cancer, or burns with high metabolic rates that lead to the loss of large amounts of protein.

KEY TERMS

Alpha helix—A type of secondary structure in which a single peptide chain arranges itself in a three-dimensional spiral.

Beta sheet—A type of secondary structure in which several peptide chains arrange themselves alongside each other.

Cachexia—A condition in which the body weight “wastes” away, characterized by a constant loss of weight, muscle, and fat.

Creatine—A substance found in skeletal muscles; it is produced by other amino acids.

Domain—A relatively compact region of a protein, separated from other domains by short stretches in which the protein chain is more or less extended; different domains often carry out distinct parts of the protein’s overall function.

Enzymes—Enzymes are protein catalysts that increase the speed of chemical reactions in the cell without themselves being changed.

Hormones—Hormones are messengers that travel to tissues or organs, where they may stimulate or inhibit specific metabolic pathways.

Messenger ribonucleic acid (mRNA)—A molecule of RNA that carries the genetic information for producing one or more proteins; mRNA is produced by copying one strand of DNA, but is able to move from the nucleus to the cytoplasm (where protein synthesis takes place).

Peptide bond—A chemical bond between the carboxyl group of one amino acid and the amino nitrogen atom of another.

Phenylketonuria (PKU)—A rare hereditary condition in which phenylalanine (an amino acid) is not

properly metabolized. PKU may cause severe mental retardation.

Polypeptide—A group of amino acids joined by peptide bonds; proteins are large polypeptides, but no agreement exists regarding how large they must be to justify the name.

Primary structure—The linear sequence of amino acids making up a protein.

Quaternary structure—The number and type of protein chains normally associated with each other in the body.

Protein-calorie malnutrition—A lack of protein and calories are consumed to sustain the body composition, resulting in weight loss and muscle wasting.

Ribosome—A very large assemblage of RNA and protein that, using instructions from mRNA, synthesizes new protein molecules.

Secondary structure—Certain highly regular three-dimensional arrangements of amino acids within a protein.

Tertiary structure—A protein molecule’s overall three-dimensional shape.

Transfer ribonucleic acid (tRNA)—A small RNA molecule, specific for a single amino acid, that transports that amino acid to the proper spot on the ribosome for assembly into the growing protein chain.

Wasting—When inadequate calories are consumed, it can lead to “wasting” or depletion of body mass. Wasting results in weight loss in such tissues as skeletal muscle and adipose tissue (fat).

- Have malabsorption syndromes, celiac disease, or other disorders characterized by poor food absorption.

A low-protein diet excludes dairy products and meats, and requires that about three-fourths of the daily allowance of protein come from high-value protein sources. Supplements may be prescribed to prevent amino-acid deficiencies. Low-protein diets are used in treatment of conditions such as **liver** cirrhosis and kidney disease (excluding chronic renal failure patients who have increased protein needs because of losses that occur during dialysis).

Common diseases and disorders

The metabolic pathways in the body for protein metabolism and energy metabolism are interrelated. Certain metabolic conditions distort this relationship, namely diabetes, kidney failure, fever, cancer, and liver cirrhosis.

Inborn errors of metabolism (also called human hereditary biochemical disorders) have genetic origins; these errors interfere with the synthesis of proteins, carbohydrates, fats, enzymes, and many other substances in

the body. Abnormalities in the breakdown, storage, or production of proteins, fats and carbohydrates, or in the energy cycles of cells are typically the manifestation of this disorder. Disease and death may result from the absence or excess of normal or abnormal metabolites. For example, phenylketonuria (PKU) is a hereditary condition in which phenylalanine (an amino acid) is not properly metabolized. PKU may cause severe mental retardation. Some inborn errors of metabolism require dietary and/or nutrient modification depending on the specific metabolic error. A low-phenylalanine diet is normal treatment for PKU.

Celiac disease, also known as nontropical sprue, gluten enteropathy, or celiac sprue, is an inherited disorder resulting in malabsorption because of an allergic reaction after consumption of a protein called gluten. This intolerance causes patients with celiac disease to suffer weight loss, **diarrhea**, malnutrition, and bloating. By eliminating foods containing gluten from the diet, further damage to the intestines can be prevented, symptoms are relieved, and malabsorption of nutrients is corrected. Gluten is found in wheat, rye, barley, and oats. Registered dietitians and physicians can assist the patient with the diet modifications needed for each disease.

Other conditions that may occur due to protein metabolism or absorption abnormalities include:

- muscle wasting and atrophy, which may occur when there is decreased protein absorption and metabolism due to causes such as malabsorption syndrome
- edema (fluid retention in the body's tissues) due to decreased protein absorption
- malnutrition and weight loss due to decreased fat, carbohydrate, and protein absorption

Protein-calorie malnutrition (or protein-energy malnutrition) is a condition associated most closely with weight loss, starvation, or illness and is common in cancer patients. It occurs when a lack of protein and calories are consumed to sustain body composition. When inadequate calories are consumed, the body's functionality declines, which may lead to illness and perhaps death. Exhaustion, weakness, decreased resistance to infection, and a progressive wasting of body muscle and fat stores occur.

Certain conditions may require protein restrictions; for example, acute liver or kidney failure, and uremia (increased urea in the blood).

Powder and tablet forms of amino acids have become popular as health supplements. But their prolonged excessive use can upset the natural amino acid balance and lead to kidney, liver, and nervous system

damage. Do not take these supplements without first consulting a registered dietitian or physician.

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- Omran M. L., and J. E. Morley. "Assessment of protein energy malnutrition in older persons, part I: History, examination, body composition, and screening tools." *Nutrition* 16, no. 1 (January 2000): 50-63.

ORGANIZATIONS

- American Dietetic Association. 216 W. Jackson Blvd., Chicago, IL 60606-6995. (312) 899-0040. <<http://www.eatright.org/>>.
- Food and Nutrition Information Center Agricultural Research Service, USDA. National Agricultural Library, Room 304, 10301 Baltimore Avenue, Beltsville, MD 20705-2351. (301) 504-5719. Fax: (301) 504-6409. <<http://www.nal.usda.gov/fnic/>>. fnic@nal.usda.gov.

Crystal Heather Kaczkowski, MSc.

Prothrombin time see **Coagulation tests**

PSA test see **Tumor marker tests**

Psychiatric assisting

Definition

A psychiatric assistant, also known as a psychiatric technician or mental health technician, works in a variety

KEY TERMS

Interdisciplinary team—A team of professionals from many different disciplines, such as nurses, psychotherapists, social workers, psychologists, occupational therapists, and physicians.

Paraprofessional—A paraprofessional assists professional-level personnel such as nurses, physicians, and therapists in hospitals, medical facilities, and mental health facilities.

of inpatient psychiatric settings with mentally ill adults and children or those with behavioral disorders.

Description

Psychiatric assistants or technicians work with emotionally disturbed or mentally impaired individuals, usually in psychiatric hospitals or mental health clinics. They work as members of interdisciplinary teams of mental health professionals, such as psychiatrists, psychologists, registered nurses, clinical social workers, and others. In general, psychiatric aides help patients with personal grooming and participation in educational, recreational, and therapeutic activities. They may interact and spend more time with patients than any other treatment team members. Psychiatric assistants usually have some type of formal training or education in the behavioral sciences. These paraprofessionals participate in both the planning and implementing of individual patient treatment plans. They may be given responsibility for interviewing patients, record keeping, assisting in administration of medications, and coordinating therapy and group therapy sessions. Psychiatric assistants must have good observation skills, as their job entails recognizing and reporting changes in the behavior of patients to other team members.

Work settings

Psychiatric assistants or technicians work in a wide variety of settings, including psychiatric hospitals, community general hospitals, community mental health centers, psychiatric clinics, schools for the mentally retarded, social service agencies, geriatric **nursing homes**, child or adolescent centers, and halfway houses. They generally work a 35- to 40-hour week. Because patients need care 24 hours a day, scheduled work hours may include nights, weekends, and holidays. Most of the psychiatric assistants' work time is spent on their feet.

Psychiatric assistants are often confronted with violent patients who must be restrained, which is an emotionally draining and sometimes dangerous task. However, many psychiatric assistants glean satisfaction from assisting those in need of support and encouragement. Individuals in this field should be healthy, tactful, patient, understanding, assertive, emotionally stable, dependable, and have a strong desire to help people. They should also be able to work as part of a team, have good communication skills, and be willing to perform repetitive routine tasks. Opportunities for advancement within these occupations are limited. To enter other health occupations, psychiatric assistants often need additional formal training. Some employers and unions provide opportunities by simplifying the educational paths to advancement. Working as a psychiatric assistant can also help individuals decide whether to pursue a career in the health care field.

Education and training

Most psychiatric technicians are required to have at least a bachelor's degree and several hours of clinical training on the psychiatric unit. Individual requirements vary from state to state, but many states require specific college coursework credits in nursing science, mental disorders, developmental disabilities, and **pharmacology**. To help keep psychiatric assistants current with recent advances in their field, some states require employees to complete several hours of continuing education courses every two years in order to maintain their position or certification. Some facilities provide classroom instruction for newly hired assistants, and others rely exclusively on informal on-the-job instruction from a licensed nurse or an experienced team member. Such training may last several days to a few months. From time to time, psychiatric assistants may also attend lectures, workshops, and in-service training.

Advanced education and training

Advanced training and education is not always required of psychiatric assistants. However, some psychiatric assistants choose to pursue a master's degree in clinical social work or psychology to further their career and gain useful clinical expertise. Advanced or "senior" psychiatric assistants may be required to hold a postgraduate degree in some states. The American Association of Psychiatric Technicians offers a voluntary certification exam for psychiatric assistants to test their knowledge of basic psychiatric technology. This certification is a benefit to mental health assistants, psychiatric aides and related employees in the 46 states that do not have licensed psychiatric technicians, and also to those in

the armed forces. The examination is a 201-question, open-book written test that individuals can take at home. Although it tests for basic knowledge about nursing, mental illness and developmental disabilities, it is not nearly as comprehensive as the licensing exams that some states require. National certification allows individuals to put the initials NCPT after their names, which stands for Nationally Certified Psychiatric Technician. In some cases, those who are certified receive better pay and promotional opportunities. In some instances, such as for mental health workers employed by the Navy, certification is required.

Future outlook

Nationally, employment of psychiatric assistants is predicted to grow more slowly than average through 2008. On the one hand, some growth will result from the increasing population of elderly people. Elderly adults may have such mental health problems as **Alzheimer's disease** that require care. In addition, outpatient mental health centers will need more aides, because people are often more accepting of treatment for drug abuse and **alcoholism**. Thus, more people will go to these centers, and there will be a greater need for psychiatric assistants. On the other hand, employment in hospitals is predicted to decline. Because hospitals employ about half of all psychiatric assistants, this decline will have a significant effect on the occupation. The main reason for this decline is that hospitals are admitting fewer psychiatric patients because of poor reimbursement rates from insurance companies and government agencies. The turnover rate in this field is high because of low wages and lack of advancement opportunities. Therefore, many jobs are expected to open as workers leave this occupation.

According to the American Association of Psychiatric Technicians, a major area of expansion for psychiatric assistants is the compelling need to provide treatment to thousands of state prison inmates with serious mental illness and developmental disabilities. The Department of Corrections estimates that one out of every 12 inmates suffers from serious mental illness. Because the prison population is expected to grow to more than 240,000 inmates by the turn of the century, a tremendous opportunity exists for psychiatric assistants and technicians. Psychiatric assistants function in various aspects of this challenging new program, including crisis intervention, mental health screening, patient assessment, implementation of treatment programs, supervising suicide risks, administering medications, maintaining **medical records**, and quality assurance. Another function involves parole programs that prepare inmates for productive lives after release.

Resources

ORGANIZATIONS

- The American Association of Psychiatric Technicians.
<<http://www.psych-health.com/main.htm>>
Indiana Career and Postsecondary Advancement Center.
<http://icpac.indiana.edu/career_profiles>.

Bethanne Black

Psychiatric rehabilitation

Definition

Psychiatric rehabilitation involves helping people with mental illness gain or improve skills while obtaining the necessary resources and support to reach their goals.

Purpose

The purposes of psychiatric rehabilitation include helping individuals cope more effectively with the symptoms of their disorders; preventing or delaying the reemergence of symptoms; assisting the individual in managing or reducing secondary symptoms not relieved by medication, e.g., social withdrawal or apathy; teaching or restoring social and living skills that may never have been learned or that have atrophied during periods of illness or hospitalization; and enhancing support while lessening **stress** in the individual's environment.

Therefore, the goals of rehabilitation professionals are to sustain symptomatic relief, establish or reestablish interpersonal and independent living skills, and help individuals reach a satisfactory quality of life.

Description

The concepts of mental health and mental illness are culturally determined. In the United States mental illness is generally viewed as a maladaptive response to stress, evidenced by thoughts, feelings, and behaviors that interfere with social, occupational, or physical functioning.

Of the estimated 40 million people in the United States who have psychiatric disabilities, approximately five million are considered seriously mentally ill. People with psychiatric disabilities often have limited daily functioning that includes difficulties in relating, problems coping with stress, difficulty concentrating, and a lack of energy or initiative.

Psychiatric rehabilitation takes place in a variety of settings, including mental health centers, hospitals, shel-

tered workshops, halfway houses, correctional facilities, places of employment, and the individual's home. It most often involves assessment, training, and modification of personal and community environments. Because rehabilitation focuses on adjustment to everyday life, it is important for the individual to participate as much as possible in choosing the objectives.

Complications

Medications prescribed for severe mental illnesses, called neuroleptic drugs, have a number of side effects. Standard drugs prescribed for **schizophrenia**, one of the most debilitating mental illnesses, include Haldol, Thorazine, Trilafon, Mellaril, Serentil, Stelazine, and Prolixin. Side effects include agitation, sleepiness and lethargy, dry mouth, eye problems, allergic reactions, weight gain, menstrual irregularities, and **sexual dysfunction**. Malignant neuroleptic syndrome, a less common but more serious side effect, causes very high body temperatures that can be fatal in some cases if not treated promptly. Hyperprolactinemia or high levels of the female hormone prolactin are common among those taking neuroleptics. This side effect causes menstrual abnormalities while increasing the risk for **osteoporosis** and **breast cancer**.

The most disturbing and common of the side effects are known as extrapyramidal symptoms, which cause movement and coordination difficulties. Women are at higher risk for these symptoms, and the risk increases with the length of time the drug is taken and age. Nearly every neuroleptic drug can cause extrapyramidal side effects, which occur in up to 70% of patients taking these medications. A condition known as acute dystonia can develop shortly after taking **antipsychotic drugs**, resulting in abnormal muscle spasms, particularly of the neck, jaw, trunk, and eye muscles. The most serious effect of antipsychotic therapy is tardive dyskinesia, which causes repetitive and involuntary movements or tics—most often of the mouth, lips, legs, arms, or trunk.

Results

The effectiveness of medication is determined by the degree to which it helps the individual manage the symptoms of their illness. Effectiveness of treatments that help develop an individual's coping skills are assessed on the basis of how well the individual is able to develop these skills.

Health care team roles

Professionals involved in psychiatric rehabilitation vary according to setting and may include nurses, psychiatric social workers, rehabilitation counselors, clinical psychologists, psychiatrists, recreation therapists, and paraprofessionals.

A psychiatric nurse's responsibilities may include case management, client advocacy, managing medications, facilitating therapy (individual, family, or group), clinical supervision, serving as a liaison, and consulting.

Psychiatric social workers are skilled in assessing family, social, and environmental factors that contribute to dysfunctional behavior in the individual or the family. They are also primary contributors to the planning and implementation of follow-up care.

Rehabilitation counselors most often are involved in case management and in assisting individuals with employment, housing, coping skills, and academic preparation.

Psychologists most directly involved in the diagnosis and treatment of mental illness are called clinical psychologists. Clinical psychologists are concerned with the diagnosis of mental illness and have expertise in diagnosing and assessing treatment effects by using personal inventories and tests, including intelligence tests.

The role of the psychiatrist involves making medical diagnoses, prescribing medications, and administering such additional treatments as electroconvulsive therapy (ECT), commonly known as shock treatment.

Recreation or activity therapists provide structured activities designed to help individuals deal with their problems. They assist in diagnostic and personality evaluation through observing clients during activities. Activity therapists often prescribe activities that enable individuals to express emotions and develop skills in relating with others.

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Bill Asenjo, MS, CRC

Psychological tests

Definition

Psychological tests are written, visual, or verbal evaluations administered to assess the cognitive and emotional functioning of children and adults.

Purpose

Psychological tests are used to assess a variety of mental abilities and attributes, including cognitive skills, motivation, personality traits, and neurological functioning.

Achievement and ability tests

For children, academic achievement, ability, and intelligence tests may be used as tools in school placement; in determining the presence of a learning disability or a developmental delay; in identifying giftedness; or in tracking intellectual development. Intelligence testing may be used with adults to determine vocational ability (e.g., in career counseling) or to assess adult intellectual ability in the classroom.

Personality tests

Personality tests are administered for a wide variety of reasons, from diagnosing psychopathology (e.g., personality disorder, depressive disorder) to screening job candidates. They may be used in an educational or vocational setting to determine personality strengths and weaknesses, or in the legal system to evaluate parolees.

Neuropsychological tests

Patients who have experienced a traumatic **brain** injury, brain damage, or organic neurological problems (for example, **dementia**) are administered neuropsychological tests. Neuropsychological testing evaluates cognitive function, including general intelligence, attention, **memory** span, and judgment; and motor, sensory and

speech ability. Tests can also be used to assess emotional stability, quality of language production, distractibility and other qualities. These tests can document impairments that can be used to diagnose specific neurological illness or damage. In addition, certain neuropsychological measures may be used to screen children for developmental delays and/or learning disabilities.

Precautions

Psychological testing requires a clinically trained examiner to administer the tests. All psychological tests should be administered, scored, and interpreted by a trained and experienced professional—preferably a psychologist or psychiatrist with expertise in the appropriate area.

Psychological tests are only one element of a psychological assessment. They should never be used alone as the sole basis for a diagnosis. A detailed history of the test subject and a review of psychological, medical, educational, or other relevant records are required to lay the groundwork for interpreting the results of any psychological measurement.

Cultural and language differences in the test subject may affect test performance and may result in inaccurate test results. The test administrator should be informed before psychological testing begins if the test taker is not fluent in English and/or belongs to a minority culture. In addition, the subject's motivation and motives may also affect test results.

Description

Psychological tests are formalized measures of mental functioning. Most are objective and quantifiable; however, certain projective tests may involve some level of subjective interpretation. Also known as inventories, measurements, questionnaires, and scales, psychological tests are administered in a variety of settings, including preschools, primary and secondary schools, colleges and universities, hospitals, outpatient healthcare settings, social agencies, prisons, and employment or human resource offices. They come in a variety of formats, including written, verbal, and computer-administered.

Achievement and ability tests

Achievement and ability tests are designed to measure the level of an individual's intellectual functioning and cognitive ability. Most achievement and ability tests are standardized, meaning that norms were established during the design phase of the test by administering the test to a large representative sample of the test population. Achievement and ability tests follow a uniform test-

KEY TERMS

Norms—A fixed or ideal standard; normative or mean score for a particular age group.

Psychopathology—A mental disorder or illness, such as schizophrenia, personality disorder, or major depressive disorder.

Quantifiable—Can be expressed as a number. The results of quantifiable psychological tests can be translated into numerical values, or scores.

Reliability—Capable of producing trustworthy results. Projective tests, such as the Rorschach and Thematic Apperception (TAT) tests, often produce unreliable results because they are easily influenced by the examiner's own assumptions.

Representative sample—A random sample of people that adequately represent the test-taking population in age, gender, race, and socioeconomic standing.

Standardization—The process of determining established norms and procedures for a test to act as a standard reference point for future test results.

Validity—Producing creditable results because of precision of method or adherence to an established norm. Projective tests, such as the Rorschach and Thematic Apperception (TAT) tests, often have questionable validity because they are easily influenced by the examiner's own assumptions.

ing protocol, or procedure (i.e., test instructions, test conditions, and scoring procedures), and their scores can be interpreted in relation to established norms. Common achievement and ability tests include the Wechsler intelligence test (WISC-III and WAIS) and the Stanford-Binet intelligence scales.

Personality tests

Personality tests and inventories evaluate the thoughts, emotions, attitudes, and behavioral traits that comprise personality. The results of these tests determine an individual's personality strengths and weaknesses, and may identify certain disturbances in personality, or psychopathology. Such tests as the Minnesota Multiphasic Personality Inventory-2 (MMPI-2) and the Millon Clinical Multiaxial Inventory III (MCMI-III), are used to screen individuals for specific psychopathologies or emotional problems.

Another type of personality test is the projective personality assessment. A projective test asks a subject to interpret some ambiguous stimuli, such as a series of inkblots. The subject's responses provide insight into his or her thought processes and personality traits. The best known projective psychological test is the Rorschach, or inkblot test. The patient is asked to look at each blot and to say what it looks like or what it could be. Because the stimulus is ambiguous, the patient must impose his or her own interpretation. In doing so, thoughts, feelings, and themes, some of which are unconscious, are projected into the material. Projective tests have lower validity and reliability than objective tests. However, the information they provide tends to be richer and more varied. Another projective assessment, the Thematic Apperception Test (TAT), asks the subject to tell a story about a series of pictures. The TAT is often used in a test battery in conjunction with the Rorschach. The TAT purports to provide information about important themes in a person's life or the content of their thinking, whereas the Rorschach provides information about the process and form of a person's thoughts. Although these tests are widely used, research has demonstrated that the examiners' subjective interpretations often affect the outcomes of these tests.

Neuropsychological tests

Many insurance plans cover all or a portion of diagnostic neuropsychological or psychological testing. As of 1997, **Medicare** reimbursed for psychological and neuropsychological testing. Billing time typically includes test administration, scoring and interpretation, and reporting.

Preparation

Prior to the administration of any psychological test, the administrator should provide the test subject with information on the nature of the test and its intended use; complete standardized instructions for taking the test (including any time limits and penalties for incorrect responses); and information on the confidentiality of the results. After these disclosures are made, **informed consent** should be obtained from the test subject before testing begins (except in cases of legally mandated testing, in which consent is not required of the subject).

Results

All psychological and neuropsychological assessments should be administered, scored, and interpreted by a trained professional. When interpreting test results for test subjects, the test administrator will review with sub-

jects: what the test evaluates, its precision in evaluation, any margins of error involved in scoring, and what the individual scores mean in the context of overall test norms and the background of the test subject.

Health care team roles

Nursing staff and allied health professionals can assist in the administration of psychological tests by being familiar with each test and the reason it is being administered. Prior to the administration of psychological tests, nursing staff can provide appropriate **patient education** materials as necessary.

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ORGANIZATIONS

The American Psychological Association. Committee on Psychological Tests and Assessments. 750 First St. NE, Washington, DC 20002-4242. (202) 336-5500. <<http://www.apa.org/psychnet>>.

The ERIC Clearinghouse on Assessment and Evaluation. O'Boyle Hall, Department of Education, The Catholic University of America, Washington, DC 20064. (800) 464-3742. <<http://www.ericae.net>>.

Bethanne Black

Psychotherapy

Definition

Psychotherapy can be defined as a means of treating such psychological or emotional problems as neurosis or personality disorder through verbal and nonverbal communication. It is the treatment of psychological distress through talking with a specially trained therapist, and learning new ways to cope rather than merely using medication to alleviate the distress. It is done with the immediate goal of aiding the person in increasing self-knowledge and awareness of relationships with others. Psychotherapy is carried out to assist people in becoming

more conscious of their unconscious thoughts, feelings, and motives.

Psychotherapy's longer-term goal is making it possible for people to exchange destructive patterns of behavior for healthier, more successful ones.

Different approaches to psychotherapy

The psychodynamic approach was derived from principles and methods of psychoanalysis, and it encompasses psychoanalysis, Jungian analysis, Gestalt therapy, client-centered therapy, and somatic or body therapies, among other forms of psychotherapy. Psychoanalysis is therapy based upon the work of Austrian physician Sigmund Freud (1856–1939), and those who followed—Carl Jung, Alfred Adler, Erich Fromm, Karen Horney, and Erik Erikson. The basis of psychoanalytic therapy is the belief that behavior and personality develop in relation to unconscious wishes and conflicts from childhood. Gestalt therapy, developed by Frederick (Fritz) Perls, emphasizes the principles of self-centered awareness and accepting responsibility for one's own behavior. Client-centered therapy was formulated by Carl Rogers; it introduced the idea that individuals have the resources within themselves for self-understanding and for change. Part of this concept is that the therapist exposes his or her own true feelings and does not adopt a professional posture, keeping personal feelings unclear. Somatic or body therapies include: **dance therapy**, holotropic breathwork, and Reichian therapy.

The behavioral approach to psychotherapy encompasses various behavior modification techniques and theories, including assertiveness training/social skills training, operant conditioning, hypnosis/hypnotherapy, sex therapy, systematic desensitization, and others. Systematic desensitization was pioneered by Joseph Wolpe after he became frustrated with psychoanalysis. This therapy is a combination of deep muscular **relaxation** and emotive imagery exercises, in which the client relaxes and the therapist verbally sets scenes for the client to imagine. These scenes include elements of the client's fears, building from the smallest fear toward the largest fear. The therapist monitors the client and introduces the scenes, working to maintain the client's relaxed state.

The cognitive approach stresses the role that thoughts play in influencing behavior. Rational-emotive therapy and reality therapy are both examples of the cognitive approach. Rational-emotive therapy was pioneered by Albert Ellis in the mid-1950s. This therapy is based on the belief that events in and of themselves don't upset people, but people get upset about events because of their attitudes toward the events. Ellis's therapy set out to

change people's attitudes about events through objective, firm direction from the therapist and talk therapy. Reality therapy, developed by William Glasser, is based upon the idea that humans seek to satisfy their complex needs, and the behaviors they adopt are intended to accomplish that satisfaction. In Glasser's theory, some people usually fulfill themselves and are generally happy, while others are unable to fulfill themselves and get angry or depressed.

The family systems approach includes family therapy in several forms and attempts to modify relationships within the family. Family therapy views behaviors and problems as the result of family interactions, rather than as belonging to a specific family member. One theory, developed by Murray Bowen, has become its own integrated system with eight basic concepts, including differentiation of self and sibling position. This system attempts to help an individual become differentiated from the family, while remaining in touch with the family system.

In the practical application of these approaches, psychotherapy can take many forms. Some of the most commonly practiced forms include:

- Counseling, the provision of both advice and psychological support, is the most elemental form of psychotherapy. Counseling can be short-term therapy done to assist a person in dealing with an immediate problem such as marital problems or family planning, substance abuse, bereavement, or terminal illness. Or it can be longer-term, more extensive treatment that addresses feelings and attitudes that impair success.
- Group psychotherapy requires less therapist time, and is thus less expensive. In fact, the interactions that occur between members of the group are expected to provide the change and healing each member receives. The therapist functions as a facilitator, or one who encourages and directs the group interchanges. Group therapy provides each member with the additional benefit of sharing and feedback from others experiencing similar emotional problems. This sharing and feedback has been found to be therapeutic; and the group can actually function as a trial social setting, allowing people to try out newly-learned behaviors.
- Family therapy began in the 1930s, when Freudian analyst Alfred Adler used it in working with his patients' entire families. Since the 1950s, it has been a widely used and highly respected modality of therapy based upon the belief that the relationships and interactions within a family have a profound impact upon the patient's mental difficulties. Family therapy generally does not deal with internal conflicts, but rather encourages positive interactions between the various family members.

All forms of psychotherapy require an atmosphere of absolute mutual trust and confidentiality. Without this total safety, no form of therapy will be successful.

Origins

Psychotherapy had its beginnings in the ministrations of some of the earliest psychologists, priests, magicians, and shamans of the ancient world. They attempted to determine the causes of a person's emotional distress by talking, counseling, and educating, and interpreting both behavior and dreams. Many of these practices became suspect as the work of charlatans, and fell into disrepute over the centuries. There was little change or progress in the treatment of mental illness over the centuries that followed.

Austrian physician Franz Anton Mesmer (1734–1815) began using what he termed *magnetism* and both the power of suggestion and hypnosis in 1772. Mesmer's treatments, too, fell into disrepute after his theories were rejected by a medical board of inquiry in 1784. Then, nearly a century later, Mesmer's ideas were rediscovered by French neurologist Jean-Martin Charcot (1825–1893). Dr. Charcot used suggestion and hypnosis for treating psychological difficulties at the Salpêtrière Hospital in Paris in the late nineteenth century. Mesmer is now known as the Father of Hypnosis.

In the late nineteenth and early twentieth century, Austrian physician Sigmund Freud studied Charcot's work, and came to believe that hypnosis was less a treatment for mental illness than a means of determining its underlying cause. Freud used hypnosis as one means of uncovering the often traumatic, not consciously recalled memories of his neurotic patients, just as he used their dreams to evaluate their mental conflicts. He later abandoned hypnosis because he did not induce successful trances in his neurology patients. His *The Interpretation of Dreams*, published in 1899, made the point that a person's dreams were actually a window into the inner, unknown mind—the royal road to the unconscious. He used the information he obtained not only to help his patients, but also to collect data that eventually helped verify some of his psychodynamic assumptions.

Sigmund Freud theorized that the human personality is composed of three basic parts, the id, the ego, and the superego. The id is defined as the most elemental part, the one that unconsciously motivates people toward fulfilling instinctive urges. The ego is more related to intellect and judgment. It arbitrates between the internal, usually unrecognized desires all human beings have and the reality of the external world. The superego, unconscious controls dictated by moral or social standards outside of

ourselves, is probably most easily described as another name for the conscience.

Freud believed that mental illness was the result of people's being unable to resolve conflict, or inadequate settlement of disharmony among the ego, superego, and id. To deal with these internal psychic conflicts, people develop defense mechanisms, which is normally a healthy response. The defense mechanisms become harmful to mental health when overused, or used inappropriately. Freud further postulated that childhood psychic development is primarily based upon sexuality; he divided the first eighteen months of life into three sex-based phases, oral, anal, and genital.

Freud's earliest students, including Carl Jung and Alfred Adler, came to believe that Freud had overestimated the influence sexuality has on psychic development, and found other influences that help to shape human personality. In the late 1800s and into the twentieth century, 1904 Nobel Prize winner Ivan Petrovich Pavlov pioneered the research that would later result in behavioral therapies, such as the work of American behaviorist Burrhus Frederic Skinner. And in the 1930s, American psychologist Carl Ransom Rogers began his school of psychology that emphasized the importance of the relationship between the patient (or client, according to Rogers) and the therapist in bringing about positive psychic change.

Primal therapy, developed by Arthur Janov in the 1960s, is based upon the assumption that people must relive early life experiences with all the acuity of feeling that was somehow suppressed at the time in order to free themselves of compulsive or neurotic behavior. Primal therapy was a cathartic approach that many therapists now believe can impede progress because a person can become addicted to the release (even "high") associated with the catharsis and seek to keep repeating it for the momentary satisfaction. Transactional analysis, based on Eric Berne's work, came into favor in the 1970s, and supposes that all people function as either a parent or child at various times. It teaches the person to identify which role he or she is filling at any given time and to evaluate whether this role is appropriate.

Benefits

The generally accepted aims of psychotherapy are:

- Increased insight into or improved understanding of one's own mental state. This can range from simply knowing one's strengths and weaknesses, to understanding that symptoms are signs of a mental illness, to deep awareness and acceptance of inner feelings.

- The resolution of disabling conflicts, or working to create a peaceful and positive settlement of emotional struggles that stop a person from living a reasonably happy and productive life.
- Increasing acceptance of self by developing a more realistic and positive appraisal of the person's strengths and abilities.
- Development of improved and more efficient and successful means of dealing with problems so that the patient can find solutions or means of coping with them.
- An overall strengthening of ego structure, or sense of self, so that normal, healthy means of coping with life situations can be called upon and used as needed.

Though there are no definitive studies proving that all five of these goals are consistently realized, psychotherapy in one form or other is a component of nearly all in patient and community-based psychiatric treatment programs.

Description

Classic Freudian psychotherapy is usually carried out in 50-minute sessions three to five times per week. The patient lies on a couch while he or she talks with the therapist. Freudian therapy characteristically requires ongoing treatment for several years, though in Freud's era it did not. Most other forms of individual psychotherapy, including Jungian, counseling, humanistic, Gestalt, or behavioral therapies, are carried out on a weekly basis (or more frequently, if necessary), in which the person meets with his or her therapist in the therapist's office, and may or may not continue for longer than a year.

Group therapy is held in a variety of settings. A trained group therapist chooses the people that presumably would benefit and learn from interactions with one another. The size of a group is usually five to 10 people, plus a specially trained therapist who guides the group discussion and provides examination of issues and concerns raised.

Child psychotherapy is done for the same reasons as adult psychotherapy—to treat emotional problems through communication. The obvious difference is that child psychotherapy must acknowledge the child's stage of development. This recognition means that the therapist may use different techniques, including play, rather than only talking to the patient.

A newer direction in the treatment of mental disorders is the use of brief psychotherapy sessions, often combined with medication, to treat neurotic conditions. Another short-term psychotherapy modality is often

KEY TERMS

Behavioral therapy—A collection of techniques for treating mental disorders based upon changing abnormal behavior rather than attempting to analyze its fundamental basis. It is particularly used in phobic or obsessional disorders, and seeks to eliminate symptoms rather than uncovering the underlying psychological cause.

Magnetism—(Animal magnetism) A discredited theory put forth by Viennese physician Franz Anton Mesmer, stating that all persons possess magnetic forces that can be used to influence magnetic fluid in other people and therefore effect healing. Mesmer opened a clinic in Paris in 1778, and appeared to cure people apparently suffering from hysterical conditions, such as emotionally caused paralysis.

Neurosis—A term commonly used to describe a range of relatively mild psychiatric disorders in which the sufferer remains in touch with reality. Neurotic disorders include mild depression; anxiety disorders (including phobias and obsessive compulsive disorders); somatization disorders; dissociative disorders; and psychosexual disorders.

Personality disorder—A group of conditions characterized by a general failure to learn from experience or adapt appropriately to changes, resulting in personal distress and impairment of social functioning.

termed crisis intervention, and is used to aid people in dealing with specific crises in their lives, such as the death of a loved one.

Research and general acceptance

Psychotherapy in its many forms has been accepted and used throughout the world for over one hundred years. It is normally covered as a valid treatment of mental disorder by both public and private health insurers. Because the various types of psychotherapy have different aims, and mental illnesses usually do not have absolute measurable signs of recovery, evaluating psychotherapy's effectiveness is difficult. As a general rule, the majority of people who undergo treatment with psychotherapy can expect to make appreciable gains. Studies have revealed, however, that not everyone who goes into therapy will be helped, or helped as much as others, and some will even be harmed.

Training and certification

Though the actual clinical practice of psychotherapy is very much the same among disciplines, therapists come from a variety of different fields, including medicine, psychology, social work, and nursing.

Psychiatrists are required to complete four years of medical school and one year of internship, followed by a three-year residency in psychiatry. In order to be a psychoanalyst, a minimum of three years, further training at a psychoanalytic institute is necessary, along with personal ongoing analysis.

Psychologists earn a Ph.D. in clinical psychology followed by a year of supervised practice, and additionally may take specialized training at a specific psychotherapeutic school, including therapy for themselves.

Social workers who specialize in mental health must earn a master's degree or doctorate before being allowed to practice.

Psychiatric nurses generally earn a master's degree and practice in hospitals or community mental health centers.

Most states in the United States require a license to practice as a psychotherapist, and by law in the majority of the states, they are accountable only to the other members of their profession.

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Joan Schonbeck

Psyllium preparations see **Laxatives**

PTSD see **Post-traumatic stress disorder**

Puberty

Definition

Puberty is the period of human development during which physical growth and sexual maturation occur.

Description

Beginning as early as age eight in girls—and two years later on average in boys—the hypothalamus (part of the **brain**) signals hormonal changes that stimulate the pituitary. In turn, the pituitary releases its own hormones called gonadotrophins that stimulate the gonads and **adrenal glands**. From these glands comes a flood of sex hormones—androgens and testosterone in the male, estrogens and progestins in the female—that regulate the growth and function of the sex organs. The gonadotrophins are the same for males and females, but the sex hormones they induce are different.

In the United States, the first sign of puberty occurs on average at age 11 in girls, with menstruation and fertility following about two years later. Boys lag behind by about two years. Puberty may not begin until age 16 in boys and may continue in a desultory fashion beyond age 20. In contrast to puberty, which triggers physiological changes, adolescence is more of a social/cultural term referring to the interval between childhood and adulthood.

Diagnosis

Puberty has been divided into five Sexual Maturity Rating (SMR) stages by two doctors, W. Marshall and J. M. Tanner. These ratings are often referred to as Tanner Stages 1-5. Staging is based on pubic hair growth, male genital development, and female breast development. Staging helps determine whether development is normal for a given age. Both genders also grow axillary (armpit) hair and develop pimples. Males develop muscle mass, a deeper voice, and facial hair. Females redistribute body fat. Along with the maturing of the sex organs, there is a pronounced growth spurt averaging 3-4 inches (7.5-9 cm) and culminating in full adult stature. Puberty can be precocious (early) or delayed. It all depends upon the sex hormones.

Puberty falling outside the age limits considered normal for any given population should prompt a search for the cause. As health and **nutrition** have improved over the past few generations, there has been a gradual lowering of the average age for the normal onset of puberty.

- Excess hormone stimulation is the cause of precocious puberty. It can come from the brain in the form of gonadotrophins or from the gonads and adrenals.

Overproduction may be caused by functioning tumors or simple glandular overactivity. Brain overproduction can also be the result of brain infections or injury.

- Likewise, delayed puberty is due to insufficient hormone. If the pituitary output is inadequate, so will be the output from the gonads and adrenals. On the other hand, a normal pituitary will overproduce if it senses there are not enough hormones in circulation.
- There are several congenital disorders (polyglandular deficiency syndromes) that include failure of hormone output. These children do not experience normal puberty, but it may be induced by giving them the proper hormones at the proper time.
- Finally, there are abnormalities in hormone production in females that produce male characteristics—so called virilizing syndromes. Should one of these appear during adolescence, it will disturb the normal progress of puberty. The reader should note that virilizing requires abnormal hormones in a female, while feminizing results from the lack of hormones in a male. Each embryo starts out life as a female. Male hormones transform it into a male if they are present.

Delayed or precocious puberty requires measurement of the several hormones involved to determine which are lacking or which are in excess. There are **blood** tests for each one. If a tumor is suspected, imaging of the suspect organ needs to be done with x rays, computed tomography scans (**CT scans**), or magnetic resonance imaging (MRI).

Treatment

Puberty can be a period of great **stress**, both physically and emotionally. The psychological changes and challenges of puberty are compounded if its timing is off.

If puberty is early, the offending gland or tumor may require surgical attention, although there are several drugs now that counteract hormone effects. If it is delayed, puberty can be stimulated with the correct hormones. Treatment should not be delayed, because necessary bone growth is also affected.

Prognosis

For individuals facing delayed or accelerated puberty, properly administered hormones can restore the normal growth pattern.

Health care team roles

Pediatricians or family physicians usually diagnose abnormalities of puberty. Endocrinologists may assist

KEY TERMS

Adrenals—Glands on top of the kidneys that produce four different types of hormones.

Computed tomography scan (CT)—A method of creating images of internal organs using x rays.

Embryo—The life in the womb during the first two months.

Hormone—A chemical produced in one place that has an effect somewhere else in the body.

Hypothalamus—Part of the brain located deep in the center of the skull and just above the pituitary.

Gonads—Glands that make sex hormones and reproductive cells—testes in the male, ovaries in the female.

Magnetic resonance imaging (MRI)—A method of creating images of internal organs. Magnetic resonance imaging (MRI) uses magnetic fields and radio-frequency signals.

Pituitary—The “master gland” of the body, controlling many of the others by releasing stimulating hormones.

Syndrome—A collection of abnormalities that occur often enough to suggest they have a common cause.

with assessment and treatment. Therapists and counselors may provide emotional support as needed.

Prevention

As puberty is an entirely normal process, there is neither a way nor a need to prevent it.

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American Psychiatric Association. 1400 K Street NW, Washington, DC 20005. (888) 357-7924. Fax: (202) 682-6850. apa@psych.org.

American Psychological Association. 750 First Street NW, Washington, DC, 20002-4242. (800) 374-2721 or (202) 336-5500. <<http://www.apa.org/>>.

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Planned Parenthood. <http://www.plannedparenthood.org/TEENISSUES/TEENMAINHTM/Girls_and_Puberty.html>

L. Fleming Fallon, Jr., MD, DrPH

Public health

Definition

Public health is the science and clinical practice of population and community-based efforts to prevent disease and disability, and promote physical and mental

health. It considers the health of groups, communities, or populations as opposed to the health of individuals. Public health addresses a variety of medical and social issues including:

- environmental health
- nutrition and food safety
- immunization and infectious diseases
- injury and violence prevention
- maternal, infant, and child health
- substance abuse
- chronic disease prevention and treatment
- access, availability, and affordability of health care
- education, screening, and outreach services

Description

The science of public health is called epidemiology. It is the study of the occurrence of disease in such naturally existing populations as nations, cities, or communities. The term “epidemiology” comes from the Greek word epidemic, which means “upon the people.” The earliest epidemiologists (public health scientists) worked to prevent the spread of epidemics.

Today, epidemiologists gather and analyze information about populations to manage and prevent disease. Epidemiologists are trained in highly specialized research methods: surveillance, investigation, analysis, and evaluation. Surveillance refers to systematic data collection and analysis; it enables the epidemiologists to detect changes that may require investigation. Epidemiological investigation involves observation, detailed descriptions of the problem, documentation of data, and analysis. Evaluation is the process that helps to answer such a question as “How often should men between the ages of 40 and 60 be screened for **hypertension** (high **blood** pressure)?”

By analyzing population data, epidemiologists also are able to describe diseases and determine the factors that cause them. Epidemiology is a quantitative science; it measures rates and proportions. Two commonly used rates are prevalence and incidence rates. Prevalence describes the characteristics of a given population at a specific moment in time; it is like a snapshot.

Incidence describes the rate of development of a disease in a given population over a specified time interval. Incidence offers a longer view of population dynamics, like a video, as opposed to the snapshot offered by the prevalence rate. Epidemiologists also analyze such other rates as morbidity (disease-related illness) and mortality (death).

Public health practitioners rely on the findings of epidemiologists to develop health services, allocate resources, and determine standards of care. The results of epidemiological studies also influence health policy. For example, epidemiological research helps to determine how many health care professionals are needed based on population; the effectiveness of various treatments; and schedules for immunization or screening.

Viewpoints

Historically, public health disease prevention activities focused primarily on sanitation (also referred to as environmental health) and hygiene. Public health measures aimed to ensure the safety of food and water supplies, and to prevent transmission of communicable (capable of being transmitted) diseases. In some developing countries, these same basic public health problems, such as adequate food supplies and potable (fit to drink) water, continue to threaten health and longevity.

During and after World War II, such advances in medicine as the development of **antibiotics**, cardiac surgery, and physical rehabilitation changed the emphasis of public health in the United States. Federal, state, and local governments enacted legislation to protect public health. Federal laws aimed at safeguarding public health. Major regulations passed during the twentieth century include:

- the 1938 Food, Drug and Cosmetic Act, which bans distribution of unsafe products and prohibits false advertising
- the 1972 Clean Water Act, which forbids release of pollutants into rivers, streams, and waterways
- the 1974 Safe Drinking Water Acts, which established standards for safe drinking water
- the 1976 Resource Conservation and Recovery Act, which stipulates the safe storage, transport, treatment and disposal of hazardous waste materials
- the 1990 Clean Air Act, which reduced industrial discharge or emission of pollutants into the air and set standards for vehicular emissions

Today, public health practitioners continue to work to prevent disease. However, their efforts are often directed to addressing such social issues as access to health care, and promoting such lifestyle changes as smoking cessation, responsible sexual behavior, and violence prevention.

Frequently, public health professionals must work cooperatively with persons in other disciplines to achieve health promotion objectives. For example, public health practitioners may work with educators and schools to

KEY TERMS

Communicable—Capable of being transmitted.

Epidemiology—The study of disease occurrence in human populations.

Incidence—The rate of development of a disease in a given population over time.

Potable—Safe to drink.

Prevalence—The rate describing the characteristics of a given population at a specific moment in time.

help combat illiteracy, since persons unable to read may be less able to obtain needed health care services. Similarly, they may work with urban planners and housing specialists to identify such health hazards as lead-based paints or asbestos.

The Healthy People 2010 initiative is a national plan to assist states, communities and professional associations to develop programs to improve health. Coordinated by the Office of Disease Prevention and Health Promotion (ODPHP) of the Department of Health and Human Services, the program's goals are to: increase quality and years of healthy life; and eliminate health disparities. Healthy People 2010 targets ten areas for improving health standards in the United States. They are:

- physical activity
- overweight and obesity
- tobacco use
- substance abuse
- responsible sexual behavior
- mental health
- injury and violence
- environmental quality
- immunization
- access to health care

Professional implications

Medical, nursing and allied health professionals and practitioners work in the field of public health. Public health professionals are employed by hospitals, health plans, managed care organizations, clinics, medical relief organizations (e.g., American Red Cross, American Heart Association, American Cancer Society) and

schools as well as federal, state, and local government health departments. Careers in public health include:

- public health nursing
- environmental health technologists and specialists
- restaurant and food safety inspectors
- community health educators
- epidemiologists, biostatisticians, and researchers
- administrators
- patient and consumer health advocates

Public health nursing began in the United States during the late 1800s. Public health nurses helped to prevent and manage outbreaks of smallpox, cholera, typhoid, **tuberculosis**, and other communicable diseases. The profession continues to attract nurses interested in community health education and preventive services. Public health nurses (also called community health nurses) work in clinics, schools, voluntary agencies, and provide skilled nursing assessments, visiting nurse services, and **home care**.

Federal government agencies that belong to the U.S. Department of Health and Human Services provide many vital public health services. The agencies devoted to health care include the Health Care Financing Administration (HCFA), Office of Development Services, Food and Drug Administration (FDA), National Institutes of Health (NIH) and the Centers for Disease Control and Prevention (CDC).

HCFA administers **Medicare** and **Medicaid**, programs that finance health care services for older adults, persons with disabilities and those unable to afford medical care. The FDA is the agency responsible for ensuring food, drug, and cosmetic safety. It also enforces labeling practices, so that consumers receive accurate, truthful information about the content, benefits, and risks of products).

Each of the 13 institutes of the NIH is involved in organ or disease-specific research activities. The seven centers of the CDC research and track infectious and other diseases in order to identify sources of disease and prevent their spread.

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Atlanta, GA 30333. (800) 311-3435.
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Public health administration

Definition

Public health administration is the component of the field of public health that concentrates on management of people and programs. On a day-to-day basis, administration is needed to ensure that organizations operate efficiently and with success. Programs must be guided. The field of administration is concerned with theory and techniques derived from a variety of fields, mainly management.

Description

The work of a public health administrator is at the same time similar to and different from that of persons engaged in administration in other fields. The administrative elements are similar. These include supervising employees, coordinating programs, preparing budgets, monitoring programs, and evaluating results and outcomes. Other aspects that are germane to the field of public health are different from other fields. Public health administrators are concerned with health and disease prevention programs. They administer educational campaigns and try to keep the people they serve healthy. Other health professionals have similar aims of maintaining health but often are restorative or curative rather than preventive.

There are 10 core public health functions with which an administrator must be familiar. There is a specialized body of public health law. Data are constantly being generated. They must be sorted, classified, stored, and interpreted. There are systems to keep track of diseases, vital

events, waste materials, insects and a host of other aspects of public health. Data that are developed must be organized and presented to such various constituencies as members of the public, governmental agencies and professionals. The overall health of the public being served must be periodically assessed. Intervention programs must be created, implemented and evaluated. Other forms of research are conducted.

The day-to-day activities of a public health administrator include human resources management; finance; performance measurement and improvement; communications and marketing; and maintaining relations with members of the media and local government. A public health administrator must build relationships with such various constituencies as consumer groups, health providers and legislators. Leadership is an important aspect of public health administration.

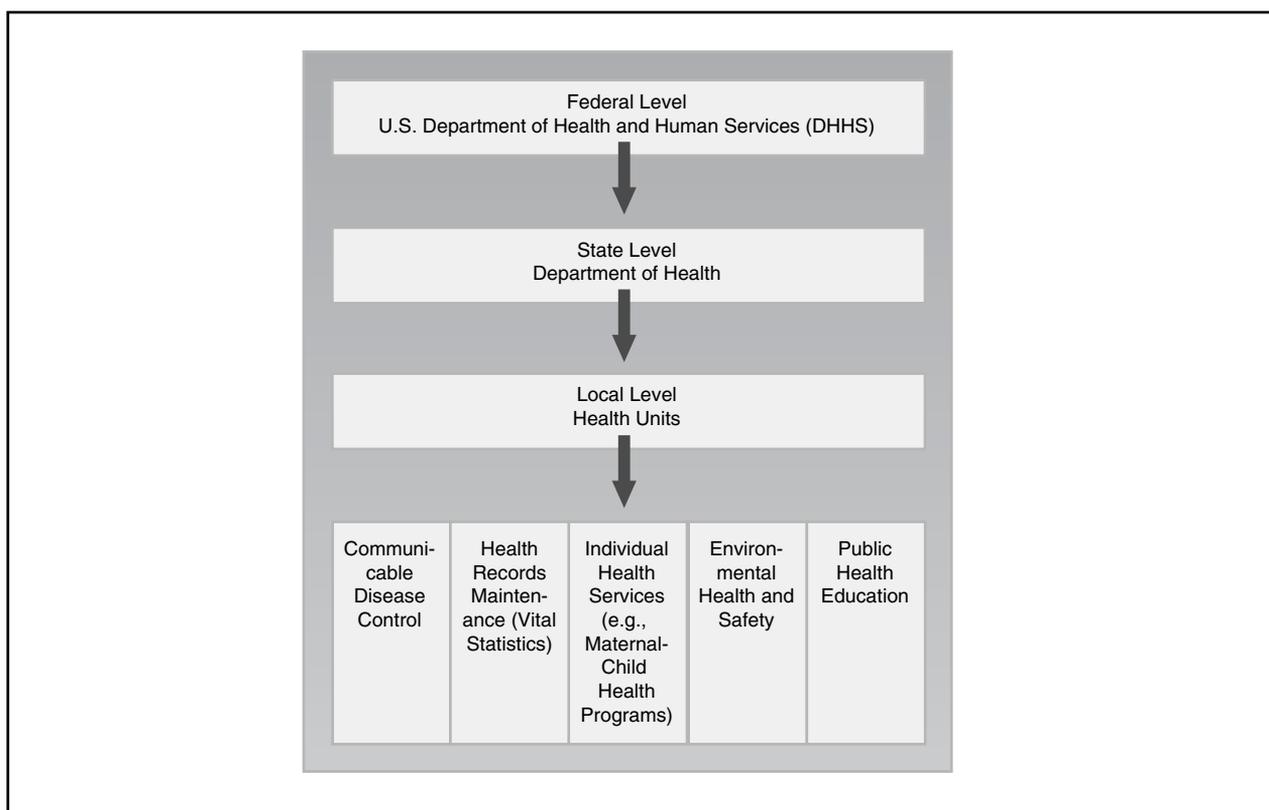
Work settings

The most common work setting for a public health administrator is an office within a local health department or public health agency. There are approximately 3,300 local boards of health in the United States. Their size varies from a single municipality to an entire state. Many consist of one or more counties. Each employs a staff of professionals who provide specialized services. Each provider has a supervisor; larger organizations have more than one layer of supervision. In addition, there are public and private organizations that provide public health services. Governments also employ public health administrators. The number of persons who provide some administrative services within the realm of public health is thus extensive. A conservative estimate for the United States would exceed 20,000 persons.

The majority of public health administrators work in offices. However, this is not universally the case. Using data from a study conducted by the National Association of Local Boards of Health, as of 1997 approximately 70% of all health boards had access to computers, but only 18% had access to the Internet. Among public health employees, as of 2001 about 5% lacked access to computers. This number is declining with passing time. Most administrators have and regularly use electronic tools. Many administrators who work in the field routinely use laptop communication devices.

Education and training

Basic preparation for a career in public health administration usually begins with a college degree. There are persons currently in the work force with less formal education. These people have been typically been



Levels of public health administration. (Delmar Publishers, Inc. Reproduced by permission.)

working in the public health system for many years, having started at a time when formal training in public health or administration was uncommon and largely unavailable. However, their numbers are decreasing. As these people retire, their replacements are entering with more formal training and credentials.

It is possible to learn administration from experience on the job but the time required is increasing each year. As of 2001, a college degree is the functional minimum level of education for admission into the field of public health administration. The actual field of study can vary but an undergraduate degree in management, public health, nursing, community health, applied health, allied health or a related discipline is useful. An optimal undergraduate curriculum should include course work in the following subject areas: management, accounting, finance, economics, biology, environmental health or science, marketing, business, health law, and budgeting. These courses will most likely be supplemented by advanced formal education and practical on-the-job training.

Initial training begins with job orientation. This is relatively similar for most entry-level positions in the

field. During orientation, the structure and reporting relationships of an organization are described. Basic laws and other legal requirements are outlined. Job duties of a particular position are explained. Organizational regulations and requirements are reviewed.

Ongoing training occurs at two levels. The first is specific to a particular working agency or environment. It consists of office and organizational updates, program changes, and information pertaining to other local issues. The second is specific to the field of public health. These updates typically occur at professional conferences and through articles in the secondary literature of public health. They consist of changes in programs that have been proposed or imposed by federal or other funding agencies. They also include new findings related to theories or practice that have been developed by researchers. Changes in reporting procedures are in this category.

Advanced education and training

Advanced training in public health administration can be obtained from a formal graduate degree program

or through continuing education offerings. The most commonly earned graduate credential is a Master of Public Health (MPH) degree. This degree provides a broad-based curriculum for anyone in the field of public health and is appropriate for persons just entering the field as well as those with experience. Other master-level preparations are also useful. These include Master of Business Administration (MBA), Master of Health Services Administration (MHSA), Master of Public Administration (MPA), Master of Hospital Administration (MHA) and Master of Management (MM) degrees. The core requirements of the different degree programs are similar and typically include course work in statistics, economics, management, finance, marketing, issues, law and human resource administration. Elective courses help to tailor a graduate curriculum to the specific needs of each individual student.

There are some differences among the degree courses described. These are typically related to the focus afforded by the training. For example, an MPH degree is specifically concentrated on public health. An MBA provides more general training. While both are useful, the MPH is focused on health. In an analogous manner, MHSA course work focuses on issues related to managing health service providers and organizations. MPA focuses on administration in a public or not for profit environment. The MHA is geared for hospital administrators while the MM is very general. An MPH degree curriculum includes courses in epidemiology and environmental health. The others typically substitute additional courses in economics, accounting, or labor relations.

Some workers in public health administration require continuing education units to maintain a license or certification. Examples of such workers include nurses, social workers, health officers, sanitarians, and physicians. The rules for many of these professionals are not set by federal or national agencies but rather may be specific to the state that has issued the credential. Professionals earning continuing education credits may include courses and seminars that cover aspects of public health administration. In this way, they acquire new and updated knowledge.

Public health administration as a profession does not require practitioners to be certified as of 2001. There is a movement to require certification for public health administrators. If this trend becomes law, more individuals will be seeking advanced education credits in the future. A likely degree option is the MPH.

Future outlook

The future outlook for persons seeking employment in public health administration is quite favorable. With the advent of managed care, prevention and public health have assumed new emphasis in the mainstream practice of medicine. Demand for persons with training in public health administration is likely to increase. In addition, as of 2001, performance standards are being instituted within the field of public health. This trend will increase the demand for people with advanced and specific training in public health administration. With increased requirements for training and preparation, salaries for public health administrators are also likely to rise. As the baby boomer generation ages and retires, the number of agencies and organizations providing services is expected to increase. These demands, too, are likely to drive up salaries for public health administrators.

All persons seeking to enter the field of public health administration will require professional training and preparation. This requirement will translate into opportunities for teachers of this subject. As of 2001, there are not enough people with appropriate professional experience and training to meet the demand for teachers in schools and programs of public health. With demand for trained persons increasing, the demand for teachers is likely to increase over the demand in the recent past.

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Epidemiology—The study of patterns and distribution of disease in large groups of people.

Vital event—An occurrence for which a certificate is typically issued. Examples of vital events include births, deaths, marriages and adoptions.

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Association of State and Territorial Health Officials. 1275 K Street NW, Suite 800, Washington, DC 20005-4006. (202) 371-9090. Fax: (202) 371-9797. <<http://www.astho.org/>>. llomax@astho.org.

Health Resources and Services Administration. 5600 Fishers Lane, Room 8-103, Rockville, MD 20857. (301) 443-0062. Fax: (301) 443-1164. <<http://www.hrsa.gov/>>. comments@hrsa.gov.

National Association of County and City Health Officials. 1100 17th Street, Second Floor, Washington, DC 20036. (202) 783-5550. Fax: (202) 783-1583. <<http://www.naccho.org/>>.

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Puerperal infection

Definition

Puerperal **infection** is a bacterial infection that occurs following **childbirth**. The diagnostic criteria require that the childbearing woman have a temperature elevated over 100.4°F (38°C) on any two of the first 10 post-partum days after day one, or over 101.5°F (38.6°C) during the first 24 hours.

Description

The incidence of puerperal infection is 1%-8% of the post-partum female population in the United States. The incidence is 5 to 10 times higher when a woman delivers by cesarean section. As most births in the United States occur in hospitals, the majority of puerperal infections are considered nosocomial, or hospital-acquired. With **antibiotics** readily available in industrialized countries, death related to puerperal infection is very rare, at 0.3 in 100,000. In developing nations, the death rate due to puerperal infection is estimated to be 100 times higher. Puerperal infection may occur in the genital tract, breast, urinary tract, **lungs**, **blood** vessel, or wound.

Causes and symptoms

The usual cause of puerperal infection is a bacterial infection in the genital tract, primarily the uterus. This infection, called endometritis, is associated with prolonged rupture of membranes; difficult vaginal birth which involved the use of forceps or vacuum extractor; multiple vaginal examinations; low socioeconomic status; and the primary predisposing factor of cesarean section delivery, with an incidence of postoperative infection reported at 29%-85%.

Symptoms of endometritis include elevated temperature, low abdominal **pain** or tenderness, vaginal discharge, or a heavy, malodorous lochia usually in the first two to seven days post-partum. Endometritis is usually polymicrobial; that is, more than one bacterial species is found upon culture. The mixed species tend to multiply their negative effects. Other symptoms in puerperal infection are dependent on the infected site. **Mastitis** or breast infection can be caused by bacterial contamination from the breastfeeding infant’s mouth. Symptoms include elevated temperature, localized inflammation, breast tenderness, general malaise, and muscle aching. Symptoms of a urinary tract infection include elevated temperature, frequent voiding, urgency to void, and pain upon voiding. Back pain, as well as nausea and vomiting, are common with pyelonephritis. Lung infection, or

pneumonia, may be seen especially in the patient who has received **general anesthesia**. Symptoms include decreased or abnormal breath sounds, cough, and chest wall discomfort. An infection in a blood vessel, phlebitis, may be caused by the introduction of **bacteria** by a contaminated intravenous needle or at the site of a blood clot, thrombophlebitis. Wound sites in the post-partum woman may include the episiotomy or cesarean section incision. These sites, if infected, would have inflammation, swelling, and drainage, and the patient would have an elevated temperature. It is interesting to note that while vaginal secretions contain up to 10 billion organisms per gram of fluid, only 1% of post-partum women develop infection in perineal tears or episiotomies.

Diagnosis

Diagnosis of puerperal infection is made on the basis of the presenting symptoms, which must be thoroughly investigated. In addition, diagnostic testing may include a **complete blood count**, chest x-ray, **urinalysis**, or **wound culture**. High vaginal or endocervical cultures are not helpful in identifying a uterine pathogen, and transabdominal uterine aspiration is not recommended, as it may only serve to spread the infection. Blood cultures may be done, but they are positive only 8% of the time. Radiologic testing is helpful if symptoms are resistant to initial treatment or if pneumonia is suspected. Ultrasound or a computed tomography scan (CT scan) may identify a potential abdominal **abscess** or blood clot. **Magnetic resonance imaging** (MRI) may also be used if symptoms of a blood clot are present.

Treatment

Antibiotic therapy is the mainstay of treatment in puerperal infection. Hospitalization may or may not be necessary. Clindamycin and gentamicin may be used as initial therapy, as they are broad-spectrum antibiotics; that is, covering more than one organism. Ampicillin may be added if symptoms persist. If an abscess has been diagnosed, surgical drainage may be required. In the presence of thrombophlebitis, heparin therapy will be needed to provide anticoagulation.

Prognosis

With access to appropriate antibiotics, the prognosis of rapid recovery from puerperal infection is excellent.

Health care team roles

Physicians and nurses are involved in the prevention, diagnosis, and treatment of puerperal infection.

KEY TERMS

Endometritis—Inflammation of the mucous membrane lining the inner surface of the uterus.

Lochia—Discharge from the uterus of blood, mucus, and tissue during the puerperal period.

Mastitis—Inflammation of the breast.

Nosocomial—Pertaining to a hospital or infirmary.

Post-partum—After childbirth.

Puerperal—Period immediately following childbirth.

Good **prenatal care** is essential for avoiding the risk of infection after childbirth. Post-partum nurses assess patients for signs and symptoms of infection and educate patients about these signs and symptoms prior to discharge. Home health nurses making follow-up visits assess patients for signs and symptoms of infection. Emergency physicians are seeing an increasing number of post-partum patients presenting with a **fever** or evidence of infection due to earlier discharge from the hospital after childbirth.

Prevention

Identification of such risk factors as premature rupture of membranes or the use of prophylactic antibiotics at the time of an emergent cesarean section will lower the incidence of puerperal infection. The fundamental practice of strict **aseptic technique** is the first line of prevention.

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Janine Diebel, R.N.

Pulmonary artery catheterization see **Swan-Ganz catheterization**

Pulmonary function test

Definition

Pulmonary function tests are a group of procedures that measure the function of the **lungs**, revealing problems in the way a patient breathes. These tests can determine the cause of shortness of breath and may help confirm the diagnosis of such lung diseases as **asthma**, chronic bronchitis, or **emphysema**. The tests may also be performed before any major lung surgery to make sure the person will not be at risk of complications because of reduced lung capacity.

Purpose

Pulmonary function tests can help diagnose a range of respiratory diseases that might not otherwise be obvious to the clinician or the patient. These tests are important, since many kinds of lung problems can be successfully treated if detected early.

The tests are also used to measure how a lung disease is progressing, and how serious the lung disease has become. Pulmonary function tests can also be used to assess a patient's response to different treatments.

If a patient shows signs of decreased lung function relative to the normal values for a person of his or her race, sex, age, height, and weight, that person may suffer from a pulmonary disease. There are two types of causes of abnormal pulmonary function, obstructive lung diseases and restrictive lung diseases.

Obstructive lung diseases are characterized by a decreased ability to get air out of the lungs. A patient with an obstructive lung disease generally does not experience difficulty getting air into his or her lungs. Obstructive lung diseases are most easily remembered with the acronym CABBE: **cystic fibrosis**, asthma, bronchiectasis, chronic bronchitis, and emphysema.

Restrictive lung diseases are characterized by a decreased capacity to draw air into the lungs. A patient with a restrictive lung disease generally does not experience difficulty getting air out of his or her lungs. The cause of restrictive lung diseases may be either directly related to a dysfunction of the lungs (intrapulmonary) or not related to a dysfunction of the lungs (extrapulmonary). Intrapulmonary restrictive lung diseases include **pneumonia**, pulmonary fibrosis, and pulmonary **edema**. Extrapulmonary causes of restrictive lung diseases include rib **fractures**, head trauma, and neuromuscular disorders.

Precautions

Before any pulmonary function test is performed by a patient, the clinician ordering the test should be aware of any conditions that the patient may have that may affect the reliability of the test results. Also, because pulmonary function testing requires deep breathing, the test itself may aggravate these same conditions.

Conditions in a patient that contraindicate pulmonary function testing include: the coughing-up of **blood** from the respiratory tract (hemoptysis); a collapsed or partially collapsed lung (pneumothorax); an unstable **heart** condition, recent heart attack, or blood clot near the lungs; an abnormal localized bulging of a blood vessel (aneurysm) in the chest, abdomen, or head; recent surgery of the chest or abdomen; recent eye surgery; and current nausea or vomiting. If a patient suffers from one or more of these conditions, pulmonary function tests should be postponed until these conditions are resolved.

The patient should not wear clothing that constricts the chest area. Patients should not have eaten a heavy meal three hours or less before the test. Smokers should provide their smoking history and the time of their last cigarette. In order for pulmonary function tests to yield accurate results, the patient must be able to respond to direction; so the tests may not be useful in very young children, uncooperative patients, and physically incapacitated individuals.

Description

One of the most common of the pulmonary function tests is spirometry. This test, which can be given in a hospital or doctor's office, measures how much and how fast the air is moving in and out of the lungs. This test is covered in greater detail in the separate **spirometry tests** entry.

A peak flow meter can determine how much a patient's airways have narrowed. A test of **blood gases** is a measurement of the concentration of oxygen and car-

bon dioxide in the blood, which shows how efficient the **gas exchange** is in the lungs.

Another lung function test reveals the efficiency of the lungs in absorbing gas from the blood. This efficiency is measured by testing the volume of carbon monoxide a person breathes out after a known volume of the gas has been inhaled.

Preparation

The healthcare provider conducting a pulmonary function test should explain the test and any and all potential side effects to the patient prior to the test being performed. The health care provider should then demonstrate the proper breathing technique for the patient, and the patient should then practice this technique until he or she is able to accurately duplicate the proper technique on two consecutive trials. The health care provider should also indicate that while most side effects of pulmonary function tests are extremely rare, the patient should stop the test if he or she becomes extremely uncomfortable or feels intense **pain** in the head, eye, chest, or abdomen while performing the test.

Prior to the test, the age, race, and sex of the patient should be recorded, along with a height measurement in stocking feet and a weight measurement. This information will allow each individual's results to be compared to normal values for people in the same demographic category.

Aftercare

There is usually no patient care required after the administration of a pulmonary function test. If a patient feels lightheaded or dizzy, he or she should lie down until the symptoms subside. In rare cases, oxygen may have to be administered to prevent pneumothorax or to restore normal breathing patterns.

Complications

In general, pulmonary function tests are safe procedures that simply require deep breathing. In very rare instances complications can occur. These include pneumothorax; increased fluid pressure between the bones of the **skull** and the **brain** (increased intracranial pressure); loss of consciousness, dizziness, and/or lightheadedness; chest pain; uncontrollable coughing; and contraction of an **infection** from the test equipment.

Results

Normal results

Normal test results are based on a person's age, height, weight, race, and gender. Normal results are



A cystic fibrosis patient receives treatment. (Custom Medical Stock Photo. Reproduced by permission.)

expressed as a percentage of the predicted lung capacity for a person of the same age, height, weight, race, and sex. Any measurement within 20% of the predicted value is considered a normal result.

Abnormal results

Abnormal results mean that the person's lung capacity is less than 80% of the predicted value. Such findings usually mean that there is some degree of chest or lung disease.

Health care team roles

Pulmonary function tests are generally ordered by a primary care doctor (M.D. or D.O.) or advanced practice nurse; and performed either by a physician, nurse, or respiratory technician under the direction of a doctor specifically trained in pulmonary function testing. When the results of pulmonary function testing are inaccurate, the most frequent reason is inadequate **patient education**

KEY TERMS

Asthma—A disease that causes recurrent and generally unpredictable narrowing of the larger airways of the lungs (bronchi), which makes breathing difficult. Asthma may be caused by infection, allergies, smoking, exercise, or stress.

Bronchitis—Inflammation of one or more of the airways (bronchi) that lead from the windpipe (trachea) into the lungs. Bronchitis is usually caused by an infection.

Emphysema—A disease in which the small air sacs in the lungs become damaged, causing shortness of breath. In severe cases it can lead to respiratory or heart failure.

Obstructive lung disease—Any disease that lessens a patient's ability to get air out of his or her lungs. Generally, people with obstructive lung disease do not have difficulty getting air into their lungs.

Pneumothorax—A collapsed or partially collapsed lung.

Restrictive lung disease—Any disease that lessens a patient's ability to get air into his or her lungs. Generally, people with restrictive lung disease do not have difficulty getting air out of their lungs.

and/or technician training. It is recommended that personnel conducting pulmonary function testing have one of the following credentials: certified **respiratory therapy** technician (CRTT); registered respiratory therapist (RRT); certified pulmonary function technologist (CPFT); or registered pulmonary function technologist (RPFT). A doctor specializing in diseases of the lungs (pulmonologist) may be consulted to examine abnormal pulmonary function test results.

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Paul A. Johnson

Pulmonary rehabilitation

Definition

Pulmonary rehabilitation is a multidisciplinary, individually designed intervention program, including **exercise** and education, that helps patients with chronic lung disorders manage the physiological and psychosocial symptoms of their condition and improve their level of daily functioning and well-being.

Purpose

The purpose of a pulmonary rehabilitation program is to help patients with chronic obstructive pulmonary disease (COPD) or other chronic lung conditions manage their condition. Exercise and education are provided to help increase the patient's level of fitness and independent functioning; reduce dyspnea and psychological symptoms (**anxiety**, depression, social isolation); slow down or prevent the progression of disease; and improve quality and possibly length of life.

Pulmonary rehabilitation has not been found to improve pulmonary function, and that is not its goal. Other measures of physiologic improvement such as improved muscle function, cardiac function, and aerobic function have been found, and the main purpose of **cardiac rehabilitation** is to "reverse the deconditioning and psychosocial accompaniments of pulmonary disability." Pulmonary rehabilitation is also increasingly recognized as valuable in preparation for lung transplantation and lung volume-reduction surgery, which require patients to have good physical conditioning.

Precautions

Patients should be examined by a physician before beginning rehabilitation. Certain coexisting medical conditions, especially those that preclude or limit exercise, may contraindicate pulmonary rehabilitation, or require

Essentials of pulmonary therapy

Treatment components	Purpose	How to perform	When to use
Breathing exercises	Assists in removing secretions; relaxation; and used to increase thoracic cage mobility and tidal volume	Patient is taught to produce a full inspiration followed by a controlled expiration; use hand placement for sensory feedback	When patients are breathing spontaneously
Coughing	Removal of secretions from the larger airways	Steps: (1) Inspiratory gasp; (2) Closing of the glottis; (3) Contraction of expiratory muscles; (4) Opening of the glottis	When patients are breathing spontaneously
Percussion	Used with postural drainage for mobilization of secretions	Rhythmic clapping of cupped hands over bare skin or thin material covering area of lung involvement; performed during inspiration and expiration	When coughing or suctioning, breathing exercises, and patient mobilization are not adequate to clear retained secretions
Postural drainage	Mobilize retained secretions through assistance of gravity	Patient positioned so that involved segmental bronchus is uppermost	Same as above
Vibration	Used with postural drainage for mobilization of secretions	Intermittent chest wall compression over area of lung involvement; performed during expiration only	Same as above

SOURCE: Mackenzie, C.F., et al. *Chest Physiotherapy in the Intensive Care Unit*. Baltimore, MD: Williams & Wilkins, 1981.

modification and special precautions. Since treatment is individualized, any special needs will be addressed in the exercise prescription and program design. Some particular conditions that may contraindicate participation in pulmonary rehabilitation include acute respiratory **infection**, ischemic cardiac disease, congestive **heart failure**, serious **liver** dysfunction, disabling stroke, severe psychiatric or cognitive disorders, acute cor pulmonale, severe pulmonary **hypertension**, and metastatic **cancer**.

Description

Pulmonary rehabilitation is a multidisciplinary, comprehensive program of education, exercise, and behavior modification, individually designed for patients with such lung diseases as COPD. COPD includes such conditions as chronic bronchitis and **emphysema**, which can be progressive and life-threatening. Other chronic lung conditions that may be suitable for pulmonary rehabilitation include **cystic fibrosis**, **asthma**, bronchiectasis, and environmental lung disease, as well as such neuromuscular disorders as **Parkinson's disease** and **multiple sclerosis**.

The rehabilitation program is designed to help patients learn more about their condition and how to manage its symptoms, as well as to take active steps, such as smoking cessation, oxygen use, and exercise, in order to improve their level of physical functioning; stop the progression of the disease as much as possible; and learn how to better live with the condition. Improved physical functioning, reduction in physical and psychological symptoms, and ability to perform activities of daily living (ADLs) more easily and independently, can contribute to improved quality of life.

A typical program, which is individually designed but involves group participation, may last up to three hours per session, a few days each week. Programs generally last a few weeks to a few months, and prepare the patient to continue exercise, symptom management, and other skills learned in the program on their own. An in-home follow-up program may also be included. Patients may participate in rehabilitation as inpatients or outpatients, and will also be encouraged to exercise on their own at home if it is safe for them to do so without monitoring. Some insurance companies cover all or part of the rehabilitation program.

The two main components of the daily program are exercise and education. Exercise is important for maintaining or improving muscle strength, endurance and overall fitness, which may have declined due to inactivity and symptoms of the disease. Decreased physical activity and associated decline in fitness play a large part in causing the physical limitations associated with COPD. A regular exercise program can improve overall fitness and energy, and make performance of ADLs easier.

The exercise program is individually prescribed to meet the physical needs of each patient, and includes a warm-up and cool-down period, and aerobic activity. The warm-up and cool-down periods may include stretching and light strength or resistance training. Exercises involving upper and lower extremities are important for overall fitness and for improvement in function during specific activities. For example, lower body exercise helps with ambulation, stair climbing, and general fitness; and conditioning of the arms facilitates improved functioning in many tasks that require arm and upper body use, such as grooming, cooking, and household

KEY TERMS

ADL—Activity of daily living.

COPD—Chronic obstructive pulmonary disease. Included are such conditions as chronic bronchitis and emphysema.

Dyspnea—Difficulty breathing or shortness of breath

Spirometer—A device used to measure lung performance.

tasks. Some of the muscle groups used in arm and upper torso positioning serve respiratory functions, and thus upper extremity conditioning can also have a beneficial effect on ventilation.

The aerobic exercise component comprises such activities as walking or using a stationary bicycle, treadmill, or other equipment. Exercise is monitored by physical therapists, respiratory nurses, or other qualified health care providers. **Blood pressure, heart rate, oxygen saturation, and dyspnea levels** are evaluated to determine the appropriate exercise prescription, and may be monitored during exercise sessions. Ventilatory training may also be included in the exercise program for certain patients. This therapy involves controlled breathing exercises; such **chest physical therapy** techniques as postural drainage, chest percussion, directed cough, and vibration; and training of the inspiratory muscles.

The educational component of the rehabilitation program consists of classes, reading materials, and counseling or training sessions that cover various specific subjects, procedures, and issues of importance to patients with chronic pulmonary disease. Education is provided by a variety of professionals, including respiratory nurses, respiratory therapists, occupational therapists, physical therapists, social workers, and dietitians. A psychologist or other mental health professional may provide counseling to address depression, anxiety, social isolation, or other psychosocial symptoms related to COPD.

Some of the educational subjects covered include anatomy and physiology related to pulmonary function and disease; exercise theory; **nutrition**; techniques for using oxygen and inhalers; and ways to conserve energy. Education related to good nutrition and weight management can be helpful, because patients may be undernourished and have muscle wasting of the respiratory muscles, which can make breathing more difficult. If anemia is present, it can decrease oxygen-carrying capacity. Electrolyte imbalances affect cardiopulmonary perform-

ance, so these and other deficiencies should be treated in order to improve functioning. If patients are overweight, the extra weight increases oxygen and energy demands and may increase fatigue. Patients who have not yet stopped smoking should be strongly encouraged to do so.

Preparation

Examination and referral by a physician are generally required before a patient begins pulmonary rehabilitation. A medical history should be provided to the rehabilitation team. Some tests that may be administered prior to the patient's entry into a rehabilitation program include pulmonary function tests (PFTs), chest x-rays, arterial **blood gas (ABG)** analysis, pulse oximetry, and sputum examination. PFTs are performed with a spirometer to measure lung performance and determine the presence and extent of lung disease. A chest x-ray can detect emphysema and other lung disease, including **lung cancer**, for which there is increased risk among smokers with COPD. Pulse oximetry measures oxygen in the blood and helps determine when supplemental oxygen is required. Exercise tests may be used to determine the length and intensity of the exercise prescription.

Aftercare

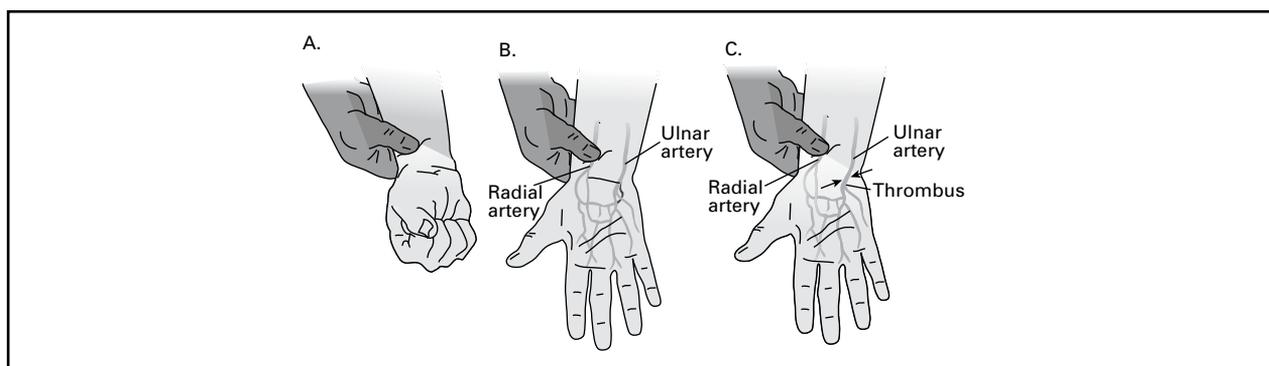
Patients may be able to participate in various follow-up or maintenance programs or support groups, as well as check-ins with their physician, in order to maintain benefits and continue monitoring their condition.

Complications

Risk of such complications as muscle injury or cardiac reactions is always present with exercise, but will be minimized by careful exercise prescription and monitoring. Disease-related complications that should be watched for include **fever**, unusual or extreme shortness of breath, irregular pulse, unanticipated weight changes, gastric complaints, or any other change that is unusual for the patient.

Results

The primary goals of cardiac rehabilitation are to reduce symptoms and respiratory impairment, and to improve the patient's quality of life and possibly prolong their life. Some of the specific changes that affect overall improvement in health, functioning and quality of life include: improvement in pulmonary function, reduction of the work involved in breathing, increased efficiency of energy use, improved exercise performance, increased function in activities of daily living, alleviation of dysp-



Thumb placement for pulse assessment. (Delmar Publishers, Inc. Reproduced by permission.)

nea, nutritional correction, and improved emotional state. Other possible results are a decrease in frequency and duration of hospital stays and decrease in use of other health care resources.

Health care team roles

The various educational and therapeutic components of a comprehensive pulmonary rehabilitation program are best addressed by a variety of health care professionals. The team may include respiratory nurses; respiratory, physical and occupational therapists; psychologists or other mental health professionals; exercise specialists; and dietitians, as well as a program director. The physical therapist may be involved in exercise prescription and monitoring; providing education in areas related to anatomy, physiology, exercise, and **physical therapy**; and providing such other therapeutic treatments as chest physical therapy.

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Diane Fanucchi, B.A., C.M.T.

Pulse assessment

Definition

Pulse assessment is the detection of a patient's pulse.

Purpose

Pulse assessment is performed to establish a baseline on a patient's admission (from which to compare any significant changes), and to detect any abnormalities from the healthy state.

Precautions

As there may be no prior knowledge of the patient's previous pulse recordings for comparison, it is important for the nurse or other health professional to know the range of normal values that apply to patients of different ages. Any known medical and surgical history or abnormal readings of any of the **vital signs**, as well as details



A doctor checks a patient's pulse at the bilateral radial artery. (Photograph by Dagmar Ehling. Science Source/Photo Researchers. Reproduced by permission.)

of any current medication the patient is taking, should be obtained. Exertion, such as climbing stairs, may affect the results. Therefore the patient should have rested prior to having their pulse taken, and refrained from consuming tobacco, caffeinated drinks, and alcohol 30 minutes prior to the procedure. Of course, these precautions cannot be taken in an emergency situation.

Description

The pulse is checked as one indicator of abnormalities of the **heart** by observing the rate, rhythm, and the strength and tension of the beat against the arterial wall. The pulse may be recorded hourly to every four hours, or p.r.n. (when required), based on the patient's condition. For example, the pulse may be recorded postoperatively every 15 minutes in the recovery room.

Preparation

The equipment required for pulse assessment is a watch with a sweep second hand or a digital readout. The pulse may be read where a surface artery runs over a bone, e.g. the radial artery (in the forearm), carotid artery

(in the neck), temporal artery (at the temple), popliteal artery (at the back of the knee), or dorsalis pedal artery (at the instep). The radial artery in the wrist is the option used most often. The physician may choose such sites as the carotid artery pulse if atrial or ventricular problems are suspected.

To take the radial pulse, the patient should be sitting or lying comfortably, so that the readings are taken in similar positions each time and that there is little excitement to affect the results. The patient's forearm should not be raised to a level higher than the heart, as this position will change the reading. The nurse should place the index, middle, and ring fingers over the radial artery, which is located above the wrist on the anterior surface of the thumb side of the wrist. Apply gentle pressure to avoid obstructing the patient's **blood** flow. The rate, rhythm, strength and tension of the pulse should be noted. Using a watch, the pulsations that are felt where the artery rests against the bone are counted for half a minute, and the result doubled to give the beats per minute. However, any irregularities noted within the 30-second count means that the pulse should be recorded for one full minute to avoid any discrepancies.

Aftercare

The nurse should make the patient comfortable and reassure him or her that recording the pulse is part of normal health checks and that it is necessary to ensure the patient's health is being correctly monitored. Any abnormalities in the pulse must be reported in the nurse's notes and relayed to the attending physician.

Results

The average heart rate for older children and adults can range from 50 to 90 beats per minute (bpm). This is an average; rates vary between males and females, with age, and with the patient's health and level of fitness. It is not abnormal for athletes to display a low pulse rate.

The pulse is an indicator of the health of the heart and the arterial circulation. Such factors as **anxiety**, medication, or pulmonary disease may also cause the heart rate to be faster or slower.

A low-volume, or weak, pulse may be caused by a number of factors, including **myocardial infarction**, **shock**, intracranial pressure, or the use of vasoconstrictor drugs.

Pulse pressure may become raised due to arteriosclerosis, as the heart has to pump harder to promote the flow of blood around the body. This high-pressure pulse is called a bounding pulse, and may also be caused by such conditions as **fever**, **pregnancy**, or thyrotoxicosis. It may also be an indicator that pulmonary disease is present.

Other conditions that can be detected in part by pulse assessment include tachycardia (a heartbeat that is too fast) and bradycardia (a heartbeat that is too slow). The nurse would also be able to detect missed heart beats and pulsus alternans (alternating strong and weak beats).

The pulse is recorded and compared with normal ranges for the patient's age, gender, and medical condition, and a decision is made regarding the interpretation of the results as to whether any further action should be taken.

Health care team roles

Patients may ask questions about specific concerns they have regarding pulse recordings or a particular disease. Nurses should have a thorough knowledge of what pulse irregularities indicate to enable them to answer the patient's questions, or provide counseling on the prevention of illness and injuries, or direct the person to their doctor. Further tests may be performed to evaluate the heart and diagnose abnormalities.

KEY TERMS

Amplitude—The fullness of the pulse.

Arteriosclerosis—Hardening and thickening of the walls of the arteries, causing loss of elasticity. It may also include calcium deposits in the arteries.

Bradycardia—A slow heartbeat or pulse below 60 bpm in an adult.

p.r.n.—*pro re nata*, when required.

Pulsus alternans—Alternating weak and strong beats of the pulse.

Tachycardia—A rapid heartbeat or pulse above 100 bpm in an adult.

Thyrotoxicosis—Hyperthyroidism.

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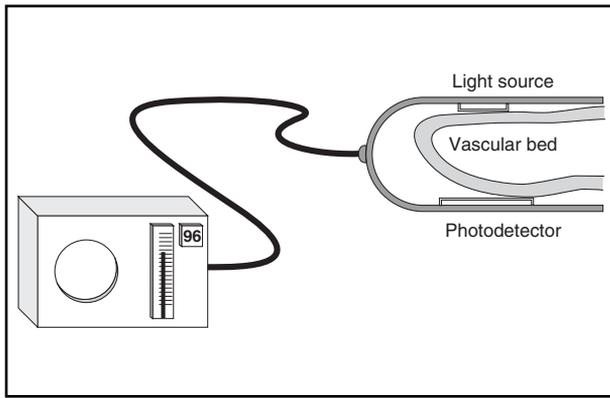
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Margaret A. Stockley, RGN

Pulse oximeter

Definition

The pulse oximeter is a photoelectric instrument for measuring oxygen saturation of the **blood**.



A pulse oximeter uses infrared light and a photo sensor to detect the amount of oxygen in a patient's blood.

(Illustration by Argosy. Courtesy of Gale Group.)

Purpose

A pulse oximeter measures the amount of oxygen present in the blood by registering pulsations within an arteriolar bed. It is a noninvasive method widely used in the hospital, including for newborns, patients with pulmonary disorders, and patients undergoing pulmonary and cardiac procedures. Oxygen levels can be estimated during **exercise**, surgery or medical procedures, or while the patient is asleep.

Description

Oximeters are used in such hospital settings as intensive care units, pulmonary units, and in health care centers. Portable hand-held devices are available, and are used for spot-checking patients and for in-home use with a doctor's supervision.

The oximeter consists of a light-emitting diode (LED); a photodetector probe containing a permanent or disposable sensor; alarms for pulse rate and oxygen levels; a display screen; and cables. The device works by emitting beams of red and infrared light that are passed through a pulsating arteriolar bed. Sensors detect the amount of light absorbed by oxyhemoglobin and deoxyhemoglobin in the red blood cells. The ratio of red to infrared light measured by the photodetector indicates the amount of oxygen present in the blood. The sensor is attached to the body over the arteriolar area in the ear, the finger tip, the big toe, or across the bridge of the nose. Clip sensors can be used on fingers and the earlobe.

Operation

Several steps can be taken to enhance accurate readings. If possible, the patient should be instructed not to

KEY TERMS

Arteriolar bed—An area in which arterioles cluster between arteries and capillaries.

Arterioles—The smallest branches of arteries.

Capillaries—Tiny blood vessels with a diameter of a red blood cell through which a single layer of cells flows.

Deoxyhemoglobin—Hemoglobin with oxygen removed.

Oxyhemoglobin—Hemoglobin combined with oxygen.

smoke 24 hours prior to pulse oximetry. Fingernail polish should be removed if the oximeter will be attached to the finger. For patients with poor circulation, hands should be slowly warmed with warm towels before attaching the oximeter. Abnormally high or low temperatures, as well as reduced hemoglobin, can influence the amount of oxygen adhering to the hemoglobin within the red blood cells, altering the reading.

Care should be taken with attaching the sensors and selecting the site for optimum reading levels. The sensor should be wrapped securely around the finger to prevent outside light from interfering with the reading and rendering it invalid. An appropriate site is chosen to monitor the oxygen levels by ensuring that there is strong arterial pulsation, and that the capillary bed fills promptly if squeezed.

The device must not be used near flammable anesthetics.

Maintenance

Older devices may be affected by motion. They should be checked regularly to insure proper function.

Health care team roles

Nurses and allied health professionals attach the pulse oximeter and explain to the patient that it is used for monitoring purposes. Staff monitor the site where the sensor has been applied every four hours for clip sensors and every six hours for wrapped sensors. Any loss of pulsation, swelling, or change in color requires a change of site.

Training

Staff should be familiar with the device and the department's protocol to ensure standardization in operating the equipment.

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Margaret A. Stockley, RGN

Punctures *see* **Wounds**

Pyelography *see* **Intravenous urography**

Pyorrhea *see* **Periodontitis**

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Q

Qigong

Definition

Qigong (pronounced “chee-gung,” also spelled *chi kung*) is translated from the Chinese to mean “energy cultivation” or “working with the life energy.” Qigong is an ancient Chinese system of postures, exercises, breathing techniques, and meditations. Its techniques are designed to improve and enhance the body’s *qi*. According to traditional Chinese philosophy, *qi* is the fundamental life energy responsible for health and vitality.

Origins

Qigong originated before recorded history. Scholars estimate qigong to be as old as 5000–7000 years. Tracing the exact historical development of qigong is difficult, because it was passed down in secrecy among monks and teachers for many generations. Qigong survived through many years before paper was invented, and it also survived the Cultural Revolutions in China of the 1960s and 1970s, which banned many traditional practices.

Qigong has influenced and been influenced by many of the major strands of Chinese philosophy. The Taoist philosophy states that the universe operates within laws of balance and harmony, and that people must live within the rhythms of nature—ideas that pervade qigong. When Buddhism was brought from India to China around the seventh century A. D., **yoga** techniques and concepts of mental and spiritual awareness were introduced to qigong masters. The Confucian school was concerned with how people should live their daily lives, a concern of qigong as well. The martial arts were highly influenced by qigong; and many of them, such as **t’ai chi** and kung fu, developed directly from it. Traditional Chinese medicine also shares many of the central concepts of qigong, such as the patterns of energy flow in the body. Acupuncture and **acupressure** use the same points on the body that qigong seeks to stimulate. In China,

qigong masters have been renowned physicians and healers. Qigong is often prescribed by Chinese physicians as part of the treatment.

Due to the political isolation of China, many Chinese concepts have been shrouded from the Western world. Acupuncture was only “discovered” by American doctors in the 1970s, although it had been in use for thousands of years. With an increased exchange of information, more Americans have gained access to the once-secret teachings of qigong. In 1988, the First World Conference for Academic Exchange of Medical Qigong was held in Beijing, China, where many studies were presented to attendees from around the world. In 1990, Berkeley, California hosted the First International Congress of Qigong. In the past decade, more Americans have begun to discover the beneficial effects of qigong, which motivate an estimated sixty million Chinese to practice it every day.

Benefits

Qigong may be used as a daily routine to increase overall health and well-being, as well as for disease prevention and longevity. It can be used to increase energy and reduce **stress**. In China, qigong is used in conjunction with other medical therapies for many chronic conditions, including **asthma**, **allergies**, **AIDS**, **cancer**, headaches, **hypertension**, depression, mental illness, strokes, **heart** disease, and **obesity**.

Description

Basic concepts

In Chinese thought, *qi*, or *chi*, is the fundamental life energy of the universe. It is invisible but present in the air, water, food and sunlight. In the body, *qi* is the unseen vital force that sustains life. We are all born with inherited amounts of *qi*, and we also get acquired *qi* from the food we eat and the air we breathe. In qigong, the breath is believed to account for the largest quantity of acquired

qi, because the body uses air more than any other substance. The balance of our physical, mental, and emotional levels also affect qi levels in the body.

Qi travels through the body along channels called meridians. There are twelve main meridians, corresponding to the twelve principal organs as defined by the traditional Chinese system: the lung, large intestines, **stomach**, spleen, heart, **small intestine**, urinary bladder, kidney, **liver**, **gallbladder**, pericardium, and the “triple warmer,” which represents the entire torso region. Each organ has qi associated with it, and each organ interacts with particular emotions on the mental level. Qigong techniques are designed to improve the balance and flow of energy throughout the meridians, and to increase the overall quantity and volume of qi. In qigong philosophy, mind and body are not separated as they often are in Western medicine. In qigong, the mind is present in all parts of the body, and the mind can be used to move qi throughout the body.

Yin and yang are also important concepts in qigong. The universe and the body can be described by these two separate but complementary principles, which are always interacting, opposing, and influencing each other. One goal of qigong is to balance yin and yang within the body. Strong movements or techniques are balanced by soft ones, leftward movements by rightward, internal techniques by external ones, and so on.

Practicing qigong

There are thousands of qigong exercises. The specific ones used may vary depending on the teacher, school, and objective of the practitioner. Qigong is used for physical fitness, as a martial art, and most frequently for health and healing. Internal qigong is performed by those wishing to increase their own energy and health. Some qigong masters are renowned for being able to perform external qigong, by which the energy from one person is passed on to another for healing. This transfer may sound suspect to Western logic, but in the world of qigong there are some amazing accounts of healing and extraordinary capabilities demonstrated by qigong masters. Qigong masters generally have deep knowledge of the concepts of Chinese medicine and healing. In China, there are hospitals that use medical qigong to heal patients, along with herbs, acupuncture, and other techniques. In these hospitals, qigong healers use external qigong and also design specific internal qigong exercises for patients' problems.

There are basic components of internal qigong sessions. All sessions require warm-up and concluding exercises. Qigong consists of postures, movements, breathing techniques, and mental exercises. Postures may involve standing, sitting, or lying down. Movements include

stretches, slow motions, quick thrusts, jumping, and bending. Postures and movements are designed to strengthen, stretch, and tone the body to improve the flow of energy. One sequence of postures and movements is known as the “Eight Figures for Every Day.” This sequence is designed to quickly and effectively work the entire body, and is commonly performed daily by millions in China.

Breathing techniques include deep abdominal breathing, chest breathing, relaxed breathing, and holding breaths. One breathing technique is called the “Six Healing Sounds.” This technique uses particular breathing sounds for each of six major organs. These sounds are believed to stimulate and heal the organs.

Meditations and mind exercises are used to enhance the mind and move qi throughout the body. These exercises are often visualizations that focus on different body parts, words, ideas, objects, or energy flowing along the meridians. One mental **exercise** is called the “Inner Smile,” during which the practitioner visualizes joyful, healing energy being sent sequentially to each organ in the body. Another mental exercise is called the “Microscopic Orbit Meditation,” in which the practitioner intently meditates on increasing and connecting the flow of qi throughout major channels.

Discipline is an important dimension of qigong. Exercises are meant to be performed every morning and evening. Sessions can take from 15 minutes to hours. Beginners are recommended to practice between 15–30 minutes twice a day. Beginners may take classes once or twice per week, with practice outside of class. Classes generally cost between \$10–\$20 per session.

Preparations

Qigong should be practiced in a clean, pleasant environment, preferably outdoors in fresh air. Loose and comfortable clothing is recommended. Jewelry should be removed. Practitioners can prepare for success at qigong by practicing at regular hours each day to promote discipline. Qigong teachers also recommend that students prepare by adopting lifestyles that promote balance, moderation, proper rest, and healthy diets, all of which are facets of qigong practice.

Precautions

Beginners should learn from an experienced teacher, as performing qigong exercises in the wrong manner may cause harm. Practitioners should not perform qigong on either full or completely empty stomachs. Qigong should not be performed during extreme weather, which may have negative effects on the body's energy systems.

Menstruating and pregnant women should perform only certain exercises.

Side effects

Side effects may occur during or after qigong exercises for beginners, or for those performing exercises incorrectly. Side effects may include dizziness, dry mouth, fatigue, headaches, insomnia, rapid heartbeat, shortness of breath, heaviness or numbness in areas of the body, emotional instability, **anxiety**, or decreased concentration. Side effects generally clear up with rest and instruction from a knowledgeable teacher.

Research and general acceptance

Western medicine generally does not endorse any of the traditional Chinese healing systems that utilize the concept of energy flow in the body, largely because this energy has yet to be isolated and measured scientifically. New research is being conducted using sophisticated equipment that may verify the existence of energy channels as defined by the Chinese system. Despite the lack of scientific validation, the results of energy techniques including qigong and acupuncture have gained widespread interest and respect. Furthermore, qigong masters have demonstrated to Western observers astounding control over many physical functions, and some have even shown the ability to increase electrical voltage measured on their skin's surface. Most of the research and documentation of qigong's effectiveness for medical conditions has been conducted in China, and is slowly becoming more available to English readers. Papers from the World Conferences for Academic Exchange of Medical Qigong are available in English, and address many medical studies and uses of qigong.

Training and certification

In China, qigong has been subject to much government regulation, from banning to increased requirements for teachers. In the United States at this time, qigong has not been regulated. Different schools may provide teacher training, but there are no generally accepted training standards. Qigong teachings may vary depending on the founder of the school, who is often an

KEY TERMS

Martial arts—Group of diverse activities originating from the ancient fighting techniques of the Orient.

Meridians—Channels or conduits through which qi travels in the body.

Qi—Basic life energy, according to traditional Chinese medicine.

Yin/Yang—Universal characteristics used to describe aspects of the natural world.

acknowledged Chinese master. The organizations listed below can provide further information to consumers.

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- Qigong Magazine*. PO Box 31578. San Francisco, CA 94131. (800) 824-2433.

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- Chinese National Chi Kung Institute. PO Box 31578. San Francisco, CA 94131. (800) 824-2433.
- International Chi Kung/Qi Gong Directory. 2730 29th Street. Boulder, CO 80301. (303) 442-3131.
- Qigong Human Life Research Foundation. PO Box 5327. Cleveland, OH 44101. (216) 475-4712.

Douglas Dupler

Quadriplegia see **Paralysis**

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R

Radial keratotomy

Definition

Radial keratotomy (RK) is eye surgery performed to correct **myopia** by changing the cornea's shape.

Purpose

RK was introduced in North America in 1978. RK is one of several surgical techniques for reducing or eliminating the need for corrective lenses. It is most successful in patients with low to moderate nearsightedness—people whose eyes require up to -5.00 diopters of correction.

Precautions

RK cannot help patients whose nearsightedness is caused by keratoconus, a condition in which the cornea is cone-shaped. The procedure usually is not performed on patients under 18 because their **vision** is unstable. Women who are pregnant, have just given birth, or are breast-feeding should not have RK because hormones may cause temporary corneal changes. **Glaucoma** patients or patients with any disease that interferes with healing should not have RK.

Radial keratotomy weakens the cornea, making it vulnerable to injuries long after surgery. A **head injury** after RK can cause the cornea to tear and can lead to blindness. Sports enthusiasts should be warned of this danger.

RK's success cannot be guaranteed. An ophthalmologist estimates the probability of the surgery's success in correcting vision. In some cases, patients with myopia that has caused their near vision to be clear prior to surgery may need corrective lenses for near vision following surgery. Some patients still require lenses for distance vision. RK does not eliminate **presbyopia** and the eventual need for reading glasses.

Description

With clear vision, light passes through the cornea and the lens of the eye and focuses on the retina. In a myopic patient, the eyeball is usually too long, so that light focuses in front of the retina. RK reduces myopia by flattening the cornea. This flattening reduces the cornea's focusing power, allowing the light to focus further back onto the retina, forming a clearer image.

For RK, a surgeon uses a small diamond-blade knife to make four to eight radial incisions approaching the edge of the cornea. These slits are made in a pattern that resembles the spokes of a wheel. As the cornea heals, its center flattens.

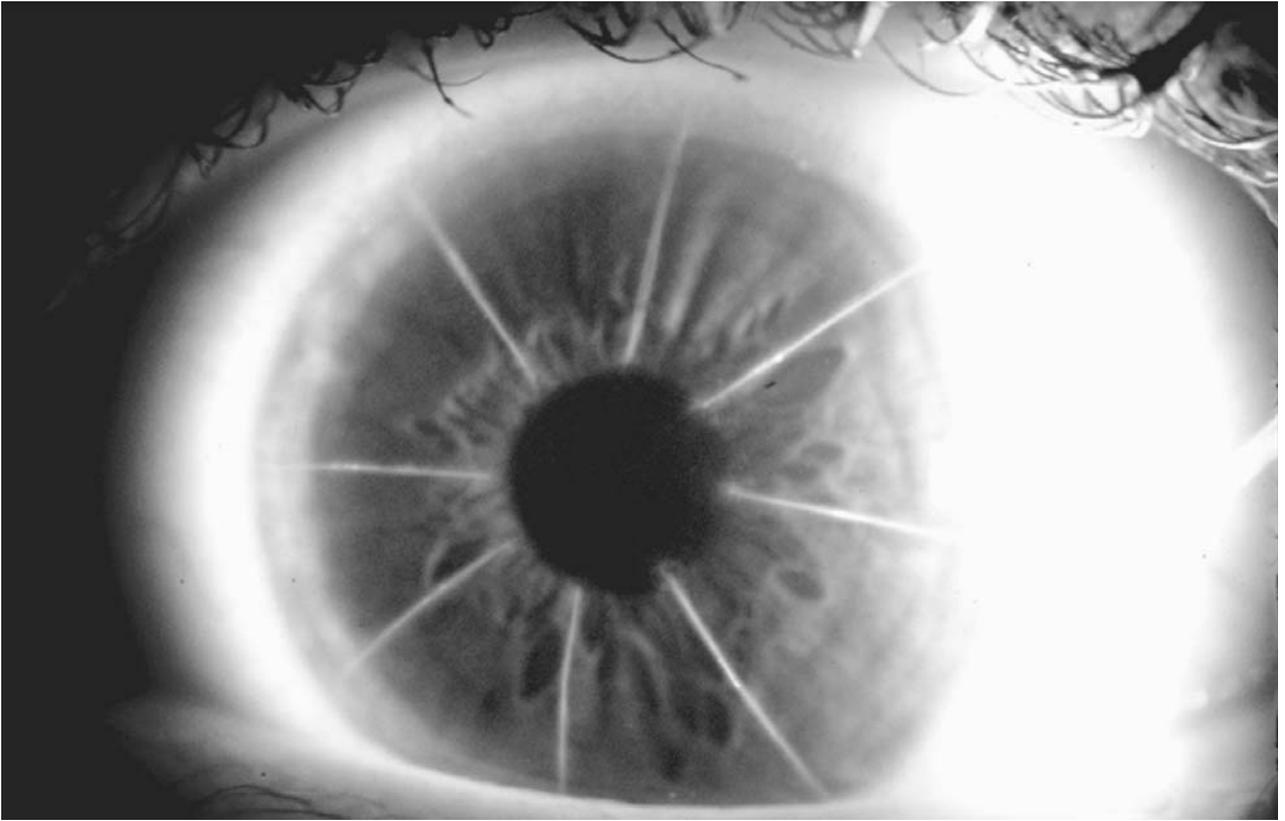
Before surgery the patient is given a sedative. A local anesthetic—usually eye drops—is used to numb the eye. The patient remains conscious during the procedure. The surgeon utilizes a surgical **microscope** to magnify the cornea while making the slits. The treatment usually lasts 30 minutes.

Most ophthalmologists perform RK on one eye at a time. Surgeons once thought they could use the results of the first eye to predict how the well the procedure would work on the second eye. However, a study in the *American Journal of Ophthalmology* in 1997 found that this was not the case. The authors cautioned that there might be other reasons not to operate on both eyes at once, such as increased risk of **infection**.

RK's costs depends on the surgeon, but usually range from \$1,000 to \$1,500 per eye. It is usually not covered by insurance.

Preparation

RK patients should be carefully screened by an ophthalmic assistant or physician before surgery is approved to avoid possible complications. This screening should include a comprehensive eye exam, either by the ophthalmologist, or a co-managing optometrist at least a few days before surgery. At this time, the physician or ophthalmic



Radial keratotomy scars on the cornea of an eye. (Photograph by Bob Masini, Phototake NYC. Reproduced by permission.)

assistant should chart any dry eye or any corneal disease that may hinder surgery. They also should perform corneal topography, which creates a map of the patient's eye.

Assistants must advise patients to discontinue wearing contact lenses weeks prior to the visual exams to make sure vision is stable; and they must also advise the doctor of contact lens wear.

Before surgery, ophthalmic staff administer eye drops and a sedative to the patient. The physician tests the patient's vision, and the patient rests while waiting for the sedative to take effect. Immediately before the surgery, ophthalmic staff administer local anesthetic eye drops.

Before beginning the procedure, the surgeon measures the cornea's thickness to decide how deep the slits should be, and marks an area in the center of the cornea called the optical zone. This is the part of the cornea in the area over the pupil that the patient sees through. No cuts are made in this region.

Aftercare

After surgery, some patients feel **pain** and are given eye drops and medications to relieve discomfort. For sev-

eral days the eye may feel scratchy and look red. This is normal. The eye also may water, burn, and be sensitive to light.

Patients should be advised to use eye drops for several weeks to protect against infection. Patients also should be told to protect the head and eyes.

The cornea heals slowly, and full recovery can take months. This is one reason RK has fallen out of favor with surgeons and patients. Laser-refractive surgeries, such as laser-assisted in situ keratomileusis (LASIK), have better results with faster recovery. Such procedures as LASIK and corneal rings have rendered RK virtually obsolete.

While the cornea is healing, patients may experience better eyesight in the morning than in the evening (or vice versa); pain; glare; starburst or halo effects; or a hyperopic shift. As the cornea flattens, vision may become more hyperopic. For this reason, the surgeon may initially undercorrect the patient. This gradual shift may occur over several years. This procedure leaves permanent scars on the cornea.

If RK does not completely correct nearsightedness, corrective lenses may be needed. Presbyopic patients will still require reading glasses.

Patients return to the surgeon for a follow-up exam one day post-operatively. After that, patients may be referred to the co-managing optometrist for the subsequent three or four visits. Patients should be advised to report any pain or nausea immediately to the attending physician.

Complications

Complications from RK include:

- cataract
- infection
- lasting pain
- tears along an incision, especially after being hit in the head or eye
- vision loss
- hyperopic shift

Complications are reduced when an ophthalmologist experienced with RK performs the surgery. Younger patients also tend to heal faster.

Results

The desired result of radial keratotomy is myopia reduction. A study reported by the National Eye Institute in 1994 tracked the success of 374 patients who had RK 10 years earlier. The study found that:

- 85% had at least 20/40 vision
- 70% did not need corrective lenses for distance vision
- 53% had 20/20 vision without glasses
- 30% still needed glasses or **contact lenses** to see clearly
- 1-3% had worse vision than before they had RK
- 40% had a hyperopic shift

Health care team roles

Allied health professionals help prepare patients for refractive surgery. Advanced and intermediate level ophthalmic technicians perform refractions and help determine the patient's eligibility for surgery. These professionals also may perform corneal topography.

Specially trained ophthalmic nurses assist during surgery. They prepare the operating room and equipment, and administer eye drops. Advanced ophthalmic technologists, who are trained for such additional duties as taking ophthalmic photographs and using ultrasound, may administer eye medications, perform tests, maintain surgical equipment and assist in refractive surgery.

KEY TERMS

Cornea—The transparent part of the eye that covers the iris and the pupil.

Diopter (D)—Unit describing the amount of focusing power of a lens.

Iris—The colored part of the eye.

Laser-assisted in situ keratomileusis (LASIK)—A type of refractive eye surgery using a laser and microkeratome to change the shape of the cornea.

Local anesthetic—Used to numb an area in which surgery or another procedure is to be done, without causing the patient to lose consciousness.

Myopia—Nearsightedness. People with myopia cannot see distant objects clearly.

Ophthalmologist—A physician who specializes in treating eyes.

Photorefractive keratectomy (PRK)—A type of refractive eye surgery using a laser to change the shape of the cornea.

Pupil—The part of the eye that looks like a black circle in the center of the iris. It is actually an opening through which light passes.

Retina—A membrane lining the back of the eye onto which light is focused to form images.

Training

The American Society of Cataract and Refractive Surgery keeps physicians informed of the latest advances in surgery. Optometrists are advised to observe surgeries and attend seminars to learn more about follow-up treatments.

Ophthalmic assistants who want to assist in these surgeries can receive additional training from certified education programs.

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American Academy of Ophthalmology. P.O. Box 7424, San Francisco, CA 94120-7424. (415) 561-8500. <<http://www.eyenet.org>>.

American Optometric Association. 243 N. Lindbergh Blvd., St. Louis, MO 63141. (314) 991-4100. <<http://www.aoanet.org/aoanet/>>.

American Society of Cataract & Refractive Surgery. 4000 Legato Road, Suite 850, Fairfax, VA 22033. (703) 591-2220. <<http://www.ascrs.org>>.

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Mary Bekker

Radiation injuries

Definition

Radiation injury, also known as radiation sickness, results from exposure to excessive radiation. The seriousness of the condition depends on the type of radiation, amount of radiation, length of exposure time, and the part of the body affected. Radiation can be defined as the process of emitting energy in the form of particles or waves. Radiation is emitted by atoms in the process of changing, whether the atomic action is a naturally occurring or humanly directed process.

Description

Found throughout the universe, radiation comes in many forms. The better known forms of radiation include light, television and radio waves, microwaves, and radar, which generally do not cause injury. There are a number of potentially damaging forms of radiation including, for example, x rays, gamma rays, the energy emitted by such radioactive substances as uranium, and the radiation generated during nuclear reactions. Perhaps the most infamous events associated with widespread radiation injury and sickness occurred during the atomic bombing of

Hiroshima and Nagasaki, Japan, which helped bring about the end of World War II; and the more recent nuclear meltdown at Chernobyl in 1986.

Radiation exposure can occur as a single large exposure, referred to as acute; or as a series of small exposures over time, referred to as chronic. Radiation sickness is generally associated with acute exposure. Chronic exposure is usually associated with such delayed medical problems as **cancer** and premature aging.

Radiation can cause damage by separating molecules into electrically charged particles, a process known as ionization. Some forms of ionizing radiation include cosmic rays, gamma rays, and x rays. Ionizing radiation damages deoxyribonucleic acid (DNA), which causes genetic mutation.

Several units of measure are used to quantify radiation energy. The roentgen, named after Wilhelm Conrad Roentgen, who discovered x rays in 1895, measures ionizing energy in air. A rad (short for radiation) indicates the transferred absorbed dose. The rem (taken from "Roentgen equivalent man") measures tissue response.

A roentgen generates approximately one rad of effect, producing approximately one rem of response. The gray and the sievert are international units equivalent to 100 rads and rems, respectively. A curie, named after the French physicists (Pierre and Marie Curie) who first began working with radiation, is a measure of radioactivity given off by a radioactive element. The average annual human exposure to natural background radiation is roughly 3 milliSieverts (mSv).

Radiation is pervasive. For example, the sun generates cosmic rays, and there are traces of radioactive elements in the air (radon), as well as in the Earth (uranium and radium, among others). Any amount of ionizing radiation will produce some damage.

Although the earth's atmosphere protects us from most of the sun's radiation, living at 5,000 ft (1,700 m) altitude in, for example, Denver, Colorado, doubles the exposure to radiation; and a flight in a commercial airliner increases it 150-fold.

Ionizing radiation is used for medical diagnosis and treatment, most commonly in the form of x rays and **CT scans**. Nuclear medicine employs radioactive isotopes to diagnose and treat medical conditions. Radioactive elements localize to specific tissues, giving off tiny amounts of radiation. Detecting that radiation provides anatomical and functional information. Radioactive chemicals are also used in the treatment of certain conditions, most common of which is the overactive thyroid. Because the thyroid is the only gland that utilizes iodine, all iodine in the body is concentrated there. A radioactive isotope of

iodine (I-131) will gradually destroy overactive thyroid tissue.

Before the potential dangers posed by excessive radiation exposure were known, those who first began working with x rays frequently died from its long-term effects, most commonly leukemia. Doses now used for medical examinations are ordinarily too small to be of concern. Methods of magnification, lead shielding, and a greater awareness of the risks have nearly eliminated the danger from diagnostic radiation. However, no level of exposure is completely safe.

It is believed that radiation is responsible for less than 1% of all human disease and for approximately 3% of all cancers. This figure does not include **lung cancer** from environmental radon, which is difficult to determine because such effects are confounded by tobacco's similar effects. Because cancers are usually faster-growing than their host tissues, they can be selectively killed by carefully measured radiation. This is most true of the lymphomas. Other cancers are less radiosensitive. Whenever radiation is used to treat cancer, care must be taken to measure the dose and aim it accurately. Even so, many cancers differ so little from the surrounding tissue that undesirable damage is unavoidable.

Newer techniques of directing radiation now provide greater safety. The gamma knife is a new surgical tool that focuses radiation with a high degree of accuracy in three dimensions, sparing surrounding tissue from radiation injury.

Causes and symptoms

Radiation damage depends upon the amount of radiation, the time over which it is absorbed, and the susceptibility of the tissue. The fastest-growing tissues are the most vulnerable, because radiation as much as triples its effects during the growth phase. Bone marrow cells that produce **blood** are the fastest-growing cells. Fetuses are also extremely vulnerable. Germinal cells in the testes and ovaries may be rendered useless by very small doses of radiation. More resistant cells include those of the skin. **Brain** cells are most resistant because they grow the slowest.

The most common symptoms of radiation sickness include:

- nausea and vomiting
- **diarrhea**
- skin **burns** (redness, blistering)
- weakness, fatigue, exhaustion, fainting
- dehydration



This person's nose is inflamed and scaly due to radiation exposure. (Custom Medical Stock Photo. Reproduced by permission.)

- inflammation of areas (redness, tenderness, swelling, bleeding)
- hair loss
- ulceration of the oral mucosa
- ulceration of the esophagus and gastrointestinal system
- vomiting blood
- bloody stool
- bleeding from the nose, mouth, gums, and rectum
- bruising
- sloughing of skin
- open sores on the skin

Exposure over time causes accumulating damage, which if not sufficient to kill cells, distorts their growth and causes scarring and cancers. In addition to leukemia, cancers of the thyroid, brain, bone, breast, skin, **stomach**, and lung are more likely to occur.

Mortality and morbidity risk are dictated by the total dose absorbed.

- Massive doses incinerate tissue immediately.
- A sudden whole-body dose over 50 Sv produces such profound neurological, **heart**, and circulatory damage that patients die within two days.
- Doses in the 10–20 Sv range strip intestinal lining and lead to death within three months from vomiting, diarrhea, starvation, and **infection**.
- Victims receiving 6–10 Sv all at once usually experience bone marrow failure and death within two months, due to loss of **blood coagulation** factors and the protection against infection provided by white blood cells.
- Those exposed to 2–6 Sv may survive if they are treated with blood transfusions and antibiotics.

KEY TERMS

DNA—Deoxyribonucleic acid.

Gonad—Testes (males); ovaries (women).

Isotope—An unstable form of an element that emits radiation.

- One or 2 Sv produces a brief, non-lethal sickness with vomiting, loss of appetite, and generalized discomfort.

Treatment

It is important to ascertain the dose received as early as possible, so that attention can be directed to those victims in the 2–10 Sv range who might survive with treatment. Blood transfusions, protection from infection, and possibly the use of blood formation stimulants save many victims in this category.

Radiation exposure usually damages the skin and requires careful **wound care**, dead tissue removal, and possible skin grafting. **Infection control** is imperative.

Alternative treatment

Studies strongly suggest that diets rich in free radical scavengers, also known as antioxidants, are recommended. The more commonly recommended antioxidants include beta-carotene, **vitamins E and C**, and the trace mineral selenium. Beta-carotene is present in yellow and orange fruits and vegetables. **Vitamin C** can be found in citrus fruits. Traditional Chinese medicine (TCM) and acupuncture, botanical medicine, and **homeopathy** all have contributions to make to recovery from radiation injuries.

Prognosis

Prognosis depends on the amount of exposure to radiation and the corresponding level of injury. High doses of radiation can be fatal, and minimal exposure can have virtually no effect. Some exposures may affect victims later in life, in the form of slow-growing cancers or reproductive difficulties.

Health care team roles

Physicians diagnose and treat radiation injuries. Nurses administer appropriate medications and otherwise supervise patient care. X ray technologists can help prevent radiation exposure to themselves and to their patients by making sure equipment is proper working

order and that appropriate preventative measures, such as the use of shields and radiation badges, are taken.

Resources

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Bill Asenjo, PhD, CRC

Radiation sickness see **Radiation injuries**

Radiation treatments see **Radiotherapy**

Radioactive iodine uptake test see **Thyroid radionuclide scan**

Radioallergosorbent test (RAST) see **Allergy tests**

Radioimmunoassay see **Immunoassay tests**

Radiologic technology

Definition

Radiologic technology is a general term applied to the allied health profession that encompasses the use of ionizing radiation (x-ray), sound or radio waves, radioactive substances to produce an image, and magnetic imaging. These resultant images are used by the radiologist to help in making a diagnosis.

Description

Radiologic technology is a broad-based category that includes general x-ray, ultrasound, **mammography**, nuclear medicine, computerized axial tomography (CAT scan), radiation therapy, and **magnetic resonance imaging (MRI)**. General x-ray technology is a primary link between the physician and the diagnosis. X rays are often required so that the physician can diagnose and treat the patient based on the patients' complaints or conditions.

The x-ray image is created by the controlled and careful use of radiation through the body part being examined. The image is captured on a film, which is placed under the patient. The x-ray beam passes through the body part being examined, and creates a latent image on the film. The latent image is processed, and then is evaluated by the radiologist, with the written and/or verbal report given to the referring physician. Some examples of subspecialties of medical radiography are contrast studies, pediatrics, trauma, surgery, and special procedures (e.g., **angiography** or other interventional procedures).

Mammography is another name for breast imaging and evaluation of breast disease. Mammographers are radiographers who are proficient in screening and diagnostic imaging, as well as such interventional procedures as needle localizations (pre-biopsy), core biopsies, and breast ultrasound.

Ultrasonography is the imaging of anatomy using high-frequency sound waves. The sonographer obtains diagnostic images or patterns that the physician evaluates in the diagnosis of disease. A scan is created by using gel and a transducer, or probe, moving it over the surface of the relevant anatomy. The transducer bounces sound into and back from the anatomic area, and an image is then created on the monitor attached to the machine. This specialty has several distinct areas: **abdominal ultrasound**, adult and pediatric **echocardiography**, obstetrical-gynecological ultrasound, and vascular ultrasound.

Nuclear medicine is very different from medical radiography, because in radiography the x-ray beam from the machine is the source of radiation. It is instantaneous, and is controlled by the technical factors selected by the radiographer. In nuclear medicine, the patient becomes the source of radiation, and the radiation itself is constantly emitted. The patient orally ingests or is intravenously injected with a radioactive substance, or radioisotope. The images are 'collected' via the nuclear medicine camera sorting radioactive signals from the patient. The radioactivity levels are different for the body part or organs being imaged. The nuclear medicine technologist has protocols that are followed for selecting the type of radioisotope to inject, based on the exams ordered.

Computerized axial tomography, or CAT scans, are studies that image the body using multiple projections of the x-ray beam to create sectional images of an organ or anatomic region. These axial sections are selected and manipulated by the technologist, using computer programs that direct the protocols for these exams.

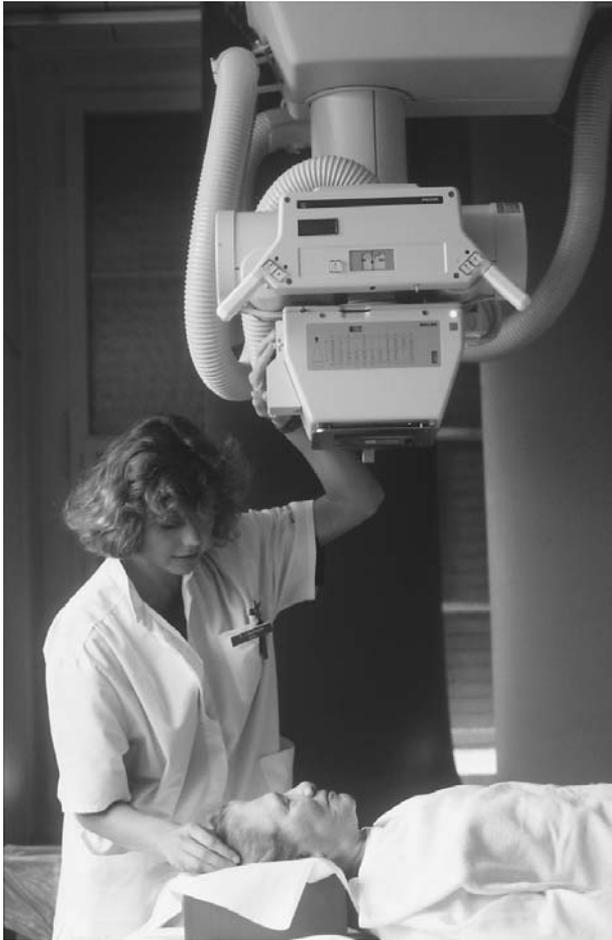
The radiation therapy technologist applies therapeutic radiation doses in strictly controlled circumstances to cure



A patient is prepared for a magnetic resonance imaging (MRI) brain scan. (Photograph by Simon Fraser. Science Source/Photo Researchers. Reproduced by permission.)

or arrest disease. In daily or weekly contact with the **cancer** patient, and working directly with the physician, the technologist assists in the calculation of radiation dosage, and operates a variety of sophisticated radiation treatment equipment and instruments, including computers.

MRI (magnetic resonance imaging) uses radio waves and a strong magnetic field rather than ionizing radiation to provide three-dimensional images of the organs or body structures being examined. The technique has proven critical in diagnosing a variety of conditions throughout the body, including cancer, cardiovascular disease, stroke, and bone and joint disorders. MRI requires specialized equipment and expertise; and allows evaluation of some body structures that may not be as visible with more conventional imaging methods. MRI is highly accurate in showing soft tissue structures near and around bones, the **cardiovascular system**, as well as major organs. Additionally, because it is a non-ionizing



A radiologic technologist positions a patient for an x ray.
(Science Source/Photo Researchers. Reproduced by permission.)

modality, it is gaining increasing popularity in imaging the reproductive system.

Work settings

The majority of radiology technologists work in a hospital setting. Others are employed in government, health industries, **public health**, mental health, education, private offices and clinics. Those professionals with advanced degrees might also pursue careers in the areas of management, quality control, equipment maintenance, or application specialties.

Education and training

The radiologic technologist must first complete a two-year accredited radiology technology program. This consists of both classroom and clinical training. Typically, student radiographers will demonstrate their ongoing training in the classroom, and will rotate through

each segment of the radiology department. The students will work with the registered technologist, and must show clinical competency prior to working independently. The students will pass clinical tests in order to progress through the training process. Upon completion of the program, the students will be required to take the national registry exam given by the American Registry of Radiologic Technology (ARRT). This is a national registry for technologists who pass and maintain the standards set forth by this organization.

Advanced education and training

For those radiographers that choose to specialize in the previously mentioned areas, further study is mandated. In some cases, both clinical and didactic requirements exist. Some disciplines will require approximately one year beyond the requisite radiography coursework, such as sonography, CAT scan, MRI, and mammography. For a nuclear medicine technologist, it is the standard to obtain a four-year university degree. In each case, the technologist needs recorded hours of clinical experience in the core discipline. The registered technologist (RT) must also document 24 hours of continuing education credits every two years in order to maintain certification and compliance with the ARRT as well as with state and federal agencies that regulate certain areas such as mammography.

Future outlook

Employment opportunities for radiologic technologists continue to expand. These professionals are expected to be increasingly in demand due to technological expansions, and the increased need for faster, more detailed diagnoses. As technology refines, so must the varying disciplines of radiologic technology. With the introduction of digital imaging, and better quality equipment and contrast media, changes continue at breakneck speed. In addition, access to higher technology has become more widespread as these newer modalities become the gold standard in some cases. Although this is positive for the profession, there continues to be a shortage of primary x-ray technologists, as those new graduates pursue specialties and bigger salaries. This specialization, while important, has caused serious hardship in many radiology departments, working with staffing shortages and creating tech fatigue, while the demand remains high. This is a challenge that is being addressed industry-wide.

KEY TERMS

Contrast—A substance used by injection or ingestion to demonstrate certain organs or anatomy.

Latent image—The x-ray image created on film, prior to development.

Processing—Film development.

Radioactive—Giving off radiation.

Radioisotope—A chemical element used in injections for nuclear medicine that can be detected in the body by the emission of radiation.

Radiologist—The physician who interprets the films and makes a diagnosis.

Resources

BOOKS

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Cruise, Kristi R. L. and James Robert Cruise. "Radiology Administrators' Opinions of Education." *Journal of the American Society of Radiologic Technologists* 72 (March-April, 2001), 314-319.

ORGANIZATIONS

American Society of Radiologic Technologists (ASRT). 15000 Central Ave. SE, Albuquerque, NM 87123-3917. (800) 444-2778 or (505) 298-4500. Fax: (505) 298-5063. <<http://www.asrt.org>>.

Radiological Society of North America (RSNA). 820 Jorie Boulevard, Oak Brook, IL 60523-2251. <<http://www.rsna.org>>.

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Radiotherapy

Definition

Radiotherapy is the use of high-energy penetrating radiation (x rays, gamma rays, proton rays, and neutron rays) to kill **cancer** cells.

Purpose

The primary purpose of radiotherapy is to eliminate or shrink localized cancers. It is also sometimes used to treat metastases— often **brain** metastases—in cases in which surgical treatment would be riskier. The aim of radiotherapy is to kill as many cancer cells as possible, while doing as little damage as possible to healthy tissue. In some cases, the purpose is to kill all cancer cells and effect a cure. In other cases, when cures are not possible, the purpose is to alleviate the patient's **pain** by reducing the size of the tumors that cause pain.

For some kinds of cancers (for example, Hodgkin's disease, non-Hodgkin's lymphoma, **prostate cancer**, and laryngeal cancer), radiotherapy alone is often the preferred treatment. Radiation is, however, also used in conjunction with surgery, **chemotherapy**, or both; and survival rates for combination therapy in these cases are often greater than survival rates for any single treatment modality used alone. Radiotherapy is especially useful when surgical procedures cannot remove an entire tumor without damaging the function of surrounding organs. In these cases, surgeons remove as much tumor mass as possible, and the remainder is treated with radiation (irradiated).

Precautions

Radiotherapy has serious side effects; therefore, anyone considering it should be sure that it is the best possible treatment option for their cancer. Cancer treatment research moves so rapidly that some doctors may not be aware of the latest advances in treatments outside their own specialties that might be safer and better. Accordingly, patients who have had radiotherapy recommended to them should consider getting a second opinion.

Description

Radiotherapy is also known as radiation therapy, radiation treatment, x-ray therapy, cobalt therapy, and electron beam or "gamma knife" therapy. Recent advances in medical technology have made it even more useful for patients and have reduced some of its unpleasant side effects. Radioactive implants allow delivery of radiation to localized areas, with less injury to surrounding tissues than radiation from an external source that must pass through those tissues. Proton radiation also causes less injury to surrounding tissues than traditional photon radiation, because proton rays can be tightly focused. Current research with radioimmunotherapy and neutron capture therapy may provide ways to direct radiation exclusively to cancer cells—and in the case of radioimmunotherapy, to cancer cells that have metastasized (spread to other sites throughout the body).



Patient undergoing radiation therapy on a linear accelerator to treat Hodgkin's disease. The illuminated discs over the patient's chest indicate the areas that are to receive radiation. The pattern is defined by an arrangement of lead blocks suspended below the head of the accelerator, which shields the lungs from excess irradiation. *Martin Dohm, Photo (Photograph by Researchers, Inc. Reproduced by permission.)*

How radiotherapy works

High-energy radiation kills cells by damaging their DNA and thus blocking their ability to divide and proliferate. Other cytotoxic mechanisms include the production of poisonous OH⁻ free radicals in the cellular cytoplasm.

Radiation kills normal cells about as well as cancer cells; but cells that are undergoing rapid growth and division (such as cancer cells, skin cells, **blood** cells, **immune system** cells, and **digestive system** cells) are the most susceptible to radiation. Fortunately, most normal cells are better able to repair radiation damage than are cancer cells. Accordingly, radiation treatments are parceled into component treatments that are spaced over a given time interval (usually about seven weeks). The spacing of radiation treatments allows cells to repair themselves during the time between treatments. Since the repair rate of normal cells is greater than the repair rate of cancerous cells, a smaller fraction of the radiation-damaged cancerous cells will have been replaced by the time of the next treatment. This procedure is called fractionation because the total radiation dose is divided into fractions. Fractionation allows cancer cells to be killed more effectively with less ultimate damage to the surrounding normal cells. Ideally all the cancer cells will be gone after the last treatment session.

Types of radiation used to treat cancer

PHOTON RADIATION. Early radiotherapy made use of x rays and gamma rays. X rays and gamma rays are essentially high-energy, ionizing electromagnetic rays composed of massless particles of energy called photons.

The distinction between the two is that gamma rays originate from the decay of radioactive substances (like radium and cobalt-60), while x rays are generated by devices that excite electrons (such as cathode ray tubes and linear accelerators). These ionizing rays are part of the electromagnetic spectrum, which also includes ultraviolet, visible, and infrared light; radio waves; and microwaves. Ionizing rays act on cells by disrupting the electrons of atoms within the molecules inside cells. These atomic changes disrupt molecules and hence disrupt cell functions, most importantly their ability to divide and make new cells.

PARTICLE RADIATION. Particle radiation is expected to become an increasingly important part of radiotherapy. Proton therapy has been available since the early 1990s on a limited scale. Proton rays consist of protons, which have mass and charge, in contrast to photons, which have neither mass nor charge. Like x rays and gamma rays, proton rays disrupt atomic electrons in target cells. The advantage of proton rays is that they can be directed to conform to the shape of the tumor more precisely than x rays and gamma rays. Consequently, proton rays cause less injury to surrounding tissue and fewer side effects. They allow physicians to deliver higher radiation doses to tumors without increasing damage to the surrounding tissue. Proton therapy is therefore more effective and requires fewer treatment sessions than conventional x-ray therapy.

Neutron therapy is a second type of particle radiation. Neutron rays are very high-energy rays composed of neutrons, which are particles with mass but no charge. Unlike x rays, gamma rays, and proton rays, they disrupt atomic nuclei rather than electrons; thus the likelihood of cells repairing this kind of intensive damage is very small. Neutron therapy can also effectively treat larger tumors than conventional radiotherapy. The central parts of large tumors lack sufficient oxygen to be susceptible to damage from conventional radiation, which depends on oxygen. Neutron radiation, however, can do its damage in the absence of oxygen, so it can kill cells in the centers of large tumors. Neutron therapy has been shown to be especially effective for the treatment of inoperable salivary gland tumors, bone cancers, and some advanced cancers of the **pancreas**, bladder, lung, prostate, and uterus.

Another promising type of neutron therapy, neutron capture therapy, is still in the experimental stage. It has, however, the advantage of being able to deliver high doses of radiation to a very limited area. Neutron capture therapy begins with a medication that binds to tumor cells but not to other cells. The medication is chemically combined with boron and given to the patient. The tumor is then irradiated with neutrons. When the neutrons inter-

act with the boron atoms, the boron nuclei split, creating tiny nuclear fission events just big enough to kill one cell. If the drug doesn't bind to neighboring noncancerous cells, then only cancer cells will be damaged, and the damage to these cells should be irreversible.

Phototherapy is the newest approach to radiotherapy. In phototherapy, a porphyrin derivative is used to attach to and illuminate the tumor. The tumor can then be targeted for selective uptake of radiation.

Modes of delivery

EXTERNAL BEAM THERAPY. Traditionally, radiotherapy has been delivered from a beam of radiation originating outside the body. This modality is called "external beam therapy." The external beam passes through the body before and after it irradiates the tumor; thus it can injure tissue in its path.

BRACHYTHERAPY. In brachytherapy, the radiation remains inside the body. Brachytherapy uses such gamma ray-generating radioactive isotopes as cesium-137 or iodine-125. The isotope is placed in small tubes and implanted close to or inside the tumor. The patient stays in the hospital for a few days; after that time, the radioactive isotope has either decayed to a low level, or the implant is removed. This form of therapy is especially useful in treating tumors for which surgery or external beam therapy radiation would cause critical damage to tissues surrounding the tumor. Brachytherapy has been effective against prostate cancer and cervical cancer.

RADIOIMMUNOTHERAPY. Until the mid-1990s, the only way to treat cancer that has spread (metastasized) to multiple locations throughout the body has been with traditional chemotherapy, which uses drugs that kill cells that divide and reproduce quickly (proliferate) in a non-specific way. Recently, cancer vaccines have been used successfully to extinguish metastatic melanoma. Vaccine treatment is a form of immunotherapy; it specifically kills melanoma cells and not other cells, even though they may also be proliferating.

Radioimmunotherapy is another form of immunotherapy that is still experimental. Researchers expect that radioimmunotherapy will be able to kill metastatic cancer cells almost anywhere in the body. Antibodies are immune system molecules that specifically recognize and bind to only one molecular structure, and they can be designed to bind specifically to a certain type of cancer cell. To carry out radioimmunotherapy, antibodies with the ability to bind specifically to a patient's cancer cells will be attached to an isotope that emits gamma rays when it is injected into the patient's bloodstream. These special antibody molecules will travel around the body until they encounter a cancer cell, and

then they will bind to it. Then the gamma rays will kill the cancer cell. It will be difficult, however, for researchers to calculate the correct dose of antibody and isotope that will kill an unknown number of cancer cells and at the same time use isotope levels that won't destroy the antibody molecules before they encounter cancer cells.

Preparation

Before radiotherapy, the size and location of the patient's tumor, as well as the nature of the surrounding tissue in the path of the radiation beam, must be determined as accurately as possible so that the radiation treatment will be maximally effective. **Magnetic resonance imaging (MRI)** and computed tomography (CT) are used to provide detailed images of the tumor. The correct radiation dose, the number of sessions (fractions), the interval between sessions, and whether to give each fraction from the same direction or from different directions to lower the total dose imparted to a given surrounding area, are calculated on the basis of the tumor type, its size, and the sensitivity of the nearby tissues.

Shields are sometimes constructed for the patient to protect certain areas of the body. The patient's skin may be marked with ink or tattoos to help achieve correct positioning for each treatment, or molds may be built to hold tissues in exactly the right place each time.

Three-dimensional conformal external beam therapy

For some types of tumors, including prostate cancer, a beam-shaping technique known as three-dimensional conformal therapy is used to deliver higher doses of radiation to the tumor site while sparing surrounding tissue to a greater extent than is possible with the nonconformal approach. Three-dimensional conformal therapy requires **CT scans** that allow the radiologist and physicist to accurately plan field shapes and prepare shields appropriately shaped for the treatment plan.

Intensity-modulated radiotherapy (IMRT)

As with three-dimensional conformal therapy, intensity-modulated radiotherapy requires a CT scan prior to dose planning. The information from the CT scan is used to plan the delivery of the radiation. The key difference between three-dimensional conformal therapy and IMRT is that IMRT produces a plan that can be transferred to a floppy or optical disk. The diskette is then used to control a dynamic beam-shaping device called a collimator that is attached to the linear accelerator. The collimator has multiple small fingers about three millimeters wide that

KEY TERMS

Antibody—A protein molecule made by the immune system cells in response to a foreign substance; it recognizes and binds specifically to that substance.

Atom—The smallest part of an element having the chemical properties of the element.

Cancer vaccine—A drug given to induce a patient's immune system to attack his or her cancer.

Fractionation—In radiotherapy, a procedure in which a radiation treatment regimen is divided into many (usually 10–25) treatment sessions over a time span of several weeks.

Gamma rays—Short-wavelength, high-energy electromagnetic radiation emitted by radioactive substances.

Hodgkin's disease—Cancer of the lymphatic system, characterized by lymph node enlargement and the presence of large polyploid cells called Reed-Sternberg cells.

Immunotherapy—A treatment modality that utilizes cells or molecules of the immune system.

Ionizing radiation—High-energy radiation that has enough energy to move atomic electrons out of their orbits and thereby ionize the surrounding medium.

Isotope—One of two or more atom types of the same element that have the same number of protons in their nuclei but different numbers of neutrons.

Melanoma—One of the three most common types of skin cancer; melanoma is the most dangerous type because it frequently metastasizes.

Metastasis (plural, metastases)—A secondary tumor resulting from the spread of cancerous cells from the primary tumor to other parts of the body.

Neutron—A subatomic particle with a charge of zero and a mass slightly greater than that of a proton.

Proton—A subatomic particle with a charge of +1 and a mass about 1836 times that of an electron.

X rays—Short-wavelength, high-energy electromagnetic radiation produced by atom bombardment.

move in and out of the radiation field during treatment. The information on the floppy or optical disk controls the movement of the beam-shaping fingers. The beam rotates around the patient in some treatment regimens. The ability of IMRT to precisely shape the beam in very small increments even while it's moving allows the therapist to deliver even higher doses to the tumor and spare even more of the healthy surrounding tissues than three-dimensional conformal therapy does. For some tumors, like prostate cancer, even greater precision can be attained by using a special ultrasound machine. Prior to each treatment, the ultrasound machine is used to pinpoint the location of the prostate gland relative to the radiation source. The information from the ultrasound scan allows the therapist to position the patient with a degree of precision measured in millimeters before the therapy begins.

Aftercare

Follow-up is important for patients who have received radiotherapy. They should go to their radiation oncologist at least once within the first several weeks after their final treatment to see if their treatment was successful. They should also see an oncologist every six to twelve months for the rest of their lives so they can be checked to see if the tumor has reappeared or spread.

Treatment of symptoms following radiotherapy depends on which part of the body is being treated and the type of radiation. Nevertheless, many patients experience skin burn, hair loss, fatigue, nausea, and vomiting regardless of the treatment area.

Affected skin should be kept clean and can be treated like a sunburn, with skin lotion or **vitamin A** and **D** ointment. Patients should avoid perfume or scented skin products, and protect affected areas from the sun.

Nausea and vomiting are expected when the dose is high, or if the abdomen or another part of the digestive tract is irradiated. Sometimes nausea and vomiting occur after radiation to other regions, but in these cases the symptoms usually disappear within a few hours after treatment. Nausea and vomiting can be treated with **antacids** or with such antiemetics as Compazine, Tigan, or Zofran.

Fatigue frequently sets in after the second week of therapy and may continue until about two weeks after the therapy is finished. Patients may want to limit their activities, cut back their work hours, or take time off from work. They also may need to take naps and get extra sleep at night.

Patients who receive external beam therapy do not become radioactive and should be assured that they do

not pose a danger to others. Some patients who receive brachytherapy, however, do go home with low levels of radioactivity inside their bodies. These patients should be given instructions about any dangers they might pose to children and people of childbearing age, and how long these dangers will last.

Emotional support is an important part of the care for patients undergoing any treatment for cancer. Radiotherapy can cause significant changes in a patient's appearance—particularly hair loss—and many patients fear that their spouses or partners will no longer find them attractive. There are many support groups available for radiotherapy patients and their families, as well as resources to help them cope with the external side effects of radiation treatment.

Complications

Radiotherapy can be highly toxic to patients because it kills normal cells as well as cancerous ones. There are risks of anemia, nausea, vomiting, **diarrhea**, hair loss, skin burn, sterility, and death. The benefits of radiation therapy, however, almost always exceed the risks involved.

Results

The probable outcome of radiation treatment is highly variable depending on the disease. For some diseases like Hodgkin's disease, about 75% of the patients are cured. Moreover, up to 86% of prostate cancer victims treated with both external and internal radiation are symptom-free five years after radiotherapy. On the other hand, radiation therapy is less successful in treating **lung cancer**; only about 9% of lung cancer patients are cured.

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ORGANIZATIONS

American Cancer Society. 1599 Clifton Road NE, Atlanta GA 30329-4251. (800) ACS-2345. <<http://www.cancer.org>>.

National Association for Proton Therapy. 7910 Woodmont Avenue, Suite 1303, Bethesda, MD 20814. (301) 913-9360. <<http://www.protontherapy.org/Default.htm>>.

Radiological Society of North America, Inc. 820 Jorie Boulevard, Oak Brook, IL 60523-2251. (630) 571-2670. Fax: (630) 571-7837. <<http://www.rsna.org>>.

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Radiotherapy and You. A Guide to Self-Help During Treatment. Bethesda, MD: National Institutes of Health. National Cancer Institute. <<http://cancer.net.nci.nih.gov/Radiation/radintro.html#anchor632185>>.

3D-Conformal Radiation Therapy. Kimmel Cancer Center, Radiation Oncology, <<http://www.kcc.tju.edu/RadOne/cracky/three.htm>>.

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Range-of-motion exercises see **Exercise**

Rapid plasma reagin test see **Syphilis tests**

Rapid streptococcus antigen tests

Definition

A rapid streptococcus antigen test is used to quickly diagnose **strep throat**, a contagious **infection** of the pharynx caused by a Group A streptococcus (*Streptococcus pyogenes*), commonly referred to as GAS.

Purpose

Rapid streptococcus antigen tests are used to identify a strep throat. While a **throat culture** remains the gold standard for diagnosis of group A streptococcus infection, this procedure takes 24-48 hours for results. A rapid strep test takes only five minutes to perform. Since streptococci are sensitive to penicillin and related drugs, antibiotic therapy can be initiated immediately when the test is positive. A positive test result eliminates the need for bacterial throat culture.

Precautions

An untreated strep throat can increase the patient's risk of developing scarlet or rheumatic **fever**, which is associated with **meningitis**; and diseases affecting the **heart**, skin, **kidneys**, and joints. False-negative results occur with this test with a frequency ranging from 4-39%. Therefore, negative test results should be confirmed by throat culture.

Description

Approximately 10-19% of all sore throats are caused by group A beta-hemolytic streptococci. The majority of strep throat infections occur in children between the ages of five and fifteen, although adults with weakened immune systems are also at risk. The highest incidence of strep throat occurs during the winter and early spring months. Rapid streptococcal tests utilize antibodies to detect streptococcal antigens. There are four different direct streptococcal antigen detection platforms available in a wide number of different commercial products. These are latex agglutination; optical immunoassay; double antibody sandwich immunoassay; and immunochromatographic detection. The majority of rapid assays used today are based on double antibody sandwich and/or immunochromatography because these techniques do not require mixing, multiple reagent addition, or washing. An example of a combined double antibody sandwich immunochromatography method is described below.

The first step of a rapid strep test is the extraction of specific Group A streptococcal carbohydrate antigen from the swab. The swab is placed in a test tube to which the extracting reagents have been added. The swab is rotated vigorously in the solution while pressing the tip against the sides of the test tube. After all fluid is pressed from the swab, it is discarded and the extract is applied to a nitrocellulose membrane containing both immobilized antibodies and nonimmobilized antibodies to different regions of the Group A strep antigen. The nonimmobilized antibodies are conjugated to dyed colloidal gold particles. If Group A streptococcal carbohydrate antigen is present in the extract, the conjugated antibodies bind to it, forming antigen-antibody complexes. These migrate along the membrane until they reach the reaction zone containing immobilized antibodies to the same Group A strep antigen. These antibodies capture the antigen-antibody complexes, forming a colored band or line (usually pink or blue) in the reaction zone area.

Specificity of these tests is approximately 97-98%. Few causes of false positives have been reported. False positives are possible when the patient's throat contains a

heavy growth of *Staphylococcus aureus*. False-negative test results are commonly reported and often occur when insufficient antigen is obtained from the swab extraction procedure.

Preparation

All rapid group A strep tests require a sample from the infected patient's throat. The sample is obtained by depressing the tongue and swabbing the back of the throat and tonsils, while avoiding the tongue, saliva and lips. The swab should come in contact with all the inflamed areas, vesicles and pustular tonsils. Swabs made of rayon or Dacron should be used. Swabs containing cotton, **calcium** alginate, or wooden shafts, or that have been placed in transport medium containing charcoal are not recommended.

Aftercare

There are no aftercare concerns with this test.

Complications

There are no complications associated with this test.

Results

Normal results are negative. However, these assays tend to have low sensitivity, and thus it is recommended that all negative tests be followed by culture of a different throat swab on a blood agar plate for the isolation of beta-hemolytic streptococci. A positive result indicates an infection with group A streptococcus, and does not require culture follow-up.

Health care team roles

These tests are usually performed in a doctor's office by a nurse.

Resources

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RDS *see* **Respiratory distress syndrome**

Reactive airway disease *see* **Asthma**

Recreation therapy

Definition

Recreation therapy, or therapeutic recreation, strives to improve the functioning and independence of individuals who are ill or disabled. Recreation therapists provide services in clinical facilities and in the community.

Description

Incorporating a variety of interventions to treat individuals with physical, cognitive, and emotional conditions, recreation therapists educate their patients to make them better-informed participants in their own health care. As a result, patients are taught to use activity to cope with the stresses of illness and disability. Therapeutic recreation activities may include, for example, wheelchair sports, **exercise** programs, and social activities—which preserve physical, cognitive, social and emotional health, thereby reducing the need for medical services.

A recreation therapist's responsibilities vary according to the setting and the patients served. Most recreation therapists are involved in the assessment of physical, mental, emotional, and social functioning towards determining the patient's needs, interests, and abilities based on information from standardized evaluations, observations, **medical records**, medical staff, family, and the patients themselves. The role of the recreation therapist is to then develop and implement therapeutic interventions consistent with the individual's needs and interests. For example, patients who place themselves in isolation may be encouraged to play games with others; a person with **paralysis** may be instructed in adaptation and compensatory strategies to throw a ball or swing a racket. Patients may be instructed in **relaxation** techniques to reduce **stress** and tension, correct stretching and limbering exercises, proper body mechanics for participation in recreation activities, pacing and other energy conservation techniques, and individual as well as team activities.

Work settings

Recreation therapists employed in hospitals are typically members of an interdisciplinary treatment team

that develops patient treatment plans. Recreation therapists are often responsible for one or more group activities each day. Such activities might include, for example, stress management groups, community outings, family activities, exercise, and leisure education groups. Depending on the needs of the individuals, recreation therapists are responsible for the provision of programs that may include adapted aquatics, wheelchair basketball, social recreation for adults with mental retardation, downhill skiing for individuals with physical disabilities, summer camps, or adapted golf lessons. In addition, the patient may be met by the recreation therapist to conduct an assessment, or for developing a discharge plan. Responsibilities also include documenting the individual's progress in charts and communicating with other professionals, as well as with the patient's family members. Recreation therapists employed in an institution are usually expected to plan evening and weekend activities, special events, and holiday activities. Patients are often encouraged to participate in the creation and organization of these activities. The recreation therapist is also responsible for adapting activities as needed, and for providing adaptive equipment to enable the participation of individuals with disabilities or limitations. These services are designed to help meet the goals identified in the individual's treatment plan.

A variety of agencies and organizations employ recreation therapists. They may hold positions in acute-care hospitals, rehabilitation centers, **nursing homes**, psychiatric hospitals, community recreation centers, pediatric hospitals, group homes, senior centers, community mental health centers, public and private schools, correctional facilities, and private practice. Individuals of all ages and walks of life benefit from the services provided by recreation therapists.

The services of community-based recreation therapists are also used in park and recreation departments, special education programs for school districts, or programs for older adults and people with disabilities. In these programs, clients are helped to develop leisure activities. The role of the recreation therapist is to provide them with opportunities for exercise, mental stimulation, creativity, and fun.

In schools, recreation therapists assume an important role in helping counselors, parents, and special education teachers address the special needs of students. Recreation therapists are especially important in helping to ease the transition phase into adult life for children with disabilities. The recreation therapist may work with the client, the client's family, and other professionals to design and implement treatment and education plans.

Many recreation therapists fulfill the role of advocate on behalf of the individual with a disability. This may include addressing such issues as limited transportation resources, inaccessible facilities, and legislation that affects people with disabilities. Participation on advisory committees is a frequent activity of the recreation therapist, whose job also includes consultations with outside agencies to ensure that resources and services are provided for people with disabilities.

Education and training

Most employers require a minimum of a bachelor's degree in therapeutic recreation or in recreation with an option or emphasis in therapeutic recreation. In addition, an associate degree in recreation therapy; training in art, drama, or music therapy; or qualifying work experience may be sufficient for employment in nursing homes.

A bachelor's degree in therapeutic recreation is awarded upon successful completion of required course work and a supervised internship. During an internship, students are placed in an agency for a minimum of one semester so that what they have learned in the classroom can be put into practice.

In recent years, professional credentialing has become more important for employment. National certification is available through the National Council for Therapeutic Recreation Certification (NCTRC), an independent credentialing body. The National Council for Therapeutic Recreation Certification awards the title of Certified Therapeutic Recreation Specialist (CTRS) based upon prescribed education and experience requirements and successful performance on a 200-item national examination. Some states have additional requirements for licensure, registration or certification as well. Credentialing helps ensure that the minimum requirements needed to safely provide therapeutic recreation services have been met.

Future outlook

Employment opportunities for recreation therapists are expected to grow. The projected demand is due to the increase in the need for long-term care, and physical and **psychiatric rehabilitation**.

In 1996, there were approximately 38,000 employed recreation therapists. Hospitals have 42% in their employ; nursing homes had 38% employed. Residential facilities, community mental health centers, **adult day care** programs, correctional facilities, community programs for people with disabilities, and substance abuse

centers had these therapists working for them. One out of every four recreation therapists were self-employed; this vocational path generally involves contracting with long-term care facilities or community agencies to develop and oversee programs.

Resources

ORGANIZATIONS

American Therapeutic Recreation Association.
<<http://www.atra-tr.org>>.

National Therapeutic Recreation Society (NTRS).
<<http://www.nrpa.org/branches/ntrs.htm>>.

OTHER

Resources for the Recreation Therapy Professional.
<<http://www.recreationtherapy.com/>>.

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Rectal cancer see **Colorectal cancer**

Rectal medication administration

Definition

Rectal medicines are medications prepared specifically for insertion into the rectum. They are compounded in many forms. Liquid rectal medicine solutions are given by enema. Creams, lotions and ointments are applied externally or inserted internally using an applicator. Suppositories are prepared by mixing medicine with a wax-like substance to form a semi-solid, bullet-shaped form that will melt after insertion into the rectum.

Purpose

Rectal medications are administered for a localized effect on the rectum or for a systemic effect when a patient is vomiting, unable to swallow, or unconscious. Rectal medicine is most commonly used as a localized treatment for constipation or as a topical treatment for rectal inflammation or **infection**. Rectal suppositories may be used for the treatment of **fever**, nausea, and **pain**; they may also be prescribed to induce sedation or bronchodilation, or to reduce the nausea and vomiting that can accompany **chemotherapy**. Medicated **enemas** may be used to cleanse the bowel, to combat **bacteria**, or to kill parasites.

Precautions

Rectal medications must be used with caution in the cardiac patient who has arrhythmias or has recently had a **myocardial infarction** (i.e., **heart attack**). Insertion of a rectal medicine can cause vagus nerve stimulation and may trigger an arrhythmia—such as bradycardia. Rectal medicines should not be given to the patient with undiagnosed abdominal pain because peristalsis of the bowel can cause an inflamed appendix to rupture. Rectal medicines should be used cautiously in patients who have undergone recent surgery on the rectum, bowel, or prostate gland. If the patient has rectal bleeding or a prolapse of rectal tissue from the rectal opening, the medicine should be withheld and the physician consulted before administration. Rectal medicines should not be taken orally, and only medications labeled as rectal preparations should be placed in the rectum.

Description

Administration of rectal medication should be done after the patient is positioned correctly. Lifting the upper buttocks will enable visualization of his or her rectal opening. External lotions, ointments or creams can be applied directly, using a gloved finger or a 4x4 gauze pad. Prior to administering internal rectal medicine, the tip of the suppository, enema catheter, or applicator should be lubricated with a water-soluble lubricant. To insert a rectal suppository, the lubricated, tapered end of the suppository should be placed at the rectal opening and gently pushed into the rectum. The suppository should be pushed continually toward the umbilicus until the full length of the nurse's gloved index finger has been inserted into the rectal opening (i.e., about 3 inches, or 7.5 cm, for an adult patient). When inserting suppositories into children, the suppository should be pushed about 1 inch (2.5 cm) beyond the rectal opening, or up to the first knuckle of the nurses's index finger. When inserting suppositories into infants, the little finger should be inserted one-half inch (1.25 cm) beyond the rectal opening. The buttocks should be released and the finger removed.

Administration of internal rectal medicated cream or ointment requires placement of the applicator's lubricated tip at the rectal opening, gently pushing the applicator into the rectal opening about 3 inches (7.5 cm) for an adult (or as indicated on the applicator's directions). The correct dosage of medicine should then be squeezed into the rectum. After withdrawal of the applicator tip, the buttocks should be released.

To administer rectal medicine using an enema solution, the lubricated tip of the enema catheter must also be

placed at the rectal opening. The tip of the catheter should then be gently advanced into the rectum, about 3 inches (7.5 cm) for an adult (or as indicated on the enema tubing). After the patient is alerted, the enema tubing should be opened, allowing the enema solution to flow into the rectum. A prepared enema should also be administered in this manner. When all of the solution has been administered, the enema catheter should be removed. Then, the buttocks should be released.

Preparation

Before administering rectal medicine, the door to the room should be closed to assure patient privacy. The patient should be encouraged to empty his or her bladder and bowels before the procedure. After removing lower garments and underwear, the patient should be positioned in bed on his or her left side, with the top knee bent and pulled slightly upward. A waterproof pad should be placed under the patient's hips to protect the bedding, and a sheet should be draped over the patient to cover all of his or her body except the buttocks.

After placing a bedpan within quick access, the nurse should explain the procedure to the patient. This explanation should include the importance of breathing slowly through the mouth to enhance relaxation of the rectal sphincter and to avoid oppositional pressure. The patient should be made aware that there may be an urge to push the medicine out, but that he or she should try to hold it for at least 10–15 minutes after instillation (30 minutes for suppositories), as most rectal medications need time to be absorbed. It is advisable for the professional to check the medication label each time the medicine is given, to avoid medication errors. It must be the right medicine and the right dose (strength), the right time, the right patient, and the right method. The expiration date on the label should be inspected. If the medicine is outdated, it should not be used.

The nurse should wash his or her hands and put on gloves. The foil wrap should be removed from the rectal preparation or suppository. To prepare internal rectal creams, lotions or ointments, the applicator should be examined so that the nurse can estimate the proper amount to instill after insertion. In preparation for rectal enema instillations, the directions on the package of pre-mixed disposable enemas should be read. Most pre-mixed disposable enemas come with the tip already lubricated. The cap from the tip should be removed, and air should be expelled from the apparatus before use. If liquid medicine solutions are given using a standard enema bag and tubing, the procedure for enema instillation should be followed.

KEY TERMS

Arrhythmia—An irregularity of the heartbeat.

Bradycardia—An abnormal slowing of the heart rate to fewer than 60 beats per minute.

Myocardial infarction—A cardiac condition caused by decreased blood flow and oxygen to the heart muscle; may cause tissue death and heart damage. Commonly known as a heart attack.

Peristalsis—The wave-like muscular contractions of the intestinal walls that move food and refuse through the gastrointestinal system.

Prostate gland—A gland found in males, located below the bladder and around the urethra, that secretes the fluid for semen and controls the release of urine from the bladder.

Rectum—The last portion of the large intestine located just above the anal canal, where stool collects prior to evacuation from the body.

Vagus nerve—One of the paired cranial nerves that supplies motor and sensory enervation to the abdominal and thoracic organs.

Aftercare

After administering rectal medicines, the nurse should remain near the patient in case there is a need for assistance with the bedpan, or to walk to the bathroom. If a suppository is expelled within the first few minutes of insertion, the tip should be relubricated and reinserted. Medicated enemas that are expelled immediately may need to be repeated, using fresh solution. Directions provided with a prepared enema should be followed, but the physician may need to be consulted. To assist the patient with retaining the medicine, the nurse can apply gentle pressure to the rectal opening, using a 4x4 gauze pad or by squeezing the buttocks together after rectal medicine instillation. A 4x4 gauze pad should also be tucked between the buttocks to collect seepage; this may help the patient feel more secure. After the procedure is completed, the patient should be covered and instructed to remain still for 10–15 minutes (30 minutes if a suppository was inserted). This period will allow time for medication absorption. Items that can be reused, such as enema pouches, tubing, and applicator tips, should be cleaned with warm running water and allowed to air-dry. Ointments and creams need to be recapped and returned to the medicine boxes. Disposable items and gloves should be placed in an appropriate trash bag that can be sealed and discarded.

Complications

Rectal medicines can cause tissue irritation or allergic reactions. If irritation, swelling, redness, bleeding or prolapse of the rectal tissue is apparent, or if the patient complains of pain or burning, the medication should be stopped and the physician notified.

Results

When given correctly, rectal medications work within 30–60 minutes to relieve pain, nausea, constipation, or fever. Rectal ointments for swelling and irritation of hemorrhoids may reverse the condition within several days. Because of their liquid state, rectal enemas are absorbed quickly and work rapidly. Retention enemas are meant to be held for 30 minutes to achieve full therapeutic effect.

Health care team roles

Rectal medicines are administered by a licensed nurse (R.N. or L.P.N.) in the health care setting. An alert and cooperative patient may be allowed to apply external and internal rectal ointments and suppositories under the direction of the nurse. The nurse, however, should assess the site and the effectiveness of the medicine. The patient or members of the patient's family can be taught to administer rectal medicines in the home setting.

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Red blood cell indices

Definition

Red **blood** cell (RBC) indices are calculations derived from the **complete blood count** that aid in the diagnosis and classification of anemia. Measurements needed to calculate indices are the red blood cell count, hemoglobin, and **hematocrit**. The hematocrit is the percentage of blood by volume that is occupied by the red cells. The three RBC indices are:

- Mean corpuscular volume (MCV). The average size of the red blood cells expressed in femtoliters. MCV is calculated by dividing the hematocrit (as percent) by the RBC count in millions per microliter of blood, then multiplying by 10.
- Mean corpuscular hemoglobin (MCH). The average amount of hemoglobin inside an RBC expressed in picograms. The MCH is calculated by dividing the hemoglobin concentration in grams per deciliter by the RBC count in millions per microliter, then multiplying by 10.
- Mean corpuscular hemoglobin concentration (MCHC). The average concentration of hemoglobin in the RBCs expressed as a percent. It is calculated by dividing the hemoglobin in grams per deciliter by the hematocrit, then multiplying by 100.

Purpose

Red blood cell indices help classify types of anemia, a decrease in the oxygen carrying capacity of the blood. Healthy people have an adequate number of correctly sized red blood cells containing enough hemoglobin to carry sufficient oxygen to all the body's tissues. Anemia is diagnosed when either the hemoglobin or hematocrit of a blood sample is too low.

The mechanisms by which anemia occurs will alter the RBC indices in a predictable manner. Therefore, the RBC indices permit the physician to narrow down the possible causes of an anemia. The MCV is an index of the size of the RBCs. When the MCV is below normal, the RBCs will be smaller than normal and are described as microcytic. When the MCV is elevated, the RBCs will be larger than normal and are termed macrocytic. RBCs of normal size are termed normocytic. Failure to produce hemoglobin results in smaller than normal cells. This occurs in many diseases, including **iron deficiency anemia**, thalassemia (an inherited disease in which globin chain production is deficient), and **anemias** associated with chronic **infection** or disease. Macrocytic cells occur when division of RBC precursor cells in the bone marrow

is impaired. The most common causes of macrocytic anemia are **vitamin B₁₂** deficiency, folate deficiency, and **liver** disease. Normocytic anemia may be caused by decreased production (e.g. malignancy and other causes of bone marrow failure); increased destruction (hemolytic anemia); or blood loss. The RBC count is low, but the size and amount of hemoglobin in the cells are normal.

A low MCH indicates that cells have too little hemoglobin. This is caused by deficient hemoglobin production. Such cells will be pale when examined under the **microscope** and are termed hypochromic. **Iron** deficiency is the most common cause of a hypochromic anemia. The MCH is usually elevated in macrocytic anemias associated with vitamin B₁₂ and folate deficiency.

The MCHC is the ratio of hemoglobin mass in the RBC to cell volume. Cells with too little hemoglobin are lighter in color and have a low MCHC. The MCHC is low in microcytic, hypochromic anemias such as iron deficiency, but is usually normal in macrocytic anemias. The MCHC is elevated in hereditary spherocytosis, a condition with decreased RBC survival caused by a structural protein defect in the RBC membrane.

Cell indices are usually calculated from tests performed on an automated electronic cell counter. However, these counters measure the MCV, which is directly proportional to the voltage pulse produced as each cell passes through the counting aperture. Electronic cell counters calculate the MCH, MCHC, hematocrit, and an additional parameter called the red cell distribution width (RDW). The RDW is a measure of the variance in red blood cell size. It is calculated by dividing the standard deviation of RBC volume by the MCV and multiplying by 100. A large RDW indicates abnormal variation in cell size, termed anisocytosis. The RDW aids in differentiating anemias that have similar indices. For example, thalassemia minor and iron deficiency anemia are both microcytic and hypochromic anemias, and overlap in MCV and MCH. However, iron deficiency anemia has an abnormally wide RDW but thalassemia minor does not.

Precautions

Certain prescription medications may affect the test results. These drugs include zidovudine (Retrovir), phenytoin (Dilantin), and azathioprine (Imuran). When the hematocrit is determined by centrifugation, the MCV and MCHC may differ from those derived by an electronic cell counter, especially in anemia. Plasma trapped between the RBCs tends to cause an increase in the hematocrit, giving rise to a somewhat higher MCV and lower MCHC.

RBC indices require 3-5 mL of blood collected by venipuncture. A nurse or phlebotomist usually collects

KEY TERMS

Anemia—A variety of conditions in which a person's blood can't carry as much oxygen as is needed by the tissues.

Hypochromic—A descriptive term applied to a red blood cell with a decreased concentration of hemoglobin.

Macrocytic—A descriptive term applied to a larger than normal red blood cell.

Mean corpuscular hemoglobin (MCH)—A calculation of the average weight of hemoglobin in a red blood cell.

Mean corpuscular hemoglobin concentration (MCHC)—A calculation of the average concentration of hemoglobin in a red blood cell.

Mean corpuscular volume (MCV)—A measure of the average volume of a red blood cell.

Microcytic—A descriptive term applied to a smaller than normal red blood cell.

Normochromic—A descriptive term applied to a red blood cell with a normal concentration of hemoglobin.

Normocytic—A descriptive term applied to a red blood cell of normal size.

Red blood cell indices—Measurements that describe the size and hemoglobin content of red blood cells.

Red cell distribution width (RDW)—A measure of the variation in the size of red blood cells.

the sample following standard precautions for the prevention of transmission of bloodborne pathogens.

Aftercare

Discomfort or bruising may occur at the puncture site. Pressure to the puncture site until the bleeding stops reduces bruising; warm packs relieve discomfort. Some people feel dizzy or faint after blood has been drawn and should be treated accordingly.

Complications

Other than potential bruising at the puncture site, and/or dizziness, there are no complications associated with this test.

Results

Normal results for red blood cell indices are as follows:

- MCV: 80-96 fl (femtoliters)
- MCH: 27-33 pg (picograms)
- MCHC: 33-36%
- RDW: 12-15%

Health care team roles

A phlebotomist, or sometimes a nurse, collects the blood; and a clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) or clinical laboratory technician, or CLT(NCA)/medical laboratory technician MLT(ASCP) performs the testing. Results are interpreted by a physician.

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Red blood cell test see **Hemoglobin test**

Reflex tests

Definition

Reflex tests are simple physical tests of nervous system function.

Purpose

A reflex is a simple nerve circuit. A stimulus, such as a light tap with a rubber hammer, causes sensory **neurons** (nerve cells) to send signals to the **spinal cord**. There, the signals are conveyed both to the **brain** and to nerves that control muscles affected by the stimulus.

Without any brain intervention, these muscles may respond to an appropriate stimulus by contracting.

Reflex tests measure the presence and strength of a number of **reflexes**. In so doing, they help to assess the integrity of the nerve circuits involved. Reflex tests are performed as part of a neurological exam, either a “mini-exam” done to quickly confirm integrity of the spinal cord, or a more complete exam performed to diagnose the presence and location of a **spinal cord injury** or neuromuscular disease.

Deep tendon reflexes are responses to muscle stretch. The familiar “knee-jerk” reflex is an example of a reflex. This tests the integrity of the spinal cord in the lower back region. The usual set of deep tendon reflexes tested, involving increasingly higher regions of the spinal cord, includes:

- ankle
- knee
- abdomen
- forearm
- biceps
- triceps
- patellar

Another type of reflex test is called the Babinski test, which involves gently stroking the sole of the foot to assess proper development and function of the spine and cerebral cortex.

Precautions

Reflex tests are entirely safe, and no special precautions are needed.

Description

The examiner uses a reflex hammer or rubber mallet to strike different points on the examinee’s body, and observes the response. The points chosen for eliciting reflexes are the tendons of specific muscles. Tapping specific sites is intended to provide a quick stretch to the muscle. Muscle spindles, or receptors, mediate the reflex lying within the muscle—not the site of the hammer strike. The examiner may position, or hold, one of the limbs during testing, and may require exposure of the ankles, knees, abdomen, and arms. Reflexes can be difficult to elicit if the individual being examined is paying too much attention to the stimulus. To compensate for this, that person may be asked to perform some **muscle contraction**, such as clenching teeth or grasping and pulling the two hands apart. When performing the



A doctor tests a patient’s reflex during a physical examination. (Photograph by Will & Deni McIntyre. Science Source/Photo Researchers. Reproduced by permission.)

Babinski reflex test, the examiner will gently stroke the outer soles of the person’s feet with the mallet while checking to see whether or not the big toe extends out as a result.

Preparation

The examiner positions the person to be examined in a comfortable position, usually seated on the examination table with legs hanging free. There is no other preparation.

Aftercare

A reflex examination is not invasive. No care after the examination is required.

Complications

The pressure exerted by a reflex hammer is minimal and does not hurt the person being examined. A reflex

Muscle stretch (deep tendon) reflexes

Reflex	Stimulus	Response
Biceps	Tap biceps tendon	Contraction of biceps
Brachioradialis (periosteradial)	Tap styoid process of radius (insertion of brachioradialis)	Flexion of elbow and pronation of forearm
Jaw (maxillary)	Tap mandible in half-open position	Closure of jaw
Patellar	Tap patellar tendon	Extension of leg at knee
Tendocalcaneus	Tap Achilles tendon	Plantar flexion at ankle
Triceps	Tap triceps tendon	Extension of elbow
Wrist extension	Tap wrist extensor tendons	Extension of wrist
Wrist flexion	Tap wrist flexor tendon	Flexion of wrist

SOURCE: Rothstein, J.M., S.H. Roy, and S.L. Wolf. *The Rehabilitation Specialist's Handbook*, 2nd ed. Philadelphia: F.A. Davis Co., 1998.

examination is not invasive. There are no complications from performing the examination.

Results**Normal results**

The strength of the response depends partly on the strength of the stimulus. For this reason, an examiner will attempt to elicit the response with the smallest stimulus possible. Learning the range of normal responses requires some clinical training. Responses should be the same on both sides of the body. A normal response to the Babinski reflex test depends upon the age of the person being examined. In children under the age of one and a half years, the big toe will extend out with or without the other toes. This is due to the fact that the fibers in the spinal cord and cerebral cortex have not been completely covered in myelin, the protein and lipid sheath that aids in processing neural signals. In adults and children over the age of one and a half years, the myelin sheath should be completely formed; and as a result, all the toes will curl under (plantar flexion reflex).

Abnormal results

Weak or absent response may indicate damage to the nerves outside the spinal cord (peripheral neuropathy), damage to the motor neurons just before or just after they leave the spinal cord (motor neuron disease), or muscle disease. Excessive response may indicate spinal cord damage above the level controlling the hyperactive response. Different responses on the two sides of the body may indicate early onset of progressive disease, or localized nerve damage, as from trauma. An adult or older child who responds to the Babinski with an extended big toe may have a lesion in the spinal cord or cerebral cortex.

Health care team roles

A reflex examination is usually conducted by a physician. Neurologists (doctors with specialized training in neurology) often perform reflex tests. Physician assistants, physical therapists, and nurses may also test reflexes as they examine or evaluate individuals.

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- American Academy of Family Physicians. 11400 Tomahawk Creek Parkway, Leawood, KS 66211-2672. (913) 906-6000. <<http://www.aafp.org/>>. fp@aafp.org.
- American Academy of Neurology. 1080 Montreal Avenue, St. Paul, Minnesota 55116. (651) 695-1940. <<http://www.aan.com/resources.html>>. web@aan.com.
- American College of Physicians. 190 N Independence Mall West, Philadelphia, PA 19106-1572. (800) 523-1546 x2600 or (215) 351-2600. <<http://www.acponline.org/cgi-bin/feedback>>.

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KEY TERMS

Lesion—A pathologic change in body tissue.

Myelin—A substance composed largely of fat that constitutes the sheaths of various nerve fibers throughout the body.

Neurology—The study of nerves.

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Reflexes

Definition

Reflexes are the body's automatic reaction to some type of sensory stimuli. They involve nerve impulses passing from a receptor to a nerve center and then outward to, for example, a nerve or a gland.

Description

Reflexes are classified as unconditioned and conditioned.

Unconditioned reflexes

Unlike most human behaviors, unconditioned reflexes occur without specific learning or experience. They are considered involuntary acts, because a response occurs automatically when a stimulus (for example, a pinprick) takes place.

Unconditioned reflexes that protect us from harm are called nociceptive reflexes. For example, sneezing, coughing, and gagging are automatic responses to **foreign bodies** in the nose and throat. Eye blinking or winking helps protect the eye from harm. Reacting quickly to touching a hot stove is yet another example of a nociceptive reflex.

Most reflex acts are very complicated. However, in simple reflexes four events are involved: reception, conduction, transmission, and response. The stimulation is received by receptors, or sensitive nerve endings. These may be in the eye, ear, nose, tongue, or skin. Energy from the stimulus is changed into nerve impulses and conducted from the receptor to the **central nervous system**. From there, the nerve impulses are transmitted to the motor nerves, which control muscle action. The motor nerves conduct the impulses to the muscles and glands, causing them to respond or act. For example, touching a hot stove stimulates receptors in the skin of the finger. This creates a nerve impulse that travels along a sensory nerve to the **spinal cord**. In the spinal cord, the sensory nerve fibers interlace with motor nerve fibers. The nerve impulse passes from the sensory fibers to the motor fibers, which relay it to the muscles, causing them to contract. When the muscles contract, the person's hand jerks back.

People have many reflex reactions to such emotional stimuli as anger or fear, including changes in **blood pressure** and respiration. Lie detectors measure specific physical reactions to emotional stimuli.

Conditioned reflexes

Conditioned reflexes are acquired as the result of experience. When an action is performed repeatedly, the nervous system learns to react automatically. Walking, running, and typing are examples of learned conditioned activities that require a large number of complex muscular coordinations.

Conditioned reflexes work by association. For example, a dog's mouth begins to water when the animal smells food. The Russian physiologist Ivan P. Pavlov showed that the flow of saliva, originally an automatic reaction to the **smell** of food, may become a conditioned reflex. Pavlov rang a bell each time he brought food to a dog. Eventually, the dog's mouth began to water when Pavlov merely rang the bell without food being present. The dog associated the ringing of the bell with the food, just as it associated the odor with the food.

Function

In a simple reflex, a sensory receptor initiates a nerve impulse in an afferent sensory nerve fiber that conducts it to the spinal cord. In the gray matter of the spinal cord, the afferent nerve impulse is fired over the synaptic gap to an efferent motor fiber that passes along the impulse to the appropriate muscle, producing the reflex.

KEY TERMS

Afferent—Conveying impulses toward a nerve center, such as the brain or spinal cord.

Efferent—Conveying nervous impulses away from the central nervous system to nerves or neurons.

Nociceptive—A stimulus that causes pain or injury.

Synaptic gap—The space between neurons across which a nerve impulse is transmitted by a neurotransmitter. Also referred to as a synaptic cleft.

Role in human health

Nerve cells are sensitive to disturbances caused by tumors, trauma, circulatory problems, metabolic disorders, and a host of other diseases that can be diagnosed by determining which reflexes show abnormalities. Abnormal reflexes may suggest the presence of significant central nervous system or peripheral nerve problems.

Reflex tests measure the presence and strength of a number of reflexes to help assess the integrity of the nerve circuits involved. Reflex tests are performed as part of a neurological exam to quickly confirm the integrity of the spinal cord, or to diagnose the presence and location of **spinal cord injury** or neuromuscular disease.

Common diseases and disorders

Some of the more common reflex-related diseases and disorders include stroke, traumatic **brain** or spinal cord tumors or injury, **multiple sclerosis**, Wernicke-Korsakoff syndrome, **cerebral palsy**, and diabetic neuropathy.

Stroke

Stroke is a brain disorder involving loss of brain functions due to interruption of the brain's **blood** supply.

Brain and spinal cord injury

Brain and spinal cord injuries most commonly result from motor vehicle accidents, **falls**, **sports injuries**, industrial accidents, gunshot **wounds**, and criminal assault. Damage to the spinal cord affects all nerve function at and below the level of the injury, including muscle control and sensation.

Brain and spinal tumors

Brain and spinal cord tumors are abnormal growths of tissue found inside the **skull** or the spinal column. The

word tumor is used to describe both abnormal growths that are new (neoplasms) and those present at birth (congenital).

Multiple sclerosis

Multiple sclerosis involves inflammation within the central nervous system, followed by demyelination, which is a loss of the protective myelin sheaths that surround nerve fibers. When the myelin is damaged, nerve impulses are not transmitted quickly and efficiently. As a result of the inflammatory process, lesions develop in the brain and spinal cord, causing a variety of neurologic symptoms, such as **vision** loss, numbness or tingling, weakness, unsteady gait, double vision, fatigue, heat intolerance, partial or complete **paralysis**, and electric shock sensations when bending the neck. These symptoms may cease or may persist after an attack. Symptoms may become progressively worse over time. For individuals with progressive forms of multiple sclerosis, these symptoms may gradually worsen over time without rapid or abrupt changes.

Wernicke-Korsakoff syndrome

Wernicke-Korsakoff syndrome usually affects people between 40 and 80 years old. The onset is gradual. The syndrome is actually two disorders that may occur independently or together. Wernicke's disease involves damage to multiple nerves in both the central nervous system and the peripheral nervous system. It may also include symptoms caused by alcohol withdrawal. The cause is generally attributed to malnutrition—especially lack of vitamin B₁ (**thiamine**), which commonly accompanies habitual alcohol use or **alcoholism**.

Korsakoff syndrome, or Korsakoff psychosis, involves impairment of **memory** and such intellectual/cognitive skills as problem-solving or learning, along with multiple symptoms of nerve damage. The most distinguishing symptom is confabulation (fabrication), during which the person makes up detailed, believable stories about experiences or situations to cover the gaps in their memory. Korsakoff psychosis involves damage to areas of the brain.

Cerebral palsy

Cerebral palsy is a persistent qualitative motor disorder caused by nonprogressive damage to the brain. Although manifested primarily by motor dysfunction, the disorder also may involve sensory deficits and impairment of the intellect. The majority of cases are caused during labor and delivery or during the first month of infancy. Cerebral palsy may be caused by premature birth, prolonged labor, or traumatic delivery. Any situa-

tion that interferes with fetal oxygen supply can produce brain damage and cerebral palsy.

Diabetic neuropathy

Diabetic neuropathy is a nerve disorder caused by diabetes. Symptoms of neuropathy include numbness and sometimes **pain** in the hands, feet, or legs. Nerve damage caused by diabetes can also lead to problems with such internal organs as the digestive tract, **heart**, and sexual organs, causing indigestion, **diarrhea** or constipation, dizziness, bladder infections, and impotence.

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National Institute of Neurological Disorders and Stroke.
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National Stroke Association. 9707 E. Easter Lane, Englewood, CO 80112. (800) STROKES. (303) 649-9299.
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Spinal Cord Injury Resource Center. <<http://www.spinalinjury.net/>>.

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Refractive eye surgeries

Definition

Refractive eye surgeries are medical procedures used to correct such refractive errors as **myopia**, **hyperopia**, and **presbyopia**. The three most widely utilized refractive surgeries approved by the U.S. Food and Drug Administration (FDA) are photorefractive keratectomy (PRK); laser-assisted in-situ keratomileusis (LASIK); and laser thermal keratoplasty (LTK). PRK and LASIK use an excimer laser to correct myopia by reshaping the cornea. The two techniques differ in how the surface layer of the cornea is treated.

Purpose

Refractive surgeries are performed to correct hyperopia, myopia, and presbyopia in patients who don't want to wear eyeglasses or **contact lenses**. After refractive surgery, most patients are able to see well enough to pass a driver's license exam without glasses or contact lenses. Some patients will still need corrective lenses, but the lenses won't need to be as strong or thick.

Precautions

Medical history is important in determining the appropriate refractive surgery patients. Patients for LASIK and PRK must be older than 18 years of age, have healthy corneas, and have **vision** that has been stable for the past year. People who may not be good candidates are pregnant women or women who are breastfeeding; patients with very small or very large refractive errors; those with low contrast sensitivity; people with scarred corneas or macular disease; or those with autoimmune diseases or diabetes. Patients with **glaucoma** should not have LASIK because the intraocular pressure (IOP) of the eye is raised during the procedure. A patient with persistent lid infections (i.e., blepharitis) may not be a good candidate because of an increased **infection** risk.

LTK patients must be at least 40 years old; have stable vision for at least six months; fall in the low-to-moderate range of hyperopia (+0.75–+2.50 diopters); and have no more than 0.75 diopters of **astigmatism**. Pregnant or nursing women, patients with clinically significant corneal dystrophy or scarring in the 6 mm or 7 mm central zone, patients with a history of herpetic keratitis, patients with an autoimmune disease, collagen vascular disease, clinically significant atopic syndrome, insulin-dependent diabetes, or an immune-compromised status should not have LTK.

Description

Refractive surgeries that correct myopia are similar in nature. PRK and LASIK are both performed with an excimer laser, which uses a cold beam of ultraviolet light to reshape the cornea so that light will focus properly on the retina. In myopia, the cornea is either too steep or the eye is too long for a clear image to be focused on the retina. PRK and LASIK flatten the cornea so that the image will focus more precisely on the retina.

In PRK, the surface of the cornea is removed by the laser. In LASIK, the outer layer of the cornea is sliced, lifted, and moved aside while the cornea is reshaped with the laser. The outer layer is then replaced to speed healing. For LASIK and PRK, the patient's eye is numbed with anesthetic drops. No injections are necessary.

Before LASIK, the cornea's surface is marked with a dye marker so that the flap of cornea can be precisely aligned when it is replaced. The ophthalmologist places a suction ring from a microkeratome, a lathe-like surgical instrument, on the corneal limbus (where the clear cornea meets the white of the eye). When the device is properly positioned, the surgeon applies suction by using a foot pedal, causing the eye's pressure to elevate to 80 mmHg from a minimum of 65 mmHg. During this time, the microkeratome lathes the top 10% of the total corneal thickness, which creates a thin flap of tissue. The thin layer is folded back, the cornea is reshaped with the laser beam, and the flap layer is replaced. Because the flap is not permanently removed, patients have a faster recovery time and experience far less discomfort than with PRK. A physician or ophthalmic assistant administers antibiotic drops, and the eye is patched until the following day's checkup.

In PRK, a small area of the surface layer of the cornea is vaporized. It takes about three days for the surface cells to grow back, and vision will be blurred.

PRK and LASIK take only a few minutes. Patients are usually able to return home immediately after surgery.

The LTK system resembles a slit lamp used in a general eye exam, so it is non-threatening to patients. Before the procedure, an ophthalmic assistant administers three sets of anesthetic eyedrops with three minutes between each set. Ophthalmologists use a retractor to keep the eyelids open, and the other eye is patched. There is a three-minute waiting period after insertion of the laser to evaluate the tear film for irregularities or uneven dry spots on the cornea. The patient focuses on a fixating light, and the 16-spot nomogram for the degree of correction is programmed into the LTK unit's computer. The laser is applied for three seconds.

After the procedure, the ophthalmic assistant or physician will give the patient topical antibiotic drops. There is no postoperative patching. Some patients may experience a foreign-body sensation for a few hours after LTK. It sometimes takes a few weeks for vision to stabilize. Patients are usually seen one day postoperatively.

The cost of refractive surgery can vary with geographic area and the surgeon. In general, the procedure costs \$1,350–\$2,500 per eye for PRK and about \$500 more per eye for LASIK. LTK is slightly more expensive than LASIK, at about \$3,000 per eye. Refractive surgery usually isn't covered by insurance.

Preparation

Refractive eye surgery patients should be carefully screened by an ophthalmic assistant or physician before surgery is approved to avoid some possible complications. This screening should include a comprehensive eye exam, either completed by the ophthalmologist or a co-managing optometrist at least a few days before the surgery. At this time, the physician or ophthalmic assistant should chart any dry eye or corneal disease that may hinder surgery. They should also perform corneal topography, which creates a topographical map of the patient's eye.

Assistants need to advise patients to discontinue wearing contact lenses prior to the visual exams to make sure vision is stable, and advise the doctor of contact lens wear.

Before surgery, ophthalmic staff administer eye-drops and a sedative to the patient. The physician tests the patient's vision, and the patient rests while waiting for the sedative to take effect. Immediately before the surgery, ophthalmic staff administer local anesthetic eye-drops.

Ophthalmic staff also will check the microkeratome settings before surgery and test their accuracy. Some complications from refractive surgery result from a faulty microkeratome.

Aftercare

The patient returns to the surgeon for a follow-up visit the next day. After that, postoperative treatment may be handled by a co-managing optometrist. The doctor usually prescribes antibiotic and anti-inflammatory eye-drops. PRK patients have a longer recovery time and may need steroidal eye-drops for months. After LASIK, antibiotic and anti-inflammatory drops are prescribed for one week.

LTK patients are treated similarly, with antibiotic drops and an over-the-counter **pain** reliever. Patients may have a foreign-body sensation for a few hours. It may take a few weeks for the eye to stabilize.

The attending physician will require the patient to return for a few months so that the patient's eye health and vision stability can be monitored. After that, yearly checkups are recommended.

Complications

There is a risk of under- or over-correction with LASIK and PRK. If vision is under-corrected, a second procedure can be performed to achieve results that may

be closer to 20/20 vision. About 5–10% of PRK patients return for an enhancement, as do 10–25% of LASIK patients. Patients with very high myopia (over -15.00 diopters) may experience improvement after LASIK, but are not likely to achieve 20/40 vision or better without glasses.

Severe dry eye syndrome is a possible complication of LASIK, and has been reported more often as the number of procedures performed has increased. The condition may be permanent. Physicians may prescribe intensive artificial tear therapy; and the use of punctal plugs or other procedures may be required.

Haze is another possible side effect, and is more likely to occur after PRK. Corneal scarring, halos, glare at night, or an irritating bump on the cornea are other side effects. Infection and vision loss are also possible with these procedures, but are extremely rare.

Most LASIK complications are related to the creation and realignment of the flap. The microkeratome must be in good working order and sharp. LASIK requires surgical skill and the complication rate is related to the experience level of the surgeon. In one study, the rate of LASIK complications declined from 3% for surgeons during their first three months using this technique, to 1% after a year's experience in the technique, to 0% after 18 months of experience.

Because LTK was approved in mid-2000, many of its complications have not yet been identified. Potential complications include corneal infiltrate or ulcer, uncontrolled intraocular pressure, late onset of haze, decrease in best spectacle-corrected visual acuity, or retinal detachment. In some cases the procedure is not successful at all.

Results

Most patients experience vision improvement immediately after refractive surgery. Vision tends to become sharper a few days after surgery and then stabilizes. Final visual acuity is achieved within three to six months with LASIK and six to eight months with PRK.

LASIK is more complicated than PRK because of the microkeratome procedure. However, LASIK generally has faster recovery time, less pain, and less chance of halos and scarring than PRK. LASIK can treat higher degrees of myopia (-5.00–25.00 diopters). LASIK also requires less use of steroids.

An LTK patient's vision will be overcorrected (improvement will be initially dramatic) for one to three months. The effect of improved near vision may diminish over time as distance vision improves.

KEY TERMS

Blepharitis—An inflammation of the eyelid.

Cataract—A condition in which the lens of the eye turns cloudy and interferes with vision.

Cornea—The clear, curved tissue layer in front of the eye. It lies in front of the colored part of the eye (iris) and the black hole in the center of the iris (pupil).

Diopter (D)—A unit of measure of the power or strength of a lens.

Excimer laser—An instrument that is used to vaporize tissue with a cold, coherent beam of light with a single wavelength in the ultraviolet range.

Hyperopia—The inability to see near objects as clearly as distant objects, and the need for accommodation to see objects clearly.

Intraocular lens (IOL) implant—A small plastic device (IOL), usually implanted in the lens capsule of the eye to correct vision after the lens of the eye is removed. This is the implant that is used in cataract surgery.

Macular degeneration—A condition usually associated with age, in which the area of the retina called the macula is impaired. This condition interferes with vision.

Microkeratome—A precision surgical instrument that can slice an extremely thin layer of tissue from the surface of the cornea.

Myopia—A vision problem in which distant objects appear blurry. Myopia results when the cornea is too steep or the eye is too long and the light doesn't focus properly on the retina. People who are myopic or nearsighted can usually see near objects clearly, but not far objects.

Refractive surgery—A surgical procedure that corrects visual defects.

Retina—The sensory tissue in the back of the eye that is responsible for collecting visual images and sending them to the brain.

There regression has been noted with LTK. The LTK mean rate of change decreases progressively, reaching only .02 diopters per month between 18 and 24 months. If the regression continues at the expected rate, the corrective effect would dissipate no sooner than 11 years after the procedure.

Health care team roles

Allied health professionals play an important role in preparing patients for refractive surgery. Advanced and intermediate-level ophthalmic technicians perform refractions and help determine the patient's eligibility for refractive surgery. These professionals also may perform corneal topography.

Specially trained ophthalmic nurses assist during the surgery. They check the microkeratomes and administer eyedrops. Advanced ophthalmic technologists, who are specially trained for such additional duties as taking ophthalmic photographs and using ultrasound, may administer eye medications, perform ophthalmologic tests, maintain ophthalmic surgical equipment and assist in refractive surgery.

Patient education

Refractive surgeons should carefully screen patients for these procedures and make sure the patients are aware of possible complications before the procedure begins. Some highly myopic patients expecting "perfect" vision will be disappointed when they discover they still need eyeglasses for distance vision.

Ophthalmic staff also need to stress that while LTK vision improvements may be startling at first, those changes are likely to fade. These patients should be advised they may still need glasses for fine print. Aging and the onset of presbyopia will still affect their vision.

Training

Ophthalmologists are advised to observe other surgeons perform these procedures before they begin. Laser companies offer seminars to help doctors perfect their techniques. Other groups, such as the American Society of Cataract and Refractive Surgery, keep physicians informed of the latest advances. Co-managing optometrists are advised to observe surgeries and attend seminars to learn more about follow-up treatments.

Ophthalmic assistants who want to assist in these surgeries can receive additional training from certified education programs.

Resources

PERIODICALS

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Brint, Stephen F., et al. "Photorefractive Keratectomy versus Laser in Situ Keratomileusis: Comparison of Optical Side Effects." *Ophthalmology* 107 (2000): 925-933.

Chynn, Emil William. "Refractive Business. No Time Like the Present." *Ophthalmology Times* (15 Feb. 1998): 11-12.

Gorman, David, and Arthur M. Cotliar. "Refractive Surgery Options: RK vs PRK vs LASIK." *Newsweek*, 16 June 1997, S38.

Vinals, Antonio. "No Regression Seen 2 Years After LASIK." *Ophthalmology Times* (1 Mar. 1998): 1, 34.

Vinals, Antonio. "Study Documents LASIK Learning Curve." *Ophthalmology Times* (1 Mar. 1998): 1, 35.

ORGANIZATIONS

American Academy of Ophthalmology. PO Box 7424, San Francisco, CA 94120-7424 (415) 561-8500. <<http://www.eyenet.org>>.

American Society of Cataract and Refractive Surgery. 4000 Legato Road, Suite 850, Fairfax, VA 22033-4055. (703) 591-2220. <<http://www.ascrs.org>>.

Food and Drug Administration. 5600 Fishers Lane Rockville, MD 20857. (888) 463-6332. <<http://www.fda.gov>>.

OTHER

"Career Cards-Vision Care." *East Texas Area Health Education Center*. <<http://www.etxahec.org/hcp/20a.htm>>.

"Laser Vision Correction Surgery." *Your Eye Site*. <<http://www.youreyesite.com/laserrisks.htm>>.

Mary Bekker

Regional anesthetic see **Anesthesia, local**

Regional enteritis see **Crohn's disease**

Registered nurse

Definition

Registered nurses, or RNs, are health care professionals who work as part of health care teams to promote health and prevent and treat disease. They are patient advocates and health care educators working to teach not only patients but also families and the community.

Description

With about 2.1 million positions in the field, RNs make up the largest health care occupation. More than half of all health professions students are nursing students, and there are four times as many RNs in the United States as physicians. Most nurses as of 2001 are women; only 5-7% of all nurses are men.

Nurses work collaboratively with physicians and other health care providers, although the nursing profes-

sion is independent of medicine and other health disciplines. RNs' roles span from direct patient care to case management. Nurses are an integral part of the health care system. In fact, most health care services involve nursing care in some form.

In the area of direct patient care, RNs have many responsibilities:

- They observe, assess, and record patients' symptoms, responses to treatment, and progress.
- They provide assistance to physicians and other health care providers during examinations and treatments.
- They administer medications and take vital signs.
- They help patients to rehabilitate and heal.
- They educate patients and families about appropriate care after treatment, as well as long-term health.
- They develop and manage plans for nursing care.

In hospitals, RNs often work as staff nurses, providing care at the bedside and managing patients' medical needs. In some cases, RNs in hospitals supervise licensed practical nurses and aides.

RNs who work in office settings, for physicians or in clinics, assist administratively in the office and help the medical staff with patient preparation and examination. They administer medications, perform some lab tests and injections, as well as dress **wounds** and incisions. RNs also assist with minor surgery techniques and record-taking.

Nurses in the nursing home setting provide a variety of care to elderly or sickly patients who cannot care for themselves because of age or illness. RNs in nursing home settings spend a good deal of their time developing treatment plans and performing other administrative duties, including supervising LPNs and nursing aides. They also provide direct patient care, assessing residents' medical conditions, monitoring treatment, and performing more advanced tasks, such as starting intravenous fluids. Nurses in this setting might concentrate on an area of specialization, such as long-term rehabilitation, in which they would care for stroke and **head injury** patients.

Home health nurses are often RNs who provide periodic at-home care for patients who might be recovering from illness or suffering from a chronic condition. While home health nurses work independently during their time in the home, the care they provide is prescribed by a physician or nurse practitioner.

RNs in **public health** nursing work in a variety of government and community organizations, including as school nurses and in public health clinics. The focus in this area of nursing is to make health care accessible to populations, including the underserved and those in rural

areas. The goal is to improve overall health care in a community. Public health nurses work with community members to plan and implement programs to enhance community health care and educate groups about good health practices, such as disease prevention, child care and **nutrition**. They work in partnership with families, schools and other public organizations to help educate members about health. And these RNs make arrangements for such health screenings as immunizations and **blood pressure** and cholesterol testing.

Occupational health or industrial nurses provide health care services on-site in different environments. These nurses might work at a company's headquarters providing nursing care to employees or at a resort providing nursing care to tourists. RNs in this environment provide emergency care, prepare accident reports and make arrangements for any necessary additional care. Especially in the employee environment, they might coordinate health screenings, health counseling and assess work environments for safety.

In 1998, RNs' median annual income was \$40,690. The median income that year of RNs working in hospitals was \$39,900; home health care services \$39,200; offices and clinics run by MDs \$36,500; and nursing and personal care facilities \$36,300.

The job market has been changing for RNs, making them more in demand. Much of this growth in opportunity is due to changing demographics. As more people become elderly, more will need nursing care and many more will need long-term care. The expansion of managed care has led to an increased emphasis on primary care. Another factor in the growth of the need for RNs is advancing technology, which requires the knowledge of RN or higher-level nurses. Essentially, the world is open to RNs because of opportunity and need now and in the future.

Work settings

The largest group of nurses work in hospitals, where they usually focus on a particular area of care, such as emergency room, intensive care, critical care, maternity, oncology, or pediatrics; or rotate throughout the hospital.

Nurses also work caring for patients on an outpatient basis in doctors' offices, clinics, surgery centers and emergency medical clinics. Some also work in **nursing homes**; public health facilities, such as government or private agencies and schools; on-site work environments in the occupational health or industrial nursing field; or in administrative positions within a corporate or organizational setting overseeing other nurses.

Nurses who work in hospitals generally work in fast-paced, pressure-filled environments. Many hospitals today are short-staffed due to budget cuts and the nursing shortage. Nurses in these and other environments spend considerable time standing and perform tasks that are hard on the body, such as lifting patients. Nurses often work all types of shifts, including daytime, weekend, and night shifts. Many nurses see the flexibility in scheduling as a positive factor—especially if they juggle childcare responsibilities. Nursing can be a dangerous occupation. They often care for people with infectious diseases, such as hepatitis, and are near radiation, chemicals used for instrument sterilization, and anesthetics. To avoid possible hazards, nurses must adhere to rigid safety guidelines. There is also an emotional toll involved with the job, as nurses often have close daily contact with patients who are severely ill or dying.

Education and training

RNs must graduate from a nursing program and pass a national examination to become licensed. They must periodically renew their licenses and, depending on which state they work, must also take continued education courses for license renewal.

There were more than 2,200 entry-level RN programs in the United States in 1998. RNs can pursue one of three educational options. They can complete an associate degree in nursing, which is usually offered at community and junior colleges and is about two years long; a bachelor of science degree in nursing, taken at colleges and universities and usually taking from four to five years; or a diploma program, which is given in hospitals and lasts about two to three years. Licensed graduates at any of these levels usually qualify to start work at the staff nurse level. Most RNs graduate with either an associate's or bachelor's degree. Today an increasing number of nurse executives are saying that they want a majority of their hospital staff nurses to have bachelor's degrees because of the more complex demands of patient care. In 1996, 27% of RNs reported have a diploma, 31% had a bachelor's degree and 32 percent held an associate's degree. There have been discussions in some states of requiring an RN to obtain a bachelor's degree or higher; however, this trend would not affect current associate degree RNs and would probably take place on a state-by-state basis. Most agree that there are more opportunities for advancement for RNs with bachelor's degrees in nursing. A bachelor's degree is often necessary for administrative positions and is required for admission to graduate nursing programs of all types, including research, consulting, teaching and clinical specialization.

Students in nursing programs take courses in anatomy, physiology, microbiology, nutrition, psychology, chemistry, nursing, and other behavioral sciences. In addition to classroom instruction, nursing students receive supervised clinical experience in hospitals and other health care facilities. Nursing students receive a variety of clinical experience in settings such as hospital maternity, psychiatric, pediatric and surgical wards. They also gain experience in public health departments, home health agencies, and ambulatory clinics.

Advanced education and training

RNs can go on to become **advanced practice nurses**, which include nurse practitioners, clinical nurse specialists, certified registered nurse anesthetists, and certified nurse-midwives. Advanced practice nurses generally have master's degrees or certificates. Nurse practitioners deliver front-line primary and acute care. They can prescribe medications, and diagnose and treat common acute illnesses and injuries. Nurse practitioners provide immunizations, conduct physical exams, and provide care to manage chronic diseases, such as diabetes. Certified nurse-midwives are trained to provide prenatal and gynecological care to healthy women. They also deliver babies in all types of settings, including the patient's home, and provide **postpartum care**. Clinical nurse specialists specialize in such areas as cardiology, oncology and pediatrics. Certified registered nurse anesthetists administer anesthetics to patients in in-patient, outpatient and in-office settings. They are often the sole providers of anesthesia.

RNs can also go on to careers in teaching, research, or administration. These areas require master's degrees in nursing or PhD or doctorate-level degrees. Doctorally-prepared RNs tend to go into education or research.

Future outlook

Registered nursing is projected to among the 10 top occupations in the United States to have the largest number of new jobs. Many areas of the country are suffering from severe nursing shortages and the problem is expected to get worse as baby boomers age. It is estimated that if current trends continue, demand for nurses will outweigh their supply by the year 2010. It is projected that by 2015, some 114,000 jobs for full-time equivalent RNs will go unfilled in the United States. In sum, nurses will be able to pick and choose the paths of their careers. It is expected that job growth in nursing will be faster than average, largely because of technical advances in patient care. These advances will diagnose disease earlier and improve upon current treatments. With the median age of nurses over 40, many nurses will be retiring. Many of the

positions in the future will come from openings left by these aging nurses. Areas that are expected to experience significant growth in nursing are ambulatory care settings, nursing homes, and home health care.

While hospitals will continue to need a tremendous number of nurses, hospitals are expected to grow more slowly than other health care environments. This is because the number of inpatients is expected to remain somewhat steady; patients are being released earlier and more procedures are being done outside hospitals. Nurses will find more opportunity in the hospital's specialty areas, including outpatient services, such as **chemotherapy** and rehabilitation. Home health employment for nursing will probably grow rapidly. A growing number of elderly who need nursing care but do not want to leave their homes will stimulate the expansion of this area of nursing. Nurses who are able to perform complex procedures in the home will be at the forefront of those able to take advantage of the home health opportunity. Nurses who want to work in nursing homes will find much faster than average growth in opportunities due to the growing number of people who are too old to live on their own.

Resources

ORGANIZATIONS

American Association of Colleges of Nursing. 202-463-6980.
<<http://www.aacn.nche.edu>>.

American Nurses Association. 600 Maryland Avenue, SW, Suite 100 West. Washington, DC 20024. 202-651-7000.
<<http://www.nursingworld.org>>.

OTHER

Occupational Outlook Handbook. U.S. Department of Labor, Bureau of Labor Statistics. Division of Information Services. 2 Massachusetts Ave., NE., Room 2860. Washington, D.C. 20212.
(202) 691-5200.<<http://stats.bls.gov>>.

Lisette Hilton

Registered dietician see **Dietetics**

Relaxation

Definition

Relaxation therapy is a broad term used to describe a number of techniques that promote **stress** reduction, the elimination of tension throughout the body, and a calm and peaceful state of mind.

Origins

Relaxation therapy has been around for thousands of years in the forms of transcendental **meditation** (TM), **yoga**, **t'ai chi**, **qigong**, and vipassana (a Buddhist form of meditation meaning insight and also known as mindfulness meditation). Progressive relaxation, a treatment that rids the body of **anxiety** and related tension through progressive relaxation of the muscle groups, was first described by Dr. Edmund Jacobson in his book *Progressive Relaxation*, published in 1929. And in 1975, Dr. Herbert Benson published his groundbreaking work *The Relaxation Response*, which described in detail the stress-reduction mechanism in the body that short-circuits the "fight-or-flight" response and lowers **blood pressure**, relieves muscle tension, and controls **heart rate**. This work gave further credence and legitimacy to the link between mind and body medicine. A number of today's commonly used relaxation techniques, such as cue-controlled relaxation, are a direct result of Benson's work in this area.

Benefits

Stress and tension have been linked to numerous ailments, including heart disease, high **blood pressure**, atherosclerosis, irritable bowel syndrome, ulcers, anxiety disorders, insomnia, and substance abuse. Stress can also trigger a number of distinct physical symptoms, including nausea, headache, hair loss, fatigue, and muscle **pain**. Relaxation therapies have been shown to reduce the incidence and severity of stress-related diseases and disorders in many patients.

Description

There are a number of different relaxation methods available. Some of the most widely taught and practiced by health care providers include progressive relaxation, cue-controlled relaxation, breathing exercises, guided imagery, and biofeedback.

Progressive relaxation

Progressive relaxation is performed by first tensing, and then relaxing, the muscles of the body, one group at a time. Muscle groups can be divided a number of different ways, but a common method is to use the following groupings: 1) Hands and arms; 2) head, neck, and shoulders; 3) torso, including chest, **stomach** and back; and 4) thighs, buttocks, legs, and feet. The patient lies or sits in a comfortable position, and then starts with the first muscle group, focusing on the feeling of the muscles and the absence or presence of tension. The patient then tenses the first muscle in the group; holds the tension for

approximately five seconds; and releases and relaxes for up to 30 seconds. The contrast allows the individual to notice the difference between feelings of tension and feelings of relaxation. The procedure is repeated with the next muscle in the group, and so on, until the first group is completed. The patient then starts on the next muscle group.

Progressive relaxation can be guided with verbal cues and scripts, either memorized by the patient or provided on instructional audiotapes. The procedure remains the same, but the individual is prompted on which muscles to flex and relax, and given other cues about noticing the difference between the tense and relaxed state. Some individuals may prefer progressive relaxation that is prompted with a tape, because it allows them to completely clear their minds and to just follow the given instructions.

Deep breathing exercises

Individuals under stress often experience fast, shallow breathing. This type of breathing, known as chest breathing, can lead to shortness of breath, increased muscle tension, and inadequate oxygenation of blood. Breathing exercises can both improve respiratory function and relieve stress and tension.

Before starting to learn breathing exercises, individuals should first become aware of their breathing patterns. This can be accomplished by placing one hand on the chest and one hand on the abdomen, and observing which hand moves further during breathing. If it is the hand placed on the chest, then chest breathing is occurring and breathing exercises may be beneficial.

Deep breathing exercises are best performed while lying flat on the back, usually on the floor with a mat. The knees are bent, and the body (particularly the mouth, nose, and face) is relaxed. Again, one hand should be placed on the chest and one on the abdomen to monitor breathing technique. The individual takes a series of long, deep breaths through the nose, attempting to raise the abdomen instead of the chest. Air is exhaled through the relaxed mouth. Deep breathing can be continued for up to 20 minutes. After the exercise is complete, the individual checks again for body tension and relaxation. Once deep breathing techniques have been mastered, an individual can use deep breathing at any time or place as a quick method of relieving tension.

Release-only relaxation

Like progressive relaxation, release-only relaxation focuses on relieving feelings of tension in the muscles. However, it eliminates the initial use of muscle tensing as practiced in progressive relaxation, focusing instead solely

on muscle relaxation. Release-only relaxation is usually recommended as the next step in relaxation therapy after progressive relaxation has been mastered.

In release-only relaxation, breathing is used as a relaxation tool. The individual sits in a comfortable chair and begins to focus on breathing, envisioning tension leaving the body with each exhalation. Once even, deep, abdominal breathing is established, the individual begins to focus on releasing tension in each muscle group until the entire body is completely relaxed.

Cue-controlled relaxation

Cue-controlled relaxation is an abbreviated tension relief technique that combines elements of release-only relaxation and deep breathing exercises. It uses a cue, such as a word or mental image, to trigger immediate feelings of muscle relaxation. The cue must first be associated with relaxation in the individual's mind. This is accomplished by choosing the cue and then using it in breathing and release-only relaxation exercises repeatedly until the cue starts to automatically trigger feelings of relaxation outside of the treatment sessions. Cues can be as simple as the word "relax," and are frequently used on relaxation audiotapes. They can also be a visual cue, such as a mental image of a white-sand Caribbean beach, a flower-filled meadow, or other relaxing images. Guided imagery also uses such visualization exercises to produce feelings of relaxation.

Guided imagery

Guided imagery is a two-part process. The first component involves reaching a state of deep relaxation through breathing and muscle relaxation techniques. During the relaxation phase, the person closes his eyes and focuses on the slow in-and-out of his breathing. Or, they might focus on releasing the feelings of tension from their muscles, starting with the toes and working up to the top of the head. Relaxation tapes often feature soft music or such tranquil, natural sounds as rolling waves and chirping birds in order to promote feelings of relaxation.

Once complete relaxation is achieved, the second component of the exercise is the imagery, or visualization itself. Relaxation imagery involves conjuring up pleasant, relaxing images that rest the mind and body. These may be experiences that have already happened, or new situations.

The individual may also use mental rehearsal. Mental rehearsal involves imagining a situation or scenario and its ideal outcome. It can be used to reduce anxiety about an upcoming situation, such as **childbirth**, surgery, or even such a critical event as an important

competition or a job interview. Individuals imagine themselves going through each step of the anxiety-producing event and then successfully completing it.

Biofeedback

Biofeedback, or applied psychophysiological feedback, is a patient-guided treatment that teaches an individual to manipulate muscle tension through relaxation, visualization, and other cognitive techniques. The name biofeedback refers to the biological signals that are fed back, or returned, to the patient in order for the patient to develop techniques of controlling them.

During biofeedback, one or more special sensors are placed on the body. These sensors measure muscle tension, **brain** waves, heart rate, and body temperature; and translate the information into a visual and/or audible readout, such as a paper tracing, a light display, or a series of beeps. While the patient views the instantaneous feedback from the biofeedback monitors, he begins to recognize what thoughts, fears, and mental images influence his physical reactions. By monitoring this relationship between mind and body, he can then use thoughts and mental images deliberately to manipulate heart beat, brain wave patterns, body temperature, and other bodily functions, and to reduce feelings of stress. This is achieved through relaxation exercises, mental imagery, and other cognitive therapy techniques.

As the biofeedback response takes place, the patient can actually see or hear the results of his efforts instantly through the sensor readout on the biofeedback equipment. Once these techniques are learned and the patient is able to recognize the state of relaxation or visualization necessary to alleviate symptoms, the biofeedback equipment itself is no longer needed. The patient then has a powerful, portable, and self-administered treatment tool to deal with problem symptoms.

There are dozens of other effective therapies that promote relaxation, including hypnosis, meditation, yoga, aromatherapy, **hydrotherapy**, t'ai chi, massage, **art therapy**, and others. Individuals should choose a type of relaxation therapy based on their own unique interests and lifestyle requirements.

Preparations

If an individual is considering relaxation therapy to alleviate such physical symptoms as nausea, headache, high blood pressure, fatigue, or gastrointestinal problems, he or she should consult a doctor first to make sure there isn't an underlying disorder or disease causing the symptoms. A complete **physical examination** and comprehensive medical history will be performed, and even

if an organic cause for the symptoms is found, relaxation exercises may still be recommended as an adjunctive, or complementary, treatment to relieve discomfort.

Relaxation therapy should always take place in a quiet, relaxing atmosphere where there is a comfortable place to sit or recline. Some people find that quiet background music improves their relaxation sessions. If an instructional audiotape or videotape is to be used, the appropriate equipment should be available.

The relaxation session, which can last anywhere from a few minutes to an hour, should be uninterrupted. Taking the phone off the hook and asking family members for solitude can ensure a more successful and relaxing session.

Precautions

Most commonly practiced relaxation techniques are completely safe and free of side effects.

Relaxation techniques that involve special exercises or body manipulation such as massage, t'ai chi, and yoga should be taught or performed by a qualified health care professional or instructor. These treatments may not be suitable for individuals with certain health conditions such as arthritis or **fibromyalgia**. These individuals should consult with their health care professional before engaging in these therapies.

Biofeedback may be contraindicated (not recommended) in some individuals who use a pacemaker or other implantable electrical devices. These individuals should inform their biofeedback therapist before starting treatments, as certain types of biofeedback sensors have the potential to interfere with their use.

Relaxation therapy may not be suitable for some patients. Patients must be willing to take a very active role in the treatment process, and to practice techniques learned in treatment at home.

Some relaxation therapies may also be inappropriate for cognitively impaired individuals (e.g., patients with organic brain disease or a traumatic brain injury) depending on their level of functioning. Given the wide range of relaxation therapies available, if one type of relaxation treatment is deemed inappropriate for these patients, a suitable alternative can usually be recommended by a qualified health care professional.

Side effects

Relaxation therapy can induce sleepiness, and some individuals may fall asleep during a session. Relaxation therapy should not be performed while operating a motor vehicle or in other situations where full and alert atten-

KEY TERMS

Qigong—An exercise practice derived from traditional Chinese medicine that is designed to facilitate energy flow throughout the body.

T'ai chi—A martial art that uses exercise to balance the body's energy flow to the body center in order to promote physical well-being.

tion is necessary. Other than this, there are no known adverse side effects to relaxation therapy.

Research and general acceptance

Relaxation therapies have been successfully used in relieving stress and anxiety for many years, and are generally well-accepted by the medical community for this purpose.

Recent research published in 1999 has also indicated that relaxation therapy may be useful in reducing the incidence of **preterm labor** in women at risk for delivering prematurely. The study also found that women who discontinued relaxation exercises for whatever reasons delivered earlier and had lower birth-weight babies than those who continued the treatment.

Training and certification

Relaxation therapy techniques are used by many licensed therapists, counselors, psychologists, psychiatrists, and other health care professionals. There are many self-help books, audiotapes, and videos available that offer instruction in relaxation techniques.

Resources

BOOKS

Davis, Martha et al. *The Relaxation & Stress Reduction Workbook*, 4th edition. Oakland, CA: New Harbinger Publications, Inc., 1995.

PERIODICALS

Lindgren, Maryclaire. "Relaxation Techniques Improve Preterm Labor Outcomes." *Women's Health Weekly* (July 26, 1999): 5-7.

ORGANIZATIONS

The American Psychological Association. 750 First St. NE, Washington DC 20002-4242. (800) 374-2721. <<http://www.apa.org>>.

OTHER

Brennan, Patricia. "Stress First Aid Kit." (Guided imagery audiotape set.) Available from Inside Out Publishing at (888) 727-3296 or <<http://www.facingthedawn.com>>.

Paula Ford-Martin

Renal calculi *see* **Kidney stones**

Renal failure, acute *see* **Acute kidney failure**

Renal failure, chronic *see* **Chronic kidney failure**

Renal radionuclide scan *see* **Kidney radionuclide scan**

Renin assay *see* **Plasma renin activity**

Reproductive health

Definition

A person's reproductive health is the maintenance of the health of his or her reproductive systems, which include respectively the penis and the testes, and the vagina, uterus, and breasts. The reproductive health spectrum also includes **pregnancy** and **infertility**.

Description

The reproductive systems

The **female reproductive system** comprises ovaries, fallopian tubes, uterus, vagina, breasts, and external genitalia. The ovaries hold the eggs and release them during ovulation. When an egg is fertilized, it travels through the fallopian tubes and is implanted in the uterus. The uterus, through the placenta and umbilical cord, nurtures the fetus for approximately 40 weeks, at which time the woman delivers.

The **male reproductive system** consists of the testes, epididymis, vas deferens, urethra, seminal vesicles, prostate, and penis. During intercourse, the penis—the copulating organ—becomes engorged with **blood** and becomes erect. Upon ejaculation, mature sperm cells are ejected into the vagina after moving through the vas deferens, passing the seminal vesicles and prostate gland. After the semen is deposited in the vagina, the sperm swim through the cervix, into the uterus, and up into the fallopian tubes. The egg is fertilized in the fallopian tubes, if indeed an egg is present.

Infertility

A person is infertile when he or she is unable to perform the function of reproduction. Infertility is considered a disease and affects more than six million men and women in the United States, according to the American Society for Reproductive Medicine (ASRM).

Infertility disorders in men include azoospermia, in which no sperm cells are produced; and oligospermia, in which few sperm cells are produced. Although the number of cases is rare, infertility can be caused by a genetic disorder. Typically, male infertility rests with the testes, responsible for the production of sperm. Disorders of the thyroid, adrenal and pituitary glands, **liver**, and kidneys—as well as infections and trauma to the testes—can contribute to male infertility.

Further, hazards in a man's workplace can affect his ability to have healthy children. These are called reproductive hazards, and include radiation, chemicals, drugs (legal and illegal), heat, and lead. Still, every man does not suffer the effects of workplace hazards; frequency, length, and method of exposure (inhalation, skin contact, ingestion) are a few of the factors that affect whether the man is exposed to any dangerous degree. These hazards, unfortunately, can arrest or slow the production of sperm. If there are fewer sperm to fertilize the egg, there will be fewer chances that the egg will be fertilized; if there are no sperm produced, the man is termed "sterile." If the workplace hazard has prevented sperm from being produced at all, the man is permanently sterile.

As of 2001, it is projected that reproductive issues will be the focus of greater attention in the United States in years to come. Reproductive issues are already included in the National Occupational Research Agenda (www.cdc.gov/niosh.com) coordinated by the National Institute of Occupational Safety and Health (NIOSH).

In women, infertility can be caused by an ovulation disorder, blocked fallopian tubes, pelvic inflammatory disease (PID), or endometriosis.

The vast majority of individuals suffering from infertility—85 to 90%—can be treated with medication or surgery. The remaining percentage of persons may turn to in vitro fertilization, in which conception takes place outside the body and the embryo is implanted in the uterus by a physician.

Viewpoints

Abortion

One of the most explosive and controversial aspects of reproductive health is abortion. Issues of morality, religion, and politics are often part of these discussions.

Worldwide, it is estimated that nearly half of all human pregnancies are unplanned. Many result from incorrect use or failure of contraceptives. Women may also become pregnant because they do not have access to family planning alternatives or are pressured by a partner not to use contraceptives.

Abortion became legal in 1973 following the landmark U.S. Supreme Court decision in *Roe vs. Wade*. Since then, the Court has heard at least 20 major cases challenging the law. The Supreme Court, however, has upheld *Roe vs. Wade* as of 2001.

Most abortions are performed within the first trimester, or the first three months of pregnancy. Fewer than 9% of abortions are performed in the second trimester; and in only rare cases when there is serious health concern are abortions performed in the final trimester.

Contraception

The purpose of contraceptives is to avoid pregnancy by preventing the likelihood of fertilization or implantation of a fertilized egg. Women can use devices that fit into either the vagina or uterus; these are known as barrier methods. There are advantages and disadvantages to each method. Sometimes they can cause such serious side effects as excessive menstrual bleeding. Barrier contraceptive devices, in addition to preventing pregnancy, also can help prevent sexually transmitted diseases (STDs) and the human **immunodeficiency** virus (HIV), the virus that causes the acquired immunodeficiency syndrome (**AIDS**). Male barrier methods include latex condoms.

Female barrier methods include the diaphragm, female condom, cervical cap, sponge, and intrauterine device (IUD). These devices can also be used with a chemical combination known as a spermicide, which helps to kill sperm during intercourse.

A diaphragm is a dome-shaped flexible barrier with a rim that fits into the vagina and prevents sperm from reaching the cervix. Health professionals recommend that diaphragms be used with spermicide to achieve an 82–94% effectiveness rate against pregnancy. Instruction is required on how to insert and remove the diaphragm. This device, which can be inserted up to six hours before intercourse, must remain in the vagina for six hours after intercourse. There are two disadvantages to the diaphragm. The diaphragm may be dislodged during sex. There is also an increased risk of bladder and urinary tract infections.

The female condom is designed to line the inside of the vagina. Made from polyurethane, unlike male condoms (which are made from latex), and used without a

spermicide, the female condom can be inserted up to eight hours before intercourse.

The cervical cap is a small dome, but is not as flexible as the diaphragm. It is placed tightly on the cervix one-half hour to 48 hours prior to intercourse, and is used with spermicide. When used alone, the cervical cap provides an 82–94% effectiveness rate. With spermicide, the cervical cap provides an even greater degree of confidence against unwanted pregnancy. There are several reasons that cervical caps are not widely used. Some women have difficulty with their insertion, which must be done at least one-half hour before intercourse. There is some discomfort when they are being inserted. Cervical caps can also be difficult to remove, and repeated intercourse dictates reapplication of the unit. There is some risk of irritation and allergic reaction. Last, because of the risks of toxic shock syndrome (TSS), women should not wear the cervical cap more for more than 48 hours after intercourse.

The contraceptive sponge also acts as a barrier and is used with a spermicide. The sponge is available without a prescription, and the woman does not need training to insert and remove it. However, the spermicide used with the sponge may be irritating and cause allergic reactions. The sponge should not be used more than once, and should be left in the vagina for six hours after intercourse. If left in for more than six hours, the woman is at risk for toxic shock syndrome.

The IUD, inserted by a health professional, blocks the fallopian tubes so that sperm have fewer chances of passing through the tubes to fertilize the woman's egg. In the event that sperm do pass through the tubes and an egg is fertilized, the IUD can prevent the fertilized egg from becoming implanted in the uterus. An IUD, however, can cause cramping and bleeding in women, and can be spontaneously expelled. This device has also been known to increase a woman's risk of developing PID, may increase her menstrual flow, and cause cramping. The rate of effectiveness with the IUD is greater than 99%.

Birth control pills (also called "combined pills") are more than 99% effective against pregnancy. They do not offer any protection against sexually-transmitted diseases (STDs). While they have some other disadvantages for women, such as possible dizziness, nausea, menstruation changes, and weight and mood fluctuations, there are also advantages. These include continuous contraceptive protection, if taken as prescribed. They are reversible. When one stops taking them, the pills stop working, and another method of birth control must be used immediately. Birth control pills must be taken daily, and are contraindicated for smokers over 35 years of age. They also increase blood clot risk.

The minipill, which is progestin only, has a 95% estimated effectiveness rate. It can also cause irregular bleeding, breast tenderness, weight gain, and a slightly increased chance of ectopic pregnancy; it does provide some protection against PID. It is completely ineffective as a barrier to STDs.

With a greater than 99% rate effectiveness and continuous protection against pregnancy for up to five years, the woman who has had a subdermal implant does not need to be bothered remembering to take a pill. An in-office procedure is required, though, to surgically introduce the implant. The patient may suffer from side effects, which may include menstrual bleeding irregularities and weight change.

Another birth control method with a greater than 99% effectiveness rate is the contraceptive injection (depot medroxyprogesterone acetate). One has three months' of protection, with no need to remember to do anything related to birth control on a daily basis. The woman requires quarterly injections at the doctor's office by the doctor or nurse. As with the implant, there may be side effects, which also include changes in menstrual bleeding and weight.

Tubal ligation, performed surgically by a physician, is a procedure that is irreversible. After a woman has undergone this procedure, she has a greater than 99% guarantee against becoming pregnant.

Men have far fewer choices in barrier contraceptives, but condoms remain the most popular choice. They are easy to obtain and the best means of protection from STDs and HIV. Made from latex, condoms are placed over the penis before intercourse to prevent the ejaculation of sperm into the woman's vagina. They can be used with or without spermicides. Without a spermicide, condoms are 88–98% effective against pregnancy. With spermicide, condoms may provide even higher protection against pregnancy. The disadvantages of using a condom are possibly reduced feeling by the man. There may also be less sexual spontaneity—and, of course, condoms can break.

The man also has the option of having a vasectomy. A surgical procedure that is permanent, the vasectomy provides continuous contraceptive protection. It is over 99% effective, and has no side effects.

Spermicide may be used alone, but it must be inserted within one hour before intercourse; requires reapplication for repeated intercourse; must be left in place for six to eight hours afterward; and is often messy. It may give some protection against chlamydia and gonorrhea. Spermicide's effectiveness rate against pregnancy is 79–97% when properly used. It provides a greater measure of safety when used with a condom.



Abortion rights supporters march through Washington. (UPI/Corbis-Bettmann. Reproduced by permission.)

Lastly, there is periodic abstinence, which requires no equipment, foams, or gels. It does, however, necessitate extremely careful planning, motivation, and patience. When a couple is practicing abstinence, intercourse during half of the menstrual cycle is prohibited. If a woman has an irregular cycle, the couple cannot use this method, as fertile periods cannot be determined with any degree of confidence.

Family planning

Couples trying to control the frequency and number of pregnancies can do so through family planning. Women may want to increase their chances of getting pregnant or determine the most infertile times to have intercourse so that they can prevent pregnancy. Women may choose to use barrier methods or oral contraceptives to prevent pregnancy, and men may use condoms.

In “natural family planning,” women chart their menstruation and ovulation to determine fertile and infertile periods—but without actually having to use artificial **contraception**. Typically, women ovulate on the 14th day of their monthly cycle, which is the best time to become pregnant—although a woman is fertile over a range of days because sperm can remain viable inside the

genital tract for up to 48 hours. Basal body temperatures and the texture of cervical mucus should be recorded. These data will aid in the determination of the woman’s fertile days.

In 1970, President Richard Nixon signed into law Title X of the **Public Health Service Act**, referred to as “America’s family planning program.” The program provides funding for low-income women who need contraceptives to prevent pregnancy. The program set a minimum standard of care that requires women to have options among contraceptive methods, and prohibits coercion of women to choose one method over another. Individuals are charged fees for service based on their income and ability to pay. Title X monies do not fund abortions. The program provides for pelvic exams, Pap tests, breast examinations, safe-sex counseling, infertility screening, and referrals to specialized health care when needed.

Professional implications

There is a variety of health disciplines that serves the needs of individuals seeking reproductive health services. Gynecologists treat women seeking services that

KEY TERMS

Azoospermia—In infertile men, it refers to the lack of sperm being produced.

Cervix—The lowest part of the uterus that connects the vagina to the uterus.

Contraceptives—Devices or medications designed to prevent pregnancy by either suppressing ovulation, preventing sperm from passing through the cervix to fertilize an egg, or prevent implantation of a fertilized egg.

Diaphragm—A barrier form of contraception that is a flexible, dome-shaped device with a rim that blocks sperm from passing through the cervix.

Endometriosis—The presence and growth of functioning endometrial tissue in places other than the uterus that often results in severe pain and infertility.

Epididymis—Elongated cordlike structure along the posterior border of testes.

Fallopian tubes—Tubes that are part of a woman's reproductive system that extend from the uterus to the ovaries and carry a fertilized egg to the uterus for implantation.

Infertility—When a person is unable to perform the function of reproduction because of a physical, mental, or hormonal problem.

In vitro fertilization—When an egg is fertilized by sperm outside of the body.

Oligospermia—Low sperm count in men.

Ovulation—The discharge of a mature ovum, or egg, from the ovary.

Prostate—A gland made up of muscular and glandular tissue that surrounds the urethra at the bladder in men.

Testes—Male gonads; the paired egg-shaped glands normally located in the scrotum where sperm develop.

Urethra—Membranous canal through which urine is released from the bladder to the outside of the body.

Vas deferens—The tube cut in a vasectomy.

include Pap exams, breast exams, and pelvic exams; obstetricians provide medical care for women who are pregnant and planning to carry their babies to term.

These professionals can refer women to specialists for further care as necessary—such as radiologists (who perform mammograms and a variety of ultrasound procedures) and oncologists (in cases of possible or confirmed diagnoses of gynecological cancers). In lieu of an obstetrician, a pregnant woman may consult a midwife. Women may also consult their primary care doctors for basic reproductive health questions. Primary care physicians typically can perform routine Pap and pelvic exams and give advice on contraception.

Similarly, men can consult their primary care doctors for reproductive health care. For further problems and follow-up, however, urologists should be consulted.

For other issues related to reproductive health—particularly those of an emotional nature—licensed social workers, psychologists, psychiatrists, and sex therapists may be helpful.

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Meghan M. Gourley

Reproductive system, female

Definition

The female reproductive system is composed of organs that produce female eggs (called female gametes or ova); provide an environment for fertilization of the egg by a male sperm (male gamete); and support the development and expulsion of a fetus in **pregnancy** and **childbirth**.

Description

The normal female reproductive system is composed of external and internal genitals (genitalia).

External genitals

The external genitals (together, they are called the “vulva”) are composed of the genital structures visible from outside the body: the greater lips (labia majora); the lesser lips (labia minora); the clitoris; and the opening of the vagina to the outside (the other end of the vagina opens inside the body to the womb). The labia majora are two large lips that protect the other external genitals. The outer surface of these lips is covered with oil-secreting (sebaceous) glands; their inner surface has hair. The lesser lips (labia minora) are found just inside the greater lips and protect the immediate opening to the vagina (this opening is called the “introitus,” Latin for “entrance”) and the opening to the urethra (which carries urine from the bladder out of the body). The clitoris is a small structure found at the top of the lesser lips; it is very sensitive to stimulation and may become erect. The perineum is the area between the vagina and the anus in the female (in the male, the perineum is the area between the scrotum and the anus). Two glands, one located on either side of the introitus, are called Bartholin’s glands; they secrete a mucus that provides lubrication during sexual intercourse.

Internal genitals

The internal genitals are the vagina, the womb (uterus), the fallopian tubes, and the ovaries. The vagina extends approximately 3 to 4 inches (7 to 10 cm) from the outside of the body to the opening of the womb. The lower third of the vagina (closest to the outside) is encircled by muscles that control its opening and closing. The womb is the organ found at the top of the vagina and consists of two main parts: the neck (cervix) and the body (corpus). The neck is the opening of the womb to the vagina that allows sperm to enter the womb and allows menstrual fluid to exit. The neck is an important means of protecting the body of the womb from disease-causing

germs; a thick mucus normally covers the neck of the womb but changes in consistency during ovulation to allow sperm to penetrate. The body of the womb is the main part of the womb—the womb in the narrower sense of the word. It can enlarge to hold a developing fetus during pregnancy. The inner lining of the body of the womb is called the endometrium, which thickens and then sheds menstrual fluid during each menstrual period if fertilization does not occur.

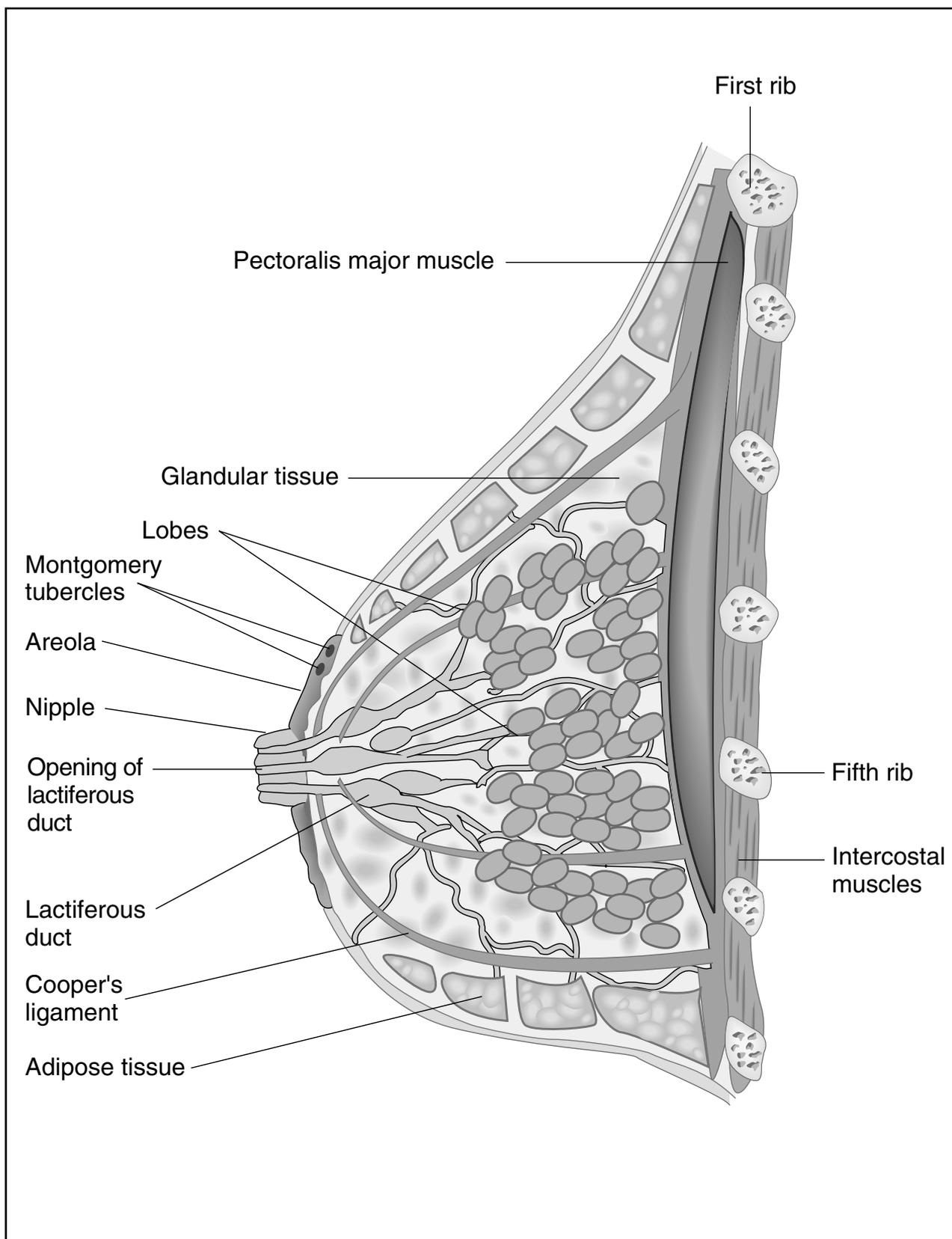
The fallopian tubes (also called the oviducts or uterine tubes) are muscular structures that extend from the upper edges of the womb to the ovaries. The fallopian tubes facilitate the transfer of a mature egg from one of the two ovaries to the body of the womb. A fallopian tube is the site of normal fertilization. The ovaries are a pair of small oval-shaped structures and are suspended near the fallopian tubes by ligaments. A female human being will not produce any new developing eggs (oocytes) after she is born; although she is born with approximately two million eggs, only about 300,000 to 400,000 remain at onset of **puberty**, and only about 300 of these will develop fully and enter a fallopian tube for possible fertilization. The eggs start as oocytes and develop in what are called ovarian or Graafian follicles, small spherical sacs that burst when the mature egg (called an ovum) is ready to be released into a fallopian tube for possible fertilization, or for discharge in the menstrual fluid if fertilization does not take place.

The human egg is a round cell that, when mature, is surrounded by a number of protective layers (the oolemma, zona pellucida, and zona radiata). It contains half the number of chromosomes of a human cell that is not egg or sperm (that is, 23 instead of 46 chromosomes) and is therefore called a haploid (one-fold) cell. When the egg is fertilized by sperm, the resulting cell will have the full number of forty-six chromosomes and will be considered a diploid (two-fold) cell.

Function

Menstruation

The menstrual cycle ranges from 21 to 40 days in most women, with an average cycle lasting 28 days. The first time a girl has a period (the onset of menstruation) is called “menarche”; the permanent cessation of menstruation some decades later is called “menopause” and marks the traditional end of a woman’s ability to reproduce. In the 1990s, women past **menopause** have been impregnated with another woman’s egg after it has been fertilized by artificial insemination, and these older women have successfully given birth to healthy babies.



Cross section of the female breast. (Delmar Publishers, Inc. Reproduced by permission.)

Menstruation occurs when the lining of the womb begins to shed menstrual fluid; the first day of bleeding is the first day of the menstrual cycle. The menstrual cycle has two phases. The follicular phase extends from the first day of the cycle until immediately before a mature egg gets released from the ovary.

In the second phase of the menstrual (ovulatory) cycle, called the “luteal” phase, the mature follicle bursts and releases an egg, a process called ovulation. The second phase of the menstrual cycle lasts approximately fourteen days until the first day of the next period (using as an example the average 28 day menstrual cycle). The ruptured empty follicle collapses to form the corpus luteum.

Fertilization

During the ovulatory phase of the menstrual cycle, the mature egg is released from the ovary and swept into the fallopian tube. If sperm cells are present in the fallopian tube, fertilization may occur. Pregnancy begins at the moment of fertilization (also called conception), when the sperm penetrates the egg. The fertilized egg, also called a zygote, then begins to move down the fallopian tube into the womb, where it implants itself in the thick tissue of the lining of the womb. In the womb, this replicating cluster of cells is called a blastocyst; after two weeks of development, it is called an embryo; eight weeks after conception, it is called a fetus.

Hormones

A complex balance of hormones is required for reproduction. There are two main groups of hormones that are necessary for normal functioning of the female reproductive system.

The first group contains hormones of the **central nervous system (CNS)**. A part of the **brain** called the hypothalamus is the main area of hormonal control; it secretes so-called releasing hormones that travel to the **pituitary gland** located at the base of the brain. Gonadotropin-releasing hormone (GnRH) secreted by the hypothalamus triggers the release of gonadotropic hormones from the anterior pituitary gland. Gonadotropin refers to any hormone that stimulates the gonads (the structures capable of producing eggs or sperm; that is, the ovaries or the testicles); regulates their development and their hormone-secreting functions; and contributes to the production of eggs or sperm.

There are two gonadotropic hormones secreted by the anterior pituitary gland: the follicle-stimulating hormone (FSH) and the luteinizing hormone (LH). The development of the ovarian follicles is dependent upon these hormones. FSH (as its name suggests) stimulates

the development of several follicles in each cycle. During the first half of the follicular phase, increasing levels of FSH cause maturation of ovarian follicles (only one follicle will mature completely). It is the LH that begins the second phase of the menstrual cycle, when a surge of LH causes the mature follicle to burst and release an egg. FSH and LH also control the production of ovarian hormones (the second group of hormones regulating the female reproductive system).

The ovarian hormones in turn are divided into two groups: ovarian peptide hormones and ovarian steroid hormones.

There are two ovarian peptide hormones, inhibin and relaxin. Inhibin is secreted by the granulosa cells of the follicles. It inhibits the releasing of FSH from the anterior pituitary gland and also inhibits the release of GnRH from the hypothalamus. Thus inhibin has a role in controlling further follicular development. Relaxin is produced near the end of pregnancy by the corpus luteum and promotes relaxation of the birth channel.

There are two biologically extremely active ovarian steroid hormones: estrogen and progesterone. Estrogen is produced by the granulosa cells of developing follicles and by the corpus luteum following ovulation. This production of estrogen is dependent upon luteinizing hormone (LH). The most potent estrogenic hormone in human beings is estradiol. It is synthesized and secreted by ovarian follicles, specifically by the theca interna cells (these cells synthesize androstenedione, which is then converted into estradiol and estrone). Estradiol can also be synthesized by the fetoplacental unit and, perhaps, by the adrenal cortex. It has the following biological functions: to promote the growth and maturation of the female secondary sex characters; to induce estrus; in conjunction with progesterone to prepare the endometrium for implantation of a fertilized ovum; and to support pregnancy.

Progesterone is a hormone produced by the corpus luteum. (It can also be secreted by the placenta and by the adrenal cortex.) Together with estrogen, it prepares the endometrium for implantation of the fertilized ovum, it maintains the uteroplacental unit, and it promotes the development of the fetus.

Another important endocrine organ secreting the steroid hormones (estrogen and progesterone) is the placenta. It helps maintain the uterine mucosa during pregnancy. The placenta also produces and secretes chorionic gonadotropic hormone. The actions of human chorionic gonadotropin (hCG) resemble those of LH. The presence of hCG in urine in early pregnancy is the basis of most pregnancy tests. Human chorionic gonadotropic hor-

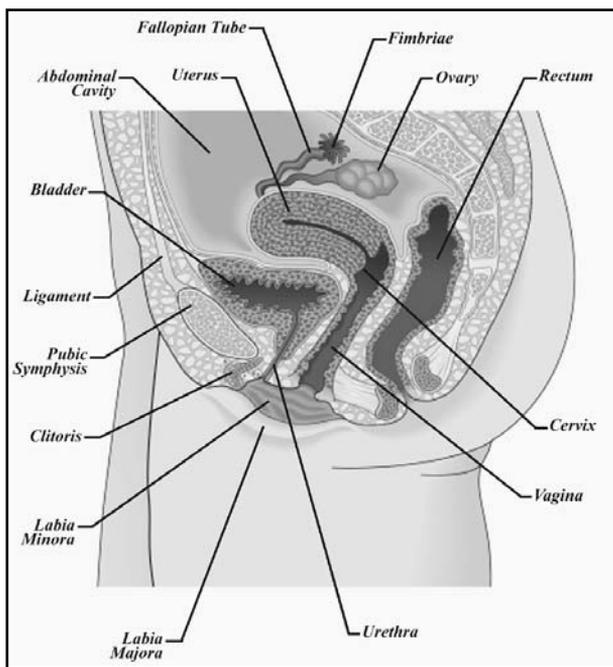


Illustration of the female reproductive system. (Kopp Illustration, Inc. Reproduced by permission.)

one maintains the secretory integrity of the corpus luteum.

Common diseases and disorders

Infertility

Infertility is diagnosed when a sexually active couple is unable to get the woman pregnant (or she is unable to carry a pregnancy to a successful childbirth) after one year of attempts. There are numerous reasons why infertility may occur:

- low number or lack of sperm cells produced by the male
- lack of ovulation (no eggs released from ovaries)
- abnormal fallopian tubes
- occurrence of what would normally be the lining of the womb somewhere else than in the womb (endometriosis), such as in the fallopian tubes
- problems with thick mucus in the neck of the womb (hence, sperm are not able to enter the womb)

A number of techniques may be used to assist a couple in getting the woman pregnant. These include fertilization in a dish (in vitro fertilization, IVF; *in vitro* is Latin for “in glass”). Eggs are removed from the woman, placed in a culture dish, and fertilized by sperm, then inserted into the womb for implantation. An alternate technique is gamete intrafallopian transfer, or GIFT.

Male and female reproductive cells are removed from the man and woman and then transferred to the fallopian tube where fertilization may take place naturally.

Cancer

Cancer (uncontrolled and abnormal new growth of cells) may occur in any of the structures of the reproductive system, male or female. Common types of cancer in women include the following:

- Cancer of the womb (uterine carcinoma). It is the most common cancer of the female reproductive system.
- Cancer of the neck of the womb (cervical carcinoma). It may be caused by the sexually transmitted human papillomavirus or HPV.
- Cancer of the ovaries (ovarian carcinoma). It has the highest death rate of all cancers of the female reproductive system.
- Cancer of the external genitals (vulvar carcinoma). It is usually a type of skin cancer.
- Cancer of the vagina (vaginal carcinoma). It may be caused by the sexually transmitted human papillomavirus (HPV).
- Cancer of the fallopian tubes. It is the rarest cancer of the female reproductive system.
- Tumors that form in the womb during or after pregnancy (hydatidiform moles).

Other

The absence or abnormal stopping of menstrual periods (amenorrhea). A number of factors may abnormally stop menstruation. They include abnormal production of LH and FSH; excessive **exercise**; extreme **stress**; and near-starvation.

Painful menstruation, that is, menstruation with severe cramps or aches (dysmenorrhea). It may be caused by excessive production of prostaglandins (the hormones that cause the womb to contract forcefully at childbirth, thus squeezing the fetus into the vagina) or by diseased genitals.

Premenstrual syndrome (PMS) occurs during the luteal phase of the menstrual cycle and is characterized by numerous symptoms. These include changes in mood and behavior, cramps, headaches, fluid retention, and fatigue. Approximately 40% of menstruating women complain of some sort of PMS.

Toxic shock syndrome (TSS) is a rare but devastating disease associated with tampon use. Although the exact cause of the disease is not known, it has been linked to **infection** by *Staphylococcus aureus*. If *S.*

KEY TERMS

Amenorrhea—Abnormal absence or stopping of menstrual cycles.

Dysmenorrhea—Painful menstruation.

Endometrium—The inner lining of the womb.

External genitals—The greater lips (labia majora), the lesser lips (labia minora), the clitoris, and the opening of the vagina.

Follicle—A small spherical sac located in an ovary in which an oocyte develops and matures; when the follicle bursts, the mature egg (ovum) is released into the fallopian tube. Only about 300 follicles burst during a woman's lifetime.

Gamete—A one-fold (haploid, that is, having 23 instead of 46 chromosomes) cell involved in sexual reproduction; the male gamete is the sperm; the female gamete is the egg.

Internal genitals—The vagina, womb, fallopian tubes, and ovaries.

Menarche—The first menstrual cycle in a girl's life.

Menopause—The permanent stopping of menstrual cycles, traditionally marking the end of a woman's ability to reproduce.

Menstruation—The discharge of the lining of the womb (endometrium) as it sheds during the menstrual cycle when pregnancy does not take place.

Zygote—A two-fold (diploid, that is, having 46 chromosomes) cell resulting from fertilization of the female egg by a sperm.

aureus enters the vagina, it is possible that tampon use could promote the growth of these deadly **bacteria**. *S. aureus* may then secrete poisons (toxins) that enter the bloodstream and lead to TSS. Symptoms start with **fever**, vomiting, **diarrhea**, and low **blood pressure**, but may eventually involve multiple organ systems and result in death.

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Stéphanie Islane Dionne

Reproductive system, male

Definition

The male reproductive system is composed of organs that work together to produce sperm and deliver them to the female reproductive tract for fertilization of the ovum.

Description

The normal male reproductive system is composed of numerous anatomical structures, including the testis, the excretory ducts, the auxiliary glands, the penis, and the various hormones that control reproductive functions.

Testis

The testis is responsible for the production and maturation of sperm in a process called spermatogenesis. It is also the site of synthesis and secretion of androgens (male sex hormones). The testes (plural) develop in the abdomen and descend into the scrotum in the normal male. The scrotum is a muscular sac in which the testes hang from the spermatic cord.

The testis is subdivided into the tubular compartment and the interstitial compartment. The tubular compartment is composed of up to 900 seminiferous tubules, which are populated by three main types of cells: germ cells, peritubular cells, and Sertoli cells. Germ cells become mature sperm in the spermatogenic process. Peritubular cells produce various factors that aid in the

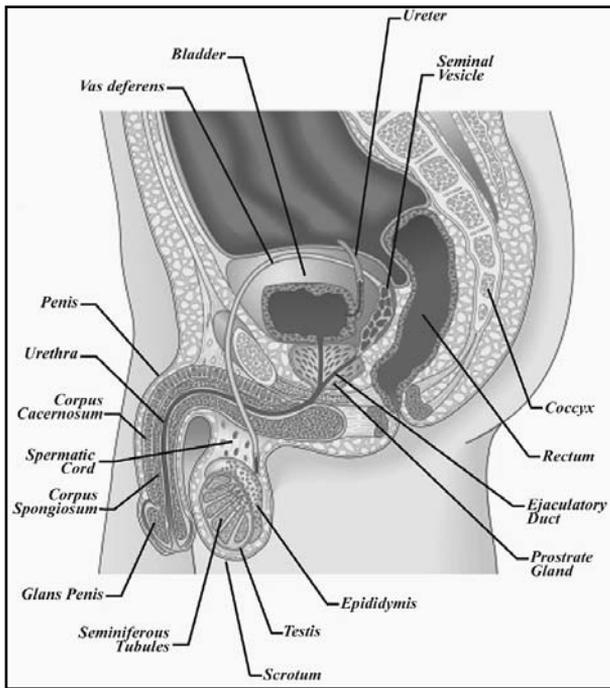


Illustration of the male reproductive system. (Kopp Illustration, Inc. Reproduced by permission.)

transportation of mature sperm to the epididymis. Sertoli cells secrete various factors that determine the sperm production and testis size of an adult male.

Androgens are produced in the interstitial compartment of the testis. Leydig cells are responsible for the production and secretion of testosterone. Immune cells such as macrophages and lymphocytes are also found in the interstitial compartment, and aid in the proliferation and hormone production of Leydig cells.

Sperm cells are composed of a head (containing the nucleus and acrosome); the body (containing the mitochondria, or energy-producing organelles); and the tail. The nucleus contains the cell's genetic material (chromatin) while the acrosome contains enzymes that are capable of penetrating the protective layers around the egg. The mitochondria provide energy for tail motility; this is essential for movement of the sperm through the female reproductive tract.

Excretory ducts

The excretory ducts are responsible for the transfer of sperm from the seminiferous tubules of the testis to the urethra, and include the epididymis, the vas deferens, and intratesticular ducts. The epididymis is a tubular structure through which sperm exiting the seminiferous tubules pass. Testicular sperm are not fully mature and would not be able to fertilize an ovum (egg). Complete maturation

occurs in the epididymis in the two to twelve days that sperm are typically stored before being passed to the vas deferens. The vas deferens functions to carry mature sperm from the epididymis to the urethra; it is also called the ductus deferens. Secretions from the auxiliary glands are mixed with sperm in the vas deferens to form semen.

Auxiliary glands

The auxiliary glands include two bulbourethral glands, one prostate, and two seminal vesicles. These glands contribute the secretions that compose semen. The bulbourethral glands (also called the glands of Cowper) secrete a fluid that lubricates the urethra prior to ejaculation. The prostate secretes a fluid rich in **zinc**, citric acid, choline, and various **proteins**. The secretions of the seminal vesicle are high in fructose (an energy source for sperm) and prostaglandins (fatty acid derivatives).

Penis

The penis is the male organ of sexual reproduction and consists of three elongated bodies that cause erection, the two corpora cavernosa and the corpus spongiosum. These tissues become engorged with **blood** when stimulated by the nervous system during arousal. Blood is supplied by the superficial and deep arterial systems (which carry blood to the penile skin and erectile tissue, respectively). The urethra runs through the corpus spongiosum to the glans penis (distal end of the penis). The organ is covered with loose skin that forms the prepuce (foreskin) over the glans penis.

Function

Endocrine control

Normal reproductive function is dependent on complex interactions between various hormones. A portion of the **brain** called the hypothalamus secretes releasing hormones that travel to the **pituitary gland**, located at the base of the brain. The secretion of gonadotropin-releasing hormone (GnRH) from the hypothalamus triggers the release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the pituitary gland. LH stimulates testosterone production by Leydig cells in the testis, and FSH promotes spermatogenesis.

Male sexual act

The male sexual act can be divided into three main steps: erection, emission, and ejaculation. Erection is the result of increased blood flow to the erectile tissues of the penis; stimulation of the nervous system during arousal causes a release of acetylcholine (a neurotransmitter) that

in turn causes vasodilation (increase in the diameter of **blood vessels**). Emission is the passage of sperm and secretions into the urethra mediated by release of the hormone adrenaline. Ejaculation occurs when the sperm are forced from the urethra by contraction of the bulbocavernosus muscles. A release of noradrenaline causes the blood vessels in the penis to contract, decreasing blood flow and resulting in detumescence (loss of erection).

Fertilization

In order to fertilize the ovum, ejaculated sperm must move into the vaginal tract, pass through the cervix, survive in the uterus, and enter the fallopian tubes. Usually only healthy, motile sperm will reach the ovum and have the opportunity to fertilize it. Numerous protective layers (including the oolemma, the zona pellucida, and the zona radiata) surround the ovum, and sperm cells must penetrate each of these layers for fertilization to occur. Binding of a sperm cell to the zona pellucida induces the acrosome reaction, which permits the sperm to penetrate the zona pellucida and reach the egg membrane. The sperm and egg membranes fuse to form a zygote, and subsequent reactions prevent the binding of additional sperm cells to the egg membrane.

Common diseases and disorders

Diseases of the male reproductive system are classified based on the localization (e.g. testis, pituitary gland, etc.) and cause (e.g. congenital malformation, cancerous tumor, etc.) of the disorder. Some common examples of andrological disorders include:

- **Infertility:** Male infertility may be the symptom of multiple disorders. A blockage in both of the vasa deferentia or a testicular disorder may result in the complete absence of sperm (azoospermia). Low sperm counts might result from a prolonged increase in scrotal temperature—as in the case of a varicocele, a disturbance in testicular blood circulation. Retrograde ejaculation is another cause of male infertility; semen travels in the wrong direction, up the urethra to the bladder instead of down toward the penis.
- **Hypogonadism:** This describes a condition in which there is decreased sexual development and growth of the testes. Hypogonadism may result from tumors, hormone imbalances, or chromosomal abnormalities. Its symptoms (after **puberty**) include voice alteration, decreased size of testes, gynecomastia (enlargement of mammary glands), an infantile penis, or osteoporosis.
- **Erectile dysfunction:** It is estimated that the incidence of erectile dysfunction (ED) is twice as high as that of coronary **heart** disease. ED may result from reduced

KEY TERMS

Acrosome—A compartment in the head of the sperm that contains enzymes that allow the sperm to penetrate the protective layers of an egg.

Androgen—A male sex hormone.

Azoospermia—The complete absence of sperm in ejaculate.

Gynecomastia—Enlargement of the male mammary gland; a symptom of hypogonadism.

Hypogonadism—A condition in which there is decreased sexual development and growth of the testes.

Leydig cells—Found in the interstitial compartment of a testis; responsible for the production and secretion of testosterone.

Sertoli cells—Found in the tubular compartment of a testis; aids in the process of spermatogenesis.

Spermatogenesis—The process of the formation of sperm.

Varicocele—An abnormal swelling of veins in the scrotum.

Zygote—The cell resulting from the fusion of the male and female gametes.

penile blood flow, low serum levels of testosterone, use of psychotropic drugs, alcohol abuse, such metabolic disorders as **diabetes mellitus**, or muscle cell impairment.

- **Prostate cancer:** The prostate surrounds the urethra and secretes seminal fluids. Prostate **cancer** is the second most common cause of cancer death of men in the United States, and the second most commonly diagnosed form of cancer (after skin cancer).

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Respiratory distress syndrome

Definition

Respiratory distress syndrome (RDS) of the newborn, known as infant RDS, is an acute lung disease present at birth. RDS usually affects premature babies who weigh less than 5.5 pounds (2.5 kg). In these babies, the lack of a pulmonary substance called surfactant allows layers of tissue called hyaline membranes to develop in the **lungs**. This development prevents the oxygen that is inhaled from passing into the **blood vessels** (capillaries) and thereby into the bloodstream. The lungs are said to be airless. Untreated, the infant will die within a few days after birth. RDS in newborns used to be called hyaline membrane disease.

Description

To breathe properly, the alveoli (small air sacs in the lungs) of a newborn infant must remain open so that oxygen in the air can enter the capillaries that surround the alveoli. Normally, during the last months of **pregnancy**, cells in the alveoli produce a substance called surfactant that maintains a low surface tension inside the alveoli. This allows the sacs to expand at the moment of birth, enabling the infant to breathe. Surfactant is produced starting at about 34 weeks of pregnancy and, by the time the fetal lungs mature at 37 weeks, a normal amount is present; after this point, it can be detected in the amniotic fluid.

When an infant is born prematurely without enough surfactant in the alveoli, the lungs may collapse, making it very difficult for the baby to get enough oxygen. Sometimes a layer of glassy, fibrous tissue called a hyaline membrane forms in the air sacs, making it even harder for oxygen to pass through the membrane to the capillaries.

Causes and symptoms

RDS nearly always occurs in **premature infants**, and the earlier the birth, the greater the chance that RDS will develop. The syndrome is also seen in some infants whose mothers have diabetes. Paradoxically, RDS is less likely to occur in the presence of conditions that are equally harmful: abnormally slow fetal growth, toxemia, and early rupture of the amniotic sac.

An infant with RDS may struggle to breathe as soon as it is born, or difficulty may develop within a few hours. Breathing becomes rapid and shallow, the nostrils flare, and the infant grunts with each breath. Muscles around the ribs and structures in the neck strain inward with each breath, showing the extreme effort that is being exerted. Before long, the intercostal muscles that move the ribs and diaphragm to draw air into the lungs become fatigued, making the breaths even more shallow. This shallow breathing diminishes the oxygen level in the **blood** so severely that the infant becomes cyanotic (the skin turns bluish). Tiny, very premature infants may not even have signs of trouble breathing. Their lungs may be so filled with hyaline membrane that when they are born they cannot even start breathing without assistance.

There are two major complications of RDS. One is pneumothorax, which means "air in the chest." When the infant itself or a ventilator breathing for the infant forces air into the lungs in an attempt to expand them, a lung may rupture, causing air to leak into the chest cavity. This air puts pressure on the lung, collapsing it and making breathing even more labored. Because pneumothorax interferes with blood flow in the pulmonary arteries, the infant's **blood pressure** may drop suddenly, diminishing blood supply to the **brain**. The other complication is intraventricular hemorrhage (bleeding into the ventricles of the brain), which can be fatal.

Diagnosis

When a premature infant has obvious trouble breathing at birth or within a few hours of birth, RDS is a possible diagnosis. If premature birth is expected, or there is some condition that calls for delivery prior to term, the amount of surfactant in the amniotic fluid indicates the extent to which the lungs have matured. If little surfactant is found in an amniotic fluid sample obtained via **amniocentesis**, then there is a definite risk of RDS. In some cases where delivery is essential to maternal or fetal survival, amniocentesis is performed at regular intervals so that the infant may be delivered as soon as the lungs are sufficiently mature. If the amniotic sac has ruptured, surfactant levels may be easily measured using a sample of vaginal fluid.

KEY TERMS

Alveoli—The small air sacs located at the ends of the breathing tubes of the lung, where oxygen normally passes from inhaled air through the membranes into the capillaries and the bloodstream.

Amniocentesis—Analysis of amniotic fluid, extracted surgically by a hollow needle from the uterus of a pregnant woman, to determine the health or other characteristics of a fetus.

Amniotic fluid—The fluid cushioning the fetus inside the uterus, which may be sampled to determine whether the fetus is making enough surfactant to breathe independently.

Endotracheal tube—A metal or plastic tube inserted in the windpipe, which may be attached to a ventilator. It may also be used to deliver such medications as surfactant.

Hyaline membranes—A fibrous layer that develops in the alveoli of many premature infants, which prevents oxygen from passing through the alveolar sac into the capillaries.

Pneumothorax—Air in the chest outside the lung,

which compresses the lung. It occurs as a result of the lung rupture, often caused by oxygen delivered under too high a pressure.

Steroids—Also known as corticosteroids or glucocorticoids, these naturally occurring substances are often given to women before they deliver a very premature infant to stimulate the fetal lungs to produce surfactant; this treatment is intended to prevent or minimize RDS.

Surfactant—A substance normally produced in fetal lungs after the 34th week of pregnancy that helps the air sacs to open up at the time of birth so that the infant can breathe independently.

Toxemia—A disease of pregnancy in which the mother's blood pressure is elevated; it is associated with both maternal and fetal complications, and sometimes with fetal death.

Ventilator—A machine that breathes for an infant with RDS until its lungs are producing enough surfactant and are able to function normally.

RDS can also be diagnosed by **chest x ray**. The syndrome has a recognizable radiologic image, and an x ray will also reveal pneumothorax (if this has occurred), as well. This test may be ordered if the infant suddenly becomes worse while on ventilation.

Treatment

If only a mild degree of RDS is present at birth, then placing the infant in an oxygen hood may be sufficient to sustain them until they can breathe independently. Nurses must closely monitor infants receiving oxygen, however, to prevent excessive oxygen saturation, which can damage the retina. This condition, called retinitis of prematurity, causes blindness. The oxygen level in the blood may be tested by analyzing the levels of arterial gases present, or more easily, by using a device called a **pulse oximeter**, which is clipped to an earlobe. A laboratory technologist usually performs all necessary blood work.

In more severe cases, a drug that mimics the action of natural surfactant (Exosurf Neonatal or Survanta), may be dripped into the lungs through an endotracheal tube. Typically, the infant will be able to breathe more easily within a few days, and such complications as lung rupture are less likely to occur. The drug is continued

until the infant starts producing its own surfactant. There is a risk of bleeding into the lungs from surfactant treatment; this affects about 10% of the smallest infants.

Infants with severe RDS may also be placed on a ventilator, a machine that delivers air under pressure through a tracheal tube to the lungs. This is performed as an emergency procedure for infants who do not breathe when born. Assisted ventilation must be closely supervised, as too much pressure can cause further lung damage, injure vocal cords, and increase the baby's risk of pulmonary **infection**. A gentler way to assist breathing is continuous positive airway pressure (CPAP), which delivers an oxygen mixture through nasal prongs or a tube placed through the nose rather than an endotracheal tube. CPAP may be tried before resorting to a ventilator, or after an infant placed on a ventilator begins to improve. Drugs that stimulate breathing may speed the recovery process.

Pneumothorax, which is a possible complication of assisted ventilation, is a medical emergency requiring immediate intervention. Air may be removed from the chest using a needle and syringe. A tube is then inserted into the lung cavity, and suction applied.

Prognosis

If an infant born with RDS is not treated promptly, lack of an adequate oxygen supply will damage the body's organs. They will eventually stop functioning, after which death follows. The **central nervous system** in particular—made up of the brain and spinal cord—is very dependent on a steady oxygen supply and is one of the first organ systems to feel the effects of RDS. On the other hand, if the infant's breathing is supported immediately after birth until the lungs mature and make their own surfactant, complete recovery within three to five days is the rule.

Health care team roles

Premature infants with respiratory disorders are usually cared for in a neonatal intensive care unit by a neonatologist, certified neonatal intensive care nurse specialist, anesthesia provider (to maintain the airway), and respiratory therapist. Once the infant has recovered, a pediatrician, family practice physician, and a pediatric nurse practitioner may provide continuing medical care. Parents and siblings of critically ill newborns may require additional support from social workers, pastoral counselors, self-help support groups, or other mental health professionals.

Prevention

The best way to prevent RDS is to delay delivery until fetal lungs have matured and are producing enough surfactant—generally at about 37 weeks of pregnancy. If delivery cannot be delayed, the mother may be given a steroid hormone, similar to a natural substance produced in the body, which crosses the placental barrier and helps the fetal lungs produce surfactant. The steroid should be given at least 24 hours before the expected delivery. If the infant does develop RDS, this treatment sharply reduces the risk of cerebral hemorrhage.

If a very premature infant is born without symptoms of RDS, it may be wise to deliver surfactant to its lungs anyway. This treatment may prevent RDS, or make it less severe if it does develop. An alternative is to wait until the first symptoms of RDS appear and then give surfactant immediately. Pneumothorax may be prevented by frequently monitoring blood oxygen content, and limiting oxygen treatment under pressure to the minimum.

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Respiratory failure

Definition

Respiratory failure occurs when the lungs' ability to either add oxygen to the bloodstream or remove carbon dioxide from it is impaired. Respiratory failure can have any one of several causes, such as lung disease or **infection**, electrolyte imbalance, interruption of the nerve signals that regulate breathing or nervous system damage, structural (rib cage) collapse, or airway obstruction.

Description

During respiration, the **lungs** extract oxygen from inhaled air, oxygenate the bloodstream, and eliminate carbon dioxide (CO₂) from the **blood** into exhaled air. In respiratory failure, the level of oxygen in the blood becomes dangerously low, and/or the level of CO₂ becomes dangerously high. This result can happen if the gas-exchange process breaks down or if ventilation is inhibited.

There are two main types of respiratory failure. Hypoxemic failure occurs when normal **gas exchange** is interrupted, causing a condition called hypoxemia. When this happens, there is too little oxygen in the blood, and all of the body's organs and tissues suffer as a result. One common type of hypoxemic respiratory failure, which occurs in both adults and **premature infants**, is **respiratory distress syndrome**, a condition in which fluid or tissue changes or physical immaturity prevent oxygen from passing out of the lungs' air sacs into the circulating

blood. Hypoxemia is also caused by exposure to high altitudes, where there is less oxygen in the air; lung diseases that impair the transfer of oxygen into the blood through the alveolar capillaries; severe anemia; and blood vessel disorders that shunt blood away from the lungs, thus preventing the lungs from picking up oxygen.

Ventilatory failure occurs when the body cannot exhale CO₂ properly. The resulting buildup in the blood is called hypercapnia. Ventilatory failure can result when the respiratory center in the brainstem fails to drive breathing, when muscle disease prevents the chest wall from expanding during inhalation, or when a patient has chronic obstructive pulmonary disease that impairs exhalation. Many of the diseases and conditions that produce respiratory failure can cause both hypoxemia and hypercapnia simultaneously.

Causes and symptoms

Respiratory failure can have a variety of causes; all of them inhibit breathing in some way.

- *Airway obstructions*: chronic bronchitis with heavy secretions, **emphysema**, **cystic fibrosis**, **asthma**, and obstructive sleep apnea, in which patients stop breathing for short periods during sleep.
- *Depressed respiration*: weakened breathing that is caused by drug abuse (especially narcotics or opiates) and/or alcohol intoxication, both of which depress the respiratory center. Extreme **obesity** can also be a factor, because it restricts chest wall expansion during inhalation, diminishing the body's ability to acquire enough oxygen.
- *Muscle weakness*: this can be caused by such neuromuscular diseases as myasthenia gravis, **muscular dystrophy**, **multiple sclerosis**, polio, and amyotrophic lateral sclerosis (ALS or Lou Gehrig's disease), as well as strokes that paralyze respiratory muscles and **spinal cord** injuries.
- *Lung diseases and disorders*: severe **pneumonia**, respiratory distress syndrome, pulmonary fibrosis and other scarring diseases of the lung, radiation exposure, burn injury from smoke inhalation, and widespread **lung cancer**. Pulmonary **edema**, often a result of **heart** disease, can also cause respiratory failure.
- *Chest wall abnormalities*: these can be caused by **scolio**sis or severe thoracic injuries, including trauma to the phrenic nerve, which supplies the lungs and diaphragm.
- *Cellular disorders*: any interruption of the Krebs cycle can impede respiration, as can such electrolyte disorders as hypokalemia.

Patients with respiratory failure often have a rapid, weak, or shallow pulse; they are also usually short of breath, restless, and may become confused and disoriented when normal blood gas levels are altered. High blood CO₂ levels can cause headaches and, in time, a semi-conscious state, or even **coma**. Low blood oxygen causes **cyanosis**, and can produce arrhythmias. Lung disease may cause abnormal breath sounds that are audible through a **stethoscope**: wheezing in asthma, rales in pneumonia, or distant breath sounds in obstructive lung disease. A patient with ventilatory failure is prone to gasp for breath, and may use the neck and shoulder muscles to help expand the chest.

Diagnosis

The signs and symptoms of respiratory failure depend on the underlying condition causing it. The key to diagnosis and treatment is measuring the levels of oxygen, carbon dioxide, and acid in the blood at regular intervals. Generally, laboratory technologists and respiratory therapists perform all needed blood work and lung-function testing.

Treatment

Nearly all patients are given oxygen as the first treatment. Then the underlying cause of respiratory failure must be addressed. **Antibiotics** are used to fight a lung infection; bronchodilators, like albuterol, and steroid therapy are commonly prescribed for patients with asthma.

Nurses and respiratory therapists have a number of methods to help patients overcome respiratory failure. These include:

- Suctioning the lungs through a small plastic tube passed through the nose. This treatment removes secretions from the airway that the patient is unable to cough up.
- Postural drainage therapy, in which the patient's position is adjusted frequently to help secretions drain into the central airways. Chest percussion and mechanical vibrators are also applied to help loosen deep secretions. The patient is then encouraged to cough up the secretions; if the patient isn't strong enough to do this, they are suctioned out.
- Deep-breathing exercises, which are often prescribed after the patient recovers, help strengthen the muscles that aid breathing. One technique has the patient breathe out against pursed lips to increase pressure in the airways, preventing them from collapsing. A device called a volumetric incentive spirometer is also used to encourage deep breathing while giving visual feedback. The patient inhales slowly through a plastic tube

KEY TERMS

Arrhythmia—Abnormal heart rhythm.

Chest percussion—A method of loosening deep lung secretions by rhythmically beating the chest with a cupped hand or mechanical vibrator directly over the affected lung areas.

Chronic obstructive pulmonary disease—Lung diseases, such as emphysema and chronic bronchitis, in which airflow is obstructed, causing labored breathing and impairing gas exchange.

Cyanosis—A bluish tinge to the skin caused by low oxygen levels in the blood.

Gas exchange—The process by which oxygen is extracted from inhaled air into the bloodstream; and, at the same time, carbon dioxide is eliminated from the blood and exhaled.

Hypokalemia—Potassium deficiency in the blood.

Hypoxemia—An abnormally low amount of oxygen in the blood, one of the the major consequences of respiratory failure.

Krebs cycle—One of a series of chemical reactions in which the body's cells metabolize glucose for energy.

Pulmonary edema—Fluid accumulation in the lungs; it is frequently a complication of heart disease and other medical disorders.

Pulmonary fibrosis—The conversion of inflamed lung tissue to scarred, fibrotic tissue that cannot carry out gas exchange. Pulmonary fibrosis is caused by such occupational toxins as asbestos and silica, connective tissue diseases like rheumatoid arthritis and lupus, and exposure to some types of medications, including bleomycin and methotrexate.

Pulmonary hypertension—Potentially life-threatening condition in which blood pressure in the pulmonary artery increases to abnormal levels. Primary pulmonary hypertension, which is rare, occurs without any known cause. Secondary pulmonary hypertension is often a complication of lung diseases like emphysema and bronchitis.

Ventilation—The movement of air in and out of the lungs.

attached to a clear plastic cylinder; the cylinder contains a piston and a ball that rests on top of it. Inhalation

raises the ball; the patient has to inhale deeply enough to move it to a predetermined mark.

Patients whose breathing remains very poor may require a ventilator until the lungs can resume their function. Although ventilation is a life-saving treatment, it is very important to use no more pressure than necessary to provide sufficient oxygen; otherwise ventilation may cause further lung damage. Drugs are administered to keep the patient calm, and the amount of fluid in the body is carefully monitored so that the heart and lungs can function as normally as possible. Steroids, which combat inflammation, may sometimes be helpful but can cause complications, including weakening of the muscles of respiration.

Prognosis

The outlook for patients with respiratory failure depends chiefly on the underlying cause. If it can be effectively treated and the patient's breathing supported during treatment, the outlook is usually promising. Good general health and some degree of lung function improve the prognosis considerably.

When respiratory failure develops slowly, secondary pulmonary **hypertension** may develop. This condition may damage the **blood vessels**, worsen hypoxemia, and eventually cause the heart to fail. If it is not possible to provide enough oxygen to the body, complications involving either the **brain** or the heart may prove fatal.

If the **kidneys** fail or the patient's lungs become infected, the prognosis worsens. In some cases, the primary disease causing the lungs to fail is irreversible. The patient, family, and physician must then decide whether to prolong life by ventilator support.

Health care team roles

Patients with respiratory failure are often cared for in the intensive care unit by critical care or intensive care physicians and nurses. Depending on the underlying cause of respiratory failure, patients may be treated by pulmonologists, cardiologists, internists, surgeons, or oncologists. The treatment team also may include respiratory therapists, laboratory technologists, radiology technologists, and physical therapists. Patients and families facing decisions about end-of-life or hospice care may benefit from counseling from social workers, religious counselors, or mental health professionals.

Prevention

Because respiratory failure is not a disease itself, but the result of another disorder, the best prevention is to

treat any lung disease promptly and effectively, and to ensure that patients whose blood electrolyte chemistry is out of balance receive supplemental therapy. Patients with lung problems should, to every extent possible, also avoid exposure to pollutants. Once respiratory failure is present, it is best for a patient to receive treatment in an intensive care unit, where specialized personnel and equipment are available. Close supervision of treatment, especially mechanical ventilation, help to minimize the risk of complications.

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Respiratory system

Definition

The respiratory system consists of organs that deliver oxygen to the circulatory system for transport to the all the cells of the body. The respiratory system also assists in the removal of carbon dioxide (CO₂), thus preventing a deadly buildup of this waste product in the body.

Description

The respiratory system consists of the upper and lower respiratory tracts, extending from the nose to the **lungs**.

The upper respiratory tract encompasses the:

- nose
- pharynx, more commonly called the throat

The lower respiratory tract includes the:

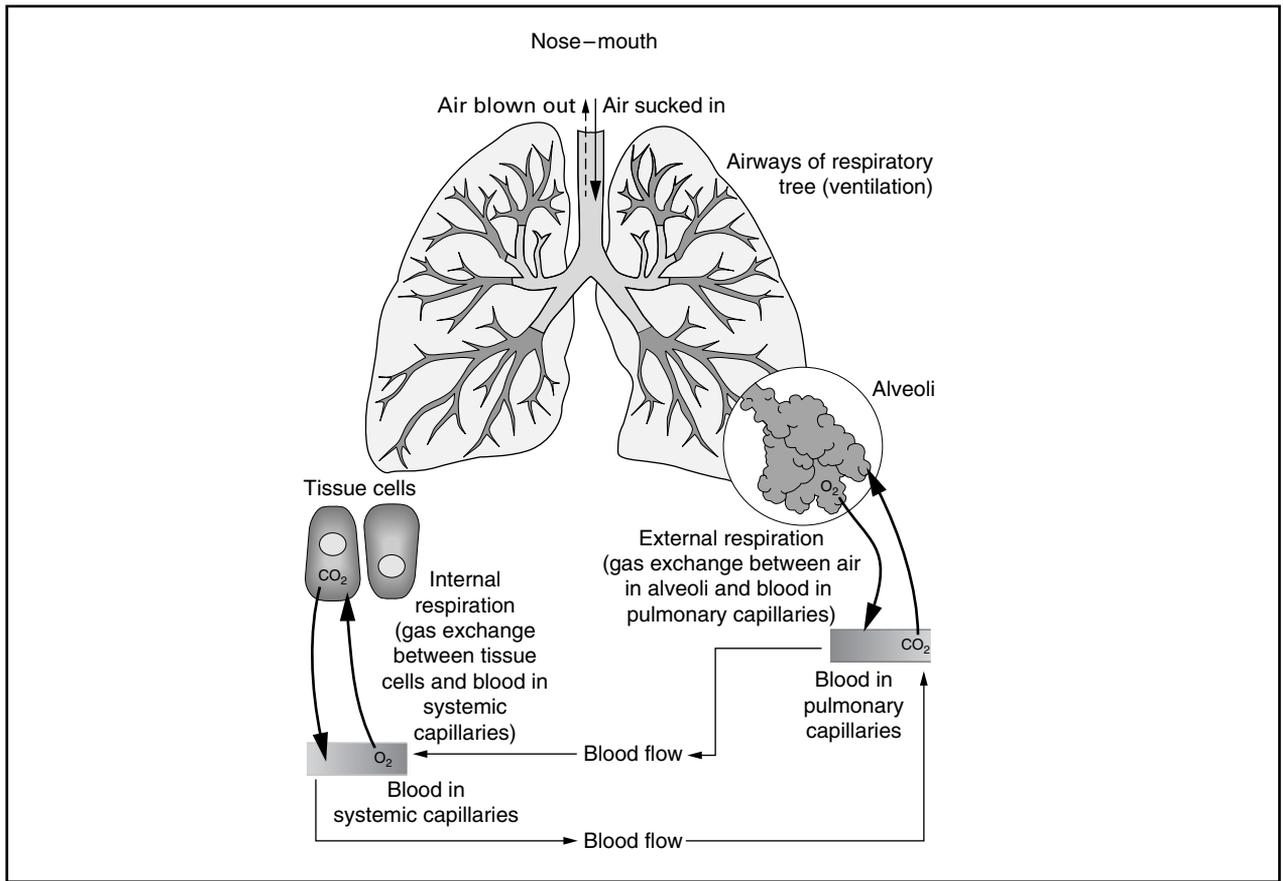
- larynx, also called the voice box
- the trachea or windpipe, which splits into two main branches called bronchi
- tiny branches of the bronchi called bronchioles
- the lungs

These organs all work together to provide air to and from the lungs. The lungs then operate in conjunction with the circulatory system to deliver oxygen and remove carbon dioxide.

Nasal passages

The flow of air begins in the nose, which is divided into the left and right nasal passages and ends in the lungs. The nasal passages are lined with epithelial cells, a mucous membrane composed mostly of a layer of flat, closely packed cells. Each epithelial cell is fringed with thousands of tiny fingerlike extensions of the cells called cilia. Goblet cells are specialized cells that produce mucus, and are among the epithelial cells. Mucus is a thick, moist fluid that coats epithelial cells and cilia. Beneath the mucous membrane, near the surface of the nasal passages, are many tiny **blood vessels** called capillaries. The nasal passages play two critical roles in transporting air to the pharynx. First, the nasal passages filter air to remove potentially disease-causing particles. Secondly, they moisten and warm the air to protect the respiratory system.

Filtering air through the nasal passage prevents airborne **bacteria**, **viruses**, smog, dust particles, and other potentially disease-causing substances from entering the lungs or the bronchioles. Just inside the nostrils are



The functions of ventilation and respiration in the respiratory system. (Delmar Publishers, Inc. Reproduced by permission.)

coarse hairs that assist in trapping airborne particles as they are inhaled. The particles then drop down onto the mucous membranes in the lining of the nasal passages. The particles are then propelled out of the nose or downward to the pharynx by the wave of mucus created by the cilia in the mucous membranes. From the pharynx, mucus is swallowed and travels to the **stomach** where the particles are subsequently destroyed by stomach acid. If there are more particles in the nasal passages than the cilia can cope with, a reflex will be triggered, producing a sneeze. The sneeze, designed to flush out the polluted air, is due to particles building up on the mucus and irritating the membrane below it.

Pharynx

As air leaves the nasal passages, it flows to the pharynx, which is a short, funnel-shaped tube about 13 cm (5 inches) long. The pharynx is also lined with a mucous membrane and ciliated cells that filter air from the nasal passages. The pharynx also includes the tonsils, which are lymphatic tissues that contain white

blood cells. If any impurities escape the hairs, cilia, and mucus of the nasal passages and pharynx, the white blood cells attack the disease-causing organisms. To prevent these organisms from moving further into the body, the tonsils are strategically located. One pair of growths of lymphoid tissue referred to as the adenoids is located high in the rear wall of the pharynx. A pair of tonsils called the palatine tonsils are positioned on either side of the tongue at the back of the pharynx. Another pair called the lingual tonsils are found deep in the pharynx at the base of the tongue. The tonsils may become swollen with **infection** during their fight against disease-causing organisms.

Larynx

Air passes from the pharynx to the larynx, which is approximately 5 cm (2 inches) long and situated near the middle of the neck. The larynx is comprised of several layers of cartilage, a tough and flexible tissue.

In addition to transporting air to the trachea, the larynx serves such other functions as:

- It prevents food and fluid from entering the air passage which would cause choking.
- Its mucous membranes and cilia-bearing cells help filter air.
- It plays a primary role in producing sound.
- The cilia in the larynx move airborne particles up toward the pharynx to be swallowed.

A thin, leaflike flap of tissue called the epiglottis prevents food and fluids from entering the larynx from the pharynx. The epiglottis is held in a vertical position, like an open trap door when a person is breathing. When swallowing, a reflex forces the larynx and the epiglottis to move toward each other. This reflex diverts food and fluids to the esophagus. The swallowing reflex may not work if one eats or drinks too rapidly, or laughs while swallowing. Food or fluid enters the larynx and a coughing reflex is initiated to clear the obstruction. This situation may cause life-threatening choking if coughing does not clear the larynx of the obstruction.

Trachea, bronchi, and bronchioles

Air is passed from the larynx into the trachea, the largest airway in the respiratory system. The trachea is a tube located just below the larynx, approximately 12 to 15 cm (5 to 6 inches) long. Fifteen to twenty C-shaped rings of cartilage form the trachea. Air passes freely at all times because the trachea is held open by the rings of sturdy cartilage. The open part of the C-shaped cartilage rings is situated at the back of the trachea with the ends connected by muscle tissue. The trachea branches into two tubes at its base, located just below where the neck meets the trunk of the body. These two tubes are called the left and right bronchi and they deliver air to the left and right lungs, respectively. The bronchi branch into smaller tubes called bronchioles within the lungs. The trachea, bronchi, and the first few bronchioles are lined with mucous membranes and ciliated cells; thus they contribute to the cleansing action of the respiratory system by moving mucus upward to the pharynx.

Alveoli and lungs

The bronchioles divide many more times in the lungs into an upside-down tree-like structure with progressively smaller branches. Tiny air sacs called alveoli are at the end of the branches. Some of the bronchioles are no larger than 0.5 mm (0.02 inches) in diameter. The alveoli comprise most of the lung tissue, with about 150 million alveoli per lung, and resemble bunches of grapes. The alveoli send oxygen to the circulatory system while removing carbon dioxide. Alveoli have thin elastic walls, thus allowing air to flow into them when they expand;

they collapse when the air is exhaled. Alveoli are arranged in clusters, and each cluster is surrounded by a dense network of capillaries. The walls of the capillaries are very thin; thus the air in the wall of the alveoli is very near to the blood in the capillaries (only about 0.1 to 0.2 microns). Carbon dioxide is a waste product that is dumped into the bloodstream from the cells. It flows throughout the body in the bloodstream to the **heart**, and then to the alveolar capillaries. The oxygen diffuses from the alveoli to the capillaries since the concentration of oxygen is much higher in the alveoli than in the capillaries. From the capillaries, the oxygen flows into larger vessels and is then carried to the heart where it is pumped to the rest of the body. The forces of exhalation cause the carbon dioxide to go back up through the respiratory passages and out of the body. Numerous macrophages are interspersed among the alveoli. Macrophages are large white blood cells that remove foreign substances from the alveoli that have not been previously filtered out. The presence of the macrophages ensures that the alveoli are protected from infection; they are the last line of defense of the respiratory system.

The lungs are the largest organ in the respiratory system and resemble large pink sponges. The left lung is slightly smaller than the right lung since it shares space with the heart, which is also located in the left side of the chest. Each lung is divided into lobes, with two in the left lung and three in the right. A slippery membrane called the pleura covers the lungs and lines the inside of the chest wall. It helps the lungs move smoothly during each breath. Normally, the two lubricated layers of the pleura have very little space between them. They glide smoothly over each other when the lungs expand and contract.

The diaphragm is the most important muscle involved in respiration. It lies just under the lungs and is a muscle shaped like a large dome. The sternum (or breastbone), ribs, and spine protect the lungs and the other organs in the chest. Twelve pairs of ribs curve around the chest and are joined to the vertebrae of the spine. The intercostal muscles are also important for respiration. They lie between the ribs and assist in breathing by helping to move the rib cage.

Function

The main function of the respiratory system is the delivery of oxygen and removal of carbon dioxide. To achieve this purpose, the nervous system controls the flow of air in and out of the lungs while maintaining a regular rate and pattern of breathing. Regulation is controlled by the respiratory center, a cluster of nerve cells in the **brain** stem. These cells simultaneously send signals to the muscles involved in inhalation: the diaphragm and

rib muscles. The diaphragm flattens out when stimulated by a nervous impulse. The thoracic or chest cavity contains the lungs. The volume of the cavity expands with the downward movement of the diaphragm, thus expanding the lungs. The rib muscles also contract when stimulated, which pulls the rib cage up and out, at the same time expanding the thoracic cavity. This movement reduces pressure in the chest. When the volume is increased in the thoracic cavity, air rushes into the lungs to equalize the pressure. This nervous stimulation is quick, and when it is over, the diaphragm and rib muscles relax and a person exhales.

Working in conjunction with the circulatory system, the oxygen-rich blood travels from the lungs through the pulmonary veins into the left side of the heart. From there, blood is pumped to the rest of the body. Blood that is oxygen-depleted, but carbon dioxide-rich, returns to the right side of the heart through two large veins called the superior and inferior venae cavae. This blood is then pumped through the pulmonary artery to the lungs, where oxygen is picked up and carbon dioxide is released. This process is repeated continually under normal circumstances.

Other functions the respiratory system assist in just by normal respiration are the regulation of acid–base balance in the body, a critical process for normal cellular function. It also protects the body against toxic substances inhaled as well as against disease–causing organisms in the air. The respiratory system also assists in detecting **smell** using the olfactory receptors located in the nasal passages. Furthermore, it aids in producing sounds for speech.

Role in human health

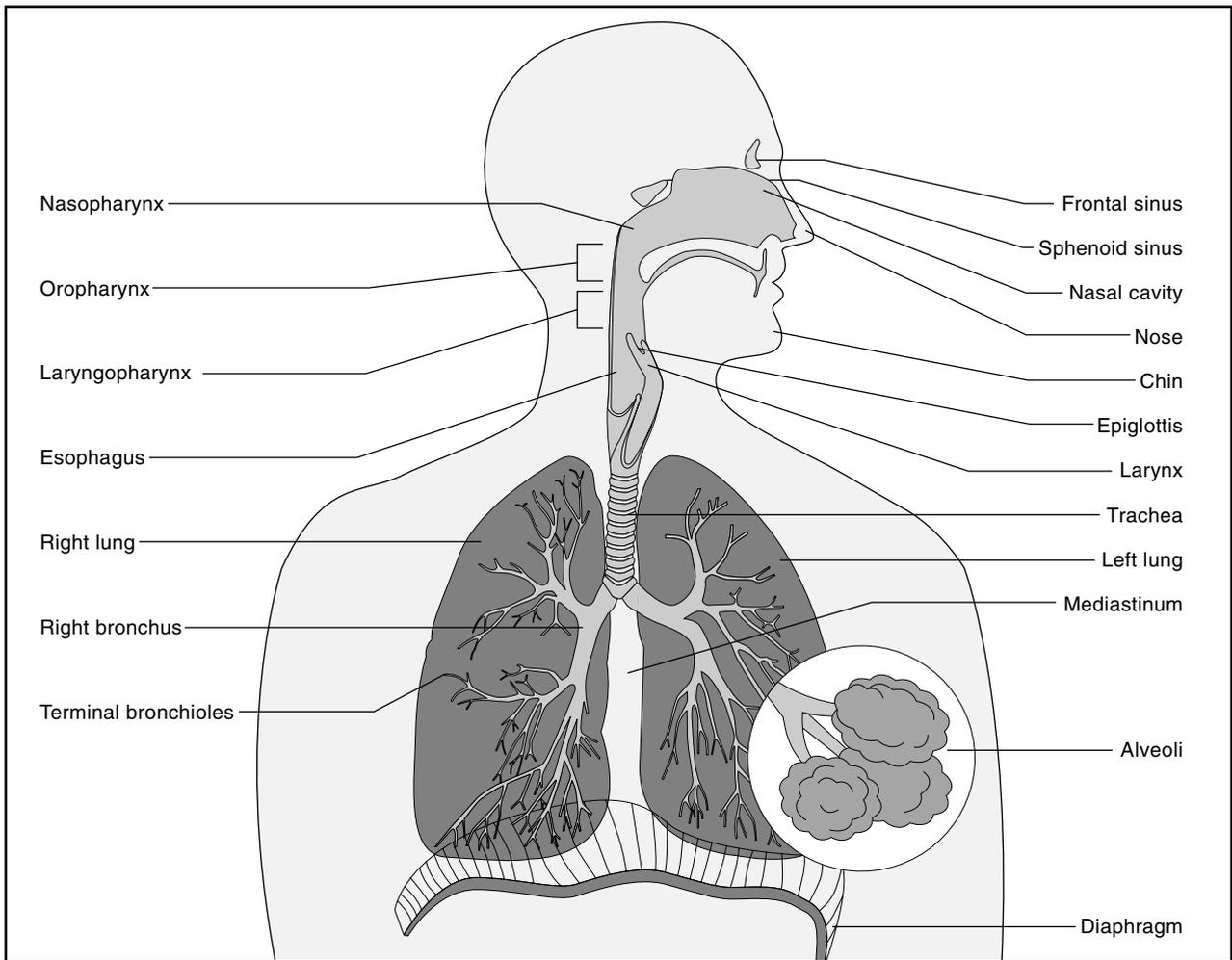
Breathing is an unconscious process carried out on a constant basis and is necessary for survival. Under normal conditions, a person takes 12–20 breaths per minute, although newborns breathe at a faster rate, at approximately 30–50 breaths per minute. The breathing rate set by the respiratory center can be altered by conscious control, for example, by holding the breath. This alteration occurs when the part of the brain involved in thinking, the cerebral cortex, sends signals to the diaphragm and rib muscles to momentarily ignore the signals from the respiratory center. If a person holds his or her breath too long, carbon dioxide accumulates in the blood, which then causes the blood to become more acidic. The increased acidity interferes with the action of enzymes, which are specialized **proteins** that coordinate all biochemical reactions in the body. To prevent too much acid from building up in the blood, special receptors located in the brain stem and in the blood vessels of the neck

called chemoreceptors monitor the acid level in the blood. These chemoreceptors send nervous signals to the respiratory center when acid levels are too high, which overrides the signals from the cerebral cortex, forcing a person to exhale and then resume breathing. The blood acid level is brought back to normal levels by exhalation, which expels the carbon dioxide. Irreversible damage to tissues occurs, followed by the failure of all body systems, and ultimately, death if the respiratory system's tasks are interrupted for more than a few minutes.

Common diseases and disorders

The diseases and disorders of the respiratory system can affect any part of the respiratory tract and may range from mild to life-threatening conditions such as:

- **Colds**—A virus that targets the nasal passages and pharynx. Symptoms include a stuffy and runny nose.
- **Hay fever** and **asthma**—Allergic reactions that may occur when the **immune system** is stimulated by pollen, dust, or other irritants. A runny nose, watery eyes, and sneezing characterizes hay fever. In **asthma**, because the bronchi and bronchioles are temporarily constricted and inflamed, a person has difficulty breathing.
- **Bronchitis**—Characterized by inflamed bronchi or bronchiole membranes, resulting from viral or bacterial infection or from chemical irritants.
- **Emphysema**—A non-contagious disease that results from multiple factors including: smog, cigarette smoke, infection, and a genetic predisposition to the condition. **Emphysema** partially destroys the alveolar tissue and leaves the remaining alveoli weakened and enlarged. When a person exhales, the bronchioles collapse, trapping air in the alveoli. This process eventually impedes the ability to exchange oxygen and carbon dioxide, leading to breathing difficulties.
- **Pneumonia**—Infections caused by bacteria or viruses can lead to this potentially serious condition. The alveoli become inflamed and fill with fluid, impairing the flow of oxygen and carbon dioxide between the capillaries and the alveoli.
- **Tuberculosis**—A condition caused by a bacterium that attacks the lungs and occasionally other body tissues. Left untreated, the disease destroys lung tissue.
- **Laryngitis**—An inflammation of the larynx caused by such irritants as cigarette smoke, overuse of the voice, or a viral infection. A person with laryngitis may become hoarse, or they may be able only to whisper until the inflammation is reduced.



Structures of the respiratory system. (Delmar Publishers, Inc. Reproduced by permission.)

- **Lung cancer**—Occurs in those individuals who are exposed to such cancer-causing agents as tobacco smoke, asbestos, or uranium; or who have a genetic predisposition to the disease. Treatments are very effective if the **cancer** is detected before the cancer has spread to other parts of the body. About 85% of cases are diagnosed after the cancer has spread; thus the prognosis is very poor.
- **Respiratory distress syndrome (RDS)**—Refers to a group of symptoms that indicate severe malfunctioning of the lungs affecting adults and infants. Adult respiratory distress syndrome (ARDS) is a life-threatening condition that results when the lungs are severely injured, for example, by poisonous gases, in an automobile accident, or as a response to inflammation in the lungs.
- **Wheezing**—A high-pitched whistling sound produced due to air flowing through narrowed breathing tubes. It may have many causes such as asthma, emphysema, **pneumonia**, bronchitis etc.
- **Shortness of breath or dyspnea**—This condition may have multiple causes such as asthma, emphysema, hyperventilation, **obesity**, cigarette smoking, lung disease, excessive **exercise**, etc.
- **Chronic respiratory insufficiency (or chronic obstructive pulmonary disease; COPD)**—A prolonged or persistent condition characterized by breathing or respiratory dysfunction resulting in reduced rates of oxygenation or the ability to eliminate carbon dioxide. These rates are insufficient to meet the requirements of the body and may be severe enough to impair or threaten the function of vital organs (**respiratory failure**).

Some of the most common symptoms of respiratory disorders are a cough, shortness of breath, chest **pain**, wheezing, **cyanosis** (bluish discoloration), finger clubbing, stridor (a crowing sound when breathing), hemoptysis (coughing up of blood), and respiratory failure. These symptoms do not necessarily signify a respiratory

KEY TERMS

Acidosis—A dangerous condition in which the blood and body tissues are less alkaline (or more acidic) than normal.

Alkalosis—Excessive alkalinity of the blood and body tissue.

Bronchi—The trachea branches into two tubes at the base of the trachea called the left and right bronchi, which extend from the trachea to deliver air to the left and right lungs, respectively. The bronchi branch into smaller tubes called bronchioles within the lungs.

Bronchioles—The bronchioles are no larger than 0.5mm (0.02 inches) in diameter and divide many times in the lungs to form a tree-like structure; they have progressively smaller branches and tiny air sacs called alveoli at the end.

Capillaries—Tiny blood vessels that lie beneath the mucous membrane near the surface of the nasal passages.

Carbon dioxide (CO₂)—A gaseous waste product that is dumped into the bloodstream from the cells; a byproduct of respiration, it is released upon exhalation of air from the body.

Cilia—Each epithelial cell is fringed with thousands of these tiny fingerlike extensions of the cells.

Diaphragm—The diaphragm is involved in inhalation. It lies just under the lungs and is a muscle shaped like a large dome.

Epiglottis—A thin, leaflike flap of tissue that prevents food and fluids from entering the larynx from the pharynx.

Mucus—A thick, moist fluid that coats epithelial cells and cilia.

pH—the negative logarithm of H⁺ (hydrogen) concentration. Acid-base balance can be defined as homeostasis (equilibrium) of the body fluids at a normal arterial blood pH ranging between 7.37 and 7.43.

Thoracic cavity—Also called the chest cavity, it is the portion of the ventral body cavity located between the neck and the diaphragm. It is enclosed by the ribs, the vertebral column, and the sternum. It is separated from the abdominal cavity by the diaphragm.

problem, but can be a sign of another problem. For example, chest pain may be due to a heart or a gastrointestinal problem.

Cystic fibrosis is a genetic disease that causes excessive mucus production and clogs the airways.

Acidosis is a condition resulting from higher than normal acid levels in the body fluids. It is not a disease but may be an indicator of disease. Respiratory acidosis is due to a failure by the lungs to remove carbon dioxide, therefore reducing the pH in the body. Several conditions such as chest injury, block of the upper air passages, and severe lung disease may result in respiratory acidosis. Blockage of the air passages may be due to bronchitis, asthma, or airway obstruction resulting in mild or severe acidosis. Regular, consistent retention of carbon dioxide in the lungs is referred to as chronic respiratory acidosis. This disorder results in only mild acidosis because of an increased bicarbonate (alkali) production by the **kidneys**.

Alkalosis is a condition resulting from a higher than normal level of base or alkali in the body fluids. Respiratory alkalosis results from decreased carbon dioxide levels caused by such conditions as hyperventilation (a faster breathing rate), **anxiety**, and fever. The pH becomes elevated in the body. Hyperventilation causes the body to lose excess carbon dioxide in expired air and can be triggered by altitude or a disease that reduces the amount of oxygen in the blood. Symptoms of respiratory alkalosis may include dizziness, lightheadedness, and numbing of the hands and feet. Treatments include breathing into a paper bag or a mask that induces rebreathing of carbon dioxide.

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National Center for Complementary and Alternative Medicine (NCCAM), 31 Center Dr., Room #5B-58, Bethesda, MD 20892-2182. (800) NIH-NCAM, Fax (301) 495-4957. <<http://nccam.nih.gov>>.

National Heart, Lung and Blood Institute. Building 31, Room 4A21, Bethesda, MD 20892. (301) 496-4236. <<http://www.nhlbi.nih.gov>>.

Crystal Heather Kaczowski, MSc.

Respiratory therapy

Definition

Respiratory therapy is a therapeutic treatment for respiratory diseases and conditions. A respiratory therapist (RT) is a health care professional who usually provides these treatments and evaluates the patient's response to the treatments.

Purpose

The purpose of respiratory therapy is to maintain an open airway for trauma, intensive care, and surgical patients; assist in **cardiopulmonary resuscitation** and support; provide life support for patients who cannot breathe on their own; provide assistance to the anesthesiologist in the operating room; provide inhaled drugs and **medical gases**, provide results from the testing of measuring lung function; and assist with **patient education**.

Description

Respiratory therapy is performed in hospitals, in neonatal, emergency, intensive care, surgical and cardiac units, and various other health care facilities. Respiratory therapy treats many kinds of patients, and provides temporary relief to patients suffering from respiratory ailments. The therapies most commonly administered are oxygen and aerosol medications, and ventilator support after intubation. RTs are assigned to patients during their shift and continuously monitor those patients and respiratory equipment.

It is essential to assess a patient's respiratory function if he/she has a known or suspected pulmonary con-

dition. Therapists perform procedures that are both diagnostic and therapeutic.

Diagnostic therapy includes:

- Obtaining and analyzing sputum and breath specimens. **Blood** specimens are also obtained and analyzed for levels of oxygen, carbon dioxide, and other gases.
- Interpreting data obtained from these specimens.
- Measuring the capacity of a patient's **lungs** to determine if there is impaired function.
- Performing other studies of the cardiopulmonary system.
- Studying disorders of people with disruptive sleep patterns.

Treatment therapy includes:

- Operating and maintaining various types of highly sophisticated equipment to administer oxygen or assist with breathing.
- Employing mechanical ventilation for treating patients who cannot breathe adequately on their own.
- Monitoring and managing therapy that will help a patient recover lung function.
- Administering medications in aerosol form to help alleviate breathing problems and to help prevent respiratory infections.
- Monitoring equipment and patient response to therapy.
- Maintaining the patient's artificial airway.

The following are the most commonly performed procedures in respiratory therapy:

- Oxygen therapy—Oxygen therapy involves the administration of oxygen at concentrations greater than that in ambient air, with the intent of treating or preventing the symptoms and manifestations of hypoxia. Indications include documented hypoxemia, severe trauma, acute **myocardial infarction**, and short-term therapy as in post-anesthesia recovery. The need for **oxygen therapy** is determined by measurement of inadequate oxygen saturations, by invasive or noninvasive means or the presence of clinical indicators. Low-flow oxygen therapy systems deliver 100% oxygen at flows lower than the patient's inspiratory flow rate. The concentration inhaled may be low or high, depending on the specific device and the patient's inspiratory flow rate. Nasal cannulas can provide 24-40% oxygen with flow rates up to 6L/min in adults. In infants and newborns, flow should be limited to a maximum of 2L/min. If the oxygen supplied to adults via nasal cannula is at a flow rate lower than or equal to 4L/min, it does not have to be humidified. Simple oxygen masks can provide 35%-50% oxygen at flow rates of 5-10 L/min. Rates should

KEY TERMS

Artificial airway—A passage for respiration that is created and maintained by a device, such as tubing. Artificial airways are usually established for patients who are at risk of having their own natural airways collapse because of trauma or another medical condition.

Mechanical ventilation—The process of maintaining respiration in a patient who cannot breathe naturally by means of a respiratory device.

be maintained at 5L/min or more to avoid rebreathing exhaled CO₂ that may be retained in the mask. Masks with reservoir bags (partial and non-rebreathers) provide FIO₂s (fraction-inspired oxygen, or the concentration of oxygen as delivered to the patient) of 0.5 or greater. High-flow systems deliver a prescribed gas mixture—either high or low FDO₂—at flow rates that exceed patient demand. Aerosol masks, tracheostomy collars, T-tube adaptors and face tents can be used with high-flow supplemental oxygen systems. O₂ therapy should be administered continuously unless needed only in specific situations, as with **exercise** or sleep.

- **Pulse oximetry**—Indications for pulse oximetry include the need to monitor the adequacy of arterial oxyhemoglobin saturation, gauge the response of O₂ saturation to therapeutic interventions, and complying with regulations. SpO₂ (a measure of oxygen saturation) is used for continuous and prolonged monitoring as in during sleep, exercise or surgical procedures. Results of SpO₂ tests validate the basis for ordering the test by reflecting the patient's clinical condition. Documentation of results should be noted in the patient's chart.
- **Incentive spirometry**—I.S. encourages patients to take long, slow, deep breaths. It is a device that provides patients with positive feedback during inhalation at a predetermined flow rate or volume and sustains the inflations for a minimum of three seconds. I.S. is used to increase transpulmonary pressure and inspiratory volumes; improve inspiratory muscle performance; and reestablish or simulate the normal pattern of pulmonary hyperinflation. Airway patency is maintained and atelectasis prevented and/or reversed if the procedure is performed on a repeat basis. It is not effective unless performed as ordered, so that proper teaching is mandatory. I.S. is used in post-surgical procedures, especially those involving the thorax or upper abdomen; or condi-

tions that portend atelectasis, as in immobility, abdominal binders, and less than optimal **pain** control.

- **Selection of aerosol delivery devices**—for delivery of aerosol to the lower airways. Devices include metered dose inhalers (MDIs), dry powder inhalers, and nebulizers. Drugs used in delivery include beta-adrenergic agents, anticholinergics, anti-inflammatory agents, and mucokinetics. For maximum success, the technique is important—for instance, coordination, breathing pattern, and inspiratory hold. Patient compliance may be a limiting factor in the procedure.
- **Arterial blood gases (ABGs)**—for arterial **blood gas analysis**. Blood is drawn from a peripheral artery (radial, brachial, femoral) via a single percutaneous needle puncture or from an indwelling arterial cannula, for a direct measurement of partial pressures of carbon dioxide (PaCO₂) and oxygen (PaO₂), hydrogen ion activity (pH), total hemoglobin (Hbtot), oxyhemoglobin saturation (HbO₂). The procedure is performed by trained health care personnel (usually the RT). ABGs are utilized to quantify the patient's response to therapeutic interventions and/or diagnostic evaluation and to monitor disease severity or progression. The sampling of arterial blood must be done according to protocol or test results may be rendered invalid.
- **Nasotracheal suctioning (NTS)**—to remove secretions, blood or vomitus from the trachea, especially if the patient is unable to cough spontaneously to maintain a patent airway. To accomplish NTS, a suction catheter is inserted through the nasal passage and pharynx into the trachea to aspiration secretions or foreign material.
- **Patient-ventilator system checks**—documented evaluation of a mechanical ventilator and of the patient's response to ventilatory support. Objectives of ventilator checks include: evaluating the patient's response to mechanical ventilation; assuring proper operation of the ventilator, that it is functioning properly and alarms are activated; verifying that inspired oxygen concentration is measured with every change in FIO₂ and that ventilator settings comply with physician orders. All of the above are documented in the patient's chart. Clinical observations of the patient's response to ventilation are also charted in narrative form.

In order for respiratory therapy to be effective, RTs have to evaluate, document, and report all of the above procedures so that appropriate action can be taken by other members of the health care team.

Aftercare

Another important part of respiratory therapy is planning and implementing safe and effective care after

discharge from the medical institution. The patient must be successfully transferred from the health care facility to another care site. Patient evaluation involves assessing the patient's current medical condition and ascertaining the type of respiratory care and support needed. Should it be invasive or noninvasive? The patient's physical, functional and psychological ability is assessed, as well as the family's psychosocial condition. The goals of care for the patient and family are also evaluated.

Complications

- Pulse oximetry is usually considered a safe procedure. Device limitations and false-negative results for hypoxemia, though, may lead to inappropriate treatment of the patient. At times, tissue injury at the monitoring site may occur due to misuse of the probe.
- Incentive spirometry. Unless closely supervised, pulse oximetry may be ineffective. It is also inappropriate as a sole treatment for major lung collapse. There may be discomfort secondary to inadequate pain control. Hyperventilation and fatigue may also occur.
- Aerosol delivery devices. Malfunction of the device or improper technique may result in underdosing or overdosing. There may be complications of specific pharmacologic agents; and repeated aerosol exposure may produce asthmatic symptoms in caregivers.
- Arterial blood gases. Dangers encountered during this procedure include air or clotted-blood emboli, introduction of contagion at sampling site and **infection**, hemorrhage, trauma to the vessel, arterial occlusion, pain.
- Nasotracheal suctioning. Mechanical trauma (laceration of nasal turbinates, perforation of pharynx, nasal irritation, mucosal hemorrhage) are hazards of this procedure. Other complications of NTS include hypoxia, cardiac dysrhythmias, hyper- or hypotension, respiratory arrest, coughing, gagging or vomiting, bronchoconstriction, atelectasis, misdirection of catheter, increased intracranial pressure.
- Patient-ventilator system checks. Disconnecting the patient from the ventilator during system checks may result in hypoventilation, hypoxemia, bradycardia, and hypotension.

Health care team roles

Physicians, registered nurses, respiratory therapists, and pulmonologists all work to maintain respiratory health in the patient. Physicians diagnose respiratory illnesses and determine which kinds of therapy will be most effective in alleviating them. Registered nurses monitor

the effects of the therapy on the patient, administer tests, and make recommendations for any needed changes to the therapy program. Respiratory therapists are trained in the use of therapy equipment and are responsible for maintaining the welfare of patients while they are undergoing therapy. Pulmonologists specialize in the study of the heart-lung system and may also recommend or adjust therapy.

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Respiratory therapy apparatus

Definition

Respiratory therapy apparatus refers to a group of different inhalation devices and equipment used to treat a variety of respiratory ailments.

Purpose

Respiratory therapy apparatus is used to aid a patient's breathing or heal damage to a patient's **lungs** and bronchial tubes due to **infection** and disease.

Description

Simply put, respiratory therapists help patients breathe better. Patients may have mechanical difficulties



A therapist helps a patient with his respiratory therapy.
(Photograph by Will & Deni McIntyre. Science Source/Photo Researchers. Reproduced by permission.)

within the lungs and trachea that make it difficult to get enough oxygen. Often these instances are life-threatening and must be treated immediately. Obstructions (e.g. a child swallowing an object) and injury (automobile accidents, **sports injuries**, natural disasters, etc.) are common situations in which breathing assistance is necessary. In these cases, intubation (the insertion of a tube into the trachea) is necessary to open the airway so that oxygen can be administered. **Ventilators** regulate the amount of oxygen that the patient receives and even how often the patient breathes. Disease and atrophy of the lungs may require the use of a ventilator to help a patient breathe.

Premature infants and some other newborns may not have lungs that are mature enough to allow them to breathe on their own. Oxygen is often administered as a life-support measure. In some cases, oxygen is given to ease the burden on the lungs until the baby is strong enough to breathe on its own.

Some patients may be suffering from chronic obstructive pulmonary disease (COPD), a group of diseases that affect the lungs, which includes **emphysema**, bronchitis, and **asthma**. Other patients may have **cystic fibrosis**, **lung cancer**, **pneumonia**, or **AIDS**. In these

cases, the respiratory therapist may administer medications through an inhaler or a hand-held nebulizer.

Other patients may have **heart** disease. The therapist may administer oxygen and also provide rehabilitation devices and techniques to increase lung capacity.

Nebulizers and inhalers

Nebulizers and inhalers provide medications in a fine mist that the patient breathes. Inhalers provide metered doses of medication and come prepackaged. They are portable and can be tucked into a pocket or handbag. So-called “rescue” inhalers are often carried by people with asthma and used when they have an episode. Special dry powder inhalers provide medications that do not work well in liquid form. These inhalers deliver the medication in fine, dry particles that are inhaled.

Metered-dose inhalers dispense specific medications and can be grouped according to type of medication. They are usually bronchodilators, inhaled steroids, cromolyn, nedrocromil, and ipratropium bromide.

Nebulizers are hand-held machines with an airflow meter that measures oxygen flow. These machines administer a variety of medications. The respiratory therapist must prepare a mixture of medication and saline solution according to the physician’s written order. Nebulizers vaporize this mixture and deliver it as a fine mist or steam. Nebulizers are usually used in the hospital or nursing home setting. Disposable nebulizers are often sent home with a patient and are cleaned and reused for a limited time. There are three types of nebulizers: large-volume, small-volume, and ultrasonic.

Intubation catheters and ventilators

Intubation catheters are inserted into the airway and fill the lungs with oxygen at a specific respiratory rate. Ventilators provide mechanical breathing through the catheters and are said to “breathe” for the patient. The amount of oxygen can be varied as well as the breathing rate.

Oxygen masks, nasal cannulas, and oxygen tanks

Oxygen masks, nasal cannulas, and oxygen tanks provide **oxygen therapy** and assistance in maintaining specific oxygen levels within the lungs. Oxygen masks fit over the mouth and nose, whereas cannulas are thin tubes inserted into the nasal openings. Tubing connects the mask or cannula to the oxygen tank from which oxygen is delivered.

Oxygen masks come in a variety of sizes. There are very small ones used to fit premature infants faces. Adult-size masks come in small, medium, and large.

Masks usually provide high flow and a high concentration of oxygen within a range to the patient. Ventilator masks come with a series of different adaptors that allow a specific percentage of oxygen flow. These adaptors are preset and can be installed on the mask to provide oxygen at a specific rate (e.g. 50% oxygen).

Nasal cannulas provide low flow and a lower concentration of oxygen. Cannulas deliver oxygen within a range. These are usually used in home health situations because of their ease of use.

Operation

The respiratory therapist will need to make sure that the equipment is running efficiently and that the medication formula is properly mixed. Masks must be of the correct size and must fit the patient snugly. Since therapy often involves patient cooperation, the therapist should instruct conscious patients clearly about the procedure and what is expected of them during treatment. For example, when using inhalers, the patient should be instructed in creating a tight seal around the inhaler nozzle with the lips and to hold the inhalation for a few seconds.

For unconscious patients, the therapist will need to make sure oxygen masks fit properly, or that intubation and ventilation is done correctly.

Maintenance

Most respiratory therapy devices are one-use only and disposable. Only in the case of pocket inhalers and take-home nebulizers does the therapist need to instruct the patient in proper cleaning of the devices. Inhalers often need just rinsing with soap and water and drying after use. Nebulizers will need to be cleaned with distilled water and vinegar, or other approved disinfectant solution. Even in hospital settings, nebulizers are changed every day, though they may be reused several times during that day. Some nebulizers may be cleaned by running them through a cycle in a dishwasher, but the therapist should check with the manufacturer first.

Intubation catheters need to be as sterile as possible in order to prevent infection or sepsis. Therefore, they are one-use disposable products.

Nebulizers will need to be inspected for wear to insure their proper working. Machines with an air compressor or motor often have air filters; these filters will need to be replaced regularly.

KEY TERMS

Bronchodilators—Medications that expand the bronchial tubes so that patients can breathe better.

Intubation—The insertion of a tube into the trachea.

Nasal cannula—A tube placed inside the nostrils to bring oxygen to the patient's lungs.

Nebulizer—A hand-held device that distributes medication to the lungs via a steam or mist derived from a mixture of medication and saline solution. The respiratory therapist prepares the mix per the physician's written order.

Trachea—Windpipe; the airway by which oxygen passes to the lungs and carbon dioxide is expelled out of the body.

Health care team roles

The respiratory therapist is a member of a large medical team that treats a patient's specific diseases and injuries; and can work in hospitals, **nursing homes**, outpatient clinics, physicians' offices, and in homes. Since respiratory therapy requires trust and cooperation from the patient, the therapist will need to be able to instruct patients clearly and in a friendly manner. The therapist will also need to be adaptable and able to deal with a variety of people across a wide age range.

The respiratory therapist is responsible for maintaining the respiratory therapy equipment, cleaning it if necessary, and requisitioning parts and apparatus (masks, catheters, etc.). The therapist also administers treatment via this equipment and monitors patient performance and response.

Training

Formal training and licensure by the state in which the therapist works is necessary for this profession. Training programs graduate registered or certified respiratory therapists. The Committee on Accreditation for Respiratory Care identified 327 registered programs and 134 certified programs in 1999. Registered respiratory therapists usually study for two years and earn an associate degree, though some receive a bachelor's degree after four years of course work. Respiratory therapists take courses in physiology and anatomy, chemistry, microbiology, physics, and mathematics. They are also trained in the use and maintenance of respiratory therapy apparatus. Apart from formal education, many therapists are receive-

ing additional on-the-job training to administer **stress** tests and electrocardiograms, or draw **blood**.

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National Board for Respiratory Care. 8310 Nieman Road, Lenexa, KS 66214- 1579. (913) 599-4200.

Janie F. Franz

Restorative dental materials

Definition

Restorative dental materials are substances that are used to repair, replace, or enhance a patient's teeth. These materials include metals, porcelains, and composite resins (often made from plastics).

Purpose

Restorative dental materials are used to create fillings, bridges, crowns, and inlays in order to restore a tooth's appearance, structure, or function.

Description

The end of the twentieth century witnessed a dramatic decline in **dental caries** and an increased interest in dental health and enhancement. Smaller cavities are being discovered in the general population and in children, with over half of those aged five to 17 having no tooth decay at all. At the other end of the spectrum, older Americans are retaining more and more of their natural teeth and are beginning to seek out dentists for restorative work.

Visits to prosthodontists (dentists who specialize in mouth reconstructions, such as crowns, fixed bridges, dentures, and implants) and cosmetic or esthetic dentists (those who repair and enhance teeth through whitening, veneer application, or attachment of permanent restora-

tions) increased from the 1990s into the twenty-first century. An American Dental Association (ADA) survey in 2000 indicated that 84% of responding dentists reported offering some form of cosmetic services to their patients.

In 2001, dentists have more tools with which to diagnose a patient's unique problems, and they are able to find more creative, conservative solutions for them. The dentistry of the 1970s provided limited options. A patient had a tooth filled or extracted, had teeth straightened with braces, or had a crown or bridge installed. Often, the crown cracked and had to be replaced, or the bridge that was fitted was a plastic tooth set in a maze of wires.

Thirty years later, dentists can whiten teeth, alter their shape, fill gaps between them, or build up a tooth that is cracked. Dentists can fill a cavity with a tooth-colored filling that appears invisible to the naked eye. They can replace a missing tooth with a porcelain bridge or a resin implant. Even crooked teeth can be greatly improved with veneers and bonding or invisible plastic braces.

Cosmetic dentists and prosthodontists create restorations in order to repair, replace, or enhance a patient's tooth or teeth.

Restoration types

All restorations perform one of three main functions. They repair, replace, or enhance. Among the types of restorations that repair are fillings. These are used to restore tooth damage that occurs as a result of dental caries (tooth decay). Metal amalgams or composite resins are used to fill cavities and restore the function and esthetics of a tooth. Inlays and crowns, used to repair damage to the teeth, replace tooth structure lost to decay or injury, protect what remains, and restore the tooth's shape and function. Inlays are more durable than amalgam fillings.

Crowns may be necessary when a tooth cracks, has its entire structure weakened by decay, or becomes brittle after a root canal. Crowns can also cover dental implants or abutment (adjacent) teeth when fitting a bridge.

Bonding and contouring

Bonding is a low-cost alternative to crowns or veneers. A tooth-colored composite resin is molded over the tooth, exposed to a special light, and then polished. It is used to restore chipped or slightly ill-shaped teeth. It is less durable and subject to chipping. Bonding is also limited to areas of the mouth that do not experience strong chewing forces, such as the front teeth.

Contouring is done to correct the shape of a tooth. This is mainly an extractive procedure because small amounts of tooth enamel are removed. This technique can be combined with bonding or veneer application.

Restorations that replace

BRIDGES. Bridges fill in a gap left by missing teeth, preventing the remaining teeth from shifting and providing a more stable surface for chewing. Bridges consist of a metal framework and one or more artificial teeth anchored to adjacent teeth (abutment teeth). Sometimes, a two-implant bridge is required. It is then cemented into place.

IMPLANTS, DENTURES, AND PARTIAL DENTURES. Implants, dentures, and partial dentures also replace missing teeth. Individual artificial teeth may be implanted or inserted into the patient's jaw. Partial dentures are dental appliances that have more than one artificial tooth inserted into a metal framework. They are usually removable and can be designed for one or both sides of the mouth.

Restorations that enhance

Crowns are used less frequently to enhance stained or damaged teeth. Newer techniques, such as bleaching or veneer application, are less invasive, save more original tooth structure, and cost less than crowns.

Veneers are ultra-thin coatings used to close gaps between teeth or cover discolored teeth. They are also used to fill in spaces between teeth, repair broken or chipped teeth, and straighten out misshapen or crooked teeth.

Materials used in fillings

The dentist cleans out the decayed part of the tooth and fills the opening with an artificial material (a filling) to protect the tooth's structure and restore the beauty and utility of the tooth.

METALS. The most common and strongest filling material is amalgam. It is a silver filling that is usually placed on the rear molars, which endure more stress during chewing. Amalgam fillings are strong and very resistant to wear, and are used for large, deep fillings. Amalgam has been in use since 1833. It is a mixture (an amalgam) of several metals, including liquid mercury (35% silver, 15% tin or tin and **copper**, 50% mercury, and a trace of **zinc**). When it is prepared, it has a malleable consistency that can easily be shaped to fit the prepared tooth. It hardens to a durable metal.

Despite its durability, many dentists and patients avoid using amalgam fillings. They have found that

amalgam has a tendency to expand with time. As a result, teeth become fractured from the inside and often split. Patients are not choosing amalgam, but this is strictly for aesthetic reasons. They darken over time and make teeth decayed. There has also been a question about the safety of amalgam since it contains mercury; also the ADA has maintained that it is safe to use as a restorative material.

Gold fillings or inlays are created outside of the mouth by a dental technician, then cemented into place. They are also used to fill the back molars and are very durable. Like amalgam, however, they are not as aesthetically pleasing as tooth-colored fillings. Still, gold has been a good source for foundation materials for porcelain over metal crowns.

Alloys of palladium, nickel, or chromium are frequently used for inlays and overlays, as well as for some base material for porcelain over metal crowns. In 2001, palladium is the metal of choice for porcelain-to-metal reconstructions. It is strong and generates fewer allergic reactions. Low-fusing porcelain allows lab technicians to add onto existing restorations.

PORCELAINS. Implants, partial dentures, dentures, crowns, and veneers are usually made from porcelain. Thin veneers made from porcelain are quite durable. All-porcelain products in the twenty-first century tend to fracture less than those of the past. Some crowns and implants are made with porcelain-covered metals. They are extremely durable, but sometimes recede from the gums, exposing the metals. Porcelain-over-gold crowns often have a golden glow that is caused by the metal beneath. This glow creates a more aesthetically pleasing crown, but it is more expensive than a crown made of other materials.

When inlays are required for teeth exposed by a smile, tooth-colored composites and porcelains are used. Reinforced porcelain and lucite porcelain are durable, but still may not be suitable for patients who grind their teeth because metal fillings withstand the stress of grinding better.

COMPOSITE RESIN. Composite fillings, often called white fillings, are made of a plastic resin and finely ground glass. They must be applied to the tooth surface in thin layers. Dentists try to match the color of composites with neighboring teeth for a more natural look, making the fillings appear invisible. Composite resin fillings are often made smaller than amalgam fillings and require less tooth preparation, thereby saving more natural tooth surface.

The composite filling is bonded to the tooth so that the tooth becomes stronger than it was before. A composite filling is also less sensitive to temperature changes in the mouth, which can damage the tooth. Thus, there is

KEY TERMS

Abutment tooth—A crowned tooth that stabilizes a bridge or partial denture.

Amalgam—A mixture of metals, primarily mercury and silver, used to make large, durable fillings. Also called silver fillings.

Composite filling—A resin material that is tooth colored and used to fill a tooth after decay has been removed. It is used most often in front teeth, but may be used in any tooth for aesthetic reasons.

Crown—A protective shell that fits over the tooth.

Denture—A dental prosthetic device consisting of a full set of teeth to fill the upper or lower jaw or both. Also called false teeth.

Enamel—The hard outermost surface of a tooth.

Impression—An exact copy of the teeth and mouth using materials that will set sufficiently so that a more durable cast of the mouth can be made from plaster, dental stone, or other casting materials.

Inlay—A filling that is made outside the tooth and then cemented into place.

Onlay—A restoration like an inlay that wraps over the crown and sides of a tooth.

Partial dentures—A dental prosthetic of two or more teeth used to replace missing teeth.

Porcelain—A strong, translucent ceramic material.

Prosthodontist—A dentist who specializes in such mouth reconstructions as crowns, fixed bridges, dentures, and implants.

Restoration—Any prosthetic device or process used to replace or improve the structure or appearance of a tooth or teeth.

less chance that the tooth will shatter because of the filling.

The major drawback of the composite resin filling is cost. The average cost is 1.5 to 2 times greater than the price of an amalgam filling. The composite resin filling can be stained by coffee and tea. Further, the large composite filling tends to wear out sooner than the large amalgam filling. However, the composite combined with porcelain is an excellent material for thin veneers. Finally, the light-cured composite's flexibility allows restorations to be repaired directly in the mouth. They are not abrasive and feel much like a natural tooth.

Operation

Crowns

The dentist first removes the decayed portion of the tooth. The tooth is then prepared for a crown. It may be tapered on the outside edges to a peg, reinforced with a cast metal core, or rebuilt with both a cast metal core and a post. An impression is made of the prepared tooth and its adjacent teeth. A retraction cord is placed around the tooth to get the impression medium under the gum, where the crown will be fitted.

A new crown will be created by the dental technician, who will use a cast made from this impression. The technique the technician uses is called lost-wax casting. A wax model is made of the crown. Another mold is made around the wax model and both are fired in a kiln. The wax melts, leaving an opening into which a restorative material can be poured. The crown may be made of gold or stainless steel alone; metal with a veneer of tooth-colored porcelain or resin; or of porcelain or resin alone. The finished crown is then placed over the prepared tooth, adjusted, and cemented into place.

When a tooth has had a root canal procedure and the root has been filled, the tooth may not be strong. In these cases, post crowns are used. The tooth is leveled at the gum line and a stainless steel or gold post is fitted into the root canal. This post can then receive the new crown and hold it in place.

For other patients, it may be necessary to implant the crown. In this case, a steel post is embedded in the patient's jawbone. It is left in place until the bone adheres to the post. The post is exposed and the crown is made and fitted.

Inlays

After the decay is removed and the cavity walls are shaped, the dentist makes a wax pattern of the space. A mold is cast from the wax pattern. An inlay is made from this mold and sealed into the tooth with dental cement.

When a restoration is cemented in place, the dentist and the dental assistant clean off all uncured restorative materials left on the tooth. Pumice or another mild abrasive is more effective in removing leftover materials than air or water spray, or even a roll of cotton.

Partial dentures, dentures, and implants

Partial dentures, dentures, implants, and veneers are created in much the same way as crowns and inlays. Teeth may already be absent, or they may need to be extracted. Impressions of the patient's mouth are taken and restorations are created from a variety of materials in

a dental laboratory. The final product is fitted and/or cemented into place at the dentist's office. For a veneer, the tooth is etched and a strong bonding agent is applied. The veneer is then cemented to the tooth.

Bonding

For bonding, thin layers of enamel are removed. The bonding material is laid over the tooth and shaped. It is cured with a special light and then polished.

Maintenance

Restoration materials are durable. Composite and amalgam fillings can last seven to ten years. They should be maintained with good **oral hygiene** and replaced as necessary. Some of the composite resins are sensitive to staining from coffee and tea. Amalgam fillings have a tendency to expand over time. As a result, teeth become fractured from the inside, and they often split. When a fracture occurs, a crown is needed. Unfortunately, amalgam fillings also darken over time and make teeth look as if they are decayed.

Cracks can occur in materials used for dentures and partial dentures, but far less frequently in older porcelain materials.

Composite resins are used to bond teeth, but they may not stand up to the patient who eats hard candy, popcorn kernels, or ice. They may require repair or touch-ups. Porcelain—a strong, translucent ceramic material—is used to make veneers, which can change the shape of teeth and fill in unsightly gaps. Porcelain veneers can become chipped or otherwise damaged, and may need to be replaced every five to twelve years.

Health care team roles

Dentists are assisted by dental assistants, who prepare patients for prosthodontic procedures. These usually involve taking x rays, making impressions of patients' teeth, making casts from the impressions, preparing restorative materials, and assisting the dentist in installing dental **prosthetics** or applying restorative materials. Cleaning and disinfecting of instruments and the treatment area are also the responsibility of the dental assistant. They take an active role in educating patients about the care and maintenance of their restorations, and instruct patients in proper aftercare, especially if there has been some invasive procedure (such as extraction or surgery). Dental assistants must be well trained in the preparation of dental materials and their applications, and must also have good communication skills, as they need to instruct patients and have the ability to reassure those who may be uncomfortable in a dentist's office.

In the laboratory, dental technicians are responsible for the creation of dental prosthetics. They must possess excellent manual dexterity and some creative skill. With recent advances in digital dentistry, the technician will require computer skills as well as manual ones.

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American College of Prosthodontists. 211 East Chicago Avenue, Suite 1000, Chicago, IL 60611. (312) 573-1260. <<http://222.prosthodontics.org>>.

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Janie F. Franz

Restraint use

Definition

A restraint, or physical restraint, is a piece of equipment or device that restricts a patient's ability to move. Restraints may keep a patient from getting out of bed or moving arms and legs excessively.



Proper use of restraints helps patients avoid harming themselves or others. (Delmar Publishers, Inc. Reproduced by permission.)

Purpose

Restraints are used to control a patient who is in danger of harming the self or others. It is sometimes necessary to restrain children who may not be capable of remaining still when they are frightened or in **pain** during some procedures. The use of physical restraints in the health care arena should be used as a last-resort option.

Precautions

Many safety measures should be considered before applying restraints. According to federal law, first and foremost is the need to try other methods to promote safety and avoid the use of physical restraints. Some examples of alternative methods are patient reorientation to physical surroundings; discussion with family and friends about staying with the patient; moving the patient's room nearer to staff members; teaching **relaxation** techniques in order to decrease **anxiety** and fear; and decreasing overstimulation. Documentation of these methods is extremely important.

Description

Several types of medical manufacturers have different names for the same types of physical restraints. The most common names and types of physical restraints are:

- soft wrist and ankle restraints
- strap fastening vest (posey jacket)
- seat belt with buckle (restraint belt)
- mittens (restraint mitts)
- leather wrist and ankle restraints

The most common reasons for the use of physical restraints are:

- When a confused patient roams through the health care facility endangering him/herself.
- When a confused patient tries to remove medically necessary tubes, intravenous lines, or protective dressings.
- When a patient has an unsteady gait (walk) and is at risk for falls.
- When a patient needs to be kept from inflicting self-harm or injury (suicidal).
- When a patient needs to be kept from inflicting harm upon health care workers, other patients, and/or visitors (homicidal).
- When a professional is performing minor surgical procedures on a child that is not able to remain still.

Preparation

Before restraint application, the health care provider should be familiar with the restraint device that will be used. Also, if a patient is violent, a five-person team is optimal for the restraining process. Each person will be responsible for one extremity, with the fifth person supervising and positioning the patient's head.

Each restraint device will have different directions for application. However, there are some universal standards for proper application. When using any type of restraining device, it is extremely important to tie or lock the restraint to the bed frame and not the bed rails, thus allowing for proper movement. With soft restraints, posey jackets, and restraint belts, a quick-release slipknot should be used to allow immediate release if needed. When leather restraints are used and applied to both arms and legs, one arm should be positioned above the patient's head while the other is positioned by the patient's side. This will decrease the possibility of the patient's rocking or tipping over the bed.

Aftercare

The nurse has to reassess restraints at least every 30 minutes. Neurovascular assessment (circulation to hands, fingers, feet, toes); skin assessment (bruising of restrained area); and meeting a patient's activities of daily living such as toileting, eating, and drinking are all aspects of restraint reassessment and care. Documentation of these interventions must be clearly identified on the patient's chart.

Complications

Most common restraint complications include:

- accidental or intentional removal of restraints by patient, family, or staff, resulting in possible removal of tubes, intravenous lines, injury to patient or others
- injury to restrained extremity (arm or leg)
- fracture or muscle strains during application with violent patient
- dislocation or contusion of extremity
- exposure to blood or body fluid while restraining violent patient (biting, spitting, urinating, etc.)
- numbness and/or tingling in restrained extremity

Results

The end results of using physical restraints are the maintenance of safety to the patient and others and the administration of medically necessary interventions.

Health care team roles

The **registered nurse (RN)** or **licensed practical nurse (LPN)** has a tremendous responsibility when caring for a patient in physical restraints. Many times restraints are needed immediately and violent attacks on health care workers can happen. The emphasis on proper documentation of alternative methods is an absolute must. Obtaining a physician's order for physical restraints is a top priority as well. Rationale for the application of restraints must be discussed with the patient and family. Adequate explanation of the interference with medical treatment or the diversion of suicidal or homicidal acts is important. Reassessment of proper restraint positioning and re-evaluation of the patient's continued need for physical restraints are also aspects of complete nursing care.

Paramedics and **emergency medical technicians (EMTs)** are confronted with the need to use physical restraints in the field (outside of the hospital). In these cases, they are allowed to use a "reasonable amount of

KEY TERMS

Extremity—A term referring to an arm or leg.

Gait—A person's characteristic manner of walking.

Neurovascular—Referring to the combined status of the neurological and circulatory systems.

Physical restraint—A piece of equipment or device that restricts a patient's capability to move.

force" in order to manage a combative patient during transport to the health care facility. Physical restraints utilized by paramedics and EMTs are plastic bound straps (zip straps), vests, and blankets. When physical restraints are necessary, law enforcement is usually involved.

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Lori Beck, RN, MSN, FNP-C

Retainers see **Orthodontic appliances**

Retinol see **Vitamin A**

Retinopathies

Definition

The retinopathies are a group of retinal diseases that cause vascular and neurological changes in the retina of the eye. They are reflective of such ongoing systemic diseases as diabetes, arteriosclerosis, **hypertension**, and sickle cell anemia.

Description

The retina is an outward extension of the **central nervous system** that lines the inside of the eye. It has 10 layers and is comprised of the photoreceptor rods and cones and such support cells as Mueller cells. The retinal pigment epithelium (RPE) is a single cell layer located behind the retina, which services the photoreceptors. Bruch's membrane is a basement membrane found between the RPE and the choroid, a highly vascular layer that includes the choriocapillaris, which supplies nutrients to the RPE and to the photoreceptors. The central retinal artery and its branches supply **blood** to the rest of the retina. The cilio-retinal artery that emerges from the optic nerve supplies the macula. The macula is located temporal to the optic nerve and is the part of the retina that contains the highest concentration of photoreceptors, especially cones. The part of the macula with the highest concentration of cones is the fovea. The vitreous humor is a gelatinous body that is located between the retina and the lens of the eye. The optic nerve is a large nerve in the posterior part of the eye through which the central artery and vein pass. It is actually formed from the axons of cells in the retina. It is through the optic nerve that visual stimuli leave the eye for the occipital lobe of the **brain**, where **vision** is processed. Hemoglobin is a molecule in red blood cells responsible for the transport of oxygen.

The presentation and pathogenesis of each of these retinal diseases are unique; and the signs can be seen by an ophthalmologist or an optometrist upon dilation of the eye. All of these retinopathies can lead to blindness.

Causes and symptoms

Diabetic retinopathy

Diabetic retinopathy is the leading cause of blindness in the United States for people between 20 and 74 years of age. Risk factors for diabetic retinopathy include hypertension, elevated HgA1C (a **hemoglobin test**), a history of smoking, and number of years as a diabetic. Within 10 years of diagnosis, over 70% of type I diabetics will have some retinopathy, and within 16 years diagnosis, 60% of type II diabetics will have retinopathy. A

diabetic may have normal vision, yet still have severe retinopathy.

The underlying pathogenesis of diabetic retinopathy is hypoxia, a decreased oxygen supply that is caused by elevated blood sugar or hyperglycemia. Glucose is needed in the cells of the body for energy, and oxygen and insulin are required for entry of the glucose molecules. The diabetic, because of insufficient insulin or because of cellular resistance to insulin, cannot absorb glucose into the cell effectively. The pathologic response of the retina to a decreased oxygen supply is first a thickening of, and then a breakdown of the retinal capillary basement membrane. Pericytes, cells that surround the capillaries and produce an inhibitor for angiogenesis, also degenerate. In the absence of this inhibitor, retinal neovascularization, or new vessel formation, is stimulated by vascular endothelial growth factor (VEGF). The new vessels that form are very fragile and can easily rupture, causing bleeding in the vitreous and subsequently leading to vitreous traction. Degeneration of retinal neural cells precedes the vascular changes of diabetic retinopathy.

Diabetic retinopathy is a condition that initially affects only the posterior pole of the retina. The peripheral retina is affected only in the extreme cases. Diabetic retinopathy is divided into two phases: nonproliferative and proliferative. In the nonproliferative phase the retina has microaneurysms, dot and blot hemorrhages, hard lipid exudates, a beading pattern of some of the venules, areas of local ischemia where there is little or no oxygen perfusion (called cotton-wool spots), or macular **edema**. The macular edema is called clinically significant macula (CSME) when there are hard exudates and macular thickening or edema, close to the fovea. In the proliferative phase of diabetic retinopathy, neovascularization of the retina and of the optic nerve can be observed. A fibrous substance that materializes when the new retinal vessels form adheres to the vitreous, causing retinal traction and retinal detachments. The newly formed **blood vessels** can invade the anterior part of the eye, causing neovascular **glaucoma**. Vitreous hemorrhaging occurs when the blood vessels attach to the vitreous. Venous and arterial occlusions are also seen in diabetic retinopathy.

Arteriosclerotic retinopathy

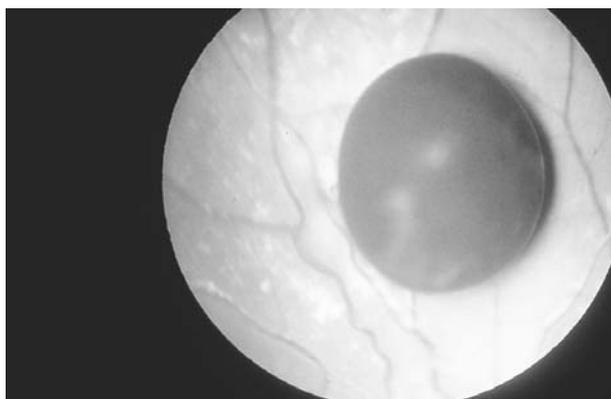
Arteriosclerotic retinopathy is the ocular manifestation of arteriosclerosis, a systemic condition in which the arterial walls thicken and harden. The risk factors for arteriosclerotic retinopathy include **heart** disease and elevated serum cholesterol. Arteriosclerotic retinopathy can be involved in hypertensive retinopathy. One of the first ophthalmoscopic signs of arteriosclerotic retinopathy is an increased arterial reflex due to thickening of the

retinal arterial walls. As the arteriosclerosis progresses, the vessels undergo color changes to a copper-wire and then to a silver-wire appearance. Arteriovenous or A-V crossing defects are also synonymous with arteriosclerotic retinopathy. In advanced arteriosclerosis, banking—a type of A-V crossing that completely cuts off distal venous circulation, forming a large dilated vein—occurs.

Arterial occlusion can occur as a result of arteriosclerotic retinopathy. An embolus from the carotid artery or from the aortic arch of the heart can travel to the retina, occluding either the central retinal artery (CRAO) or one of its branches (BRAO). An embolus from the carotid artery usually is a cholesterol plaque; and that from the heart is usually fibrotic in appearance. Immediately after a CRAO, the retina becomes ischemic and then edematous. Due to the surrounding ischemia, the fovea takes on a characteristic cherry-red appearance. A pupil abnormality, called an afferent pupillary defect (APD), may be noted. The vision loss in a CRAO is severe, sudden and painless, although the patient may have a history of amaurosis fugax. After resolution of the CRAO the retina takes on a normal appearance, but the retinal blood vessels are narrowed and the optic nerve shows pallor. Macular function will be intact if there is cilioretinal circulation. Patients with a BRAO may be asymptomatic if there is no macular involvement, but usually there is field loss in the affected quadrant as well as decreased visual acuity.

Hypertensive retinopathy

Hypertensive retinopathy is an ocular presentation of the effects of systemic hypertension, defined as systolic pressure over 140 mm/Hg and diastolic pressure over 90 mm/Hg. This type of retinopathy is usually bilateral. There is narrowing of retinal arterioles in systemic hypertension. Constriction of vessels in older hypertensive patients may not be observed because of involutational sclerosis of the arteries, which occurs during aging. When the integrity of the retinal vessels is compromised because of long-term hypertension, leakage of blood occurs; and flame-shaped hemorrhages, characteristic of hypertensive retinopathy can be observed in the retina. Also, a star-shaped pattern of exudation appears in the macula. In the advanced stages of hypertensive retinopathy there will be cotton-wool spots close to the optic nerve. In malignant hypertension the optic nerve will become swollen and the patient will often experience blurred vision; and, if the **blood pressure** is extremely elevated, encephalopathy can develop.



A close-up view of a human eye following retinal hemorrhage. (Custom Medical Stock Photo. Reproduced by permission.)

Retinal vein occlusions

Retinal vein occlusions block the drainage of the retina. They can be either central (CRVO) or branched (BRVO). They are usually seen in older patients who have arteriosclerosis, hypertension or diabetes. Vein occlusions can also strike patients with sickle-cell anemia. Papillophlebitis is a form of retinal vein occlusion that is inflammatory in nature and seen in younger patients. A hemi-central vein occlusion is similar to a CRVO, but affects only one-half of the retina. A CRVO occurs when the central retinal artery compresses the central vein as it leaves the lamina cribosa. A BRVO occurs when there is constriction of a venule by a sclerotic artery that affects only one quadrant, usually the superior temporal one.

A CRVO can be either ischemic (characterized by decreased blood flow) or nonischemic. Approximately 80% of CRVO events are nonischemic. In the nonischemic CRVO, hemorrhages are evident throughout the retina, but usually there are no cotton-wool spots. The optic nerve swelling is usually mild and macular edema is not always present. The visual acuity may be only mildly reduced. Months after such an occlusion, collateral blood vessels may appear on the optic nerve. Up to 20% of individuals with a nonischemic CRVO may progress to an ischemic event. The hallmark of ischemic CRVO is extensive capillary nonperfusion. Ophthalmoscopic examination following an ischemic event reveals extensive venous tortuosity and enlargement of the retinal veins. Edema of the macula and optic nerve are always present and cotton-wool spots are common. Visual acuity is usually less than 20/200. Neovascularization of the iris and neovascular glaucoma are common complications of CRVO. There can be optic nerve neovascularization, bleeding into the vitreous, and vitreal traction, which

KEY TERMS

Exudation—Leakage of cells, proteins, and fluids through the blood vessel wall into the surrounding tissue.

Ischemia—Lack of blood supply to a tissue or organ.

Neovascularization—Formation of new blood vessels.

Proliferative retinopathy—Retinopathy with neovascularization.

increases the risk of a retinal detachment. The signs of a BRAO are similar, but present in just one quadrant.

Sickle-cell retinopathy

The underlying cause of sickle-cell retinopathy is different from that of the other retinopathies. Sickle-cell anemia is a genetically inherited condition, seen primarily in persons of African descent. Close to 10% of African Americans carry one of the sickle-cell traits. Sickle-cell anemia is caused by mutant hemoglobin molecules which form either because of an amino acid substitution of valine for glutamic acid, causing a structural defect in the hemoglobin molecule, or because of a deficiency in the synthesis of one of the hemoglobin peptide chains. A normal red blood cell has a biconcave appearance and can easily pass through the capillary bed. A “sickle” cell does not have this biconcave shape, is less pliable than a normal red blood cell, and thus does not move well through the capillaries, triggering retinal microvascular occlusions and then ischemia.

Sickle-cell retinopathy can be non-proliferative or proliferative and affects primarily the peripheral retina. In the nonproliferative stage the retinal vessel walls begin to deteriorate. The ophthalmoscopic signs of non-proliferative sickle-cell retinopathy include: venous tortuosity; intraretinal “salmon patch” hemorrhages, found near a vessel occlusion; “black sunburst” lesions, that develop when a vascular occlusion damages the RPE; silver-wired arterioles; and breaks in Bruch’s membrane, called angioid streaks. Sickle-cell retinopathy becomes proliferative when neovascularization, in the form of arteriovenous anastomoses or connections between veins and arteries, appears in a sea-shaped formation. These vessels can adhere to the vitreous, but usually regress, forming a characteristic white tuft. Vitreous traction and retinal detachments are not common in sickle-cell retinopathy.

Diagnosis

The ophthalmologist or optometrist uses fluorescein **angiography** to determine the extent of vessel leakage and perfusion in the retinopathies. The fluorescein dye is injected into the body through a vein in the hand. Rarely does a patient have a reaction to the dye, but a localized redness at the injection site is occasionally observed. The fluorescein molecule binds to **proteins** in the blood and it is excited by light of 490 nanometers (blue light). A retinal camera filters the light, such that only blue light enters the eye. Photos taken in rapid succession reveal the extent of perfusion, leakage, and ischemia in the retina. The results of this angiography help the doctor to determine if laser photocoagulation can benefit the patient.

Treatment

In laser treatment of retinopathy, the light energy of the laser is absorbed by certain cells in the retina, destroying them and thus reducing the oxygen demand of the area, while leaving the surrounding tissue intact. Pan-retinal photocoagulation (PRP) treats neovascularization following a BRAO or hemi-retinal arterial occlusion and the neovascularization of the optic nerve in diabetic retinopathy. The macular edema of arterial occlusions and diabetic retinopathy is treated by focal argon photocoagulation. **Laser surgery** is not performed close to the fovea. Often the edema that develops during an arterial occlusion will dissipate without treatment. Laser treatment is not usually beneficial in CRAO. Peripheral scatter photocoagulation treats the neovascularization of sickle-cell retinopathy.

The vitreous hemorrhaging of diabetes and sickle-cell retinopathy may require either a vitrectomy, which is a surgical removal of part or all of the vitreous, or cryopexy, the use of low-temperature probes to kill the blood vessels. Vitrectomy has been especially beneficial in restoring vision in diabetic patients in whom retinopathy has already affected visual acuity.

There is little that can be done to treat a CRAO. Massage of the globe to dislodge the embolus, the use of carbogen to increase blood carbon dioxide levels, and anterior chamber **paracentesis** have all been employed with limited success. Hyperbaric **oxygen therapy** has been successful in treatment of CRAO in one study.

In treatment of the patient with malignant hypertension it is important to slowly lower the blood pressure in order to reduce the risk of ischemic optic neuropathy.

The intraocular pressure must be lowered in the patient with a CRAO.

Nonmedical treatments may include changes in diet and **exercise** regimens.

Prognosis

Except when vitrectomy is performed (when indicated), and once the retinopathies have had an effect on vision, there is little that can be done to restore it. The goal of many of the treatments is to prevent further damage. If the proliferative phases of these retinopathies are treated early enough, normal vision is possible. The prognosis for patients with nonproliferative retinopathy is better than for patients with proliferative disease.

Health care team roles

The role of the allied health professional in diagnosis and treatment of retinopathy is to assist the ophthalmologist or optometrist in diagnosis. Ophthalmic technicians or nurses may instill the drops for dilation of the eye, inject the fluorescein dye used in angiography. The ophthalmic technician or a retinal photographer takes the photos needed for analysis of retinopathy. Dieticians assist diabetics, hypertensives, and those with heart disease.

Prevention

The first line in prevention of the retinopathies is an annual dilated eye exam performed by an ophthalmologist or an optometrist. Patients with systemic disease that can cause retinopathy must understand the ocular complications of their disease and the consequences if medical therapy is not followed as recommended by a physician.

Depending on the type of retinopathy, other preventive measures need to be taken. All patients with retinal emboli need a cardiac workup, including analysis of blood lipid levels. This is the case even in the absence of an occlusion. Older patients need testing for temporal arteritis once CRAO is detected. Over 65% of patients with temporal arteritis will have a CRAO in the fellow eye within days of the initial event. Since 70% of patients with BRAO have hypertension, all patients with such occlusions need to be evaluated for hypertension. Since sickle-cell anemia can cause a BRVO, African Americans need a Sickledex test. In the event of unilateral hypertensive retinopathy, a carotid artery obstruction should be suspected and a carotid workup is imperative. Finally, the best prevention of the retinopathies is management of the underlying systemic diseases.

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Martha S. Reilly, OD

Retrograde cystography

Definition

A retrograde cystogram is a radiographic study of the bladder, made after a direct injection of a radiopaque contrast material by means of a urethral catheter.

Purpose

A retrograde cystogram is performed to evaluate the structure of the bladder and identify such bladder disor-

KEY TERMS

Bladder—A balloon-like organ located in the lower pelvis that stores urine.

Catheter—A thin tube used to inject fluids into or withdraw fluids from the body.

Fluoroscope—An under-table x-ray tube used in conjunction with a television monitor that allows immediate visualization of the x-ray image.

Hematuria—The presence of blood in the urine.

Stones—Also known as calculi, stones result from an excessive build-up of mineral crystals in the kidney. Symptoms of stones include intense pain in the lower back or abdomen, urinary tract infection, fever, burning sensation on urination, and/or blood in the urine.

Ureter—The tube that carries urine from the kidney to the bladder.

Urethra—The tube that empties urine from the bladder to the outside of the body.

ders as cystitis, polyps, stones, and tumors. It may also be used to diagnose recurrent urinary tract infections due to urine reflux (backward flow) into the ureters. This examination is commonly performed as an emergency procedure on patients with gross hematuria (**blood** in urine) due to a pelvic fracture or severe trauma to the abdomen, in order to detect rupture of the bladder. Retrograde cystography is frequently done on children being evaluated for a congenital abnormality, obstruction, or urethral stricture. When the urethra is also being evaluated, the study is called a cystourethrogram. If the bladder or urethra is evaluated while the patient is voiding (urinating), the study is called a voiding cystourethrogram or VCUG. A voiding cystourethrogram is often performed when the bladder is full to check for any reflux or other problems during urination.

Complications

The physician should be alerted to any previous history of an allergic reaction to an iodine-based contrast material. Since the contrast medium is injected directly into the bladder instead of the venous circulation, allergic reactions are extremely rare. A retrograde cystogram should not be performed, however, on patients who have had recent bladder surgery or an obstruction that interferes with the placement of a urinary catheter. Patients

with an active urinary tract **infection** or who may be pregnant should not be given a retrograde cystogram.

Description

To administer a retrograde cystogram, a doctor or nurse will insert a thin tube-like instrument called a Foley catheter through the patient's urethra and into the bladder. The contrast medium is then injected through the catheter into the bladder. The catheter can be inserted in an outpatient clinic before the patient is taken to the radiology department. It may also be inserted by an emergency physician when a retrograde cystogram is ordered on a severe trauma patient. The cystogram can be performed in the emergency department using a portable x-ray machine.

After the Foley catheter is inserted, 250–300 mL of a water-soluble contrast medium is injected into the bladder and the catheter is clamped. A diluted contrast agent (usually 30% sodium iodide) is used since the contrast medium is not injected intravenously. An AP (anteroposterior) view of the full bladder is taken with the tube angled 10–15 degrees caudal (in the direction of the patient's feet) to project the pubic symphysis away from the base of the bladder. The patient is turned 45 degrees onto each side for two oblique views of the bladder and completely sideways for a true lateral view. The films are reviewed by the radiologist. If no other films are needed the catheter will be removed and a post-void film is taken. If the patient is unable to urinate, the clamp will be removed, the contrast medium will then empty from the bladder through the tube, and a post-drainage film will be taken. During a voiding cystogram, films are taken by the radiologist under fluoroscopy while the patient is voiding in order to image any urethral abnormalities or urinary reflux.

A retrograde cystogram usually takes from 30 minutes to one hour, depending on how many films are requested by the radiologist.

This examination can also be performed with a radioactive tracer (isotope) in the nuclear medicine department. A cystogram performed with a tracer is known as a radionuclide retrograde cystogram.

A CT scan of the bladder may also be ordered after the injection of a radiopaque contrast material.

Preparation

Laxatives or **enemas** are sometimes given before the procedure to eliminate gas and fecal material that may prevent proper visualization of the bladder. The patient will be given a hospital gown. The x-ray technologist will explain the procedure and take a detailed

patient history concerning **allergies**, the possibility of **pregnancy**, and current medical problems. The patient is usually requested to sign a consent form.

Aftercare

The patient may have some burning on urination for a few hours after the test, due to the irritation of the urethra from the catheter. The discomfort can be reduced by a liberal fluid intake, which will dilute the urine.

Results

A normal result reveals no anatomical or functional abnormalities of the bladder.

Abnormal results may indicate:

- calculi (stones)
- inflammation (cystitis)
- blood clots
- polyps
- injury (bladder tear)
- diverticula
- cystocele (prolapse of the bladder into the vaginal cavity, common after childbirth)
- ruptures (imaged as flame-like leakages of the contrast material superior or lateral to the bladder)
- tumors (visualized in the bladder or in an adjacent structure such as the vagina or prostate)
- reflux (urine passing backward from the bladder into the ureters, causing infection)

Health care team roles

The procedure is ordered by the physician. The patient may be catheterized by a physician or nurse. The x-ray technologist prepares the contrast medium for injection and takes all the overhead views of the bladder. If the portable x-ray machine is used to perform the cystogram, all staff members remaining in the room must be shielded. The x-ray technologist works closely with the doctors and nurses to make sure the patients are catheterized before arriving in the radiology department and that an enema or laxative has been administered.

Patient education

The x-ray technologist must explain to the patient that it is necessary to fill the bladder completely to see a detailed image of the bladder outline. The patient may experience some discomfort with a full bladder; however, the films are taken at once and the catheter is removed

or unclamped. If a film must be taken while the patient is voiding, the lights can be dimmed and the water tap turned on to help the patient relax. The radiology technologist must be certified and registered with the American Society of Radiologic Technologists.

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National Kidney Foundation. 30 East 33rd St., New York, NY 10016. (800) 622-9010 or (212) 889-2210.

National Kidney and Urologic Diseases Information Clearinghouse. 3 Information Way, Bethesda, MD 20892-3580. (301) 654-4415.

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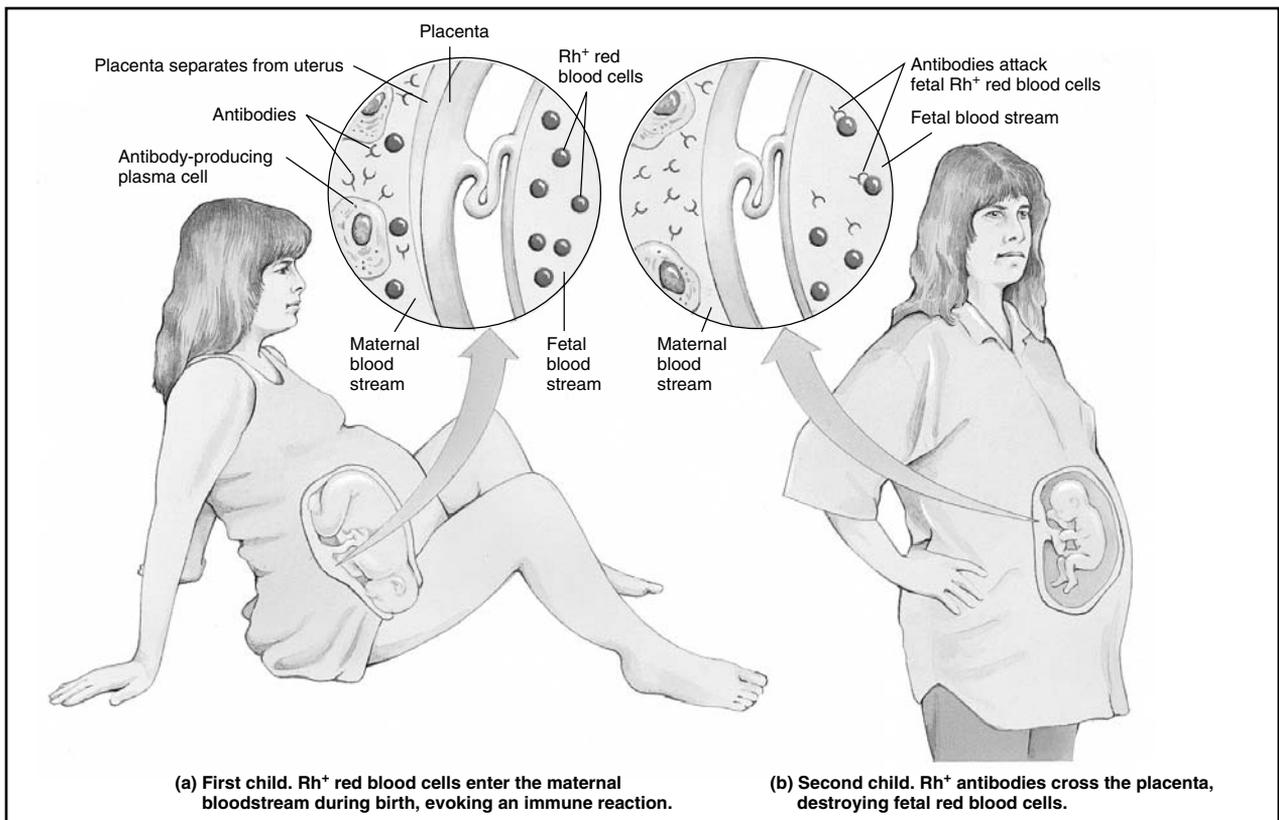
Rh factor

Definition

Rh (Rhesus) factor is a **blood** protein that plays a critical role in some pregnancies. People without Rh factor are known as Rh negative, while people with the Rh factor are Rh positive. If a woman who is Rh negative is pregnant with a fetus who is Rh positive, her body may make antibodies against the fetus’s blood. This can cause Rh disease in the baby, also known as hemolytic disease of the newborn, or erythroblastosis fetalis. In severe cases, Rh disease leads to **brain** damage and even death. Since 1968 a vaccine has existed to prevent the mother’s body from making antibodies against the fetus’s blood.

Description

Rh factor is an antigen found on the red blood cells of most people. Rh factor, like the blood types A, B, and O, is inherited from one’s parents. A simple blood test can determine blood type, including the presence of the



Rh factor incompatibility. (Delmar Publishers, Inc. Reproduced by permission.)

Rh factor. About 85% of white Americans and 95% of African-Americans are Rh positive. A person's own health is not affected by the presence or absence of Rh factor.

Rh factor is important only during a **pregnancy** in which an Rh negative woman is carrying a fetus who might be Rh positive. This can occur when an Rh negative woman conceives a baby with an Rh positive man. The gene for Rh positive blood is dominant over the gene for Rh negative blood, so their baby will be Rh positive. If the Rh positive father also carries the gene for Rh negative blood, his babies have a 50% chance of inheriting Rh negative blood and a 50% chance of inheriting Rh positive blood. If both parents are Rh negative, their babies will always be Rh negative. In order to protect their future babies from Rh disease, all women of child-bearing age should know their Rh status before becoming pregnant.

Role in human health

Rh factor in pregnancy

The danger of Rh disease begins when the mother's Rh negative blood is exposed to the baby's Rh positive

blood. This mixing of blood can occur at the time of birth, and after an abortion or **miscarriage**. It may also happen during prenatal tests such as **amniocentesis** and **chorionic villus sampling**. More rarely, blood from the mother and fetus may mingle during pregnancy, before birth. When this contact occurs, the mother's body responds by building antibodies to fight the foreign Rh blood protein. The mother's blood is now said to be "sensitized" against Rh factor blood.

Common diseases and disorders

Rh incompatibility

Once a mother's blood has become sensitized, her antibodies will attack the blood of any Rh positive fetus that she carries. The antibodies will destroy the fetus's red blood cells. If this happens, the infant will suffer from Rh factor incompatibility. It will become anemic, a condition caused by a reduction in red blood cells and marked by weakness and fatigue. Severe anemia can lead to **heart failure** and death. The breakdown of red blood cells will also cause the formation of a reddish-yellow substance known as bilirubin. An infant with high levels of bilirubin will look yellowish. This is known as **jaun-**

dice. Brain damage can occur if the bilirubin level gets high enough. However, Rh incompatibility occurs in varying degrees of severity, with brain damage at the far end of a spectrum.

Rh disease is usually not a problem during a first pregnancy. This is because the Rh negative mother probably will not become sensitized until her blood mixes with the baby's blood during birth. Her baby will be born before her blood can produce antibodies against the baby's Rh positive blood. Once a mother is sensitized, however, any future babies with Rh positive blood will be at risk for Rh disease.

PREVENTION AND TREATMENT. Since 1968 a vaccine has existed to prevent sensitization from occurring. This is the best way to eliminate Rh disease. Available as an injection, the vaccine is called Rh immune globulin (brand name RhoGAM). It blocks the action of the antibodies and prevents the mother's blood from attacking the baby's blood. To be effective, the vaccine must be given any time fetal blood mixes with maternal blood: after birth, abortion, miscarriage, or prenatal tests like amniocentesis and chorionic villus sampling. The vaccine is typically given within 72 hours of any of these events. Since mixing of the blood may also occur during the last three months of pregnancy, the vaccine is also administered at 28 weeks of pregnancy.

A pregnant woman who has already been sensitized from a previous pregnancy will want her doctor to carefully monitor the level of antibodies in her blood throughout her pregnancy. As long as the antibody levels remain relatively low, no problem exists. But if those levels rise, the fetus will need special attention. High antibody levels mean that the fetus's red blood cells are being attacked and destroyed.

A fetus whose red blood cells are being destroyed will need a blood transfusion while it is still in the uterus. Two or three transfusions may be necessary before the baby is born. If the fetus shows signs of illness close to its anticipated birth, the physician may elect to deliver the baby early, either by inducing birth or by cesarean section. The baby will then receive a transfusion after birth.

ELIMINATING RH DISEASE. Until the introduction of the Rh immune globulin vaccine, Rh disease could not be prevented. About 45 babies per 10,000 births developed the disease each year before widespread use of the vaccine in the early 1970s. Use of the Rh immune globulin vaccine has reduced the chances of the mother becoming sensitized from approximately 12-13% to 1-2%.

Nevertheless, the disease is not completely eradicated. Further steps must be taken, since this is a preventa-

KEY TERMS

Amniocentesis—A procedure in which a sample of the fluid in the amniotic sac is removed with a needle for genetic testing.

Antigen—A substance, usually a protein or carbohydrate, that stimulates a response from the immune system.

Bilirubin—Reddish-yellow substance formed by the breakdown of red blood cells.

Chorionic villus sampling—A procedure in which a sample of the membrane surrounding the fetus is taken for genetic testing.

Prenatal test—Procedure done to determine the presence of disease or defect in a fetus.

Sensitization—Occurs when a mother's blood produces antibodies against the blood of her Rh positive fetus.

ble disease. The majority of cases of Rh disease are the result of women not receiving the vaccine at the appropriate time. Poor women without health insurance, who are likely to lack adequate **prenatal care**, are especially vulnerable to this oversight. Older women may have become sensitized before the vaccine was available; foreign-born women may not have had access to the vaccine.

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Liz Marshall

Rh sensitivity see **Rh factor**

Rh typing see **Type and screen**

Rheumatoid factor test see **Autoimmune disease tests**

Rhinovirus infection see **Common cold**

Riboflavin

Description

Riboflavin, also known as Vitamin B₂, has many functions in common with the other members of the B complex family. These include support of the immune and nervous systems, and formation of healthy red **blood** cells. Riboflavin provides essential factors for the production of cellular enzymes that turn **proteins, fats, and carbohydrates** into energy. It also participates in cell reproduction, and keeps skin, hair, nails, eyes, and mucous membranes healthy. **Folic acid** (vitamin B₉) and pyridoxine (vitamin B₆) are activated by riboflavin.

General use

The RDA of riboflavin for infants under six months is 0.4 milligrams (mg). It goes up incrementally with age and caloric intake. Babies from six months to one year of age require 0.5 mg. Children need 0.8 mg at one to three years of age, 1.1 mg at four to six years, and 1.2 mg at seven to ten years. Women need 1.3 mg from 11-50 years, and 1.2 mg thereafter. Slightly more is required during **pregnancy** (1.6 mg) and **lactation** (1.7-1.8 mg). Men require 1.5 mg from 11-14 years of age, 1.8 mg from 15-18 years, 1.7 mg from 19-50 years, and 1.4 mg at 51 years and older. Riboflavin is water-soluble, and is not stored in significant quantities in the body.

High doses of riboflavin, as much as 400 mg per day, have been shown to reduce the frequency of migraine headaches by half in susceptible people. The severity of the events was also reportedly decreased. This may be an effect of improved use of cellular energy in the **brain**. It is theorized that riboflavin may help decrease the odds of getting **cataracts**, but the evidence for this protection is not definitive. One large study had a group taking both **niacin** (vitamin B₃) and riboflavin, and while the group had a significantly lower total incidence of cataracts, they had a somewhat higher than average incidence of a specific cataract subtype. **Memory** may be improved by these supplements, according to some research done on older people. Riboflavin and **vitamin C** both help boost the body's level of glutathione, which is an antioxidant with many beneficial effects. There is not enough evidence to support the effectiveness of riboflavin for sickle-cell anemia, canker sores, or as an athletic performance aid.

Preparations

Natural sources

Beef **liver** is a very rich source of riboflavin, but dairy products also supply ample amounts. Higher-fat

sources contain less than those with low fat. Many processed grain products are fortified with riboflavin, as well as other **B vitamins**. Good vegetable choices include avocados, mushrooms, spinach, and other dark green, leafy vegetables. Nuts, legumes, nutritional yeast, and brewer's yeast contain riboflavin as well. Cooked foods provide as much of this vitamin as raw ones do, since the substance is heat stable. Light, however, does break down riboflavin. To preserve it, be sure to either store dairy and grain products in something opaque or keep them away from light.

Supplemental sources

Riboflavin is available as an oral single vitamin product. Consider taking a balanced B complex supplement rather than high doses of an individual vitamin unless there is a specific indication to do so. Store supplements in a cool, dry place, away from light, and out of the reach of children.

Deficiency

Ariboflavinosis is the term for the condition of vitamin B₂ deficiency. Since small amounts can be stored in the liver and **kidneys**, a dietary inadequacy may not become apparent for several months. Insufficient levels of riboflavin have noticeable effects on several areas of the skin. Commonly the corners of the mouth are cracked. Facial skin and scalp tend to itch and scale, as does the scrotal skin. The eyes fatigue easily and are sensitive to light, and may also become watery, sore, or bloodshot. Trembling, neuropathy, dizziness, insomnia, poor digestion, slow growth, and **sore throat** and tongue have also been reported. Anemia may develop if the deficiency is severe. People who are deficient in riboflavin are likely to be lacking in other B vitamins, and possibly additional nutrients as well.

Risk factors for deficiency

Riboflavin deficiency is uncommon, but some populations may need more than the RDA in order to maintain good health. Vegans, and others who do not use dairy products, would do well to take a balanced B vitamin supplement. Those with increased need for riboflavin and other B vitamins may include people under high **stress**, including those experiencing surgery, chronic illnesses, liver disease, or poor nutritional status. Diabetics may have a tendency to be low on riboflavin as a result of increased urinary excretion. Athletes and anyone else with a high-energy output will need additional vitamin B₂. This includes anyone who exercises with some regularity. The elderly are more likely to suffer from nutritional inadequacy as well as problems with absorption.

KEY TERMS

Antioxidant—Any one of a group of substances that function to destroy cell-damaging free radicals in the body.

Migraine—A very severe headache, often accompanied by nausea and vomiting. It is usually experienced on one side of the head, and may be preceded by visual symptoms.

Neuropathy—Abnormality of the nerves, which may be manifested as numbness, tingling, or weakness of the affected area.

Smokers and alcoholics are at higher risk for deficiency, as tobacco and alcohol suppress absorption. Birth control pills may possibly reduce riboflavin levels, as can phenothiazine tranquilizers, tricyclic antidepressants, and probenecid. Consult a health care professional to determine if supplementation is appropriate.

Precautions

Riboflavin should not be taken by anyone with a B vitamin allergy or chronic renal disease. Other populations are unlikely to experience any difficulty from taking supplemental B₂.

Side effects

Taking supplemental riboflavin causes a harmless intense orange or yellow discoloration of the urine.

Interactions

Probenecid (a drug treating **gout**) impairs riboflavin absorption, and propantheline bromide (a drug treating peptic ulcers) reportedly both delays and increases absorption. Phenothiazines (**antipsychotic drugs**) increase the excretion of riboflavin, thus lowering serum levels; and oral contraceptives may also decrease serum levels. Supplementation should be discussed with a health care provider if these medications are being used. Absorption of riboflavin is improved when taken together with other B vitamins and vitamin C.

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Judith Turner

Ribs see **Thorax, bones of**

Rinne and Weber tests

Definition

Both the Rinne and the Weber tests employ the use of metal tuning forks to provide a rough assessment of a patient's **hearing** level at various frequencies. A tuning fork is a metal instrument with a handle and two prongs, or tines. Tuning forks, made of steel, aluminum, or magnesium alloy, will vibrate at a set frequency to produce a musical tone when struck. The vibrations produced can be used to assess a person's ability to hear different sound frequencies.

Purpose

A vibrating tuning fork held next to the ear or placed against the **skull** will stimulate the inner ear to vibrate, and can help determine if there is **hearing loss**. The Rinne tuning fork test helps evaluate a patient's hearing ability by air conduction compared to that of bone conduction. The Weber tuning fork test helps determine a patient's hearing ability by bone conduction only, and is useful when hearing loss is asymmetrical.

Precautions

No special patient precautions are necessary when tuning forks are used to conduct hearing tests.

Description

Two types of hearing tests using tuning forks are typically conducted. In the Rinne test, the vibrating tuning fork is held against the skull, usually on the bone behind the ear (mastoid process) to cause vibrations through the bones of the skull and inner ear. It is also held next to, but not touching, the ear, to cause vibrations in

KEY TERMS

Asymmetrical—Unbalanced, disproportionate, or unequal.

Mastoid process—The protrusions of bone behind the ears at the base of the skull.

Rinne test—A hearing test using a vibrating tuning fork that is held near the ear and held at the back of the skull.

Weber test—A hearing test using a vibrating tuning fork that is held at various points along the midline of the skull and face.

the air next to the ear. The patient is asked to determine which sound is louder, the sound heard through the bone or through the air. For the Weber test, the stem or handle of the vibrating tuning fork is placed at various points along the midline of the skull and face. The patient is then asked to identify which ear hears the sound created by the vibrations. Tuning forks of different sizes produce different frequencies of vibrations and can be used to establish the range of hearing for an individual patient.

Preparation

No special patient preparation is required for either of these hearing tests.

Aftercare

No special patient aftercare is required following the hearing tests. If hearing loss is detected using either tuning-fork test, the patient may require further testing to determine the cause and extent of hearing loss.

Complications

There are no known complications associated with the use of tuning forks to screen for hearing loss.

Results

With the Rinne test, a patient with normal hearing will hear the tone of the vibration longer and louder when the tuning fork is held next to the ear, as opposed to when it is held against the mastoid bone. Conversely, the test detects a hearing loss when a patient hears a louder and longer tone when the vibrating tuning fork is held against the mastoid bone, than when it is held next to the ear. This result is often referred to as “reversed Rinne.”

For the Weber test, the patient is considered to have normal hearing if the tone produced when the tuning fork is placed along the center of the skull or face sounds about the same volume in each ear. The volume of sound vibrations conducted through parts of the skull and face during the Weber test can indicate which ear may have a hearing loss, if the patient hears louder sound vibrations in one ear compared to sounds picked up by the opposite ear.

If either method of testing reveals abnormal results, the patient will require further evaluation.

Health care team roles

Nurses should explain the procedure to patients and answer any questions.

Patient education

Patients should be instructed to listen carefully to directions for either test and be reassured that there are no **pain** or complications associated with either test.

Training

No special training is required.

Resources

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Susan Joanne Cadwallader

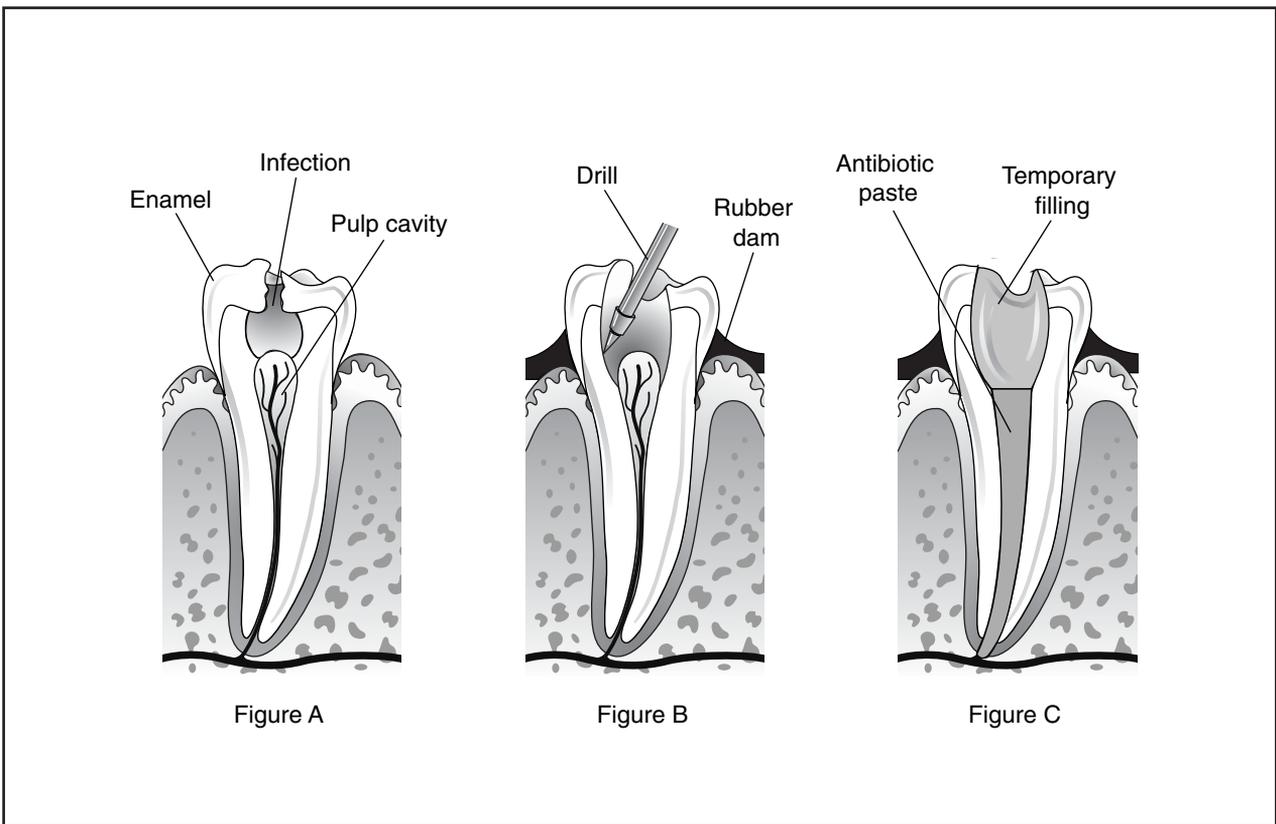
RK surgery *see* **Radial keratotomy**

RN *see* **Registered nurse**

Root canal therapy

Definition

Root canal therapy, also known as endodontic treatment, is a dental procedure in which the diseased or damaged pulp (nerve) of a tooth is removed and the inside



Root canal treatment is a dental procedure in which the diseased pulp of a tooth is removed and the inside areas are filled and sealed. In figure A, the infection can be seen above the pulp cavity. The dentist drills into the enamel and the pulp cavity is extracted (Figure B). Finally, the dentist fills the pulp cavity with antibiotic paste and a temporary filling (Figure C). (Illustration by Electronic Illustrators Group.)

areas of the nerve chambers or root canals are filled and sealed.

Purpose

Root canal therapy has become a common dental procedure. More than 14 million are performed each year, with a success rate of 95%, according to the American Association of Endodontists. Inflamed or infected pulp (pulpitis), often causing a toothache, is removed to relieve the **pain** and prevent further complications for the patient.

Precautions

Once root canal therapy is finished and the nerve is removed, the tooth becomes brittle over time and can fracture and break easily. Therefore the tooth requires extra protection and will need a crown.

Description

Root canal therapy may be performed by a general dentist or by an endodontist, a dentist who specializes in

endodontic procedures. The pulp of the tooth consists of soft tissue containing the **blood** supply from which the tooth gets its nutrients and by which the tooth senses hot and cold. This tissue is vulnerable to damage from deep dental decay, accidental injury, tooth fracture, or trauma from repeated dental procedures (such as multiple fillings over time). **Infection** may produce pain that is severe, constant, or throbbing, as well as prolonged sensitivity to heat or cold. Swelling in and around the surrounding gums along with facial swelling may be seen. However, in some cases, the pulp may die so gradually that there is little noticeable pain or swelling.

Root canal therapy is performed under **local anesthesia**. A thin sheet of rubber, called a rubber dam, is placed in the mouth to isolate the tooth. The endodontist makes an opening through the natural crown of the tooth into the pulp chamber. He will then determine the length of the root canal, usually with a series of x rays. Small wire-like files, called broaches, are used to clean the entire canal space of diseased pulp tissue and **bacteria**. The debris is flushed out (irrigated) with sterile water. The canals are also slightly enlarged and shaped to receive an inert (non-reactive) filling material called

KEY TERMS

Abscess—Gum tissue filled with pus as the result of infection. This swelling exerts pressure on the surrounding tissues, causing pain.

Apicoectomy—Also called root resectioning. The root tip of a tooth is accessed in the bone and a small amount is taken off away. A small filling is placed to reseal the canal.

Crown—The natural crown of a tooth is that part of the tooth covered by enamel. Also, a restorative crown is a protective shell that fits over a tooth.

Endodontic—Pertaining to the inside structures of the tooth, including the dental pulp and tooth root, and the periapical tissue surrounding the root.

Endodontist—A dentist who specializes in the diagnosis and treatment of disorders affecting the inside structures of the tooth.

Extraction—The surgical removal of a tooth from its socket in the bone.

Gutta-percha—An inert latex-like substance used for filling root canals.

Pulp—The soft innermost layer of a tooth, containing blood vessels and nerves.

Pulp chamber—The area within the natural crown of the tooth occupied by dental pulp.

Pulpitis—Inflammation of the pulp of a tooth involving the blood vessels and nerves.

Root canal—The space within a tooth that runs from the pulp chamber to the tip of the root.

Root canal treatment—The process of removing diseased or damaged pulp from a tooth, then filling and sealing the pulp chamber and root canals.

gutta-percha. However, the tooth is not filled and permanently sealed until it is completely free of the active infection and/or bacteria. The endodontist will place a temporary seal, or leave the tooth open to drain, and prescribe an antibiotic to counter any spread of infection from the tooth. The patient may need a number of return visits to the dental office while the root canal is being treated, and the infection brought under control.

Preparation

There is no typical preparation for root canal therapy, as the treatment is done on an emergency basis due to sudden injury or pain. The reasons why root canals are thought to be so painful are due to the sudden injury and build-up of infection in the tooth. Normal doses of local anesthetic used by the dentist are not always effective against the degree of pain the patient is already feeling. Occasionally, even high amounts of anesthesia aren't effective until the infection can be drained and brought under control.

Aftercare

The tooth may be sore for several days after filling. Such pain relievers as ibuprofen (Advil, Motrin) may be taken to ease the soreness. Ibuprofen is an effective anti-inflammatory drug and can help reduce the inflammation caused by the infection. The tissues surrounding the tooth may also be irritated due to the infection, but also due to the rubber dam used to isolate the tooth during the root canal treatment. Rinsing the mouth with warm salt-water

rinses several times a day is helpful. The patient should avoid chewing on the treated tooth for several days. A follow-up appointment should be scheduled with the dentist for six months after treatment to make sure the tooth and surrounding structures are healthy.

Risks

There is the possibility that the root canal treatment will not be successful the first time. If infection and inflammation recur and an x ray indicates re-treatment is feasible, the old filling material is removed and the canals are thoroughly cleaned out. The dentist will try to identify and correct problems with the first root canal treatment before filling and sealing the tooth a second time.

In cases in which an x ray indicates that re-treatment cannot correct the problem, endodontic surgery may be performed. An apicoectomy, or root resectioning, is the procedure by which the root portion of the tooth is accessed through the gum tissue above or below the tooth in the bone. A small portion of the root tip is taken off and a small filling is placed to reseal the canal.

In some cases, root canal treatment, re-treatment, and apicoectomy surgery are not effective and the tooth must be extracted.

Results

With successful root canal treatment, the restored tooth can last a lifetime.

Resources**PERIODICALS**

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ORGANIZATIONS

American Association of Endodontists. 211 East Chicago Avenue, Suite 1100, Chicago, IL 60611-2691. (800) 872-3636. <<http://www.aae.org>>.

American Dental Association. 211 East Chicago Avenue, Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org>>.

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Root Canal—Saving Precious Teeth (television clip). ADA Dental Minutes, August 17, 2000.

Cindy F. Ovard, RDA

Root planing see **Nonsurgical periodontal therapy**

Routine urinalysis see **Urinalysis**

Rubella test see **TORCH test**

Ruptured disk see **Herniated disk**

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Salivary gland scan

Definition

A salivary gland scan is a nuclear medicine test that establishes the function of the salivary glands. The salivary glands include the parotid glands and submandibular glands, which are located on both sides of the neck below the ears and jaw. Salivary gland function is determined by the pattern of uptake and secretion of a radioactive tracer, usually Tc99m (Technium 99). The scan also demonstrates the relative size and shape of the salivary glands.

Purpose

A salivary gland scan is indicated when a patient has recurring salivary gland swelling due to either **infection**, inflammation, or obstruction. Salivary gland scans can detect salivary gland tumors, and can help evaluate the glands of patients with persistent dry mouth.

Precautions

Salivary gland scans are a safe, effective way to diagnose salivary gland pathology. The level of radioactivity used to obtain the images is low, however, pregnant patients are cautioned not to have this test unless necessary. Women who are breastfeeding are advised to stop breastfeeding for a specific period of time, depending on the dose administered. Other recent nuclear medicine tests may affect the results of this scan, and it may be necessary to wait until previously administered radiopharmaceuticals have been cleared from the body before undergoing this test.

Description

A salivary gland scan, also called a parotid gland scan, is a non-invasive test. It is typically performed in a hospital radiology or nuclear medicine department or

out-patient radiology facility. The patient is injected with a low-level radioactive marker and is positioned in front of or under a gamma scintillation camera, which detects the radiation and produces an image. In some facilities, imaging begins immediately after the injection to observe the progressive accumulation of the radioactive tracer in the glands. If indicated, an additional procedure can be done after the initial images are obtained. The patient is given a sour substance, known as a sialogogue, such as a lemon drop or some lemon juice, to stimulate the emptying of the salivary glands. Another set of images is then made for comparison purposes. The entire process takes about 30 to 45 minutes.

Preparation

No special preparations are needed for this test. It is not necessary to fast or to restrict medications before testing. Any **blood** to be drawn for other tests may need to be taken before the radiopharmaceutical is injected. Patients must remove any metal objects from the face and neck and may be asked to remove dentures.

Images of the **thyroid gland** is typically included when imaging the salivary glands. Therefore, it should be noted if the patient is taking any medication that inhibits the uptake of the radiopharmaceutical in the thyroid gland.

Aftercare

Patients can return to normal activities immediately.

Complications

A salivary gland scan is a safe test, and there are generally no complications associated with it.

Results

A normal study reflects a normal position, size, and shape of the salivary glands, and will also demonstrate proper emptying of the glands after the oral administra-

KEY TERMS

Radiopharmaceutical—A radioactive chemical used for diagnostic or therapeutic purposes.

Sjogren’s syndrome—A disease, often associated with rheumatoid arthritis or lupus, that causes dry mouth, dry eyes, and swollen salivary glands.

Warthin’s tumor—A benign tumor of the parotid gland.

tion of the sialogogue. Abnormally functioning salivary glands, due to conditions such as Sjögren’s syndrome, fail to exhibit a normal uptake and secretion pattern. Some tumors, such as a Warthin’s tumor, prevent the emptying of the salivary gland and are seen as areas of increased concentration of radionuclide. Metastatic lesions, cysts, and abscesses are seen as areas of decreased concentration of radionuclide. This test does not differentiate between benign and malignant lesions. This requires other diagnostic imaging tests such as CT, MRI, or ultrasound.

Health care team roles

The radionuclide is administered by a nuclear medicine technologist, who is specially trained to handle radioactive materials and operate the equipment in a nuclear medicine department. The technologist may obtain pertinent patient medical history and describe the testing procedure to the patient. All data collected is interpreted by a radiologist or nuclear medicine specialist. Results of the test are sent to the referring physician.

Resources

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Christine Miner Minderovic, B.S., R.T., R.D.M.S.

Salmonella food poisoning see **Food poisoning**

Sarcomas

Definition

A sarcoma is a malignant tumor (neoplasm), or **cancer**. Certain sarcomas characteristically spread throughout the body. The word “sarcoma” has its etiology in a Greek word whose definition is “fleshy.” Tumors come from the mesenchymal tissue, from which connective tissues, **blood**, lymphatics, bone, and cartilage come. The blood carries sarcomas throughout the body into neighboring tissue, or via the bloodstream. Frequent sites of extension of the tumors are the lung, the **liver**, and the **brain**.

Description

When the original site of the cancer is the bone, there is a primary bone cancer. The tumor originates in or near a bone. Most primary bone tumors are benign, and the cells that compose them do not metastasize (spread) to nearby tissue or to other parts of the body.

Sarcomas account for fewer than 1% of all cancers diagnosed in the United States. They can infiltrate nearby tissues, enter the bloodstream, and metastasize to other bones, tissues, and organs far from the site of the original malignancy. Malignant primary bone tumors are characterized as either:

- cancers that originate in the hard material of the bone
- soft-tissue sarcomas that begin in **blood vessels**, nerves, or tissues containing muscles, fat, or fiber

Types of bone tumors

Osteogenic sarcoma, or osteosarcoma, is the most common form of primary bone cancer, accounting for about 5% of all cancers in children. Every year, 900 new cases of osteosarcoma are diagnosed in the United States. The disease usually affects teenagers and young adults, and is almost twice as common in males as in females.

Osteosarcomas grow very rapidly. Although they can develop in any bone, but they are most often seen along the edge or on the end of one of the fast-growing long bones that support the arms and legs. Approximately 80% of all osteosarcomas develop in the distal femur or in the proximal tibia (parts of the upper and lower leg nearest the knee). The next likely location for an osteosarcoma is the proximal humerus (the bone of the upper arm closest to the shoulder).

Ewing’s sarcoma is the second most common form of childhood bone cancer. Accounting for less than 5% of bone tumors in children, Ewing’s sarcoma usually begins in the soft tissue or nerves. It rapidly metastasizes to the

lungs, and may metastasize to bones in other parts of the body.

Ewing's sarcoma occurs most frequently in children aged 11–15. It is more often diagnosed in taller teens. Slightly more males than females develop common bone cancer—but this type is the most frequently found carcinoma in children. The disease is rarely diagnosed in children younger than five and adults older than 30. It primarily affects Caucasians, and rarely occurs in African Americans and native Chinese persons.

Chondrosarcomas are cancerous bone tumors that most often appear in middle age. Usually originating in cartilage in ribs, leg, or hip bones, chondrosarcomas grow slowly. They rarely metastasize to the lungs. It takes years for a chondrosarcoma to metastasize to other parts of the body, and some of these tumors never spread.

Parosteal osteogenic sarcomas, fibrosarcomas, and chordomas are rare. Parosteal osteosarcomas generally involve both the bone and the periosteum, the membrane that covers bones. Fibrosarcomas originate in the ends of the bones in the arm or leg, and then spread to soft tissue. Chordomas develop on the **skull** or **spinal cord**.

Osteochondromas, which usually develop between persons aged 10–20 years, are the most common non-cancerous primary bone tumors. Giant cell tumors generally develop in a section of the femur near the knee. Giant cell tumors are originally benign, but sometimes become malignant.

Causes and symptoms

The cause of bone cancer is unknown, but the tendency to develop it may be inherited. Children who develop bone tumors are often tall for their age, and the disease seems to be associated with growth spurts during childhood and adolescence. Injuries can make the presence of tumors more apparent, but do not cause them.

A bone that has been broken or exposed to high doses of radiation that has been used to treat other cancers is more likely than other bones to develop osteosarcoma. It should be noted, however, that the amount of radiation in diagnostic x rays poses little or no danger of bone cancer development. A history of noncancerous bone disease also increases bone cancer risk.

Cancer of the eye (retinoblastoma) is a rare tumor of the eye that develops in the cells of the retina, and occurs mostly in patients under five years of age. It is known to be hereditary—the condition is an autosomal-dominant trait.

Both benign and malignant bone tumors can distort and weaken bone, causing **pain**, but benign tumors are generally painless and asymptomatic.

Patients may feel a lump or mass, but pain in the affected area is the most common early symptom of bone cancer. Pain is not constant in the initial stages of the disease; it is aggravated by activity and may be worst at night. If the tumor is located on a leg bone, the patient may limp. Swelling and weakness of the limb may not be noticed until weeks after the pain began.

Other symptoms of bone cancer include:

- a bone that breaks with minimal trauma, also known as a pathologic fracture
- difficulty moving the affected part of the body
- fatigue
- fever
- a lump or swelling on the trunk, an arm or leg, or another bone
- persistent, unexplained back pain
- weight loss

Diagnosis

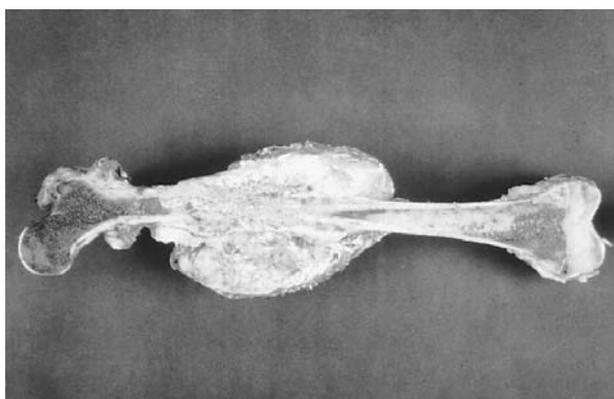
Physical examination and routine x rays may provide enough evidence to diagnose benign bone tumors, but biopsy (removal of tumor tissue for microscopic analysis) is the only definitive way to determine the nature of the tumor.

A needle biopsy involves using a fine, thin needle to remove small bits of tumor, or a thick needle to extract tissue samples from the innermost part (the core) of the growth. An excisional biopsy is the surgical removal of a small, accessible tumor and a margin of surrounding normal tissue. An incisional biopsy is performed on tumors too large or inaccessible to be completely removed. A portion of the tumor is removed by the surgeon performing an incisional biopsy. Performed under local or **general anesthesia**, biopsy reveals whether a tumor is benign or malignant, and ideally identifies the type of cancer cells the malignant tumor contains.

Primary bone cancer is usually diagnosed about three months after symptoms first appear. Twenty percent of these malignant tumors will have already metastasized to the lungs or to other parts of the body.

Imaging techniques

The following procedures are used, in conjunction with biopsy, to diagnose bone cancer:



A specimen of a femur bone indicating the cancerous growth around the knee. Osteosarcoma is the most common primary cancer of the bone. (Photo Researchers, Inc. Reproduced by permission.)

- Plain x rays. These x rays usually provide a clear image of osteosarcomas.
- The computerized tomography (CAT) scan, or computed tomographic scanning (CT), is a specialized x ray that uses a rotating beam to obtain detailed information about an abnormality and its physical relationship to other parts of the body.
- A CAT scan can show differentiation between osteosarcomas and other types of bone tumors, reveal if tumor cells have spread to other tissues, and help surgeons decide which portion of a growth is best to biopsy. Since malignant bone tumors frequently metastasize to the lungs, a CAT scan of the chest should also be performed. The CAT scan can provide information about other organs that may have been affected. Chest and abdominal CAT scans are used to determine whether Ewing's sarcoma has spread to the lungs, liver, or lymph nodes.
- Magnetic resonance imaging (MRI) is a specialized scan that relies on radio waves and powerful magnets to reflect energy patterns created by tissue abnormalities and specific diseases. MRI provides more detailed information than a CAT scan about tumors and marrow cavities of the bone, and can sometimes detect clusters of cancerous cells that have separated from the original tumor. This valuable information helps physicians select the best approach for treatment.
- Radionuclide bone scans involve the injection of a small amount of radioactive material into a vein. Primary tumors, or cells that have metastasized, absorb the radioactive material and present as dark spots on the scan.

Cytogenic and molecular genetic studies, which assess the structure and composition of chromosomes

and genes, may also be used to diagnose osteosarcoma. These tests sometimes help to determine the most appropriate form of treatment.

Laboratory studies

A **complete blood count** (CBC) reveals abnormalities in the blood, and may indicate whether bone marrow has been affected. A blood test that measures levels of the enzyme lactate dehydrogenase (LDH), can be used determine the prognosis for the survival of a given patient.

Immunohistochemistry involves adding special antibodies and chemicals, or stains, to tumor samples. This technique effectively helps the pathologist to identify cells that are found in Ewing's sarcoma, but that are not present in other malignant tumors.

Reverse transcription polymerase chain reaction (RT-PCR) relies on chemical analysis of RNA (the substance in the body that transmits genetic information) to:

- Evaluate the effectiveness of cancer therapies.
- Identify mutations consistent with the presence of Ewing's sarcoma.
- Reveal cancer that recurs after treatment has been completed.

Staging

Once bone cancer has been diagnosed, the tumor is staged. This process indicates how far the tumor has spread from its original location. The stage of a tumor helps the oncologist decide which form of treatment is indicated, and to predict how the condition will probably respond to therapy.

An osteosarcoma may be localized or metastatic. A localized osteosarcoma has not spread beyond the bone where it, originated, or beyond nearby muscles, tendons, and other tissues. Metastatic osteosarcoma has spread to the lungs, to bones not directly connected to the bone, or to other tissues or organs.

Treatment

Since the 1960s, when amputation was the only treatment for bone cancer, **chemotherapy** and innovative surgical techniques have improved survival with intact limbs. Because osteosarcoma is rare, treatment is most often sought at a cancer center staffed by specialists familiar with the disease. A treatment plan for bone cancer, which is devised after the tumor has been diagnosed and staged, may include:

- Radiation therapy. Radiation therapy is used often to treat Ewing's sarcoma.

- **Surgery.** Surgery, coordinated with diagnostic biopsy, enhances the probability that limb-salvage surgery can be used to remove the cancer, while preserving nearby blood vessels and bones. A metal rod or bone graft is used to replace the area of bone removed. Subsequent surgery may be needed to repair or replace rods that have become loose or broken. Patients who have undergone limb salvage surgery require intensive rehabilitation. It may take as long as one year for a patient to regain full use of a leg following limb salvage surgery. Some patients who undergo this procedure eventually require amputation.
- **Chemotherapy.** In addition to surgery, chemotherapy is usually administered to kill cancer cells that have separated from the original tumor and spread to other parts of the body. Although chemotherapy can increase the likelihood of future development of another form of cancer, the American Cancer Society maintains that the benefit of chemotherapeutic bone cancer treatment is much greater than its potential risk.
- **Amputation.** Amputation may be the only therapeutic option for large tumors involving nerves or blood vessels that have not responded to chemotherapy. MRI scans demonstrate the extent of disease in the limb, providing information about how much of it must be removed. The treatment, surgery, is designed to create a cuff (formed of muscles and skin) around the amputated bone. Following surgery, a prosthetic (artificial) leg is fitted over the cuff. Patients who actively participate in the rehabilitation may be walking independently as soon as three months after the amputation.
- **Rotationoplasty.** Rotationoplasty, sometimes performed after a leg amputation, involves attaching the lower leg and foot to the femur, so that the ankle replaces the knee. A prosthetic is later added to make the leg as long as it is normally. Prosthetic devices are not used to lengthen limbs that remain functional after amputation to remove osteosarcomas located on the upper arm. When an osteosarcoma develops in the jaw bone, the entire lower jaw is removed. Bones from other parts of the body are later grafted onto remaining bone to create a new jaw.

Follow-up treatments

After a patient completes the final course of chemotherapy, a number of tests—CAT or **CT scans**, bone scans, x rays, and other diagnostic tests—may be repeated to determine if any traces of tumor remain. If none are found, treatment is discontinued, but patients are advised to see their oncologists and orthopedic surgeons every two or three months for the subsequent year.

X rays of the chest and affected bone are taken every four months. An annual echocardiogram is recommended to determine whether there have been any adverse cardiovascular effects of chemotherapy, and CT scans are performed every six months.

Patients who have received treatment for Ewing's sarcoma are examined regularly—at gradually lengthening intervals—after completing therapy. Accurate growth measurements are taken at each visit and blood is drawn to test for side effects of treatment. X rays, CAT or CT scans, bone scans, and/or other imaging studies are generally performed every three months during the first year. If no evidence of tumor growth or recurrence is revealed, these tests are performed less frequently in the following years.

Some benign bone tumors shrink or disappear without treatment. However, regular examinations are recommended to determine whether these tumors have changed in any way.

Alternative treatment

Alternative treatments should never be substituted for conventional anticancer treatments or used without the approval of a physician. Some alternative treatments may be used as adjunctive and supportive therapies during and following conventional treatments.

Many patients find that alternative and complementary therapies help to reduce the **stress** associated with illness, improve immune function and feel better. While there is no evidence that these therapies specifically combat disease, activities such as biofeedback, **relaxation**, **therapeutic touch**, **massage therapy**, and guided imagery have been reported to enhance well-being.

Some cancer patients find that acupuncture alleviates pain, nausea, and vomiting. It may also be effective in helping to maintain energy and relative wellness during surgery, chemotherapy, and radiation. Massage, reflexology, and relaxation techniques are reported to relieve pain, tension, **anxiety**, and depression.

Claims of effectiveness in fighting cancer have been made for a variety of herbal medicines. These botanical remedies should only be used when prescribed by a practitioner familiar with cancer treatment.

Prognosis

Benign bone tumors rarely recur, but sarcomas can reappear, even after treatment considered effective in eliminating all the cancerous cells.

Likelihood of long-term survival depends on:

- the type and location of the tumor

KEY TERMS

Biofeedback—The technique of making unconscious or involuntary bodily processes (as heart-beat or brain waves) perceptible to the senses in order to manipulate them by conscious mental control.

CAT scan (CT scan)—Computerized axial tomography, or computed tomography, tomographic scanning; a specialized x ray that uses a rotating beam to obtain detailed information about an abnormality and its physical relationship to other parts of the body.

Chondrosarcoma—A malignant tumor derived from cartilage cells or their precursors.

Chordoma—Malignant tumor composed of remnants of the embryonic notochord—a flexible rod of cells that in the embryos of higher vertebrates forms the supporting axis of the body—and is found along the spine, attacking especially the bones at the base of the skull, or near the coccyx.

Echocardiogram (ECHO)—The use of beeps of ultrasonic waves directed through the chest wall to record the position and motion of the heart walls or internal structures of the heart.

Ewing's sarcoma—A tumor that invades the shaft of a long bone and that tends to recur, but metastasizes infrequently.

Fibrosarcoma—A sarcoma of relatively low malignancy, consisting mostly of spindle-shaped cells that generally form collagenous fibers of connective tissue.

Magnetic resonance imaging (MRI)—A specialized scan that uses radio waves and powerful magnets to reflect energy created by abnormal tissue and specific diseases.

Metastasis—Transfer of disease from one organ of the body to another not directly connected with it, as a result of transfer of pathogenic microorganisms or to transfer of cells.

- how much the tumor has metastasized, and the organs, bones, or tissues affected

More than 85% of patients survive for more than five years after complete surgical removal of low-grade osteosarcomas (tumors that arise in mature tissue and contain a small number of cancerous cells). About 25–30% of patients diagnosed with high-grade osteosar-

comas (tumors that develop in immature tissue and contain a large number of cancer cells) will die of the disease.

Two-thirds of all children diagnosed with Ewing's sarcoma live for more than five years after the disease is detected. The outlook is most favorable for children under age 10, and least favorable in patients whose cancer is not diagnosed until after it has metastasized: fewer than three of every 10 of these patients remain alive five years later. More than 80% of patients whose Ewing's sarcoma is confined to a small area, and surgically removed live for at least five years. Postsurgical radiation and chemotherapy add years to their lives. More than 70% of patients live five years or more with a small Ewing's sarcoma that cannot be removed, but only three out of five patients with large, unremovable tumors survive that long. Patients with tumors that do not respond to treatment and those who suffer recurrences have poor outlooks for long-term survival.

Health care team roles

Like other cancer patients, patients with sarcoma are usually cared for by a multidisciplinary team of health professionals. The patient's family physician or primary care provider collaborates with other physician specialists, such as surgeons and oncologists. Radiologic technicians perform x ray, CT, and MRI scans; nurses and laboratory technicians may obtain samples of blood, urine and other laboratory tests.

Before and after any surgical procedures, including biopsies, the procedures may be explained by nurses or physicians, who are also called upon to help prepare patients and families. Depending on the tumor location and treatment plan, patients may also benefit from rehabilitation therapy with physical therapists, nutritional counseling from dietitians, and counseling from social workers or other mental health professionals.

Prevention

Since the causes of most sarcomas are not known, there are no formal recommendations about how to prevent their development. Among families with an inherited tendency to develop soft tissue sarcomas, careful monitoring may help to ensure early diagnosis and treatment of the disease.

In 1999 and 2000, there were a number of studies that reported both genetic and biologic factors in sarcomas. The reports generated by these studies provide evidence that more and more sarcomas possess the same

chromosome abnormalities. The reports also point to the high complexity of these genetic changes; which further complicate identifying any single abnormality associated with sarcomas. Despite their limitations, continuing studies can yield new, therapeutic treatment modalities. These approaches will be experimental, yet they will facilitate advancement in this arena toward even better disease management.

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<<http://www.cancer.org/main.html>>.

Cancer Care, Inc. 1180 Avenue of the Americas, New York, NY 10036. (800) 813-HOPE.
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National Institutes of Health. National Cancer Institute. 9000 Rockville Pike, Bethesda, MD 20892. (800) 4-CANCER.
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Barbara Wexler

Scaling see **Nonsurgical periodontal therapy**

Schizophrenia

Definition

Schizophrenia is a psychotic disorder (or a group of disorders) marked by severely impaired thinking, emotions, and behaviors. Schizophrenic persons are typically unable to filter sensory stimuli and may have enhanced perceptions of sounds, colors, and other features of their environment. Most schizophrenics, if untreated, gradually withdraw from interactions with other people, and lose their ability to take care of personal needs and grooming.

Description

The course of schizophrenia in adults can be divided into three phases or stages. In the acute phase, a person has an overt loss of contact with reality (psychotic episode) that requires intervention and treatment. In the second or stabilization phase, the initial psychotic symptoms have been brought under control but the person is at risk for relapse if treatment is interrupted. In the third or maintenance phase, an individual is relatively stable and can be kept indefinitely on antipsychotic medications. Even in the maintenance phase, however, relapses are not unusual and people do not always return to full functioning.

The term schizophrenia comes from two Greek words that mean split mind. It was first used by a Swiss doctor named Eugen Bleuler in 1908 to describe the splitting apart of mental functions that he regarded as the central characteristic of schizophrenia.

Recently, some psychotherapists have begun to use a classification of schizophrenia based on two main types. People with Type I, or positive schizophrenia, have a rapid (acute) onset of symptoms and tend to respond well to drugs. They also tend to suffer more from so-called positive symptoms, such as delusions and hallucinations. People with Type II, or negative schizophrenia, are usually described as poorly adjusted before their schizophrenia slowly overtakes them. They have predominantly negative symptoms, such as withdrawal from others and a slowing of mental and physical reactions (psychomotor retardation).

The fourth (1994) edition of the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* specifies five subtypes of schizophrenia.

PARANOID. The key feature of this subtype of schizophrenia is the combination of false beliefs (delusions) and hearing voices (auditory hallucinations), with more nearly normal emotions and cognitive functioning (cognitive functions include reasoning, judgment, and mem-

ory). The delusions of paranoid schizophrenics usually involve thoughts of being persecuted or harmed by others or exaggerated opinions of their own importance, but may also reflect feelings of jealousy or excessive religiosity. The delusions are typically organized into a coherent framework. Paranoid schizophrenics function at a higher level than other subtypes, but are at risk for suicidal or violent behavior under the influence of their delusions.

DISORGANIZED. Disorganized schizophrenia (formerly called hebephrenic schizophrenia) is marked by disorganized speech, thinking, and behavior by an affected person, coupled with flat or inappropriate emotional responses to a situation (affect). An individual may act silly or withdraw socially to an extreme extent. Most people in this category have weak personality structures prior to their initial acute psychotic episode.

CATATONIC. Catatonic schizophrenia is characterized by disturbances of movement that may include rigidity, stupor, agitation, bizarre posturing, and repetitive imitations of the movements or speech of other people. These people are at risk for malnutrition, exhaustion, or self-injury. This subtype is presently uncommon in Europe and the United States. Catatonia as a symptom is most commonly associated with mood disorders.

UNDIFFERENTIATED. Persons in this category have the characteristic positive and negative symptoms of schizophrenia but do not meet the specific criteria for the paranoid, disorganized, or catatonic subtypes.

RESIDUAL. This category is used for persons who have had at least one acute schizophrenic episode but do not presently have strong positive psychotic symptoms, such as delusions and hallucinations. They may have negative symptoms, such as withdrawal from others, or mild forms of positive symptoms, which indicate that the disorder has not completely resolved.

Genetic profile

The risk of schizophrenia among first-degree biological relatives is 10 times greater than that observed in the general population. Furthermore the presence of the same disorder is higher in monozygotic (identical) twins than in dizygotic (non-identical) twins. Research concerning adoption studies and identical twins also supports the notion that environmental factors are important, because not all relatives have the disorder or express it. There are several chromosomes and loci (specific areas on chromosomes that contain mutated genes) that have been identified. Research is ongoing to elucidate the causes, types and variations of these mutations.

Demographics

A number of studies indicate that about 1% of the world's population is affected by schizophrenia, without regard to race, social class, level of education, or cultural influences. The outcome may vary from culture to culture, depending on the familial support of an affected person. Most people are diagnosed in their late teens or early twenties, but the symptoms of schizophrenia can emerge at any age in the life cycle. The male to female ratio in adults is about 1.2:1. Males typically have their first acute episode in their early twenties, while females are usually closer to age 30 when they are recognized with active symptoms.

Schizophrenia is rarely diagnosed in preadolescent children, although individuals as young as five or six have been reported. Childhood schizophrenia is at the upper end of the spectrum of severity and shows a greater gender disparity. It affects one or two children in every 10,000; the male to female ratio is 2:1.

Causes and symptoms

Theories of causality

One of the reasons for the ongoing difficulty in classifying schizophrenic disorders is incomplete understanding of their causes. As of 2001, it is thought that these disorders are the end result of a combination of genetic, neurobiological, and environmental causes. A leading neurobiological hypothesis emphasizes the connection between the disease and excessive levels of dopamine, a chemical that transmits signals in the **brain** (neurotransmitter). The genetic factor in schizophrenia has been underscored by recent findings that first-degree biological relatives of schizophrenics are 10 times more likely to develop the disorder than are members of the general population.

Prior to recent findings of abnormalities in the brain structure of schizophrenic persons, several generations of psychotherapists advanced a number of psychoanalytic and sociological theories about the origins of schizophrenia. These theories ranged from hypotheses about a person's problems with **anxiety** or aggression to theories about **stress** reactions or interactions with disturbed parents. Psychosocial factors are now thought to influence the expression or severity of schizophrenia, rather than directly cause it.

Another hypothesis suggests that schizophrenia may be caused by a virus that attacks the hippocampus, a part of the brain that processes sense perceptions. Damage to the hippocampus would account for a schizophrenic person's vulnerability to sensory overload. As of mid-2001,

researchers are testing antiviral medications on schizophrenics.

Symptoms of schizophrenia

People with a possible diagnosis of schizophrenia are evaluated on the basis of a set or constellation of symptoms. There is no single symptom that is unique to schizophrenia. In 1959, the German psychiatrist Kurt Schneider proposed a list of so-called first-rank symptoms, which he regarded as diagnostic of the disorder.

These symptoms include:

- delusions
- somatic hallucinations
- hallucinations
- hearing voices commenting on a person's behavior
- thought insertion or thought withdrawal

Somatic hallucinations refer to sensations or perceptions concerning body organs that have no known medical cause or reason, such as the notion that one's brain is radioactive. Thought insertion and/or withdrawal refer to delusions that an outside force (for example, the FBI, the CIA, Martians, etc.) has the power to put thoughts into one's mind or remove them.

POSITIVE SYMPTOMS. The positive symptoms of schizophrenia are those that represent an excessive or distorted version of normal functions. Positive symptoms include Schneider's first-rank symptoms as well as disorganized thought processes (reflected mainly in speech) and disorganized or catatonic behavior. Disorganized thought processes are marked by such characteristics as looseness of association, in which a person rambles from topic to topic in a disconnected way; tangentiality, which means that an individual gives unrelated answers to questions; and flights of ideas or "word salad," in which a person's speech is so incoherent that it makes no grammatical or linguistic sense. Disorganized behavior means that a person has difficulty with any type of purposeful or goal-oriented behavior, including personal self-care or preparing meals. Other forms of disorganized behavior may include dressing in odd or inappropriate ways, sexual self-stimulation in public, or agitated shouting or cursing.

NEGATIVE SYMPTOMS. The *DSM-IV* definition of schizophrenia includes three so-called negative symptoms. They are called negative because they represent the lack or absence of behaviors. The negative symptoms that are considered diagnostic of schizophrenia are a lack of emotional response (affective flattening), poverty of speech, and absence of volition or will. In general, the

negative symptoms are more difficult for doctors to evaluate than the positive symptoms.

Diagnosis

A doctor must make a diagnosis of schizophrenia on the basis of a standardized list of outwardly observable symptoms, not on the basis of internal psychological processes. There are no specific laboratory tests that can be used to diagnose schizophrenia. Researchers have, however, discovered that persons with schizophrenia have certain abnormalities in the structure and functioning of the brain compared to normal test subjects. These discoveries have been made with the help of imaging techniques such as computed tomography scans (**CT scans**).

When a psychiatrist assesses an individual for schizophrenia, the doctor will begin by excluding physical conditions that can cause abnormal thinking and some other behaviors associated with schizophrenia. These conditions include organic brain disorders (including traumatic injuries of the brain), temporal lobe epilepsy, Wilson's disease, Huntington's chorea, and encephalitis. The doctor will also need to rule out substance abuse disorders, especially amphetamine use.

After ruling out organic disorders, a clinician will consider other psychiatric conditions that may include psychotic symptoms or symptoms resembling psychosis. These disorders include mood disorders with psychotic features; delusional disorder; dissociative disorder not otherwise specified (DDNOS) or multiple personality disorder; schizotypal, schizoid, or paranoid **personality disorders**; and atypical reactive disorders. In the past, many individuals were incorrectly diagnosed as being schizophrenic. Some people who were diagnosed prior to the changes in categorization introduced by *DSM-IV* should have their diagnoses, and treatment, reevaluated. In children, a doctor must distinguish between psychotic symptoms and a vivid fantasy life, and also identify learning problems or disorders. After other conditions have been ruled out, a person must meet a set of criteria specified by *DSM-IV*:

- **Characteristic symptoms.** To make a diagnosis of schizophrenia, a person must exhibit two (or more) of the following symptoms during a one-month period: delusions; hallucinations; disorganized speech; disorganized or catatonic behavior; negative symptoms.
- **Decline in social, interpersonal, or occupational functioning,** including self-care.
- **Duration.** The disturbed behavior must last for at least six months.

- Diagnostic exclusions. Mood disorders, substance abuse disorders, medical conditions, and developmental disorders have been ruled out.

Treatment

The treatment of schizophrenia depends in part on an individual's stage or phase. People in the acute phase are hospitalized in most cases, to prevent harm to themselves or to others and to begin treatment with antipsychotic medications. A person having a first psychotic episode should be given a CT (computed tomography) or MRI (**magnetic resonance imaging**) scan to rule out structural brain abnormalities or disease.

Antipsychotic medications

The primary form of treatment of schizophrenia is antipsychotic medication. **Antipsychotic drugs** help to control almost all the positive symptoms of the disorder. They have minimal effect on disorganized behavior and negative symptoms. Between 60–70% of schizophrenics will respond to antipsychotics. In the acute phase of the illness, people are usually given medications by mouth or by **intramuscular injection**. After an affected person has been stabilized, the antipsychotic drug may be given in a long-acting form called a depot dose. Depot medications last for two to four weeks and have the advantage of protecting a person against the consequences of forgetting or skipping daily doses. In addition, some people who do not respond to oral neuroleptic medications have better results with depot form. Persons whose long-term treatment includes depot medications are introduced to the depot form gradually during their stabilization period. Most people with schizophrenia are kept on antipsychotic medications indefinitely during the maintenance phase of their disorder to minimize the possibility of relapse.

As of 2001, the most frequently used antipsychotics fall into two classes: the older dopamine receptor antagonists, or DAs, and the newer serotonin dopamine antagonists, or SDAs. Antagonists block the action of some other substance. For example, dopamine antagonists counteract the action of dopamine. The exact mechanisms of action of these medications are not known, but it is thought that they lower a person's sensitivity to sensory stimuli and so indirectly improve the person's ability to interact with others.

DOPAMINE RECEPTOR ANTAGONIST. The dopamine antagonists include the older antipsychotic (also called neuroleptic) drugs, such as haloperidol (Haldol), chlorpromazine (Thorazine), and fluphenazine (Prolixin). These drugs have two major drawbacks. It is often difficult to find the best dosage level for a given individual, and a dosage level high enough to control psychotic

symptoms frequently produces extrapyramidal side effects, or EPS. EPSs include parkinsonism, in which a person cannot walk normally and usually develops a tremor; dystonia, or painful muscle spasms of the head, tongue, or neck; and akathisia, or restlessness. A type of long-term EPS is called tardive dyskinesia, which features slow, rhythmic, automatic movements. Schizophrenics with **AIDS** are especially vulnerable to developing EPS.

SERATONIN DOPAMINE ANTAGONISTS. The serotonin dopamine antagonists, also called atypical antipsychotics, are newer medications that include clozapine (Clozaril), risperidone (Risperdal), and olanzapine (Zyprexa). The SDAs have a better effect on the negative symptoms of schizophrenia than do the older drugs and are less likely to produce EPS than the older compounds. The newer drugs are significantly more expensive in the short term, although the SDAs may reduce long-term costs by reducing the need for hospitalization. They are also presently unavailable in injectable forms. The SDAs are commonly used to treat persons who respond poorly to the DAs. However, many psychotherapists now regard the use of these atypical antipsychotics as the treatment of first choice.

Psychotherapy

Most schizophrenics can benefit from **psychotherapy** once their acute symptoms have been brought under control by antipsychotic medication. Psychoanalytic approaches are not recommended. Behavior therapy, however, is often helpful in assisting people to acquire skills for daily living and social interaction. It can be combined with **occupational therapy** to prepare individuals for eventual employment.

Family therapy

Family therapy is often recommended for the families of schizophrenic patients, to relieve the feelings of guilt that they often have as well as to help them understand a schizophrenic's disorder. The family's attitude and behaviors toward the schizophrenic are key factors in minimizing relapses (for example, by reducing stress in an individual's life), and family therapy can often strengthen the family's ability to cope with the stresses caused by the schizophrenic's illness. Family therapy that focuses on communication skills and problem-solving strategies is particularly helpful. In addition to formal treatment, many families benefit from support groups and similar mutual help organizations for relatives of schizophrenics.

KEY TERMS

Affective flattening—A loss or lack of emotional expressiveness. It is sometimes called blunted or restricted affect.

Akathisia—Agitated or restless movement, usually affecting the legs and accompanied by a sense of discomfort. It is a common side effect of neuroleptic medications.

Catatonic behavior—Behavior characterized by muscular tightness or rigidity and lack of response to the environment. In some persons, rigidity alternates with excited or hyperactive behavior.

Delusion—A fixed, false belief that is resistant to reason or factual disproof.

Depot dosage—A form of medication that can be stored in a person's body tissues for several days or weeks, thus minimizing the risk of forgetting daily doses. Haloperidol and fluphenazine can be given in depot form.

Dopamine receptor antagonists (DAs)—The older class of antipsychotic medications, also called neuroleptics. These primarily block the site on nerve cells that normally receives the brain chemical dopamine.

Dystonia—Painful involuntary muscle cramps or spasms. Dystonia is one of the extrapyramidal side effects associated with some antipsychotic medications.

Extrapyramidal symptoms (EPS)—A group of side effects associated with antipsychotic medications. EPS include parkinsonism, akathisia, dystonia, and tardive dyskinesia.

First-rank symptoms—A set of symptoms designated by Kurt Schneider in 1959 as the most important diagnostic indicators of schizophrenia. These symptoms include delusions, hallucinations, thought insertion or removal, and thought broadcasting. First-rank symptoms are sometimes referred to as Schneiderian symptoms.

Hallucination—A sensory experience of something that does not exist outside the mind. A person can experience a hallucination in any of the five senses. Auditory hallucinations are a common symptom of schizophrenia.

Huntington's chorea—A hereditary disease that typically appears in midlife, marked by gradual loss of brain function and involuntary movements. Some of its symptoms resemble those of schizophrenia.

Negative symptoms—Symptoms of schizophrenia that are characterized by the absence or elimination of certain behaviors. DSM-IV specifies three negative symptoms: affective flattening, poverty of speech, and loss of will or initiative.

Neuroleptic—Another name for the older type of antipsychotic medications given to schizophrenic persons.

Parkinsonism—A set of symptoms originally associated with Parkinson's disease that can occur as side effects of neuroleptic medications. The symptoms include trembling of the fingers or hands, a shuffling gait, and tight or rigid muscles.

Positive symptoms—Symptoms of schizophrenia that are characterized by the production or presence of behaviors that are grossly abnormal or excessive, including hallucinations and thought-process disorder. DSM-IV subdivides positive symptoms into psychotic and disorganized.

Poverty of speech—A negative symptom of schizophrenia, characterized by brief and empty replies to questions. It should not be confused with shyness or reluctance to talk.

Psychotic disorder—A mental disorder characterized by delusions, hallucinations, or other symptoms of lack of contact with reality. The schizophrenias are psychotic disorders.

Serotonin dopamine antagonists (SDAs)—The newer second-generation antipsychotic drugs, also called atypical antipsychotics. SDAs include clozapine (Clozaril), risperidone (Risperdal), and olanzapine (Zyprexa).

Wilson's disease—A rare hereditary disease marked by high levels of copper deposits in the brain, eyes and liver. It can cause psychiatric symptoms resembling schizophrenia.

Word salad—Speech that is so disorganized that it makes no linguistic or grammatical sense.

Prognosis

One important prognostic sign is a person's age at onset of psychotic symptoms. People with early onset of schizophrenia are more often male, have a lower level of functioning prior to onset, a higher rate of brain abnormalities, more noticeable negative symptoms, and worse outcomes. Persons with later onset are more likely to be female, with fewer brain abnormalities and thought impairment, and more hopeful prognoses.

The average course and outcome for schizophrenics are less favorable than those for most other mental disorders, although as many as 30% of people diagnosed with schizophrenia recover completely and the majority experience some improvement. Two factors that influence outcomes are stressful life events and a hostile or emotionally intense family environment. Schizophrenics with a high number of stressful changes in their lives, or who have frequent contacts with critical or emotionally over-involved family members, are more likely to relapse. Overall, the most important component of long-term care for schizophrenic individuals is complying with their regimen of antipsychotic medications.

Health care team roles

Physicians such as a family doctor or internist often make an initial diagnosis of schizophrenia. Psychiatrists, psychologists, or other therapists may also provide an initial diagnosis. Psychiatrists, clinical psychologists, or other trained professionals provide intervention treatment and therapy. Counselors may provide support during and after treatment. Nurses often administer medications.

Prevention

With present levels of understanding about schizophrenia, there does not appear to be any way to prevent the disease. Better understanding holds the promise of prevention if specific causal factors are environmental, chemical or viral.

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ORGANIZATIONS

- American Psychological Association. 750 First Street NW, Washington, DC, 20002-4242. (800) 374-2721 or (202) 336-5500. <<http://www.apa.org/>>.
- National Alliance for Research on Schizophrenia and Depression. 60 Cutter Mill Road, Suite 404, Great Neck, NY 11021. (516) 829-0091. Fax: (516) 487-6930. <<http://www.mhsource.com/narsad/>>. info@narsad.org.
- National Institute of Mental Health. 6001 Executive Boulevard, Rm. 8184, MSC 9663, Bethesda, MD 20892-9663. (301) 443-4513. Fax (301) 443-4279. <<http://www.nimh.nih.gov/home.cfm>>. nimhinfo@nih.gov.
- National Mental Health Association. 1021 Prince Street, Alexandria, VA 22314-2971. (800) 969-6942 or (703) 684-7722. Fax: (703) 684-5968. <<http://www.nmha.org/>>.

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L. Fleming Fallon, Jr., MD, DrPH

Sciatic nerve pain *see* **Sciatica**

Sciatica

Definition

Sciatica describes **pain** or discomfort in the distribution of the sciatic nerve or its components. This nerve runs from the lower part of the **spinal cord**, down the back of the leg, to the foot. Injury to, or pressure on, the sciatic nerve can cause the characteristic pain of sciatica—a sharp or burning pain that radiates from the lower back or hip, following the path of the sciatic nerve to the foot.

Description

The sciatic nerve is the largest and longest nerve in the body. It supplies sensation from the lower back to the foot. The nerve originates in the lumbar region of the spinal cord. As it branches off from the spinal cord, it passes between the bony vertebrae (the component bones of the spine) and runs through the pelvic girdle (hip-bones). The nerve passes near the hip joint and continues down the back of the leg to the foot.

Sciatica is a fairly common disorder. Approximately 40% of the population suffers from it at some point in their lives; however, only about 1% experience any sensory or motor deficits. Sciatic pain has several root causes, and its treatment is directed to the underlying problem.

Of the identifiable causes of sciatic pain, lumbosacral (LS) radiculopathy and back strain are the most

frequently suspected. The LS area is the lower part of the spine, and radiculopathy describes pain radiating from pressure on a spinal nerve roots. This area between the vertebrae (hard bones) is cushioned with a disk of shock-absorbing tissue. The spinal canal, comprising the spinal cord and other nerve roots, is hollow and lies in the middle of the spinal column. It is the disks between the vertebrae that enable the back to bend or flex.

A “ring” of cartilage, gristle-like in character, is found the outer edge of the disk (the annulus). The disk’s center (nucleus) is a substance like gel. When a disk ruptures, or herniates, it does so because of wear-and-tear, excessive weight, poor posture, injury (perhaps due to improper lifting), or disease. The center nucleus pushes the outer edge of the disk into the spinal canal, putting pressure on the nerves. The spinal nerve root may become compressed by the shifted tissue or the vertebrae. This compression of the nerve root sends a pain signal to the **brain**. Although the injury is actually suffered by the nerve roots, the pain may be perceived as originating anywhere along the sciatic nerve. Further, if fragments of the disk lodge in the spinal canal, the nerves that control bowel and urinary functions may be damaged. Incontinence may result.

Sciatica is largely a symptom of a **herniated disk**. However, compression of the sciatic nerve can also present as muscle spasms in the lower back (back strain). In this case, pressure is placed on the sciatic nerve. In rare cases, **infection**, **cancer**, bone inflammation, or other diseases may cause pressure. Another possible cause of sciatica is piriformis syndrome.

As the sciatic nerve passes behind the hip joint, it shares the space with several muscles. One of these muscles, the piriformis muscle, is closely associated with the sciatic nerve. In some people, the nerve actually runs through the muscle. If this muscle is injured or has a spasm, it places pressure on the sciatic nerve, in effect, compressing it.

In many sciatica cases, the specific cause is never identified. About half of affected individuals recover from an episode within a month. Some cases persist and may require aggressive treatment. In other cases, the pain returns or becomes chronic.

Causes and symptoms

Patients with sciatica may experience low back pain, but the most common symptom is pain that radiates through one buttock and down the back of the leg. The most frequently identified cause of pain is compression or pressure on the sciatic nerve. The extent of the pain varies. Some patients describe pain that centers in the

area of the hip; others feel discomfort all the way to the foot. The quality of the pain also varies; it may be described as tingling, burning, prickly, aching, or stabbing.

Onset of sciatica may be sudden, but it might also develop gradually. The pain may be intermittent or continuous. Certain activities (such as bending, coughing, sneezing, or sitting) can worsen the pain.

Sudden loss of bowel or bladder control, weakness in the legs, buttocks, or torso, as well as numbness that goes upwards from the toes or the feet, may indicate a sciatic condition.

Chronic pain may arise from more than simple compression of the nerve root. Discogenic pain, the result of injury to the innervated portions of the annulus fibrosus, is a common cause of sciatica. Pain is generally felt in the buttocks and in the posterior thigh.

According to some pain researchers, physical damage to a nerve is only half of the equation. A theory developed in 2001 proposes that some nerve injuries result when certain neurotransmitters and **immune system** chemicals that exacerbate and sustain a pain message. Even after the injury has healed or the damage has been repaired, the pain lingers. Effective management of this type of pain is difficult. Another theory that has been put forward is that back problems may be inherited. This theory presupposes that a genetic abnormality is responsible for a number of cases of spinal disk disease cases. This defect makes people susceptible to rupture when the back is strained. The investigators claimed that 25% of all cases of sciatica, lower back problems, and discomfort higher in the spine, might be attributable to this gene defect. When classic symptoms are absent, identification of the defect could enable diagnosis of disease, thereby facilitating the therapeutic process.

Diagnosis

Establishing the diagnosis requires taking a thorough medical history and performing a focused **physical examination**. The patient is asked about the location, nature, and duration of the pain, and the details of any accidents, injuries or unusual activities that may have occurred prior to the onset of sciatica. This information provides clues that may point to back strain or injury to a specific location.

Back pain from disk disease, piriformis syndrome, and back strain must be differentiated from more serious conditions, such as cancer or infection. In spring 2001, Dr. T. S. J. Elliott, professor of microbiology at University Hospital in Birmingham, England, conducted a new study—the results of which were published in *The*

Lancet. The doctor found hidden infections in 43 of 140 sciatica (30.7%) patients who suffered from persistent pain originating in the sciatic nerve. (The sciatic nerve of the leg is the largest nerve in the body.) Dr. Elliott believes that when the spine suffers a minor trauma, an organism enters the body. This organism causes sciatica that is continuous, with the resulting inflammation being caused by the infection. Further, he postulated that if imaging studies do not show injury, then there may be something to the physician's study.

More investigations need to be done, however, evaluating the success of **antibiotics** (used to fight infections) in treating sciatica. Lumbar spine stenosis, an overgrowth of the covering layers of the vertebrae that narrows the spinal canal, must also be considered.

A straight leg-raising test is often performed. The patient lies supine, and the health care provider raises the affected leg to various heights. This test pinpoints the location of the pain and may reveal whether it is caused by a disk problem. Other tests, such as observing the patient rotate the hip joint, may provide information about involvement of the piriformis muscle if the patient experience pain. Piriformis weakness is tested with additional leg-strength maneuvers.

Further tests may be conducted depending on the patient's history, results of the physical examination, and response to initial treatment. Diagnostic tests may include traditional x rays, **magnetic resonance imaging** (MRI), and computed tomography scans (**CT scans**). Other tests include **electromyography** (studies of the electrical activity generated as muscles contract), nerve conduction velocity testing, and evoked potential testing. **Myelography**, a more invasive test, involves injecting a contrast medium into the spinal subarachnoid space between the vertebrae and taking x-ray images of the spinal cord. Myelography is usually ordered when surgical treatment is considered. Since the advent of MRI, however, myelography is very rarely used. The MRI does not use ionizing radiation. Noninvasive, it produces excellent computerized images of soft tissues, such as seen in herniated discs and tumors. The MRI is based on nuclear magnetic resonance of atoms within the body; the atoms are generated by the use of radio waves. All these tests can reveal problems with the vertebrae, the disk, or the nerve itself.

Treatment

Pharmacological therapy—initial treatment for sciatica—focuses on pain relief. Regardless of the cause of the pain, **analgesics** (such as acetaminophen) may help relieve pain. **Muscle relaxants** are also used, but it hasn't been proved whether they really work. Furthermore,

the side effects of muscle relaxants may be greater than their benefits, particularly in the elderly. Generally, pain relief is accomplished with nonsteroidal anti-inflammatory drugs (NSAIDs). It should be noted, however, that anti-inflammatory medications should be administered generally for only two to four weeks, and only if no medical contraindications are present. As of 2001, the Food and Drug Administration (FDA) had also approved labeling two newer drugs for the relief of pain; they are rofecoxib (Vioxx), a NSAID with selective cyclo-oxygenase 2 inhibition; and celecoxib (Celebrex). Both have fewer gastrointestinal side effects, but must be taken advisedly by the patient at risk for peptic ulcer disease.

If the pain is unremitting, opioids may be prescribed for short-term use or a local anesthetic may be injected directly into the lower back. Massage and heat application may be suggested as adjunct therapies.

If the pain is chronic, different pain relief medications are used to avoid long-term dosing of NSAIDs, muscle relaxants, and opioids. **Antidepressant drugs**, which have been shown to be effective in treating pain, may be prescribed in conjunction with a short-term course of a muscle relaxant or a NSAID. Local anesthetic injections, or epidural steroids, are used in selected cases.

As pain permits, **physical therapy** is introduced into the treatment regime. Stretching exercises that focus on the lower back, buttocks, and hamstring muscles are suggested. The exercises may also include identifying and practicing comfortable, pain-reducing positions. Corsets and braces may be useful in some cases, but there is not any clinical evidence for their general effectiveness as of 2001. However, they may be helpful in the prevention of exacerbation of sciatica as related to certain activities.

With less pain and the success of early therapy, the patient is encouraged to follow a long-term **exercise** program to maintain a healthy back and prevent re-injury. A physical therapist may suggest exercises and regular activity, such as water exercise or walking. Patients are instructed in proper posture and body mechanics as means of minimizing symptoms during light lifting, prolonged sitting or standing, and other activities.

If the pain is chronic and conservative treatment fails—suggesting that a disk fragment has lodged in the spinal canal and is pressing on the nerve (and perhaps causing a loss of function—surgery may be required. A procedure to repair a herniated disk or excise part, or all of the piriformis muscle, may be suggested, particularly if there is neurologic evidence of nerve or nerve-root damage (radiculopathy). It should be noted, however, that as of 2001, newer and minimally invasive procedures are available to relieve the pain of sciatica. A local

anesthetic is used, and surgery is performed on an ambulatory basis. The recovery period is two to six weeks.

Massage is a recommended form of therapy, especially when the sciatic pain arises from muscle spasm. Patients may be able to relieve symptoms by icing the painful area as soon as pain occurs. The physical therapist or nurse may instruct the patient to place ice on the affected area for 20 minutes, several times a day. After two to three days, a hot water bottle or heating pad can replace the ice. Chiropractic or osteopathic therapy may offer solutions for relieving pressure on the sciatic nerve and the accompanying pain. Acupuncture and biofeedback may also be useful as pain control methods.

Prognosis

Most cases of sciatica are treatable with pain medication and physical therapy. After four to six weeks of treatment, the patient should be able to resume normal activities.

Health care team roles

The diagnosis of sciatica is usually made by a PCP or a mid-level practitioner (physician assistant [PA] or nurse practitioner [NP]). Other physician specialists, such as neurologists, orthopedists, and physiatrists (specialists in physical medicine) also may provide consultative services. Radiologic technologists generally perform diagnostic imaging studies.

The treatment plan may involve physical therapists (PTs) and physical therapist assistants (PTAs), who instruct and supervise prescribed exercise programs. Patients also may be referred to specialists in orthotics, who prescribe appliances/apparatuses to support, align, prevent, or correct deformities, improve posture, or ease the function of movable body parts. Sometimes specialists work with ergonomics. The patient may be taught proper body mechanics at home and in the workplace.

Patient education

Patient education focuses on adhering to prescribed treatment, including exercise and body mechanics (above), and preventing future injuries. Nurses, PTs, PTAs, occupational therapists, and exercise physiologists may be involved in helping patients learn how to perform the activities of daily living (ADL) without exacerbating existing injuries.

Prevention

Some sources of sciatica are not preventable, such as disk degeneration, back strain resulting from **pregnancy**,

KEY TERMS

Acupuncture—The Chinese practice of piercing specific areas of the body along peripheral nerves with fine needles to relieve pain, to induce surgical anesthesia, and for therapeutic purposes.

Biofeedback—The process of furnishing an individual with information on the state of one or more physiologic variables, such as heart rate, blood pressure, or skin temperature. The goal is to enable the patient to gain some voluntary control over them.

Disk—Dense tissue between the vertebrae that acts as a shock absorber and prevents damage to nerves and blood vessels along the spine.

Electromyography—A diagnostic test in which a nerve's ability to conduct an impulse is measured.

Lumbosacral (LS)—Referring to the lower part of the backbone or spine.

Myelography—A medical test in which a special dye—a contrast medium—is injected the spinal subarachnoid space (through which cerebrospinal fluid [CSF] circulates, and across which extend delicate connective tissue pass) to make it visible on radiographic visualization.

NSAID—Nonsteroidal anti-inflammatory drugs are medications that produce analgesic and anti-inflammatory effects.

Opioid—A synthetic narcotic that has opiate-like qualities, but is not derived from opium.

Orthotics—Serving to protect or to restore or improve function; relating to the use or application of an orthosis.

Piriformis—A muscle in the pelvic girdle that is closely associated with the sciatic nerve.

Radiculopathy—A condition in which the nerve root of a nerve has been injured or damaged.

Spasm—Involuntary contraction of a muscle.

Spinal subarachnoid space—Space through which which cerebrospinal fluid circulates, and across which extend delicate connective tissue pass.

Vertebrae—The component bones of the spine.

or accidental injuries from **falls**. Other sources of back strain, such as poor posture, overexertion, **obesity**, or

wearing high heels, may be corrected or avoided. Smoking may also predispose patients to pain, as it the supply of **blood** to intervertebral discs, and interferes with healing. An orthopedist with the Gwinnett Health System in Lawrenceville, Georgia, Dr. Walker states that “Smoking leads to drying and stiffness of the discs, making them more susceptible to injury, including herniation, and prolonged recovery time.”

General suggestions for avoiding sciatica or preventing future episodes include sleeping on a firm mattress, using chairs with firm back supports, and sitting with both feet flat on the floor. Habitually crossing the legs while sitting may place excess pressure on the sciatic nerve. Sitting for prolonged periods of time also places pressure on the sciatic nerves, so patients are advised to take short breaks and move around during the workday, when on long trips, or in other situations that require sitting for extended lengths of time. When sitting for long periods, the patient should put his or her feet up on a low stool. If it is required that something be lifted without another person, the back should be kept straight and the legs should provide the lift. The knees should be bent, and the individual should get as close to the object as possible. This will reduce the load on the lower back. To give one a wider base of support and to distribute the weight of the object being lifted, the feet should be kept apart.

Regular exercise, such as swimming and walking, can build stamina, strengthen back muscles, improve flexibility, and improve posture. Exercise also helps to maintain proper body weight and lessens the likelihood of back strain.

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Barbara Wexler

Scoliosis

Definition

Scoliosis is a side-to-side (lateral) curvature of the spine of 10 degrees or greater.

Description

When viewed from the rear, the spine usually appears to form a straight vertical line. Scoliosis is a lateral (side-to-side) curve in the spine, usually combined with a rotation of the vertebrae. The lateral curvature of scoliosis should not be confused with the normal set of front-to-back spinal curves visible from the side. While a small degree of lateral curvature does not cause any medical problems, larger curves can cause postural imbalance and lead to muscle fatigue and **pain**. More severe scoliosis can interfere with breathing and lead to arthritis of the spine (spondylosis).

Four out of five cases of scoliosis are idiopathic, meaning their cause is unknown. Children with idiopathic scoliosis appear to be otherwise entirely healthy, and have not had any bone or joint disease early in life. Scoliosis is not caused by poor posture, diet, or carrying a heavy bookbag exclusively on one shoulder.

Idiopathic scoliosis is further classified according to age of onset:

- **Infantile.** Curvature appears before age three. This type is quite rare in the United States, but is more common in Europe.
- **Juvenile.** Curvature appears between ages three and 10. This type may be equivalent to the adolescent type, except for the age of onset.
- **Adolescent.** Curvature appears between ages of 10 and 13, near the beginning of **puberty**. This is the most common type of idiopathic scoliosis.
- **Adult.** Curvature begins after physical maturation is completed.

Causes are known for three other types of scoliosis:

- **Congenital scoliosis** is due to congenital birth defects in the spine, often associated with other structural defects.
- **Neuromuscular scoliosis** is due to loss of control of the nerves or muscles which support the spine. The most common causes of this type of scoliosis are **cerebral palsy** and **muscular dystrophy**.
- **Degenerative scoliosis** may be caused by degeneration of the discs which separate the vertebrae or arthritis in the joints that link them.

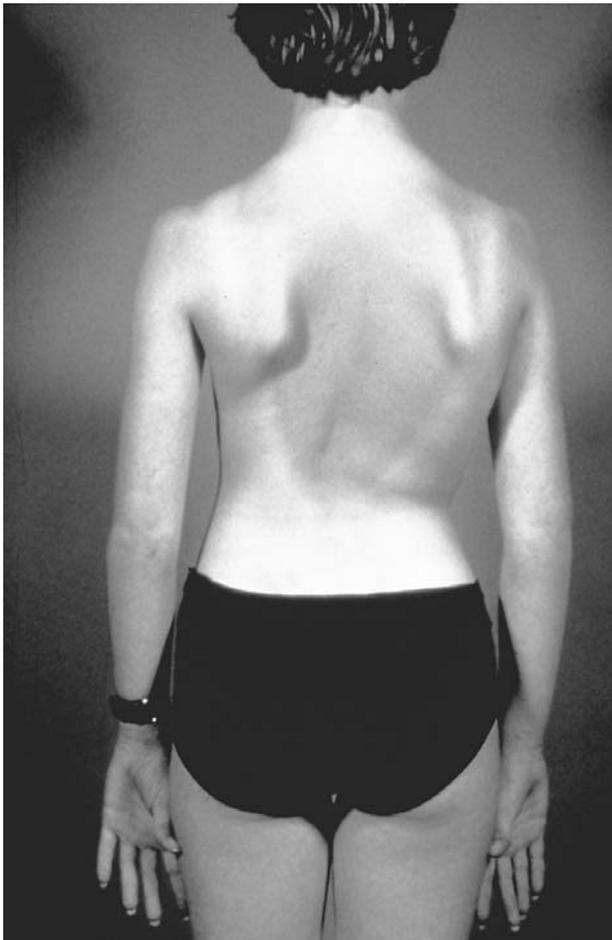
Genetic profile

Idiopathic scoliosis has long been observed to run in families. Twin and family studies have consistently indicated a genetic contribution to the condition. However, no consistent pattern of transmission has been observed in familial cases. As of 2001, no genes have been identified which specifically cause or predispose individuals to the idiopathic form of scoliosis.

There are several genetic syndromes which involve a predisposition to scoliosis. Several studies have investigated whether or not the genes which cause these syndromes may also be responsible for idiopathic scoliosis. Using this candidate gene approach, the genes responsible for Marfan syndrome (fibrillin), Stickler syndrome, and some forms of osteogenesis imperfecta (collagen types I and II) have been shown not to correlate with idiopathic scoliosis.

Attempts to map a gene or genes for scoliosis have not shown consistent linkages to any particular chromosome region.

Most researchers have concluded that scoliosis is a complex trait. As such, there are likely to be multiple genetic, environmental, and potentially additional factors that contribute to the etiology of the condition. Complex traits are difficult to study due to the difficulty in identifying and isolating multiple factors.



A woman with idiopathic scoliosis. (Custom Medical Stock Photo. Reproduced by permission.)

Demographics

The incidence of scoliosis in the general population is approximately 2–3%. Among adolescents, however, 10% have some degree of scoliosis, though fewer than 1% have curves that require treatment.

Scoliosis is found in both males and females, but a female's spinal curve is much more likely to progress than a male's. Females require scoliosis treatment about five times as often as males. The reason for these differences is not known with certainty but they may relate to increased levels of estrogen and other hormones in females.

Causes and symptoms

Scoliosis causes a noticeable asymmetry in the torso when viewed from the front or back. The first sign of scoliosis is often seen when a child is wearing a bathing suit or underwear. A child may appear to be standing with one shoulder higher than the other, or to have a tilt in the

waistline. One shoulder blade may appear more prominent than the other due to rotation. In girls, one breast may appear higher than the other, or larger if rotation pushes that side forward.

Curve progression is greatest near the adolescent growth spurt. Scoliosis that begins early in life is more likely to progress significantly than scoliosis that begins later in puberty.

More than 30 states have screening programs in schools for adolescent scoliosis. These are usually conducted by physicians, school nurses or trained physical education teachers.

Diagnosis

Scoliosis is initially noticed during a screening program or during a routine **physical examination** conducted by a pediatrician or family physician. Confirmatory diagnosis of scoliosis is often conducted by an orthopedic surgeon. A complete medical history is taken, including questions about family history of scoliosis. The physical examination includes determination of pubertal development in adolescents, a neurological exam (which may reveal a neuromuscular cause), and measurements of trunk asymmetry. Examination of the trunk is done while the person is standing, bending over, and lying down, and involves both visual inspection and use of a simple mechanical device called a scoliometer.

If a curve is detected, one or more x rays will usually be taken to define more precisely the curve or curves. An x ray is used to document spinal maturity, any pelvic tilt or hip asymmetry, and the location, extent, and degree of curvature. The curve is defined in terms of where it begins and ends, in which direction it bends, and by an angular measure known as the Cobb angle. The Cobb angle is found by projecting lines parallel to the vertebrae tops at the extremes of the curve; projecting perpendiculars from these lines; and measuring their angle of intersection. To properly track the progress of scoliosis, it is important to project from the same points of the spine each time.

Occasionally, **magnetic resonance imaging** (MRI) is used, primarily to look more closely at the condition of the **spinal cord** and nerve roots extending from it if neurological problems are suspected.

Treatment

Treatment decisions for scoliosis are based on the degree of curvature, the likelihood of significant progression, and the presence of pain, if any.

Curves less than 20 degrees are not usually treated, except by regular follow-up for children who are still growing. Watchful waiting is usually all that is required in adolescents with curves of 20–25 degrees, or adults with curves up to 40 degrees or slightly more, as long as there is no pain.

For children or adolescents whose curves progress to 25 degrees, and who have a year or more of growth left, bracing may be required. Bracing cannot correct curvature, but may be effective in halting or slowing its progression. Bracing is rarely used in adults, except where pain is significant and surgery is not an option, as in some elderly patients.

There are two different categories of braces, those designed for nearly 24 hour per day use and those designed for night use. The full-time brace styles are designed to hold the spine in a vertical position, while the night use braces are designed to bend the spine in the direction opposite the curve.

The Milwaukee brace is a full-time brace which consists of metal uprights attached to pads at the hips, rib cage, and neck. Other types of full-time braces, such as the Boston brace, involve underarm rigid plastic molding to encircle the lower rib cage, abdomen, and hips. Because they can be worn out of sight beneath clothing, underarm braces are better tolerated and often lead to better compliance. The Boston brace is currently the most commonly used. Full-time braces are often prescribed to be worn for 22–23 hours per day, though some clinicians believe that recommending brace use of 16 hours leads to better compliance and results.

Night-use braces bend an individual's scoliosis into a correct angle, and are prescribed for eight hours of use during sleep. Some investigators have found that night-use braces are not as effective as the day-use types.

Bracing may be appropriate for scoliosis due to some types of neuromuscular disease, including spinal muscular atrophy, before growth is finished. Duchenne muscular dystrophy is not treated by bracing, since surgery is likely to be required, and since later surgery is complicated by loss of respiratory capacity.

Surgery for idiopathic scoliosis is usually recommended if:

- The curve has progressed despite bracing.
- The curve is greater than 40–50 degrees before growth has stopped in an adolescent.
- The curve is greater than 50 degrees and continues to increase in an adult.
- There is significant pain.

Orthopedic surgery for neuromuscular scoliosis is often done early in life. The goals of surgery are to correct the deformity as much as possible, to prevent further deformity, and to eliminate pain as much as possible. Surgery can usually correct 40–50% of the curve, and sometimes as much as 80%. Surgery cannot always completely remove pain.

The surgical procedure for scoliosis is called spinal fusion, because the goal is to straighten the spine as much as possible, and then to fuse the vertebrae together to prevent further curvature. To achieve fusion, the involved vertebra are first exposed, and then scraped to promote re-growth. Bone chips are usually used to splint together the vertebrae to increase the likelihood of fusion. To maintain the proper spinal posture before fusion occurs, metal rods are inserted alongside the spine, and are attached to the vertebrae by hooks, screws, or wires. Fusion of the spine makes it rigid and resistant to further curvature. The metal rods are no longer needed once fusion is complete, but are rarely removed unless their presence leads to complications.

Spinal fusion leaves the involved portion of the spine permanently stiff and inflexible. While this leads to some loss of normal motion, most functional activities are not strongly affected, unless the very lowest portion of the spine (the lumbar region) is fused. Normal mobility, **exercise**, and even contact sports are usually all possible after spinal fusion. Full recovery takes approximately six months.

Prognosis

The prognosis for a person with scoliosis depends on many factors, including the age at which scoliosis begins and the treatment received. Most cases of mild adolescent idiopathic scoliosis need no treatment, do not progress, and do not cause pain or functional limitations. Untreated severe scoliosis often leads to spondylosis, and may impair breathing.

Health care team roles

A pediatrician or family physician usually makes an initial diagnosis of scoliosis. Orthopedic surgeons may provide surgical treatment. Physical therapists may provide therapeutic exercises for a person with scoliosis.

Prevention

There is no known way to prevent any of the forms of scoliosis.

KEY TERMS

Cobb angle—A measure of the curvature of scoliosis, determined by measurements made on x rays.

Scoliometer—A tool for measuring trunk asymmetry; it includes a bubble level and angle measure.

Spondylosis—Arthritis of the spine.

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American Academy of Physical Medicine and Rehabilitation. One IBM Plaza, Suite 2500, Chicago, IL 60611-3604. (312) 464-9700. Fax: (312) 464-0227. <<http://www.aapmr.org/consumers/public/amputations.htm>>. info@aapmr.org.

American Thoracic Society. 1740 Broadway, New York, NY 10019. (212) 315-8700. Fax: (212) 315-6498. <<http://www.thoracic.org/>>.

National Scoliosis Foundation. 5 Cabot Place, Stoughton, MA 02072. (800) 673-6922, or (781) 341-6333. Fax: (781) 341-8333. <<http://www.scoliosis.org/>>. nsf@scoliosis.org.

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L. Fleming Fallon, Jr., MD, DrPH

Scrotal nuclear medicine scan

Definition

Scrotal nuclear medicine scan is a study of the tissues in the scrotum, using a radioactive contrast agent to identify masses, **blood** flow, and areas of **infection**.

Purpose

The scrotal nuclear medicine scan is used to assess blood flow within the testicles and damage caused by injury. It is also used to ascertain the cause of swollen testes (testicles) which may be due to infection or the twisting of the entire tissues of the testicle. This is done in an emergency setting if the testicle swells suddenly and painfully.

This scan can be used to diagnose tumors and cysts (pockets of fluid), but testicular ultrasound has become the diagnostic tool of choice for these growths in 2001.

Precautions

There are no precautions with a scrotal nuclear medicine scan, except that the patient must remain still during the procedure.

Description

A radioisotope, technetium-99, combined with a chemical (pertechnetate) is injected intravenously while the patient is under a gamma camera that detects radiation. This special camera scans the scrotum at one minute intervals for about five minutes, then less often for another 10 or 15 minutes. It then creates pictures (either x ray or Polaroid) that reveal where the isotope is in the scrotum. Since both sides of the scrotum are scanned, even greater accuracy is obtained by comparison.

Some areas accumulate the tracer in greater than normal amounts. These are called “hot” spots and may indicate tumors or other masses. Areas that have less than normal amounts of the tracer or none at all are called “cold” spots and may indicate cysts or infection.

It is important to differentiate infection from twisting torsion and infection. A common infection called epididymitis involves a collection of tubules on top of the testicle called the epididymis that carry sperm. Twisting of the spermatic cord inside the scrotum, outside the testicle often shuts off the testes’ blood supply and is called testicular torsion. Both conditions cause a very painful, swollen testicle on one side of the scrotum. Epididymitis and testicular torsion occur most often in young men, although infection usually occurs at a slightly older age. Infection increases the blood supply, showing up as a “hot” spot on the scan, whereas testicular torsion cuts off the blood supply, appearing as a “cold” spot. The distinction is critically important, because testicular torsion must be untwisted immediately by surgery or the testicle will die. On the other hand, epididymitis responds to **antibiotics**, and surgery might further injure it.

After the patient has changed into gown, he will lie on a scanning table. The penis will be taped to the abdomen to prevent it from shadowing the scan. A towel may be used to support the testicles during the test. The tracer will be injected into a vein on the inside of the elbow, and the camera will begin taking pictures of the testicles. It is important that the patient remain still during the scans.

Two complete passes are made about 15 minutes apart. The total scrotal scan takes about 45 minutes.

Preparation

There is no preparation prior to a scrotal nuclear medicine scan. The day of the test, the patient will need to remove any jewelry, watches, and metal (belts, hair-pins, etc.) and change into a gown.

Aftercare

The patient should be able to go about normal activities after the scan. However, if surgery is performed immediately after the scan, normal post-surgical precautions should be undertaken.

Complications

The risk of complications is minimal due to the small amount of radiation to which the body is exposed. Even sensitive testicular tissue is at minimum risk. The tracer is eliminated from the body within 24 hours, and allergic reactions to the tracer are rare.

Results

Results are usually available in two days. In an emergency, results are made available in one hour. Normal results show unobstructed blood flow with no “hot” or “cold” spots. Abnormal results are shown in the scan images as:

- “Hot” spots, where the tracer accumulates in greater amounts than normal, can indicate epididymitis or a tumor.
- “Cold” spots have no accumulation of the tracer or very little. These may point to cysts, abscesses, or blood clots.
- Blood flow is uneven throughout the testicles. This indicates a narrowing or blockage of the **blood vessels**, including from torsion, or possibly direct damage from injury. Sometimes the blood flow pattern appears in a “donut” shape, which suggests that testicular torsion has occurred but that it has resolved itself within the last few days.

KEY TERMS

Epididymitis—A common infection involving a collection of tubules on top of the testicle called the epididymis that carry sperm.

Radioisotope—An unstable form of an element that gives off radiation to become stable.

Scrotum—The bag of skin below the penis that contains the testes.

Testicular torsion—A condition involving the twisting of the spermatic cord inside the testicle that shuts off its blood supply and can seriously damage the testicle.

Abnormal results may require further investigation through other tests, such as testicular biopsy or ultrasound.

Health care team roles

The nuclear medicine technologist will need to educate the patient about the procedure (for example, how the scan is done, what happens during it, what kinds of information the scan can produce for the doctor, etc.). This is very necessary to keep the patient informed and to ensure cooperation during the procedure. It is crucial that the patient remain still during the scan.

The nuclear medicine technologist who performs the scrotal scan will need to reassure the patient before and during the scan in order to keep the patient relaxed and still during the scan.

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Janie F. Franz

Scrotal ultrasound

Definition

Scrotal ultrasound is an imaging technique used for the diagnosis of suspected abnormalities of the scrotum and testes. It uses harmless, high-frequency sound waves to form an image. The sound waves are reflected by scrotal tissue to form a picture of internal structures. It is not invasive and involves no radiation.

Purpose

Ultrasound of the scrotum is the primary imaging method used to evaluate disorders of the testicles and surrounding tissues. It is used when a man has acute **pain** in the scrotum. Some of the medical problems for which the use of scrotal ultrasound is valuable include an absent or undescended testicle, inflammation of the testicle or associated structures, testicular torsion, a fluid collection (hydrocele), abnormal **blood vessels** (varicocele), or a mass (lump or tumor).

A sudden onset of pain in the scrotum is considered a serious problem. Delay in diagnosis and treatment can lead to loss of function. Epididymitis is the most common cause of this type of pain. Epididymitis is an inflammation of the epididymis, a tubular structure that transports sperm from the testes. It is most often caused by bacterial **infection**, but may occur after injury, or arise from an unknown cause. Epididymitis is treatable with **antibiotics**, which usually resolves pain quickly and ice to reduce swelling. Left untreated, this condition can lead to **abscess** formation or loss of **blood** supply to the testicle. The latter condition can cause testicular loss.

Testicular torsion is the twisting of the spermatic cord that containing the blood vessels that supply the testicles. It is caused by abnormally loose attachments of tissues that are formed during **fetal development**. Torsion can be complete, incomplete, or intermittent. Spontaneous detorsion, or untwisting, can occur, making diagnosis difficult. Testicular torsion arises most commonly during adolescence, and is acutely painful. Scrotal ultrasound is used to distinguish this condition from inflammatory problems, such as epididymitis. Testicular torsion is a surgical emergency; it should be operated on as soon as possible to avoid permanent damage to the testes.

A scrotal sac with an absent testicle may be the result of a congenital anomaly (an abnormality present at birth), where a testicle fails to develop. More often, it is due to an undescended testicle. In the fetus, the testicles normally develop just outside the abdomen and descend into the scrotum during the seventh month. Approximately

3% of full term baby boys have undescended testicles. It is important to distinguish between an undescended testicle and an absent testicle, as an undescended testicle has a very high probability of developing **cancer** if left untreated.

Ultrasound can be used to locate and evaluate masses in the scrotum. Most masses within the testicle are malignant or cancerous, and most outside the testicle are benign. Primary cancer of the testicles is the most common malignancy in men between the ages of 20 and 35. Fluid collections and abnormalities of the blood vessels in the scrotum may appear to the physician as masses and need evaluation by ultrasound. A hydrocele, the most common cause of painless scrotal swelling, is a collection of fluid between two layers of tissue surrounding the testicle. An abnormal enlargement of the veins which drain the testicles is called a varicocele. It can cause discomfort and swelling, which can be examined by touch (palpated). Varicocele is a common cause of male **infertility**, and is more common on the left testicle.

Precautions

Clear scrotal ultrasound images are difficult to obtain if a person is unable to remain still. Other than cleaning the surface of the skin upon which a transducer will be placed, there are no special precautions that are associated with ultrasonography.

Description

A transducer (an electronic imaging device) is used to both generate and receive acoustic images. It is placed against the skin over the structure to be examined. The transducer is moved over the area creating images from reflected sound waves, which appear on a monitor screen. There is no discomfort from the study itself. However, if the scrotum is very tender, even the slight pressure involved may be painful.

Preparation

The patient lies on his back on an examining table. The technologist will usually take a history of the problem, then gently palpate the scrotum. A rolled towel is placed between the patient's legs to support the scrotum. The penis is lifted up onto the abdomen and covered. A gel that enhances sound transmission is applied directly on the scrotum. The technologist then gently places a transducer (an electronic imaging device) against the skin.

Aftercare

The transducing gel is removed with soap and water. Any underlying medical condition is treated. There is no aftercare for the scrotal ultrasound examination.

Complications

There are no complications associated with ultrasonography.

Results

A normal study reveals testicles of normal size and shape, with no masses or abnormalities.

An abnormal result of an ultrasound of the scrotum may reveal an absent or undescended testicle, an inflammation problem, testicular torsion, a fluid collection, abnormal blood vessels, or a mass.

Health care team roles

A family physician, pediatrician, urologist, or emergency room doctor usually orders a scrotal ultrasound examination. An ultrasonographer or radiologist performs the examination. A radiologist interprets the images obtained.

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KEY TERMS

Epididymis—A tubular structure that transports sperm from the testes to the vas deferens, which transports it to the prostate gland.

Hydrocele—A collection of fluid between two layers of tissue surrounding the testicle; the most common cause of painless scrotal swelling.

Scrotum—The structure of skin that surrounds and protects the testicles.

Testicular torsion—A twisting of the spermatic cord that containing the blood vessels supplying the testicles.

Varicocele—An abnormal enlargement of the veins which drain the testicles.

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American Foundation for Urologic Disease. 1128 North Charles Street, Baltimore, MD 21201. (800) 242-2383 or (410) 468-1800. <<http://www.afud.org>>. admin@afud.org.

American Infertility Association. 666 Fifth Avenue, Suite 278, New York, NY 10103. (718) 621-5083. <<http://www.americaninfertility.org/>>. info@americaninfertility.org.

American Institute of Ultrasound In Medicine. 14750 Sweitzer Lane, Suite 100, Laurel, MD 20707-5906. (301) 498-4100 or (800) 638-5352. Fax: (301) 498-4450. <<http://www.aium.org/>>.

American Osteopathic College of Radiology. 119 East Second St. Milan, MO 63556. (660) 265-4011. Fax: (660) 265-3494. <<http://www.aocr.org/>>. aocr@nemr.net.

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Sedimentation rate test

Definition

The sedimentation rate test, also called the erythrocyte sedimentation rate (ESR) or sed rate test, measures the speed at which the red **blood** cells (erythrocytes or RBCs) separate from the liquid part of the blood (plasma) and settle to the bottom in a tube of anticoagulated blood.

Purpose

The sedimentation rate is a non-specific indicator of the presence of inflammation or **infection**. Although newer methods for diagnosing specific diseases have decreased the test's usefulness, it is still an important tool for the diagnosis and monitoring of two diseases: polymyalgia rheumatica and temporal arteritis. Sedimentation rate testing at regular intervals can also be helpful in predicting relapse in patients with chronic diseases such as Hodgkin's disease and other cancers.

Precautions

Patients who have **bleeding disorders** or are taking blood thinners might have trouble with bleeding following a venipuncture. Before having a blood sample drawn, such patients should tell the phlebotomist about their condition.

Description

The sedimentation rate test dates back to the early 1900s. In 1921, Westergren introduced a new method for performing the test that has become the time-honored classic. It is the recommended method of the International Committee for Standardization in Haematology and the National Committee for Clinical Laboratory Science. While automated methods can perform the sed rate in less time and with smaller samples of blood, many labs continue to use the Westergren method because it is simple and inexpensive.

For accurate results, the blood sample should be fresh (within two hours of collection is best). The sample might be rejected because it is too old or because the collection tube is underfilled, not labeled correctly, or contains blood that is hemolyzed or clotted.

The standard Westergren method includes the following steps:

- Diluting whole blood, or blood anticoagulated with EDTA, in citrate (1 volume of citrate to 4 volumes of blood).
- Aspirating the diluted blood to the 200 mm mark of a Westergren tube (30 cm in length and 2.55 mm in diameter with a uniform bore diameter) by means of a mechanical device or teat.
- Placing the tube in a vertical position in a Westergren rack in a location that is free of vibration and that is not exposed to direct sunlight.
- After exactly one hour, reading the distance the erythrocytes have fallen, and recording this value as the sedimentation rate.

Preparation

This test requires no special preparation.

Aftercare

To prevent bruising, pressure should be applied to the site of the venipuncture as soon as the needle is withdrawn. Pressure should be maintained until the bleeding stops.

Complications

No complications are associated with this test other than the possibility of having a slight bruise from having blood drawn from a vein. In very rare cases, vein inflammation or continued bleeding at the puncture site might be a problem.

Results

The sedimentation rate is measured in millimeters per hour (mm/hr). Normal values vary with age and sex, and can vary from lab to lab. A normal result does not rule out a diagnosis of inflammatory disease. An abnormal result does not diagnose any specific disease, and should be evaluated in conjunction with the patient's physical exam, medical history, and other more specific blood tests. In general, an abnormal result correlates with active inflammatory disease, and the sedimentation rate test is a useful way of monitoring disease progression or treatment. If the result is abnormal, the test should be repeated to verify its accuracy. A number of factors (such as medications, hormones, **obesity**, and improper collection or handling of the blood sample) can affect the outcome of this test.

Normal values

- Males under 50: 0–15 mm/hr.
- Males 50 and older: 0–20 mm/hr.
- Females under 50: 0–20 mm/hr.
- Females 50 and older: 0–30 mm/hr.
- Children: 3–13 mm/hr.
- Newborns: 0–2 mm/hr.

Greater than normal values

A greater than normal value can indicate inflammation due to infection, autoimmune disease (such as rheumatoid arthritis), or certain types of **cancer** (such as multiple myeloma and Hodgkin's disease). An elevated sed rate usually occurs when the level of plasma **proteins** in the blood is higher than normal. These plasma proteins (primarily fibrinogen) bind to the red blood cells, reducing the negative surface charge which normally causes the cells to repel each other. The red blood cells stack and settle to bottom of the tube faster than single red blood cells.

Lower than normal values

A lower than normal value can indicate diseases such as congestive **heart failure**, sickle cell anemia, and

KEY TERMS

Arteritis—The inflammation of an artery.

Aspirate (verb)—To draw or move by suction.

Phlebotomist—A person who draws blood from a vein.

Phlebotomy—A procedure in which a vein is punctured to obtain a blood sample.

Polymyalgia rheumatica—A disease that causes aching and stiffness in the neck, shoulder, or pelvis.

Temporal (giant cell) arteritis—A disease caused by arterial inflammation that usually results in headaches and facial pain. The production of giant cells is characteristic of this type of arteritis. If the ophthalmic artery and its branches become involved, it can also cause blindness.

Venipuncture—The puncture of a vein to withdraw a blood sample.

polycythemia (abnormally high numbers of circulating red blood cells).

Health care team roles

A phlebotomist usually draws and labels the blood sample for the sedimentation rate. However, any health care professionals trained in phlebotomy (such as doctors, nurses, clinical laboratory scientists, or medical technologists) can perform this task.

When the blood sample arrives at the lab, a clinical laboratory scientist (CLS [NCA]), medical technologist (MT [ASCP]), clinical laboratory technician (CLT [NCA]), or medical laboratory technician (MLT [ASCP]) will set up the test and record the sedimentation rate after the specified period of time, usually one hour.

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Seizure disorder

Definition

A seizure is a sudden disruption of the brain's normal electrical activity accompanied by an alteration in consciousness or other neurological and behavioral manifestations. Epilepsy is a condition characterized by recurrent seizures that may include repetitive muscle jerking called convulsions.

Description

There are more than 20 different seizure disorders. One in 10 Americans will have a seizure at some time, and at least 200,000 have at least one seizure each month.

Epilepsy affects 1% to 2% of the United States population. Although epilepsy is as common in adults over 60 as in children under 10, 25% of all cases develop before the age of five. One in every two cases develops before the age of 25. About 125,000 new cases of epilepsy are diagnosed each year, and a significant number of children and adults that have not been diagnosed or treated have epilepsy.

Most seizures are benign, but a seizure that lasts a long time can lead to status epilepticus, a life-threatening condition characterized by continuous seizures, sustained loss of consciousness, and respiratory distress. Non-convulsive epilepsy can impair physical coordination, **vision**, and other senses. Undiagnosed seizures can lead to conditions that are more serious and more difficult to manage.

Types of seizures

Generalized epileptic seizures occur when electrical abnormalities exist throughout the **brain**. A partial seizure does not involve the entire brain. A partial seizure begins in an area called an epileptic focus, but may spread to other parts of the brain and cause a generalized seizure. Some people who have epilepsy experience more than one type of seizure.

Motor attacks cause parts of the body to jerk repeatedly. A motor attack usually lasts less than an hour and may last only a few minutes. Sensory seizures begin with numbness or tingling in one area. The sensation may move along one side of the body or the back before subsiding.

Visual seizures, which affect the area of the brain that controls sight, cause people to see things that are not there. Auditory seizures affect the part of the brain that controls **hearing** and cause a person to imagine voices, music, and other sounds. Other types of seizures can cause confusion, upset **stomach**, or emotional distress. When such phenomena occur prior to the onset of a seizure, they are called auras.

GENERALIZED SEIZURES. A generalized tonic-clonic (grand-mal) seizure begins with a loud cry before the person having the seizure loses consciousness and falls to the ground. The muscles become rigid for about 30 seconds during the tonic phase of the seizure and alternately contract and relax during the clonic phase, which lasts 30 to 60 seconds. The skin sometimes acquires a bluish tint, and the person may bite the tongue, lose bowel or bladder control, or have trouble breathing.

A grand mal seizure lasts between two and five minutes, and the person may be confused or have trouble talking when consciousness is regained (postictal state). There may be complaints of head or muscle aches or weakness in the arms or legs before falling into a deep sleep.

PRIMARY GENERALIZED SEIZURES. A primary generalized seizure occurs when electrical discharges begin in both halves (hemispheres) of the brain at the same time. Primary generalized seizures are more likely to be major motor attacks than to be absence seizures.

ABSENCE SEIZURES. Absence (petit mal) seizures generally begin at about the age of four and stop by the time the child becomes an adolescent. Absence seizures usually begin with a brief loss of consciousness and last between one and ten seconds. A person having a petit mal seizure becomes very quiet and may blink, stare blankly, roll eyes, or move lips. A petit mal seizure lasts 15 to 20 seconds. When it ends, the person who had the seizure resumes whatever task was being completed before the seizure began. There will be no **memory** of the seizure, and the person may not realize that anything unusual has happened. Untreated petit mal seizures can recur as many as 100 times a day and may progress to grand mal seizures.

MYOCLONIC SEIZURES. Myoclonic seizures are characterized by brief, involuntary spasms of the tongue or muscles of the face, arms, or legs. Myoclonic seizures are most apt to occur when waking after a night's sleep.

A Jacksonian seizure is a partial seizure characterized by tingling, stiffening, or jerking of an arm or leg. Loss of consciousness is rare. The seizure may progress in characteristic fashion along the limb.

Limp posture and a brief period of unconsciousness are features of akinetic seizures, which occur in young children. Akinetic seizures, which cause the child to fall, are also called drop attacks.

PARTIAL SEIZURES. Simple partial seizures do not spread from the focal area where they arise. Symptoms are determined by what part of the brain is affected. The person usually remains conscious during the seizure and can later describe it in detail.

COMPLEX PARTIAL SEIZURES. A distinctive **smell**, **taste**, or other unusual sensation (aura) may signal the start of a complex partial seizure. These seizures start as simple partial seizures but move beyond the focal area and cause loss of consciousness. Complex partial seizures can become major motor seizures. Although a person having a complex partial seizure may appear to be conscious, the person has no knowledge of what is happening and may behave inappropriately. There will be no memory of the seizure and there may be a brief period of confusion after it ends.

Causes and symptoms

The origin of 50–70% of all cases of epilepsy is unknown. Epilepsy is sometimes the result of trauma at the time of birth. Such causes include insufficient oxygen to the brain; **head injury**; heavy bleeding or incompatibility between a woman's **blood** and the blood of her newborn baby; and **infection** immediately before, after, or at the time of birth.

Other causes of epilepsy include:

- head trauma resulting from a car accident, gunshot wound, or other injury
- alcoholism
- brain **abscess** or inflammation of membranes covering the brain or spinal cord
- phenylketonuria (PKU) (A disease that is present at birth, PKU is often characterized by seizures, and can result in mental retardation and other inherited disorders.)
- infectious diseases such as measles, mumps, and diphtheria
- degenerative disease
- lead **poisoning**, mercury poisoning, **carbon monoxide poisoning**, or ingestion of some other poisonous substance
- genetic factors

Status epilepticus, a condition in which a person suffers from continuous seizures and may have trouble breathing, can be caused by:

- suddenly discontinuing anti-seizure medication
- hypoxic or metabolic encephalopathy (brain disease resulting from lack of oxygen or malfunctioning of other physical or chemical processes)
- acute head injury
- blood infection caused by inflammation of the brain or the membranes that cover it

Diagnosis

Personal and family medical history, description of seizure activity, and physical and neurological examinations help primary care physicians, neurologists, and epileptologists diagnose this disorder. Doctors rule out conditions that cause symptoms that resemble epilepsy, including small strokes (transient ischemic attacks or TIAs), fainting (**syncope**), pseudoseizures, and sleep attacks (narcolepsy).

Neuropsychological testing uncovers learning or memory problems. Neuro-imaging provides views of brain areas involved in seizure activity.

An electroencephalogram (EEG) is the main test used to diagnose epilepsy. EEGs use electrodes placed on or within the **skull** to record the brain's electrical activity and pinpoint the exact location of abnormal discharges. A person may be asked to remain motionless during a short-term EEG or to go about normal activities during extended monitoring. Some people are deprived of sleep or exposed to seizure triggers, such as rapid, deep breathing

(hyperventilation) or flashing lights (photic stimulation). In some cases, people may be hospitalized for EEG monitoring that can last as long as two weeks. Video EEGs also document what an individual was doing when the seizure occurred and how the seizure altered behavior.

Other techniques used to diagnose epilepsy include:

- Magnetic resonance imaging (MRI) provides clear, detailed images of the brain. Functional MRI (fMRI), performed while a person does various tasks, can measure shifts in electrical intensity and blood flow and indicate the brain region each activity affects.
- Positron emission tomography (**PET**) and single photon emission tomography (SPECT) monitor blood flow and chemical activity in the brain area being tested. PET and SPECT are very effective in locating the brain region where metabolic changes take place between seizures.

Treatment

The goal of epilepsy treatment is to eliminate seizures or make the symptoms less frequent and less severe. Long-term anticonvulsant drug therapy is the most common form of epilepsy treatment.

Medication

A combination of drugs may be needed to control some symptoms, but most persons who have epilepsy take one of the following medications:

- phenytoin (Dilantin)
- carbamazepine (Tegretol)
- phenobarbital (Barbita)
- primidone (Mysoline)
- valproic acid or sodium valproate (Depakene)
- clonazepam (Klonopin)
- ethosuximide (Zarontin)

Phenytoin, carbamazepine, phenobarbital, and primidone are used to manage or control generalized tonic-clonic and complex partial seizures. Valproic acid (sodium valproate), clonazepam, and ethosuximide are prescribed for persons who have absence seizures. Gabapentin (Neurontin) and lamotrigine (Lamictal) are medications recently approved in the United States to treat adults who have partial seizures or partial and grand mal seizures.

Even a person whose seizures are well controlled should have regular blood tests to measure levels of anti-seizure medication in the blood stream and to check to see if the medication is causing any changes in the blood

or **liver**. A doctor should be notified if any signs of drug toxicity appear, including uncontrolled eye movements; sluggishness, dizziness, or hyperactivity; inability to see clearly or speak distinctly; nausea or vomiting; or sleep problems.

Status epilepticus requires emergency treatment, usually with Ativan (Valium), phenytoin, or phenobarbital. An intravenous dextrose (sugar) solution is given to persons whose condition is due to low blood sugar, and a vitamin B₁ preparation is administered intravenously when status epilepticus results from chronic alcohol withdrawal. Because dextrose and **thiamine** are essentially harmless and because delay in treatment can be disastrous, these medications are given routinely, as it is usually difficult to obtain an adequate history from a person suffering from status epilepticus.

Intractable seizures are seizures that cannot be controlled with medication or without sedation or other unacceptable side effects. Surgery may be used to eliminate or control intractable seizures.

Surgery

Surgery can be used to treat people whose intractable seizures stem from small focal lesions that can be removed without endangering them, changing their personality, dulling their senses, or reducing their ability to function.

Each year, as many as 5,000 new people may become suitable candidates for surgery, which is most often performed at a comprehensive epilepsy center. Potential surgical candidates include people with:

- partial seizures and secondarily generalized seizures (attacks that begin in one area and spread to both sides of the brain)
- seizures and childhood **paralysis** on one side of the body (hemiplegia)
- complex partial seizures originating in the temporal lobe (the part of the brain associated with speech, hearing, and smell) or other focal seizures (However, the risk of surgery involving the speech centers is that a person will lose speech function.)
- generalized myoclonic seizures or generalized seizures featuring temporary paralysis (akinetic) or loss of muscle tone (atonic)

A **physical examination** is conducted to verify that a person's seizures are caused by epilepsy, and surgery is not used to treat people with severe psychiatric disturbances or medical problems that raise risk factors to unacceptable levels.

Surgery is never indicated unless:

- The best available anti-seizure medications have failed to control the person's symptoms satisfactorily.
- The origin of a person's seizures has been precisely located.
- There is good reason to believe that surgery will significantly improve the person's health and quality of life.

Every person considering epilepsy surgery is carefully evaluated by one or more neurologists, neurosurgeons, neuropsychologists, and/or social workers. A psychiatrist, chaplain, or other spiritual advisor may help an affected individual and family members family cope with the stresses that occur during and after the selection process.

TYPES OF SURGERY. Surgical techniques used to treat intractable epilepsy include:

- **Lesionectomy.** Removing the lesion (diseased brain tissue) and some surrounding brain tissue is very effective in controlling seizures. Lesionectomy is generally more successful than surgery performed on persons whose seizures are not caused by clearly defined lesions, but removing only part of the lesion lessens the effectiveness of the procedure.
- **Temporal resections.** Removing part of the temporal lobe and the part of the brain associated with feelings, memory, and emotions (the hippocampus) provides good or excellent seizure control in 75–80% of properly selected individuals with appropriate types of temporal lobe epilepsy. Some people experience post-operative speech and memory problems.
- **Extra-temporal resection.** This procedure involves removing some or all of the frontal lobe, the part of the brain directly behind the forehead. The frontal lobe helps regulate movement, planning, judgment, and personality, and special care must be taken to prevent post-operative problems with movement and speech. Extra-temporal resection is most successful in people whose seizures are not widespread.
- **Hemispherectomy.** This method of removing brain tissue is restricted to persons with severe epilepsy and abnormal discharges that often extend from one side of the brain to the other. Hemispherectomies are most often performed on infants or young children who have had an extensive brain disease or disorder since birth or from a very young age.
- **Corpus callosotomy.** This procedure, an alternative to hemispherectomy in persons with congenital hemiplegia, removes some or all of the white matter that connects the two halves of the brain. Corpus callosotomy is performed almost exclusively on children who are



This patient's brain is exposed during surgery in order for surgeons to resect the mass responsible for his epilepsy.
(Custom Medical Stock Photo. Reproduced by permission.)

frequently injured during falls caused by seizures. If removing two-thirds of the corpus callosum doesn't produce lasting improvement in a person's condition, the remaining one-third will be removed during another operation.

- Multiple subpial transection. This procedure is used to control the spread of seizures that originate in or affect the "eloquent" cortex, the area of the brain responsible for complex thought and reasoning.

Other forms of treatment

KETOGENIC DIET. A special high-fat, low-protein, low-carbohydrate diet is sometimes used to treat persons whose severe seizures have not responded to other treatment. Calculated according to age, height, and weight, the ketogenic diet induces mild starvation and **dehydration**. This forces the body to create an excessive supply of ketones, natural chemicals with seizure-suppressing properties.

The goal of this controversial approach is to maintain or improve seizure control while reducing medication. The ketogenic diet works best with children between the ages of one and 10. It is introduced over a period of several days, and most children are hospitalized during the early stages of treatment.

If a child following this diet remains seizure-free for at least six months, increased amounts of **carbohydrates** and protein are gradually added. If the child shows no

improvement after three months, the diet is gradually discontinued.

Introduced in the 1920s, the ketogenic diet has had limited, short-term success in controlling seizure activity. Its use exposes people to such potentially harmful side effects as:

- staphylococcal infections
- stunted or delayed growth
- low blood sugar (hypoglycemia)
- excess fat in the blood (hyperlipidemia)
- disease resulting from **calcium** deposits in the urinary tract (urolithiasis)
- disease of the optic nerve (optic neuropathy)

VAGUS NERVE STIMULATION. The United States Food and Drug Administration (FDA) has approved the use of vagus nerve stimulation (VNS) in persons over the age of 16 who have intractable partial seizures. This non-surgical procedure uses a pacemaker-like device implanted under the skin in the upper left chest, to provide intermittent stimulation to the vagus nerve. Stretching from the side of the neck into the brain, the vagus nerve affects swallowing, speech, breathing, and many other functions, and VNS may prevent or shorten some seizures.

First aid for seizures

A person having a seizure should not be restrained, but sharp or dangerous objects should be moved out of reach. Anyone having a complex partial seizure can be warned away from danger by someone calling out his or her name in a clear, calm voice.

A person having a grand mal seizure should be helped to lie down. Tight clothing should be loosened. A soft, flat object like a towel or the palm of a hand should be placed under the person's head. Forcing a hard object into the mouth of someone having a grand mal seizure could cause injuries or breathing problems. If the person's mouth is open, placing a folded cloth or other soft object between the teeth will protect the tongue. Turning the head to the side will help breathing. After a grand mal seizure has ended, the person who had the seizure should be told what has happened and reminded of the present location.

Alternative treatment

Stress increases seizure activity in 30% of people who have epilepsy. **Relaxation** techniques can provide some sense of control over the disorder, but they should never be used instead of anti-seizure medication or used without the approval of a person's doctor. **Yoga, medita-**

tion, and favorite pastimes help some people relax and more successfully manage stress. Biofeedback can teach adults and older adolescents how to recognize an aura and what to do to stop its spread. Children under 14 are not usually able to understand and apply principles of biofeedback. Acupuncture treatments (acupuncture needles inserted for a few minutes or left in place for as long as half an hour) make some people feel pleasantly relaxed. **Acupressure** can have the same effect on children or on adults who dislike needles.

Aromatherapy involves mixing aromatic plant oils into water or other oils and massaging them into the skin or using a special burner to waft their fragrance throughout the room. Aromatherapy oils affect the body and the brain, and undiluted oils should never be applied directly to the skin. Ylang ylang, chamomile, or lavender can create a soothing mood. People who have epilepsy should not use rosemary, hyssop, sage, or sweet fennel, which seem to make the brain more alert.

Dietary changes that emphasize whole foods and eliminate processed foods may be helpful. Homeopathic therapy also can work for people with seizures, especially constitutional homeopathic treatment that acts at the deepest levels to address the needs of an individual.

Prognosis

People who have epilepsy have a higher-than-average rate of suicide; sudden, unexplained death; and drowning and other accidental fatalities.

Benign focal epilepsy of childhood and some absence seizures may disappear in time, but remission is unlikely if seizures occur several times a day, several times in a 48-hour period, or more frequently than in the past.

Seizures that occur repeatedly over time and always involve the same symptoms are called stereotypic seizures. The probability that stereotypic seizures will abate is poor.

About 85% of all seizure disorders can be partially or completely controlled if a person takes anti-seizure medication according to directions; avoids seizure-inducing sights, sounds, and other triggers; gets enough sleep; and eats regular, balanced meals.

Health care team roles

First aid may be provided by trained individuals. Physicians make the initial diagnosis of seizure disorders. Endocrinologists and radiologists may assist in refining a diagnosis. Neurologists, neurosurgeons, neuropsychologists, and social workers may assess persons

prior to receiving surgery for a seizure disorder. Neurosurgeons may perform surgery to remove structures in the brain that are known to cause seizures. Psychiatrists, chaplains, or other spiritual advisors may help an affected individual and relations cope with the stresses that occur during and after surgery. Nurses also teach family and friends about emergency care of patient when having a seizure, as well as **home care** following a seizure and hospitalization.

Prevention

Eating properly, getting sufficient sleep, and controlling stress and fevers can help prevent seizures. A person who has epilepsy should be careful not to hyperventilate. A person who experiences an aura should find a safe place to lie down and stay there until the seizure passes. Anticonvulsant medications should not be stopped suddenly; and, if other medications are prescribed or discontinued, the doctor treating the seizures should be notified. In some conditions, such as severe head injury, brain surgery, or subarachnoid hemorrhage, anticonvulsant medications may be given to a person to prevent seizures. Seizures that are caused by ingesting substances such as alcohol or drugs can be prevented by discontinuing use of the offending substance.

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KEY TERMS

Acupressure—An ancient Chinese method of relieving pain or treating illness by applying pressure to specific areas of the body.

Acupuncture—An ancient Chinese method of relieving pain or treating illness by piercing specific areas of the body with fine needles.

Akinetic seizure—Seizure characterized by limp posture and a brief period of unconsciousness; also called a drop attack.

Aura—A distinctive smell, taste, or other unusual sensation that precedes the onset of a seizure.

Biofeedback—A learning technique that helps individuals influence automatic (autonomic) body functions.

Clonic—Referring to clonus, a series of muscle contractions and partial relaxations that alternate in some nervous diseases in the form of convulsive spasms.

Epileptologist—A physician who specializes in the treatment of epilepsy.

Hyperlipidemia—A condition characterized by high serum triglyceride and lipid levels.

Hypoglycemia—A condition characterized by low serum glucose (blood sugar) levels.

Lesionectomy—Removal of a lesion and surrounding tissue. The term is applied to brain tissue when trying to control seizures.

Myoclonic seizures—Brief, involuntary spasms of the tongue or muscles of the face, arms, or legs.

Petit-mal seizure—Absence seizure.

Post-ictal state—A period of disorientation usually followed by sleep that occurs after a seizure.

Tonic—Characterized by tonus, a state of partial contraction that is maintained at least in part by a continuous bombardment of motor impulses.

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Selective polishing see **Tooth polishing**

Selenium deficiency see **Mineral deficiency**

Semen analysis

Definition

A semen analysis is the examination of freshly ejaculated seminal fluid. Seminal fluid is a viscous, turbid fluid produced mainly from secretions of the seminal vesicles (45–80% of volume) and prostate gland (15–30% of the volume). About 1% of the total volume is spermatozoa and testicular fluid produced by the testes. A routine analysis of seminal fluid includes the measurement of fluid volume, viscosity, pH, and fructose and measurement of sperm concentration, count, motility, viability, and morphology. Additional tests are performed as indicated. These are usually performed by andrology laboratories and include testing for sperm autoantibodies, zona free hamster oocyte penetration, cervical mucus penetration, the acrosomal reaction test, and computer assisted sperm analysis (CASA).

Purpose

In the United States, the **infertility** rate for married couples is approximately 15%. A semen analysis is the examination of a male's ejaculate, performed to determine if the cause of a couple's infertility is attributed to the male's inability to fertilize the ovum. It is also used to confirm the absence of sperm following vasectomy. In addition, a microscopic exam for sperm is performed on vaginal swabs and clothing taken in suspected rape cases as part of the crime scene investigation. This is used along with tests for acid phosphatase and prostate specific antigen to determine the presence of seminal fluid.

Precautions

The patient should abstain from intercourse for three days prior sample collection and refrain from drinking alcoholic beverages for at least 24 hours before testing. Antineoplastic agents and estrogen may lower test results. Additionally, several herbal supplements have been found to affect sperm counts and/or characteristics.

A semen specimen to investigate infertility must kept at room temperature. It should be collected by masturbation into a disposable sterile, wide-mouth container. A room close to the testing site is preferred for collection, since specimen quality deteriorates rapidly. If possible, examinations for motility and viability should be performed and smears prepared within one hour of collection. Timing is not as critical for postvasectomy testing. Physiological and environmental factors can increase the variability of semen analysis, and the World Health Organization (WHO) recommends the evaluation of two

ejaculates collected at least seven days but not more than three months apart.

Description

Male infertility may be caused by many conditions that affect the production of functional sperm. The most common cause is varicocele (hardening of the veins that drain the testes) which accounts for about 40% of cases and is treated surgically. Testicular failure accounts for approximately 10% of cases and may result from numerous causes including malignancy, mumps, Klinefelter's syndrome, injury, and radio- or **chemotherapy**. Hyperspermia, increased seminal fluid volume, also accounts for about 10% of cases. Endocrine diseases affecting spermatogenesis account for approximately 9% of cases and usually involve pituitary or adrenal hypoplasia or hyperthyroidism. Obstruction of the ejaculatory duct accounts for about 5% of cases and sperm autoantibodies for 1–2%.

Physical characteristics of the semen sample that are evaluated include volume, gross appearance (color, turbidity), viscosity, and liquifaction. Seminal fluid will coagulate within five minutes of collection due to coagulating protein secreted by seminal vesicles. The seminal fluid should liquefy within one hour at room temperature, due to the action of prostatic secretions. Failure to do so inhibits motility. After liquifaction, viscosity may be measured by observing the fluid as it drains from the tip of a 5 mL serological pipet. The fluid should flow from the tip in discrete droplets. Formation of a thread of two or more centimeters at the tip indicates abnormally high viscosity. Volume is determined by determining the amount of fluid that can be drawn into a 10 mL serological pipet.

Sperm counting methods

The sperm concentration is usually performed using a 1:20 dilution of seminal fluid in a diluent containing formalin which immobilizes the sperm. Usually five of the 0.2 x 0.2 mm squares of a hemacytometer grid are counted. The number of cells counted is equal to the sperm concentration in millions per mL. All 25 squares are counted if there are less than 10 sperm (spermatozoons) per square. A Mackler chamber, a grid consisting of 1 square millimeter divided into 100 equal squares, (0.1 x 0.1 mm, 0.01 mm deep) can be used in place of a hemacytometer. Undiluted seminal fluid is heated to 50–60°C to immobilize the sperm. Heads are counted in 10 of the squares and the total is equal to the sperm concentration in millions per milliliter. A sperm concentration less than 20 million per milliliter is termed oligozoospermia, and often results from ductal obstruction, regurgita-

KEY TERMS

Autoantibody—An antibody formed in response to, and reacting against, an antigenic constituent of the individual's own tissues.

Infertility—The diminution of absence of ability to produce offspring.

Morphology—The biological study of the form and function of living organisms.

Motility—The ability to move spontaneously.

Semen—Fluid discharged at ejaculation in the male, consisting of secretion of glands associated with the urogenital tract and containing spermatozoa.

Sperm—Vernacular term for spermatozoon, which is a mature male germ cell, the specific output of the testes, which impregnates the ovum in sexual reproduction.

Vasectomy—An operation done to sterilize a man by stopping the release of sperm into semen.

tion of sperm into bladder, or testicular failure. The total sperm count is determined by multiplying the sperm concentration per mL by the seminal fluid volume.

Motility and viability evaluation

Sperm motility should be performed within one hour of ejaculation. During this portion of the analysis, 10 microliters of semen are placed on a standard microscopic slide, and a coverglass is applied. Ten random fields are then examined at 250x to 400x magnification using phase contrast or brightfield microscopy. Two hundred sperm are graded for motility using a scale ranging from zero to four, with zero signifying no motility, and four describing sperm that exhibit rapid, progressive movement. A more detailed analysis of sperm motility is obtained using CASA. This procedure produces a computer analysis of video camera generated microscopic images of sperm movements. Various aspects of sperm movement such as curvilinear and straight-line velocity are measured and analyzed statistically.

Sperm viability is measured when the motility test is abnormal. The test is based upon the fact that living sperm exclude the dye eosin Y, but dead sperm do not. A slide is prepared by mixing a sample of the seminal fluid and the dye, and 200 sperm are counted under the **microscope**. The percentage of living sperm (unstained sperm) is recorded.

Morphology evaluation

The morphology of sperm is also assessed from a stained smear. To prepare a stained specimen, a drop of semen is placed on a glass slide and a second slide is used to spread the drop over the slide surface. The smear is air dried and fixed using ethanol-ether. The slide is stained with Papanicolaou or other suitable stain (Wright stain is not recommended). Two hundred mature sperm are evaluated for head, neck, and tail defects. Any white **blood** cells (WBCs) or immature sperm cells (round cells) are also counted per 200 mature sperm. WBCs and round cells are estimated from the average number seen per 400x field. When more than one WBC or five round cells are seen on average per field, the respective cell count should be performed. Each cell per field equates to approximately one million cells per mL of seminal fluid. There are two alternative ways of classifying sperm that give very different results. The majority of clinical labs use nonstrict criteria. This process identifies only gross abnormalities of the sperm. The alternative method, strict criteria, is used by andrology and some clinical labs. For example, the WHO criteria for the normal sperm head is as follows: length 4.0–4.5 microns, width 2.5–3.5 microns, length:width ratio 1.5–1.75, acrosomal area 40–70%, vacuolization less than 20% of head area. Studies have shown that the probability of successful fertilization via assisted reproductive technology diminishes significantly when less than 15% of the sperm are normal by strict criteria. There are several strict criteria in use, including those developed by WHO.

Other tests

Chemical tests routinely performed on seminal fluid include pH and fructose. pH is measured with pH paper, and fructose may be measured quantitatively using an enzymatic assay.

Antibodies to sperm have the potential to impair fertility. While sperm agglutinins (antibodies) may be detected in the male or female partner of up to 10% of infertile couples, they are not always responsible for infertility. There are several tests for sperm agglutinins including direct microscopic observation, the mixed antiglobulin test, and the immunobead test.

Preparation

Sterile, wide-mouth containers should be used for specimen collection. The best quality sperm are obtained when the specimen is collected after three days of sexual abstinence, but not more than five to seven days. Because the initial portion of the ejaculate contains the majority of the sperm cells, and the volume of ejaculate may provide

clues regarding infertility, *coitus interruptus* should not be used as the method of collection.

The specimen should be examined in the laboratory within one hour of collection. Typically, two to three specimens are examined over a period of several weeks. When results from two testing days are different, additional specimens collected over a two- to three-month period should be analyzed.

Aftercare

There are no aftercare requirements.

Complications

There are no complications associated this test.

Results

Each laboratory defines its own set of normal values. Many follow the recommendation of WHO. The values below are representative for the procedures described above.

- Volume: 2.0–5.0 mL.
- pH: 7.2–8.0.
- Sperm concentration: greater than or equal to 20 million per mL.
- Sperm count: greater than or equal to 40 million per ejaculate.
- Motility: Greater than or equal to 50% demonstrating forward progressive movement or 25% or more demonstrating rapid progressive movement. Prolonged abstinence may depress sperm motility. Frequent sperm agglutination suggests the presence of antisperm antibodies.
- Morphology: Nonstrict criteria: greater than 60% normal sperm. Strict criteria: 15–40 % normal sperm.
- White blood cells: less than 1 million per mL.
- Round cells: less than 5 million per mL.
- Viability: equal to or greater than 75%.
- Viscosity: droplets to threads less than 2 cm.

Post-vasectomy

Semen analysis to confirm the success of a vasectomy is concerned only with the absence or presence of sperm. Semen is collected six weeks after surgery, or after at least 20 ejaculations. Sperm should not be seen. If sperm are seen, another specimen is collected two to four weeks later. The test should be repeated several

months later to ensure that the vas deferens have not reattached.

Health care team roles

Physicians, nurses, or laboratory scientists provide collection and delivery instructions. Laboratory tests are performed by clinical laboratory scientists CLS(NCA)/medical technologists MT(ASCP), or pathologists.

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Senna see **Laxatives**

Sensory reeducation

Definition

Sensory reeducation is a therapeutic program using sensory stimulation to help sensory-impaired patients recover functional sensibility in the damaged area and learn adaptive functioning.

Purpose

Following disease, such as stroke, or accident, sensory reeducation helps patients with various forms of sensory loss and impairment retrain their sensory pathways, adapt to changed abilities, and regain function.

Precautions

There may be contraindications related to particular modalities used in sensory reeducation or related to coexisting conditions. For example, some coexisting conditions that may contraindicate electrical stimulation include thrombophlebitis, cardiac demand pacemaker, disturbances in cardiac rhythm, local inflammation or **infection**, or **cancer**. Extreme caution should be used when applying heat, cold, or electrical stimulation to sensory impaired areas to avoid possible damage due to the patient's inability to feel symptoms that may indicate dangerous temperature or stimulation levels.

A thorough medical history and examination should be conducted and any coexisting conditions noted and taken into consideration during treatment design and implementation. The patient should be educated and monitored to help prevent further damage to the sensory-impaired area.

Description

Sensory reeducation uses a variety of therapeutic, rehabilitation, and educational techniques to help sensory-impaired patients recover sensibility, fine discrimination abilities, and the ability to perform other tasks involved in daily living and work activities. In addition to actual loss of sensibility and related functional ability, paresthesias (abnormal sensations), such as numbness, tingling, or burning sensations, may be present. Some of the many possible causes of sensory impairment may include nerve damage, nerve repair surgery, stroke, aneurysm, other forms of **central nervous system** damage, and diabetes-related nerve impairment.

Many techniques of sensory stimulation are used to provide input to sensory receptors and pathways. Some forms of stimulation used include electrical stimulation; stroking the skin with textured, friction-producing items such as Velcro; and the use of specially modified tools and instruments (Dannenbaum). Other procedures and modalities that may be used include massage, vibration, pressure, biofeedback, various forms of movement and tactile stimulation, or other activities that require use of and attention to the senses. Sensory reeducation may be delivered in indirect ways as part of a larger therapeutic program, rather than being an independent, distinct therapy.

In addition to loss of tactile sensibility and related inability to distinguish heat, cold, textures, shapes, and other types of stimulation on the skin, losses related to other senses may also be addressed. One example is visual field impairment that may be caused by a stroke. Patients with visual field impairments might be taught to

attend to the neglected side, or helped to use other senses to compensate for sensory impairment and loss.

Another form of impairment that may be treated with sensory reeducation is hypersensitivity, a condition in which a patient overreacts to mild forms of stimulation. One such condition is called regional **pain** syndrome. When treating such conditions tactile stimulation, weight bearing activities, and other forms of sensory reeducation are used to desensitize the patient's sensory responses and reduce perceived discomfort.

Among the goals of sensory reeducation is the retraining of neural pathways and responses to stimuli in order to restore the patient's sensory perception. Increased sensory input and activity may help to stimulate nerve regeneration and growth. In addition, previously unused neural connections may be trained to take over for damaged pathways. This neural plasticity can be used to the advantage of the patient with nerve damage or impairment.

Some scientists believe it may be possible for a remapping to occur in the **brain** so that connections between areas of the brain and certain parts of the body, as represented on Penfield maps, can adapt and change after nerve injury or amputation, causing new connections that relay sensation.

In general, in addition to actually retraining the senses and nervous system activities, much of sensory reeducation may focus on teaching the patient functional adaptation—new ways of using the abilities they have to compensate for sensory impairments and other disabilities. Adaptation may be used to help the patient function until full rehabilitation is achieved, but it may also be a permanent adaptation when full rehabilitation is not possible.

Preparation

The patient will be interviewed and examined by the therapist to determine the types and extent of sensory impairment. An individualized rehabilitation and sensory reeducation program will be designed in accord with the patient's needs, abilities, and goals.

Aftercare

Patients may continue to see their physician and therapist for follow-up exams and treatment after completion of initial sensory reeducation to record and maintain progress made.

Complications

The therapist should be alert to any possible complications related to the primary and coexisting conditions and associated with any of the modalities used. With careful diagnosis, treatment planning, and monitoring, complications should be minimal. Special caution and supervision should be used when working with sensory-impaired patients.

Results

The patient should be helped to regain sensibility and related functions such as two-point discrimination and object recognition, and minimize discomfort. To the degree that full recover of sensibility is not possible, the patient should learn adaptive behaviors that will aid in function.

Health care team roles

The surgeon, neurologist, or primary physician may prescribe and monitor the therapy. Physical or occupational therapists and their assistants may perform sensory reeducation. Nurses and other hospital personnel may also be involved in the general rehabilitation and sensory reeducation of the patient, along with social workers, speech therapists, cognitive therapists, and other allied health care providers.

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KEY TERMS

Functional sensibility—The ability to make fine sensory discriminations in order to carry out specific somatosensory tasks.

Paresthesia—The presence of unusual sensations, such as numbness, tingling, or burning.

Penfield maps—Graphical depictions of the connections between areas in the brain and body parts with which they communicate; created by Wilder Penfield.

Reeducation—Rehabilitation by special training, such as physical therapy, that helps to restimulate nerve connections associated with sensory perception and related functional ability.

ORGANIZATIONS

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Sensory testing

Definition

Sensory testing involves the evaluation of a patient's perception in an effort to assess the integrity of the peripheral nervous system. There are many sensory receptors in the human body that provide information to the **brain** concerning an individual's surroundings. The information from sensory receptors helps the human being move and interact within the environment. For example, information from various sensory organs such as the eyes, vestibular (inner ear), and light touch are all integrated and organized by the brain to help the body complete safe and efficient movement. If sensory impairment is present, the patient's movement will likely be affected, making common tasks cumbersome and even dangerous. Therefore, individuals with possible sensory

impairment need to have a full sensory evaluation to assess the integrity of sensation.

Purpose

There are many pathologies that can cause impairments in sensation. Injury or disease can compromise the integrity of a nerve and thus impair sensory function. Peripheral neuropathy is a broad classification that describes disease or dysfunction of a peripheral nerve. A peripheral neuropathy can be acquired or inherited.

Acquired peripheral neuropathy

A common acquired peripheral neuropathy is Guillain-Barre syndrome. This syndrome is usually considered an autoimmune disorder, but the etiology (cause) is unknown. Guillain-Barre syndrome is classified as a myelinopathy where the myelin sheath (an insulating wrapping which surrounds the axons of many nerves) disintegrates. In this disorder there is marked weakness and sensory impairment on both sides of the body. Two other types of acquired peripheral neuropathy are alcoholic and diabetic neuropathies. Alcoholic neuropathy is due to **alcoholism** and diabetic neuropathy is due to diabetes, a metabolic disease. In alcoholic neuropathy, sensory and motor losses are typical, especially in the feet and lower legs. The actual cause is unknown, but may be due to the toxic effects of alcohol on the nervous system. In diabetic neuropathy sensory loss also is prominent, especially in the lower limbs. Other acquired neuropathies can be caused by laceration (i.e., knife injury), crushing injuries to the nerve, or ischemia (a condition characterized by a decreased supply of oxygenated **blood**). All can lead to sensory and/or motor impairment by compromising the integrity of the nerve.

Inherited peripheral neuropathy

The most common inherited peripheral neuropathy is Charcot-Marie-Tooth disease. It is a genetic disorder that is categorized by weakness or atrophy of the lower limbs, especially the lower leg and foot.

There are many sensory receptors corresponding to various sensations within the human body. The purpose of sensory receptors is to gather pertinent information on the surrounding environment. Sensory receptors respond to stimuli in the environment, and thus provide valuable information on a person's surroundings. Therefore, the disorders categorized as peripheral neuropathies can impair the gathering and transmission of information. The purpose of sensory testing is to evaluate the proficiency and integration of information from sensory

receptors in individuals who have known disease or injury.

Precautions

Sensory testing gives valuable information to the clinician on an individual's sensation and perception. Care must be taken when performing sensory tests if sensory loss is suspected. Applying increased pressure or heat on an individual who has a sensory deficit may injure the patient. For example, if a patient cannot sense the application of heat, there is a risk that the patient will be burned.

Description

Sensory testing should be done on both sides of the body so that comparisons can be made between sides, i.e., affected side versus non-affected side. If there is a deficit noted, it is usually termed absent, diminished, or exaggerated. If there is no deficit, sensation is termed intact.

There are seven common tests used to evaluate sensation and perception. They are: stereognosis, touch and pressure, kinesthesia, proprioception, touch localization, two-point discrimination, and recognition of textures.

Stereognosis

Stereognosis refers to the ability of an individual to identify objects placed in his/her hand, while his/her eyes are closed. The individual should be able to identify objects based on size, shape, and texture.

Touch and pressure

Touch can be assessed by gently rubbing a ball of cotton on the surface of the skin to be tested. The clinician's finger can be used to apply pressure to various locations in order to assess pressure sensation. While touch and pressure are being assessed, the subject's eyes should be closed.

Proprioception

This test evaluates the individual's perception of movement specifically related to the limbs. In this test the individual's eyes are closed while the examiner moves the unaffected limb into a position and holds the position. The examiner then asks the individual to move the affected side into the same position.

Kinesthesia

This test assesses the individual's perception of joint movement rather than position (proprioception). In this test, the examiner moves the unaffected limb and, as the

limb is moved, the individual being tested must copy the movement and follow the path with the affected or involved side. This test also is done with the individual's eyes are closed.

Touch localization

While the subject's eyes are closed, the examiner touches different areas on the skin and asks the subject, "Where am I touching?" The subject must verbally identify the location of the examiner's touch.

Two-point discrimination

This test evaluates an individual's ability to discern two points at the same time. While the subject's eyes are closed, the examiner applies point pressure in two spots separated by one to two inches. The examiner asks the subject, "Can you feel two points?" If the subject can discern two points, the examiner moves the points closer together and the test is repeated. This continues until two points cannot be discerned. These results are compared with results from the opposite side.

Recognition of textures

Various textures are placed in the individual's hand, while his/her eyes are closed. The individual must verbally identify the texture. Cotton and sandpaper are examples of items used in this test.

Another testing device, the Weinstein Enhanced Sensory Test or WEST, is primarily used to assess touch sensation. It is a precision instrument that uses hair-like filaments to record pressure or force. The instrument is a safe, valid, and reliable way of recording sensory loss.

Results

Results or outcomes of treatment are variable. Usually the initial severity of the deficit reflects the possible outcome. The greater the deficit, the greater the likelihood of long-term or total impairment.

Health care team roles

Nurses and other allied health team members need to be aware of potential sensory and perceptive disorders and their relationship to function. Early identification of sensory or perceptive impairments may minimize further complications. Physicians, nurses, and allied health professionals, such as occupational and physical therapists, usually perform sensation testing. Nurses are now becoming more familiar with the WEST device and this technology is now available for assessing the feet. This is especially useful for patients with diabetic neuropathy.

KEY TERMS

Kinesthesia—The ability to perceive where a limb or the body is moving in space. Information about the surrounding environment is processed in the brain and received from muscles, tendons, and joints.

Proprioception—The ability to perceive where a limb or the body is in space. Usually refers to a static situation.

Sensation—Awareness (as of heat or pain) due to stimulation of a sense organ.

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ORGANIZATIONS

American Diabetes Association. 1701 North Beauregard St., Alexandria, VA 22311. Phone: (800) 342-2383. <<http://www.diabetes.org>>.

American Physical Therapy Association. 1111 North Fairfax St., Alexandria, VA 22314-1488. Phone: (703) 684-APTA or (800) 999-APTA. TDD: (703) 683-6748. Fax: (703) 684-7343. <<http://www.apta.org>>.

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Sepsis syndrome see **Septic shock**

Septic shock

Definition

Septic **shock** is a syndrome in which a potentially lethal drop in **blood pressure** occurs as a result of an overwhelming bacterial **infection**.

KEY TERMS

Bacteremia—Invasion of the bloodstream by bacteria.

Description

Septic shock is a possible consequence of bacteremia, which is also called sepsis. Bacterial toxins, and the immune system's response to them, can cause a dramatic drop in **blood** pressure and may result in under-perfusion to various organs. Septic shock can lead to multiple organ failure, including **respiratory failure**, and may cause rapid death. Toxic shock syndrome is one type of septic shock.

Causes and symptoms

During an infection, certain **bacteria** can release complex molecules, called endotoxins, that may provoke a dramatic response by the body's **immune system**. Endotoxins are particularly dangerous; as they become widely dispersed, they cause arteries and the smaller arterioles to dilate. At the same time, the walls of the **blood vessels** become leaky, allowing fluid to seep into the tissues, lowering intravascular volume (the amount of fluid left in circulation). This combination, of arterial dilation and decreased intravascular volume, causes a dramatic decrease in blood pressure and impaired blood flow to multiple organs. Other changes seen in septic shock are disseminated intravascular coagulation (DIC), which can further impair organ perfusion (blood flow).

Septic shock is seen most often in patients with impaired host defenses (patients who are immunosuppressed), and is often due to nosocomial (hospital-acquired) infections. The immune system is suppressed by drugs used to treat **cancer**, **autoimmune disorders**, organ transplants, and diseases of immune deficiency such as **AIDS**. Malnutrition, chronic drug abuse, and long-term illness also increase the likelihood of succumbing to bacterial infection. Bacteremia is more likely with preexisting infections such as urinary or gastrointestinal tract infections, or skin ulcers. Bacteria may be introduced to the blood stream by surgical procedures, catheters, or intravenous equipment.

Toxic shock syndrome (TSS) is a potentially fatal disorder resulting from infection with *Staphylococcus aureus*, a toxin-producing strain of a bacteria. When it was first reported about 25 years ago, toxic shock syndrome was associated with menstruation and linked to super-absorbent tampon use. Today, it is recognized that

use of super-absorbent tampons does increase the risk of TSS, as does use of a contraceptive sponge or diaphragm. Postpartum patients (women who have just given birth) and patients with wound infections, or recovering from nasal surgery also are at risk for TSS. The illness appears suddenly, with **fever**, rash, low blood pressure, and episodes of fainting. Survival has improved since the 1980s, approximately 2–5% of patients die from this disorder. Patients recovering from TSS face increased risk of recurrence. To prevent TSS, menstruating women are advised to avoid use of super-absorbent tampons.

Symptoms

Septic shock is usually preceded by bacteremia, which causes fever, malaise, chills, and nausea. The first sign of shock is often confusion and decreased consciousness. In this beginning stage, the extremities are usually warm. Later, as the blood pressure drops, they may become cool, pale, and cyanotic (bluish). Fever may subside to normal temperatures later on in sepsis.

Other symptoms include:

- rapid heartbeat
- shallow, rapid breathing
- decreased urination
- reddish patches in the skin

Septic shock may progress to cause “adult respiratory distress syndrome,” (also called non-cardiogenic pulmonary **edema**) in which the pulmonary capillaries become leaky and the **lungs** fill with fluid. This can lead to respiratory failure. When this occurs the patient can no longer breathe without mechanical ventilation and supplemental oxygen.

Diagnosis

Diagnosis of septic shock is made when a patient with a severe infection has hypotension (low blood pressure) for which other causes such as major bleeding, **dehydration**, or massive **myocardial infarction** have been excluded. Pulmonary artery pressure may be monitored with a Swan-Ganz catheter, a catheter inserted into the pulmonary artery. Blood, urine, sputum, and cultures from other possible sites of infection determine the type of bacteria responsible for the infection. Arterial **blood gases** are also monitored to assess changes in respiratory function.

Treatment

Septic shock is treated initially with a combination of **antibiotics** and fluid replacement. The antibiotic is cho-

sen based on the bacteria known or suspected to be present. Usually, two or more types of antibiotics are started until the organism is identified. Intravenous fluids replete the intravascular fluid lost by leakage. Impaired coagulation and hemorrhage may be treated with transfusions of plasma, platelets, or red blood cells. Dopamine may be given to increase blood pressure further if necessary.

Respiratory distress is treated with mechanical ventilation and supplemental oxygen, either using a nose-piece or a tube into the trachea through the throat. The mainstay of therapy is to treat the underlying infection that caused the septic shock.

Prognosis

Septic shock is most likely to develop in the hospital, since it frequently results from hospital-acquired infection. Close monitoring and early, aggressive therapy can minimize the likelihood of progression. Nonetheless, death occurs in at least 25% of all cases.

The likelihood of recovery from septic shock depends on many factors, including the degree of immunosuppression of the patient, underlying disease, timeliness of treatment, and type of bacteria responsible. Mortality is highest in the very young and the elderly, those with persistent or recurrent infection, and those with compromised immune systems.

Health care team roles

Generally, care for the septic patient is delivered by hospital-based health care professionals in the hospital ICU (intensive care unit). Physicians, intensive care nurses, and other nursing personnel closely monitor patients' **vital signs** and administer antibiotics and fluids. Laboratory technologists perform necessary blood tests, and respiratory therapists may provide oxygen to patients in respiratory distress.

Prevention

The risk of developing septic shock can be minimized through treatment of underlying bacterial infections and prompt attention to signs of bacteremia. In the hospital, scrupulous **aseptic technique** on the part of medical professionals reduces the risk of introducing bacteria into the bloodstream.

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Barbara Wexler

Serum electrolyte tests see **Electrolyte tests**

Serum iron test see **Iron tests**

Serum protein electrophoresis test see **Protein electrophoresis test**

Sex hormones tests

Definition

Sex hormones tests include tests that measure levels of estrogen (estradiol and estriol), progesterone, and testosterone (total and free).

Purpose

In non-pregnant women, a test of estradiol (E2) levels is ordered to evaluate delayed sexual maturity, precocious **puberty**, menstrual problems, and **infertility**, and ovarian failure. It is also used to test for tumors in both males and females that secrete estrogen. The test is also used to measure estrogen secretion in males who present with gynecomastia and feminization in male children.

Estriol (E3), another estrogen, is only ordered for pregnant women (typically at 15–18 weeks gestation). The test is used as part of the triple marker screen (in association with alpha fetoprotein and chorionic gonadotropin) for **Down syndrome**.

A progesterone test is ordered to evaluate women for anovulation, and to investigate precocious puberty. Progesterone may be measured in those persons with ovarian or adrenal **cancer** that secrete progesterone.

The testosterone test (free testosterone and/or total testosterone) is used to evaluate delayed sexual development, male sexual precocity, testicular failure, virilism in females, infertility, and tumors that secrete testosterone.

Precautions

Both the estrogen and testosterone test are most often measured by radioimmunosassay and results can be

affected by radioactive scans. When RIA is used the estradiol or estriol tests should not be performed on a patient who has received radioactive dye within 48 hours prior to the test. For RIA testosterone tests, the period between the scan and the test should be at least seven days. Oral contraceptives may interfere with progesterone and estradiol results. Tetracycline, some phenothiazines, diazepam, clomiphene, and some **vitamins** may interfere with estradiol results.

Estradiol and progesterone results vary with the phase of the menstrual cycle, and this must be taken into account when interpreting the results of these tests.

Sex hormone tests are performed on **blood** collected by venipuncture. The nurse or phlebotomist performing the procedure should observe **universal precautions** for the prevention of transmission of bloodborne pathogens.

Description

The sex hormones control the development of primary and secondary sexual characteristics and regulate the sex-related functions of the body, such as the menstrual cycle, and the production of eggs or sperm. Because of their normally low concentration in plasma the sex hormones are typically measured by radioimmunoassay (RIA), chemiluminescence immunoassay, or fluorescent immunoassay.

Estradiol

While there have been more than 30 of these hormones identified, only estradiol (E2) is necessary to evaluate ovarian function. Estradiol is the most potent of the estrogens, but it accounts for only one-third of the total estrogen in premenopausal females. In the nonpregnant female the ovaries are responsible for almost all estradiol production. In **pregnancy**, some estradiol is also produced by the placenta. Estradiol is produced from cholesterol, androstenedione, and testosterone. In males, estradiol is mainly produced from testosterone by the testes, but a small amount is also made by the adrenal cortex.

In **menopause**, the ovaries stop producing estradiol and estrone (E1) becomes the principal estrogen. A small amount of estradiol is formed from adrenal conversion of androstenedione, but this accounts for only about 15% of total estrogens. Plasma estradiol will be low in menopause, and FSH and LH will usually be increased. The measurement of estrone is seldom needed, but may be used to investigate vaginal bleeding after menopause or when estrone secreting ectopic hormone production is suspected.

Prior to menopause, estradiol is most often measured to evaluate amenorrhea and ovarian failure. In primary ovarian failure the ovaries may either fail to develop (as in Turner syndrome) or fail to produce estrogens as a result of autoimmune, metabolic, or endocrine disease. The plasma estradiol will be low, but the plasma levels of both LH and FSH are elevated. If secondary sexual characteristics are undeveloped, and the person is of short stature, chromosomal studies may reveal Turner syndrome as the cause. Primary amenorrhea results in failure to have a menses by age 16. In addition to ovarian failure, primary amenorrhea may be caused by endometriosis, polycystic ovary syndrome, anatomic defects in the vagina or uterus, and other disorders. In secondary ovarian failure, amenorrhea may be caused by pituitary failure or prolactinoma. In the former, both plasma and urinary LH and FSH will be low. In prolactinoma, LH and FSH are low because their release is suppressed by excessive secretion of prolactin which inhibits corticotropin releasing hormone.

An increased plasma level of estrogen indicates ovarian hyperfunction which may occur as a result of an ovarian tumor such as a granulosa-thecal cell tumor or signals the presence of an ectopic estradiol-producing tumor.

Estradiol is also measured to evaluate the response of patients to progesterone challenge and to determine responsiveness to clomiphene. In a person with amenorrhea, estradiol greater than 40 pg/mL following progestin administration excludes estrogen deficiency as a cause of amenorrhea. Clomiphene blocks the hypothalamic response to estrogen and is a treatment for patients with anovulation who have adequate estrogen and normal pituitary function. Use of the drug requires demonstration that the ovaries can produce estradiol.

Estriol (E3)

Estriol (E3) is the principal estrogen produced during pregnancy. Estriol is produced by the placenta from dehydroepiandrosterone sulfate derived from the fetal **liver** and adrenals. Estriol levels are low by approximately 25% (less than 75 MOM) in Down syndrome and other trisomies. Tests on maternal plasma for alpha-fetoprotein, chorionic gonadotropin, and unconjugated estriol are performed at 15–18 weeks gestation. Measurement of unconjugated estriol (uE3) is a better reflection of fetal-derived estriol than is total estriol, and is measured by RIA. Estriol levels are also low for the gestational age in spontaneous abortions and in threatened pregnancy, but are no longer needed for the diagnosis of these conditions.

Progesterone

Progesterone in the nonpregnant female is produced mainly by the ovaries with a small fraction also made by the adrenals. Progesterone levels in plasma are very low prior to ovulation. At ovulation, the level begins to rise due to secretion by the corpus luteum. The progesterone level peaks in the middle of the luteal phase (about one week prior to the next menses). Progesterone causes thickening of the endometrium in order to prepare the ovum for implantation should it be fertilized. In the absence of fertilization, negative feedback of progesterone on the hypothalamus results in suppression of luteinizing hormone and the corpus luteum involutes causing the wall of the uterus to breakdown. If fertilization occurs, the corpus luteum and placenta produce large amounts of progesterone. The most common use of plasma progesterone measurement is to evaluate ovulation. Progesterone is often measured on days 21 and 22 of the menstrual cycle. At this point the progesterone should represent the midluteal peak and levels above 5 ng/L are considered evidence of ovulation. Lower levels indicate a disruption of the normal luteal phase of progesterone production.

Testosterone

In males testosterone is produced by the testes under the control of luteinizing hormone. It is responsible for development of the testes, secondary sexual characteristics, and spermatogenesis. Testosterone is subject to diurnal variation in response to LH and highest plasma levels occur at 6–9 A.M. Approximately 60% of plasma testosterone is bound to sex hormone binding globulin (SHBG) and almost 40% is bound to albumin. Only about 2% of the hormone is in the free form and is physiologically active. Measurement of free hormone levels is more sensitive than total hormone because small changes in SHBG concentration can increase free hormone levels. A reduction in binding of testosterone to SHBG can be caused by drugs or other steroid hormones, and will increase free hormone levels. In males, plasma testosterone is low in hypogonadism and is measured in male children with delayed or absent sexual maturation. Primary testicular failure may result from Klinefelter syndrome, testicular **infection**, injury, and other causes. In these cases the plasma testosterone is low, but the LH and FSH are increased. In secondary testicular failure, plasma testosterone, FSH, and LH are decreased. Testosterone levels are also useful for the differential diagnosis of gynecomastia. In addition to low testosterone, gynecomastia can be caused by drugs that interfere with testosterone action, or ectopic tumors that secrete estrogen or chorionic gonadotropin.

Testosterone levels may be measured in both males and females to identify tumors that secrete the hormone. Testosterone is produced by some testicular and ovarian tumors as well as some others. Overproduction of testosterone caused by testicular, adrenal, or pituitary tumors in the young male may result in precocious puberty. Overproduction in females caused by an ovarian tumor or adrenal adenoma causes virilization and hirsutism (excessive hair growth). In cases of ambiguous sex or virilization in female children, testosterone and adrenal androgens such as androstenedione may be measured. Most cases of congenital adrenal hyperplasia are caused by 21-hydroxylase deficiency which is associated with excessive androgen production. The enzyme deficiency blocks cortisol synthesis and causes intermediate steroids to accumulate that are converted to testosterone and other androgens. Androgens are most often measured by RIA or gas chromatography-mass spectroscopy (GC-MS).

Preparation

Progesterone and testosterone tests require a blood sample; it is not necessary for the patient to restrict food or fluids before the test. However, testosterone specimens should be drawn in the morning, because testosterone levels are highest in the early morning hours. For progesterone tests, the date of the patient's last menstrual cycle or week of gestation should be noted on the test request slip.

The estrogen test can be performed on blood and/or urine. It is not necessary for the patient to restrict food or fluids for either test. If a 24-hour urine test has been requested, the patient should be instructed to discard the first morning specimen, then save all urine voided during the next 24 hours. The blood sample should be placed on ice immediately after it is drawn. It is also important to note the patient's sex, age, and menstrual cycle phase on the test request slip.

Aftercare

Discomfort or bruising may occur at the puncture site. Applying pressure to the puncture site until the bleeding stops helps to reduce bruising; warm packs relieve discomfort. Some people feel dizzy or faint after blood has been drawn and should be treated accordingly.

Complications

Other than potential bruising at the puncture site, and/or dizziness, there are no complications associated with these tests.

KEY TERMS

Amenorrhea—Cessation of the menstrual cycle.

Gynecomastia—Excessive development of the male mammary glands, even to the functional state.

Hirsutism—Abnormal hairiness, especially in women.

Hypogonadism—Underactivity of the testes.

Orchiectomy—Removal of one or both testes.

Spermatogenesis—The production of sperm.

Virilism—The presence of male characteristics in women.

Results

Normal values for sex hormone tests are highly dependent upon age and sex and in females the time of the collection relative to the menstrual cycle. Ranges vary from laboratory to laboratory depending upon the method used. Representative values for some patient groups are shown below.

Estradiol: For adult women, estradiol levels range from 20–150 pg/mL during the follicular phase, 100–500 pg/mL during the mid-cycle phase, and 50–150 pg/mL during the luteal phase. Menopausal women have estradiol levels of less than 18 pg/mL. The normal range for adult males is approximately 18–75 pg/mL.

Increased levels of estrogen are found in the following conditions:

- ovarian tumor
- adrenocortical tumor
- some testicular tumors
- pregnancy

Decreased levels of estrogen are found in the following conditions:

- ovarian dysfunction
- interuterine death in pregnancy
- anorexia nervosa
- primary and secondary hypogonadism
- turner syndrome
- infantilism
- menopausal and post-menopausal symptoms
- pituitary insufficiency

- psychogenic stress

Progesterone levels for women during the follicular phase normally range from 0.1–1.5 ng/mL and 2–24 ng/mL during the luteal phase. The normal range for the mid-luteal peak is 4.5–25.5 ng/mL. For post menopause women, results fall below 1.0 ng/mL. Results for pregnant women are as follows:

- first trimester: 9–50 ng/mL
- second trimester: 18–150 ng/mL
- third trimester: 60–260 ng/mL

For men, the normal progesterone value is 0.1–0.3 ng/mL. For children, normal values run from 7–51 ng/mL.

Increased levels of progesterone are seen:

- during ovulation and pregnancy
- with certain types of ovarian cysts
- with a tumor of the ovary known as a choriocarcinoma

Decreased levels of progesterone are seen:

- in toxemia of pregnancy
- with a threatened abortion
- during placental failure
- after fetal death
- with amenorrhea
- due to gonadal dysfunction

Normal ranges for testosterone are generally 300–1,200 ng/dL for men, and 30–95 ng/dL for women. Boys between the ages of six and nine have normal values in the range of 3–30 ng/dL, while for girls of the same age the range is 2–20 ng/dL.

In men, increased levels are found in:

- sexual precocity
- adrenal hyperplasia
- testicular tumor
- hyperthyroidism
- testicular feminization

In men, decreased levels are found in:

- Klinefelter syndrome
- primary and secondary hypogonadism
- Down syndrome
- orchiectomy
- impotence
- gynecomastia

In women, increased levels of testosterone are most commonly associated with ovarian and adrenal tumors and hirsutism.

Health care team roles

Physicians order sex hormone tests and interpret the results often with the assistance of endocrinologists. A nurse or phlebotomist collect the blood samples. Testing is performed by clinical laboratory scientists/medical technologists.

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Victoria E. DeMoranville

Sexual arousal disorders see **Sexual dysfunction**

Sexual desire disorders see **Sexual dysfunction**

Sexual dysfunction

Definition

Sexual dysfunction is broadly defined as the inability to fully enjoy sexual intercourse. Specifically, sexual dysfunctions are disorders that interfere with a full sexual response cycle. These disorders make it difficult for a person to enjoy or to have sexual intercourse. While sexual dysfunction rarely threatens physical health, it can take a heavy psychological toll, bringing depression, **anxiety**, and debilitating feelings of inadequacy.

Description

Sexual dysfunction takes different forms in men and women. A dysfunction can be life-long and always present; acquired; situational; or generalized, occurring despite the situation. A man may have a sexual problem if he:

- Ejaculates before he or his partner desires.
- Does not ejaculate, or experiences delayed ejaculation.
- Is unable to have an erection sufficient for pleasurable intercourse.
- Feels **pain** during intercourse.
- Lacks or loses sexual desire.

A woman may have a sexual problem if she:

- Lacks or loses sexual desire.
- Has difficulty achieving orgasm.
- Feels anxiety during intercourse.
- Feels pain during intercourse.
- Feels vaginal or other muscles contract involuntarily before or during sex.
- Has inadequate lubrication.

The most common sexual dysfunctions in men include:

- Erectile dysfunction: an impairment of the erectile reflex. The man is unable to have or maintain an erection that is firm enough for coitus or intercourse.
- Premature ejaculation, or rapid ejaculation with minimal sexual stimulation before, on, or shortly after penetration and before the person wishes it.
- Ejaculatory incompetence: the inability to ejaculate within the vagina despite a firm erection and relatively high levels of sexual arousal.
- Retrograde ejaculation: a condition in which the bladder neck does not close off properly during orgasm so that the semen spurts backward into the bladder.

Until recently, it was presumed that women were less sexual than men. In the past two decades, traditional views of female sexuality were all but demolished, and women's sexual needs became accepted as legitimate in their own right.

Female sexual dysfunctions include:

- Sexual arousal disorder: the inhibition of the general arousal aspect of sexual response. A woman with this disorder does not lubricate, her vagina does not swell, and the muscle that surrounds the outer third of the vagina does not tighten—a series of changes that normally prepare the body for orgasm (“the orgasmic platform”). Also, in this disorder, the woman typically does not feel erotic sensations.
- Orgasmic disorder: the impairment of the orgasmic component of the female sexual response. The woman may be sexually aroused but never reach orgasm. Orgasmic capacity is less than would be reasonable for

her age, sexual experience, and the adequacy of sexual stimulation she receives.

- **Vaginismus:** a condition in which the muscles around the outer third of the vagina have involuntary spasms in response to attempts at vaginal penetration.
- **Painful intercourse:** a condition that can occur at any age. Pain can appear at the start of intercourse, midway through coital activities, at the time of orgasm, or after intercourse is completed. The pain can be felt as burning, sharp searing, or cramping; it can be external, within the vagina, or deep in the pelvic region or abdomen.

Causes and symptoms

Many factors, of both physical and psychological natures, can affect sexual response and performance. Injuries, ailments, and drugs are among the physical influences; in addition, there is increasing evidence that chemicals and other environmental pollutants depress sexual function. As for psychological factors, sexual dysfunction may have roots in traumatic events such as rape or incest, feelings of guilt, a poor self-image, depression, chronic fatigue, certain religious beliefs, or marital problems. Dysfunction is often associated with anxiety. If a man operates under the misconception that all sexual activity must lead to intercourse and to orgasm by his partner, and if the expectation is not met, he may consider the act a failure.

Men

With premature ejaculation, physical causes are rare, although the problem is sometimes linked to a neurological disorder, prostate **infection**, or urethritis. Possible psychological causes include anxiety (mainly performance anxiety), guilty feelings about sex, and ambivalence toward women. However, research has failed to show a direct link between premature ejaculation and anxiety. Rather, premature ejaculation seems more related to sexual inexperience in learning to modulate arousal.

When men experience painful intercourse, the cause is usually physical; an infection of the prostate, urethra, or testes, or an allergic reaction to spermicide or condoms. Painful erections may be caused by Peyronie's disease, fibrous plaques on the upper side of the penis that often produce a bend during erection. **Cancer** of the penis or testis and arthritis of the lower back can also cause pain.

Retrograde ejaculation occurs in men who have had prostate or urethral surgery, take medication that keeps the bladder open, or suffer from diabetes, a disease that can injure the nerves that normally close the bladder during ejaculation.

Erectile dysfunction is more likely than other dysfunctions to have a physical cause. Drugs, diabetes (the most common physical cause), **Parkinson's disease**, **multiple sclerosis**, and **spinal cord** lesions can all be causes of erectile dysfunction. When physical causes are ruled out, anxiety is the most likely psychological cause of erectile dysfunction.

Female

Dysfunctions of arousal and orgasm in women also may be physical or psychological in origin. Among the most common causes are day-to-day discord with one's partner and inadequate stimulation by the partner. Finally, sexual desire can wane as one ages, although this varies greatly from person to person.

Pain during intercourse can occur for any number of reasons, and location is sometimes a clue to the cause. Pain in the vaginal area may be due to infection, such as urethritis; also, vaginal tissues may become thinner and more sensitive during breastfeeding and after **menopause**. Deeper pain may have a pelvic source, such as endometriosis, pelvic adhesions, or uterine abnormalities. Pain can also have a psychological cause, such as fear of injury, guilt feelings about sex, fear of **pregnancy** or injury to the fetus during pregnancy, or recollection of a previous painful experience.

Vaginismus may be provoked by these psychological causes as well, or it may begin as a response to pain, and continue after the pain is gone. Both partners should understand that the vaginal contraction is an involuntary response, outside the woman's control.

Similarly, insufficient lubrication is involuntary, and may be part of a complex cycle. Low sexual response may lead to inadequate lubrication, which may lead to discomfort, and so on.

Diagnosis

In deciding when a sexual dysfunction is present, it is necessary to remember that while some people may be interested in sex at almost any time, others have low or seemingly nonexistent levels of sexual interest. Only when it is a source of personal or relationship distress, instead of voluntary choice, is it classified as a sexual dysfunction.

The first step in diagnosing a sexual dysfunction is usually discussing the problem with a health care professional, who will need to ask further questions in an attempt to differentiate among the types of sexual dysfunction. A physical exam of the genitals may be performed, and further medical tests may be ordered, including measurement of hormone levels in the **blood**. Men

may be referred to a specialist in diseases of the urinary and genital organs (urologist), and primary care physicians may refer women to a gynecologist.

In general, causes of sexual dysfunction are either physical or psychological. Physical causes often have an underlying condition that effect sexual function including:

- diabetes
- heart disease
- neurological disorders
- pelvic surgery or trauma
- alcoholism and drug abuse
- chronic disease such as kidney or **liver** failure
- side effects of medicines
- hormone imbalance
- heavy smoking

Psychological factors including the following:

- **stress** or anxiety
- insecurity about sexual performance
- relationship discord
- confusion regarding sexual orientation
- depression
- trauma in previous sexual experiences

The following agents have been associated with sexual dysfunction, so patients should speak to their doctors if they have concerns regarding: Tamoxifen, Luminal, Dilantin, Mysloine, Tegretol, Tricyclic, Anafranil, Prozac, Paxil, Inderal, Lopressor, Corgard, Blocadren, Tenormin, Cimetidine, Tagament, Thorazine, Haldol, Zyprexa, Xanax, Valium, and some progestin-dominant birth control pills. It is important to note that there may be alternate medications available that do not affect sexual function. Other agents may also be available to counteract any sexual dysfunctions experienced with these medications. Prescribed medication should not be discontinued without first speaking with a physician.

Treatment

Treatments break down into two main kinds, physical and behavioral **psychotherapy**.

In many cases, doctors or advance practice nurses may prescribe medications to treat an underlying physical cause or sexual dysfunction. Possible medical treatments include:

- Viagra (Sildenafil) is a treatment for erectile dysfunction in men.

- Papaverine and prostaglandin are used for erectile difficulties.
- MUSE (Medical Urethral System for Erection), a prostaglandin E-1 pellet which can be inserted into the urethra. In addition, Caverject and Edex are prostaglandin E-1 injection medications for erectile dysfunction.
- Surgically implanted inflatable penile prosthesis for erectile dysfunction.
- AndroGel, a topical gel for testosterone/androgen replacement in men. Testosterone injections and patches may also be used in men and women to stimulate sexual desire.
- Clomipramine, fluoxetine, as well as serotonin reuptake inhibitors such as Prozac, Zoloft, and Anafranil for premature ejaculation.
- Hormone replacement therapy for female dysfunctions.
- EROS-CTD, a clitoral therapy device approved by the FDA in May 2000 is designed to enhance lubrication and sensation in women who have arousal disorders. With a gentle suction, it increases blood flow to the clitoris and surrounding area.

New agents not yet FDA approved as of March 2001, but are expected to gain approval are:

- ICOS is an agent for treatment of erectile dysfunction that will likely receive FDA approval in 2001 or 2002.
- Uprima (apomorphine) claims to induce erection in men and arousal in women.
- Vasomax, an oral tablet, is said to facilitate an erection within 10–15 minutes. It is anticipated that Vasomax may aid women as well as men.
- Trials using Viagra in women are ongoing as of 2001.
- SS Cream is a topical agent with natural plant extracts which appears to desensitize the penis and is used to treat premature ejaculation.

In some cases, a specific technique may be used during intercourse to correct a dysfunction. One of the most common is the “squeeze technique” to prevent premature ejaculation. When a man feels that an orgasm is imminent, he withdraws from his partner. Then, the man or his partner gently squeezes the head of the penis to halt the orgasm. After 20–30 seconds, the couple may resume intercourse. The couple may do this several times before the man proceeds to ejaculation.

In cases where significant sexual dysfunction is linked to a broader emotional problem, such as depression or substance abuse, intensive psychotherapy and/or pharmaceutical intervention may be appropriate.

KEY TERMS

Ejaculatory incompetence—The inability to ejaculate within the vagina.

Erectile dysfunction—Difficulty achieving or maintaining an erect penis.

Impotence—The inability to achieve and sustain an erection suitable for intercourse.

Orgasmic disorder—The impairment of the ability to reach sexual climax.

Painful intercourse (dyspareunia)—Generally thought of as a female dysfunction but it also affects males. Pain can occur anywhere.

Premature ejaculation—Rapid ejaculation before the person wishes it, usually in less than one to two minutes after beginning intercourse.

Retrograde ejaculation—A condition in which the semen spurts backward into the bladder.

Sexual arousal disorder—The inhibition of the general arousal aspect of sexual response.

Vaginismus—Muscles around the outer third of the vagina have involuntary spasms in response to attempts at vaginal penetration, not allowing for penetration.

A variety of alternative therapies can be useful in the treatment of sexual dysfunction. Counseling or psychotherapy is highly recommended to address any emotional or mental components of the disorder. Botanical medicine, either western, Chinese, or ayurvedic, as well as nutritional supplementation, can help resolve biochemical causes of sexual dysfunction. Acupuncture and homeopathic treatment can be helpful by focusing on the energetic aspects of the disorder.

Some problems with sexual function are normal. For example, women starting a new or first relationship may feel sore or bruised after intercourse and find that an over-the-counter lubricant makes sex more pleasurable. Simple techniques, such as soaking in a warm bath, may relax a person before intercourse and improve the experience. **Yoga** and **meditation** provide needed mental and physical **relaxation** for several conditions, such as vaginismus. Relaxation therapy eases and relieves anxiety about dysfunction. Massage is extremely effective at reducing stress, especially if performed by the partner.

Prognosis

There is no single cure for sexual dysfunction, but almost all can be controlled. Most people who have a level of sexual dysfunction fare well once they get into a treatment program. For example, a high percentage of men with premature ejaculation can be successfully treated in two to three months. Furthermore, the gains made in sex therapy tend to be long-lasting rather than short-lived. Viagra produces an erection in 75% of men with erectile dysfunction. For men who are not responsive to drug treatment, studies with surgically implanted inflatable penile prosthesis claim a success rate at approximately 98%.

Health care team roles

Nursing and allied health professionals play a critical part in the diagnosis and treatment of sexual dysfunction. Sex therapy, which is ideally provided by a member of the American Association of Sexual Educators, Counselors, and Therapists (AASECT), universally emphasizes correcting sexual misinformation, the importance of improved partner communication and honesty, anxiety reduction, sensual experience and pleasure, and interpersonal tolerance and acceptance. Sex therapists believe that many sexual disorders are rooted in learned patterns and values. These are termed psychogenic. An underlying assumption of sex therapy is that relatively short-term outpatient therapy can alleviate learned patterns, restrict symptoms, and allow a greater satisfaction with sexual experiences.

Registered dietitians and nutritionists can be instrumental in giving dietary guidance and **nutrition** supplementation that may improve overall health and energy levels. Health improvements may impact general well-being and sexual function.

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- American Association for Marriage and Family Therapy. 1100 17th Street NW, 10th Floor, Washington, DC 20036-4601. (202) 452-0109.
- American Association of Sex Educators, Counselors & Therapists. P.O. Box 238, Mt. Vernon, IA 52314.
- American Foundation for Urologic Disease, Sexual Function Health Council. 1126 N. Charles Street, Baltimore, MD 21201. (410) 468-1800. <<http://www.impotence.org>>.
- National Kidney and Urologic Diseases, Information Clearinghouse. 3 Information Way, Bethesda, MD 20892-3580. <<http://www.niddk.nih.gov>>.
- Network for Excellence in Women's Sexual Health (NEW-SHE). Female Sexual Medicine Center, UCLA Medical Center. 924 Westwood Blvd., Suite 520, Los Angeles, California 90095. (310) 825-0025, Fax (310) 794-0211. <<http://www.newshe.com>>.

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Sexual pain disorders see **Sexual dysfunction**

Sexuality and disability

Definition

Sexuality is a wide term that encompasses more than just the sexual organs or secondary sexual characteristics of a human being. It includes body image, self image, gender identity, beliefs and feelings about sex, capacities for love and friendship, and social behavior as well as overt physical expression of love or sexual desire. A person's sexuality is influenced by ethical, spiritual, cultural, and moral concerns. It can also be greatly impacted by mental, emotional, or physical disabilities.

Description

Simply put, sexuality is a natural part of life, and it should be addressed with sensitivity, but as any other occupation or activity would be by a rehabilitation therapist or other health professional treating a patient. While the sexual activity of persons with disabilities has been studied by medical and mental health researchers for the last thirty years, however, the subject rarely arises in ordinary conversations between persons with disabilities and their health care providers. This silence reflects both the embarrassment that people feel in discussing sexual problems, as well as the social attitude that persons with disabilities are not fully human, that is, they do not have sexual desires.

Sexual activity is a complex set of behaviors that involves most of the systems of the body as well as the mind and emotions. Consequently, a physical or mental disability that interferes with cognition, motor skills, coordination, and/or sensory skills can affect one's sexuality and/or sexual activity. Such physical impairments as **brain and spinal cord injury**, **multiple sclerosis**, arthritis, or seizures produce muscle weakness, loss of endurance, a decreased range of motion, and back **pain**. Such developmental and cognitive disabilities as attention span deficit, **dementia**, mental retardation, and depression affect a person's ability to form healthy relationships with trustworthy sexual partners. Lastly, the damaged self-image that can result from such surgical

procedures as mastectomy or amputation can affect a person's desire to resume or maintain sexual activity.

Health professionals should note that sexuality is a concern of most people in contemporary society, not just of those with some form of disability. The widespread use of sex in advertising to sell consumer goods, the saturation of the mass media with images of physically perfect men and women, and the increased availability of pornography leave many adults confused about "normal" sexual behaviors, "normal" aspects of attractiveness to others, and "normal" levels of sexual desire. It is often helpful to reassure persons with disabilities that "normal" covers a wide range of degrees of interest in sexual relationships or sexual behaviors. Human sexuality is not a "one-size-fits-all" entity in either men or women.

Clients of occupational therapists, physical therapists, social workers, and other health professionals should understand that they can discuss sexual concerns. Clients should be reminded throughout the process of rehabilitation that the return of sexual feelings is a sign of healing and recovery. It is equally important, however, for practitioners to keep in mind that a client with a chronic stressful health problem may not consider sexual activity a high priority. That decision, too, should be respected.

Physical disabilities

SPINAL CORD INJURIES. Sexual function or dysfunction following **spinal cord** injury (SCI) depends on the severity of injury. Sensation can be affected throughout the limbs and body, affecting erectile function in men and lubrication in women. Just below half of studied men have reported they could have erections and achieve orgasm. Most women report that they still can achieve lubrication and orgasm, but sometimes in an altered manner. Males with spinal cord injuries often use their mouths more frequently to arouse and give pleasure to their partners.

STROKE AND TRAUMATIC BRAIN INJURY. Survivors of stroke are often concerned about the impact of changes in their physical appearance on their partner, since strokes often produce such symptoms as drooling or a droop on one side of the mouth. In addition, many persons who have had a stroke worry about having another stroke during sexual activity. Lastly, either emotional depression or medications can cause stroke patients to lose interest in sex. Frank discussion with the partner as well as experimentation with different positions for intercourse are often helpful. In no case, however, should a stroke patient stop taking a prescribed medication without consulting his or her physician.

Not much research exists on the sexual function following traumatic brain injury (TBI). However, sexual activity has been found to decrease following TBI. Existing studies report conflicting evidence regarding men and erectile dysfunction. While many men report no erectile dysfunction, other studies have shown that a majority of men are impotent following TBI. It is also possible, depending on the portion of the brain affected by TBI, for a person to exhibit inappropriate sexual behavior, which is also known as hypersexuality.

NEUROMUSCULAR DISORDERS. Neuromuscular disorders, such as **muscular dystrophy**, can result in underdeveloped genitalia, which in turn, can affect sexual function. Although few studies exist, most experts believe that given the physiology of neuromuscular disorders, people with these disorders still are able to become aroused, have erections, and experience orgasms.

The age at onset of the disorder determines how sexually active a person can be. A client who experiences neuromuscular disorders at an early age may never gain full physical dependence, and that subsequently could hinder sexual function. Physical disability leads to lessened socialization, which also can hinder sexual expression. It is also common for the parents of children with disabilities to never fully acknowledge sexual maturation or the possibility of normal sexual function in their children.

ARTHRITIS. Arthritis causes stiffness in the joints, fatigue, and pain. A decreased desire for sex may result from the tiredness and discomfort themselves, but it may also be a side effect of arthritis medications. Arthritis patients should be assessed for joint range of motion, inflammation and deformity, and muscle strength and flexibility. Because arthritis affects the use of the hands, masturbation can be difficult. Positioning during sex can be difficult because of the body's loss of flexibility. Low back pain is common in clients with **osteoarthritis**, and sexual activity may result in muscle spasms.

Rheumatoid arthritis causes bone erosion and may cause problems with erection. Some persons with rheumatoid arthritis have reported that the symptoms of the disorder become temporarily worse following sexual activity.

DIABETES. Many studies exist examining the effects of diabetes on sexual function and sex drive. Most experts believe that sexual desire in men is virtually unaffected by diabetes. Women, however, are reported to experience a decrease in sexual desire. Diabetic women also experience a higher rate of occurrence of vaginal infections, which results in a decrease in lubrication, discharge, odor, itching, and tenderness, all which affect sexual desire and function.

Diabetes greatly impacts **contraception**, fertility, successful gestation, and the long-term health of women. Diabetic women are less likely than nondiabetic to carry a child full term and have a live birth. There is a risk of **miscarriage**, birth defects, and complications during **childbirth**.

Mental disabilities

Cognitive or mental impairment does not preclude a person's engaging in sexual activity. For a client with mental retardation, information should be presented in simple, short terms. The Association for Retarded Citizens believes that persons with mental retardation have a fundamental right to learn about sexual functions and relationships as well as safe sex, and that they should be able to make informed decisions regarding their sexuality. The Arc, a national organization for people with mental retardation maintains that the retarded should not be involuntarily sterilized nor denied sterilization if they choose it for themselves.

Having a developmental disability does not preclude a person from ever having an appropriate sexual relationship. Although some individuals may be too impaired to have a safe and appropriate sexual relationship, there are many individuals with moderate developmental impairments who can engage in self-stimulation.

The Arc also urges that people with mental retardation be given education and support to protect them from abuse and exploitation while respecting their human dignity.

Children with disabilities

Children with disabilities should not be treated as if they are asexual beings, without sexual feelings and drives. At the same time they, like people with mental retardation, require appropriate protections against exploitation and abuse by adults. These protections are all the more necessary because of the increased emphasis on sexual activity in the mass media and the general culture.

Because masturbation and certain other behaviors that may be related to children's self-discovery are clearly inappropriate if performed in public, it is important for practitioners to point out their inappropriateness to children. Practitioners should not, however, refer to these behaviors as "bad," but rather as improper at certain times.

The elderly

In general, older adults are often regarded as "over the hill" with regard to sexual attractiveness, interest or activity, purely apart from any physical or mental dis-

abilities that may accompany the aging process. This prejudice is particularly strong in the case of postmenopausal women. The National Women's Health Information Center reports that many medical professionals are misinformed about the sexual potential of women of any age with disabilities and consequently do not encourage them to resume normal sexual activities. But many older women also reported to the agency that they do not receive adequate education on sexual function related to disability. It is important for health professionals to inform themselves about the effects of aging on sexuality in the elderly—particularly about the side effects of medications frequently prescribed for older adults—and convey an openness to discussing these matters with their clients.

Viewpoints

The Sexuality Information and Education Council of the United States (SIECUS), which takes stands on issues of sexuality believes that persons with disabilities have a right to sexuality education, sexual health care, and opportunities for sexual expression. It further states that public and private health agencies should ensure that persons with disabilities should be eligible for services dealing with sexuality and sexual function.

Professional implications

Rehabilitation should include advice about resuming sexual activity when such discussion is appropriate. It is important, however, for the practitioner to consider this issue prior to addressing it with a client. The practitioner should first analyze his or her own attitudes about sexuality, and understand that the client may want to discuss an aspect of sexuality or sexual function that the practitioner does not agree with or is uncomfortable discussing. If a practitioner plans to avoid discussion of a particular sexual issue with a client, they should be prepared to refer the client to appropriate counseling or therapy that will meet this need. The practitioner always should remain nonjudgmental with the client when discussing any sexuality issue.

Much like any other activity of daily living, sexuality should be addressed by the practitioner during the normal course of treatment. The issue can easily be raised in the context of such other everyday activities as grooming, bathing, or dressing. Sexual issues can be addressed in the context of communication and intimacy among partners rather than focusing on physical abilities or limitations. Practitioners can bring up the subject with an open-ended question asking the client if he/she has any questions regarding sexual activity. If the practitioner avoids discussion of sexuality, the client may assume that

the subject is inappropriate or that the practitioner is uncomfortable. Practitioners uneasy about the subject should at least put the issue on the table, leave it open for discussion, and give the client the option of declining to address it. It is also appropriate to allow the client to invite their spouse or partner to a treatment session dealing with sexuality.

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- The ARC of the United States. 1010 Wayne Ave., Suite 650, Silver Spring, MD 20910. (301) 565-3842. <<http://www.thearc.org>>.
- Center for Research on Women with Disabilities, Department of Physical Medicine and Rehabilitation, Baylor College of Medicine. 3440 Richmond Ave., Suite B, Houston, TX 77046. (800) 442-7693. <<http://www.bcm.edu/crowd>>.
- National Information Center for Children and Youth with Disabilities. PO Box 1492, Washington, DC, 20013. (800) 695-0285. <<http://www.nichcy.org>>.
- National Institute on Aging (NIA) Age Page: Sexuality in Later Life. NIA Information Center, P. O. Box 8057, Gaithersburg, MD 20898. (800) 222-2225. TTY: (800) 222-4225.
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Sexuality Information and Education Council of the United States (SIECUS). 1638 R Street, Suite 220, Washington, DC 20009. (202) 265-2405. <<http://www.siecus.org>>.

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Sexually transmitted diseases cultures

Definition

Sexually transmitted diseases are infections spread from person to person through sexual contact. A culture is a test in which a laboratory attempts to grow and identify the microorganism causing an **infection**. Laboratory culture is performed to isolate and identify the causes of several sexually transmitted infections.

Purpose

Sexually transmitted diseases (STDs) produce symptoms such as genital discharge, **pain** during urination, bleeding, pelvic pain, skin ulcers, or urethritis. Often, however, they produce no immediate symptoms. Therefore, the decision to test for these diseases must be based not only on the presence of symptoms, but on whether or not a person is at risk of having one or more of the diseases. Activities such as drug use and sex with more than one partner put a person at high risk for these diseases. STD cultures are necessary to diagnose certain types of STDs. Only after the infection is diagnosed can it be treated and further spread of the infection prevented. Left untreated, consequences of these diseases range from discomfort to **infertility** to death. In addition, these diseases in a pregnant woman can be passed from mother to fetus.

Precautions

Some infections, particularly gonorrhea, can be difficult to culture. It may be necessary to culture other sites which may be infected, such as the anus and mouth if the patient has corresponding sexual habits which may put them at risk. Also, health care workers should be aware that testing of anyone who mentions a sexual assault must be done very carefully, following a protocol which is usually best carried out in the emergency room. The physician, nurse, or physician assistant performing sample collection should observe **universal precautions** for the prevention of transmission of bloodborne pathogens.

Description

Gonorrhea, bacterial vaginosis, candidiasis, chancroid, chlamydiosis, herpes, and mycoplasma are common sexually transmitted diseases that can be cultured. The organisms which cause the first three conditions are cultured routinely while those that cause the last four are more difficult to grow and are more frequently identified immunologically or by DNA amplification. **Syphilis**, human **immunodeficiency** virus, and trichomoniasis are sexually transmitted diseases that usually are not cultured because they do not grow on artificial culture medium.

The female patient will be in the dorsal lithotomy position (lying on the back with legs raised and bent) typical for Pap testing. A speculum is moistened with warm water (no lubricant should be used) and inserted into the vagina to secure good visualization of the cervix. Any excess cervical mucous should be removed with a cotton ball (held by ring forceps). A sterile swab is inserted just inside the opening of the cervix (the os) and rotated gently for 30 seconds. Genital swabs are usually placed in a transport medium that contains charcoal to absorb toxins that inhibit the growth of gonococcus.

Care should be taken not to touch the vaginal surfaces with the swab in order to avoid the transfer of normal vaginal flora. For culture, the sample is placed in Stuart or Amies transport medium with charcoal added and delivered to the laboratory at room temperature. Since *Neisseria gonorrhoeae* are very sensitive to drying and temperature changes, plating is performed as soon as possible. For DNA probe or immunological testing (in which organisms are not cultured), the swab is broken off at the top of the sterile tube provided, and the tube is capped and sent to the laboratory. For immediate viewing, a swab sample may be placed in normal saline. One drop can then be placed between a slide and coverslip, and viewed beneath the **microscope**. This is called a “wet prep.” A wet prep is useful for diagnosing yeast infection and trichomoniasis. Pelvic inflammatory disease samples and samples from genital lesions such as chancres are collected by aspiration. Plating for *H. ducreyi* should be done from the chancre aspirate and performed immediately because the organism is fastidious.

In the male patient, a smaller sterile swab is used to remove cells and any discharge from the last 0.75 in (2 cm) of the urethra, and the swab is transported for culture (or DNA probe or immunological testing) as described for the female patient. If visible discharge is present on the surface of the penis, this should be swabbed, and it is unnecessary to enter the urethra. For anal specimens the physician inserts a sterile, cotton-tipped swab about 1 in (2.5 cm) into the anus and rotates the swab for 30 seconds. Stool must not contaminate the swab. For orophar-

ynx (throat) specimens the person’s tongue is held down with a tongue depressor, as a healthcare worker moves a sterile, cotton-tipped swab across the back of the throat and tonsillar region.

Gonorrhea

Neisseria gonorrhoeae, also called gonococcus or GC, causes gonorrhea. It infects the mucosal surfaces of the genitourinary tract, primarily the urethra in males and the cervix in females. When seen on **Gram stain**, *Neisseria gonorrhoeae* are gram-negative diplococci (pairs of round or bean-shaped **bacteria**) often located inside white **blood** cells. The best specimen from which to culture *Neisseria gonorrhoeae* is a swab of the urethra in a male or the cervix in a female. Other possible specimens include the mouth, anus, or a swab of a genital lesion. All swabs are plated on modified Thayer-Martin (MTM) agar or New York City (NYC) agar. These media are selective for the growth of *N. gonorrhoeae*. MTM is chocolate agar (heated sheep blood agar) containing colistin to inhibit the growth of gram negative bacilli, nystatin or anisomycin to inhibit yeast, vancomycin to inhibit growth of gram-positive bacteria, and trimethoprim to inhibit *Proteus spp.* NYC agar contains amphotericin B instead of nystatin and consists of clear proteose-peptone supplemented agar. In addition, the sample is plated on either 5% sheep blood agar or Columbia agar with 5% sheep blood and colistin and nalidixic acid (CNA) to isolate *Candida albicans* which causes a yeast infection in the vagina and *Gardnerella vaginalis* which causes vaginosis as well. Plates are incubated at 96.8°F (36°C) in 5–10% carbon dioxide. MTM or NYC agar are examined for growth at 24 hours and if negative again at 48 hours. After 24 hours, any suspicious colonies are Gram-stained and tested for oxidase which provides presumptive identification of *Neisseria* if positive. The physician can be notified at this point by a preliminary report that gonococcus has been identified presumptively. Further biochemical testing may be performed to differentiate *N. gonorrhoeae* from *N. meningitides* which is sometimes isolated from homosexual males. Isolated colonies should also be tested for penicillin resistance. Plates may be discarded at 48 hours if no growth is seen. Rapid non-culture DNA amplification and enzyme **immunoassay tests** are available to test for *Neisseria gonorrhoeae* and provide results on the same day.

Microscopic analysis should always be included with **genital culture**. Wet preparations can identify yeast, *Trichomonas vaginalis*, and *G. vaginalis*. The latter can be seen as rods attached to large squamous epithelial cells called “clue cells.” A Gram stain of the swab material can identify gram-negative diplococci which is presumptive evidence of gonococcal infection. In males,

a positive finding on the Gram stain obviates the need for culture and the patient can begin antibiotic treatment. In females, the diplococci must be located intracellularly in order to make a presumptive diagnosis of gonorrhea infection, and culture must be performed to confirm the diagnosis. The presence of clue cells, epithelial cells containing gram-negative or gram-variable coccobacilli, can signal the presence of *Gardnerella vaginalis*.

Chancroid

Chancroid is caused by *Haemophilus ducreyi*. It is characterized by genital ulcers with nearby swollen lymph nodes. The specimen is collected by swabbing one of these pus-filled ulcers. The Gram stain cannot differentiate *Haemophilus ducreyi* from other *Haemophilus* species. The physician must request a specific culture for a person who has symptoms of chancroid. Even using special culture, *Haemophilus ducreyi* is isolated from less than 80% of the ulcers it infects. If a culture is negative, the physician must diagnose chancroid based on the person's symptoms, and by ruling out other possible causes of these symptoms, such as syphilis (which is diagnosed by a blood test for antibodies).

H. ducreyi is fastidious and culture media should be inoculated within 10 minutes of sample collection. The swab should be spread over a chocolate (heated sheep blood agar) plate and incubated at 96.8°F (36°C) in 5–10% carbon dioxide. Isolated colonies are Gram-stained to identify the bacteria as small gram-negative bacilli, and a colony is transferred to trypticase soy broth and a suspension is made. This is plated onto Mueller-Hinton or trypticase soy agar and strips of factor X (hemin) and factor V (NAD) are applied. *Haemophilus ducreyi* requires X factor but not V factor for growth. Like other *Haemophilus* species the organism is oxidase positive and reduces nitrate. Unlike most other *Haemophilus* species it does not produce catalase and does not ferment glucose, and these tests can be used for positive identification.

Mycoplasma and Ureaplasma

Three types of mycoplasmal organisms cause sexually transmitted disease: *Mycoplasma hominis*, *Mycoplasma genitalium*, and *Ureaplasma urealyticum*. *M. hominis* causes pelvic inflammatory disease (PID) and pyelonephritis in females but does not cause urethritis, vaginitis, or cervicitis. *Ureaplasma urealyticum* can cause urethritis in males and may cause PID in females but does not cause vaginitis or cervicitis. *M. genitalium* has been implicated as a cause of urethritis and PID. Samples are collected from the cervix in a female, and from the urethra (or urine) in a male. Swabs must be immediately placed in sucrose-phosphate or other

acceptable transport medium and transported to the lab immediately. These organisms will grow on New York City agar and *M. hominis* will also grow on CNA plates, but swabs should be inoculated onto a selective agar or broth such as SP-4 which differentiates *Mycoplasma* from *Ureaplasma* based upon the ability of the latter to hydrolyze urea. Cultures are incubated aerobically at 96.8°F (36°C) and grow for two to four days. Colonies are very small and difficult to see with the unaided eye. When growth is seen, a portion of the agar is removed and stained with Dienes stain. The colonies are examined under a microscope for their characteristic fried egg appearance. They will have a dark blue center and light blue periphery. These organisms cannot be seen with the Gram stain.

Chlamydiosis

Chlamydiosis is caused by the gram-negative bacterium *Chlamydia trachomatis*. It is one of the most common STDs in the United States (approximately three million cases occur each year), and generally appears in sexually active adolescents and young adults. While chlamydiosis often does not have any initial symptoms, it can if left untreated lead to pelvic inflammatory disease and sterility. Samples are collected from one or more of these infection sites: cervix in a female, urethra in a male, or the rectum. Swabs must be immediately placed in sucrose-phosphate or other acceptable transport medium and transported to the lab immediately. Culture is successful in recovering *Chlamydia trachomatis* about 80% of the time. The organism is inoculated onto monolayers of malignant tissue culture cells such as HeLa cells or McCoy cells in shell vials. The cultures are incubated for two to three days at 96.8°F (36°C) in 5–10% carbon dioxide. Following this they are stained with fluorescent-labeled monoclonal antibodies to the major outer membrane protein (MOMP) to identify the characteristic chlamydial inclusions. This technique is expensive and requires a high level of tissue culture expertise. Consequently most labs use non-culture tests such as enzyme immunoassay or DNA amplification methods to diagnose chlamydial infections.

Genital herpes

Herpes is generally diagnosed based on the patient's symptoms and the physical exam. Approximately two-thirds of **genital herpes** is caused by herpes simplex 2 (HSV-2) and the remainder by herpes simplex 1 (HSV-1). Extremely painful blisters around the genital area are classic for initial herpes presentation. However, if questions remain, the herpes virus can be cultured from a vesicle (blister) which has been "unroofed" carefully with a scalpel blade. The base of the vesicle is swabbed

with a sterile cotton applicator, and the virus taken to the laboratory in a tube of viral transport medium. Herpes can be cultured in several cell lines including human diploid fibroblasts (HDF), HEp2 cells (epithelial cancer cells from the larynx), primary monkey kidney cells (PMK), and rabbit kidney cells (RK). Cell cultures are inoculated and allowed to grow for one to three days at 98.6°F (36°C) in 5–10% carbon dioxide. Usually by the end of the first day of culture the cytopathic effect (CPE) can be seen by observing the cells under a microscope. Herpes induces the formation of giant cells.

Antibiotic susceptibility testing

Antibiotic susceptibility is not usually required for organisms isolated from a genital culture. Gonorrhea is treated with penicillin or related drugs. Chlamydiosis and mycoplasmal infections are treated with erythromycin. Herpes is treated with acyclovir or related antivirals. Candida is treated with clotrimazole or other antifungal. Bacterial vaginosis is treated with metronidazole, *Haemophilus ducryi* is treated with ceftriaxone or erythromycin.

Preparation

Cultures should always be collected before the person begins taking **antibiotics**. Men should not urinate within one hour before collection of a urethral specimen. Women should not douche or take a bath within 24 hours of collection of a cervical or vaginal culture.

Aftercare

Patients should be instructed to have no sexual contacts until test results are reported.

Complications

The minor discomforts of genital testing are short lived, and no significant complications are common.

Results

With the exception of *Mycoplasma* and *Ureaplasma*, these microorganisms are not found under normal conditions, so tests should be negative. *M. hominis* can be found in the male urethra and *Ureaplasma urealyticum* can be found in the female genital tract in the absence of disease. Therefore positive cultures for these organisms may indicate colonization without infection and the physician must differentiate these conditions on the basis of the **physical examination** and symptoms. Therefore, these organisms are treated at the discretion of the physician. If a person has a positive culture for any other of

these microorganisms, antibiotic treatment is started and his or her sexual partners should be notified and tested. After treatment is completed, the physician may request a follow-up culture to confirm that the infection is cured.

Health care team roles

Genital cultures are ordered by a physician and collected by a physician, nurse, or physician assistant. Culture, microscopic analysis, immunoassay, and DNA testing are performed by clinical laboratory scientists/medical technologists. Wet preparations may also be performed by the physician or physician assistant or nurse practitioner with appropriate training. Nursing staff have a very important task in educating the patient in what to expect, assisting with obtaining samples, and helping to explain test results to patients. Many patients undergoing genital testing are in need of counseling regarding the risks of careless sexual behavior, and the opportunity should be used by staff for education to reduce risks in the future.

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Erika J. Norris

Shiatsu

Definition

Shiatsu is a manipulative therapy developed in Japan and incorporating techniques of *anna* (Japanese traditional massage), **acupressure**, stretching, and Western massage. Shiatsu involves applying pressure to special points or areas on the body in order to maintain physical

and mental well being, treat disease, or alleviate discomfort. This therapy is considered holistic because it attempts to treat the whole person instead of a specific medical complaint. All types of acupressure generally focus on the same pressure points and so-called energy pathways, but may differ in terms of massage technique. Shiatsu, which can be translated as finger pressure, has been described as needle-free acupuncture.

Origins

Shiatsu is an offshoot of anma that developed during the period after the Meiji Restoration in 1868. Traditional massage (anma) used during the age of shoguns was being criticized, and practitioners of *koho anma* (ancient way) displeased with it introduced new practices and new names for their therapies.

During the twentieth century, shiatsu distinguished itself from anma through the merging of Western knowledge of anatomy, *koho anma*, *ampuku* (abdominal massage), acupressure, *Do-In* (breathing practices), and Buddhism. Based on the work of Tamai Tempaku, shiatsu established itself in Japan and worldwide. The Shiatsu Therapists Association was found in 1925 and clinics and schools followed. Students of Tempaku began teaching their own brand of shiatsu, creating branch disciplines. By 1955, the Japanese Ministry of Health and Welfare acknowledged shiatsu as a beneficial treatment and licensing was established for practitioners.

Benefits

Shiatsu has a strong reputation for reducing **stress** and relieving nausea and vomiting. Shiatsu is also believed to improve circulation and boost the **immune system**. Some people use it to treat **diarrhea**, indigestion, constipation, and other disorders of the gastrointestinal tract; menstrual and menopausal problems; chronic **pain**; migraine; arthritis; toothache; **anxiety**; and depression. Shiatsu can be used to relieve muscular pain or tension, especially neck and back pain. It also appears to have sedative effects and may alleviate insomnia. In a broader sense, shiatsu is believed to enhance physical vitality and emotional well being.

Description

Shiatsu and other forms of Japanese acupressure are based on the concept of *ki*, the Japanese term for the all-pervading energy that flows through everything in the universe. (This notion is borrowed from the Chinese, who refer to the omnipresent energy as *qi* or *chi*.) *Ki* tends to flow through the body along special energy pathways called meridians, each of which is associated with

a vital organ. In Asian systems of traditional medicine, diseases are often believed to occur due to disruptions in the flow this energy through the body. These disruptions may stem from emotional factors, climate, or a host of other causes including stress, the presence of impurities in the body, and physical trauma.

The aim of shiatsu is to restore the proper flow of bodily energy by massaging the surface of the skin along the meridian lines. Pressure may also be applied to any of the 600 or so acupoints. Acupoints, which are supposedly located just under the skin along the meridians, are tiny energy structures that affect the flow of *ki* through the body. When *ki* either stagnates and becomes deflected or accumulates in excess along one of these channels, stimulation to the acupoints, which are sensitive to pressure, can unblock and regulate the *ki* flow through toning or sedating treatment.

Western medicine hasn't proven the existence of meridians and acupoints. However, in one study, two French medical doctors conducted an experiment at Necher Hospital in Paris to test validity of theory that energy is being transported along acupuncture meridians. They injected and traced isotopes with gamma-camera imaging. The meridians may actually correspond to nerve transmission lines. In this view, shiatsu and other forms of healing massage may trigger the emission of naturally occurring chemicals called neurotransmitters. Release of these chemical messengers may be responsible for some of the therapeutic effects associated with shiatsu, such as pain relief.

Preparations

People usually receive shiatsu therapy while lying on a floor mat or massage table or sitting up. The massage is performed through the clothing—preferably a thin garment made from natural fibers—and disrobing is not required. Pressure is often applied using the thumbs, though various other parts of the body may be employed, including fingertips, palms, knuckles, elbows, and knees—some therapists even use their feet. Shiatsu typically consists of sustained pressure (lasting up to 10 seconds at a time), squeezing, and stretching exercises. It may also involve gentle holding as well as rocking motions. A treatment session lasts anywhere from 30 to 90 minutes.

Before shiatsu treatment begins, the therapist usually performs a general health assessment. This involves taking a family medical history and discussing the physical and emotional health of the person seeking therapy. Typically, the practitioner also conducts a diagnostic



A woman receiving a shiatsu treatment on her shoulder. (Photo Researchers, Inc. Reproduced by permission.)

examination by palpating the abdomen or back for any energy imbalances present in other parts of the body.

Precautions

While shiatsu is generally considered safe, there are a few precautions to consider. Because it may increase **blood** flow, this type of therapy is not recommended in people with bleeding problems, **heart** disease, or **cancer**. **Massage therapy** should always be used with caution in those with **osteoporosis**, fresh **wounds** or scar tissue, bone **fractures**, or inflammation.

Applying pressure to areas of the head is not recommended in people with epilepsy or high **blood pressure**, according to some practitioners of shiatsu.

Shiatsu is not considered effective in the treatment of **fever**, **burns**, and infectious diseases.

Shiatsu should not be performed right after a meal.

Side effects

When performed properly, shiatsu is not associated with any significant side effects. Some people may expe-

rience mild discomfort, which usually disappears during the course of the treatment session.

Research and general acceptance

Like many forms of massage, shiatsu is widely believed to have a relaxing effect on the body. There is also a significant amount of research suggesting that acupressure techniques can relieve nausea and vomiting associated with a variety of causes, including **pregnancy** and anesthetics and other drugs. In one study, published in the *Journal Of Nurse-Midwifery* in 1989, acupressure was shown to significantly reduce the effects of nausea in 12 of 16 women suffering from morning sickness. Five days of this therapy also appeared to reduce anxiety and improve mood. Another investigation, published in the *British Journal Of Anaesthesia* in 1999, studied the effects of acupressure on nausea resulting from the use of anesthetics. Pressure applied to an acupoint on the inside of the wrist appeared to alleviate nausea in patients who received anesthetics during the course of laparoscopic surgery.

Shiatsu may also produce sedative and analgesic effects. The sedative powers of acupressure were investigated in a study published in the *Journals of Gerontology*

KEY TERMS

Acupressure—An ancient form of Asian healing massage that involves applying pressure to special points or areas on the body in order to maintain good health, cure disease, and restore vitality.

Analgesic—Pain reliever.

Osteoporosis—A disease of the bones due to deficiency of bone matrix, occurring most frequently in postmenopausal women.

Palpate—Feel.

in 1999, which involved over 80 elderly people who suffered from sleeping difficulties. Compared to the people in the control groups, the 28 participants who received acupressure were able to sleep better. They slept for longer periods of time and were less likely to wake up during the night. The researchers concluded that acupressure may improve the quality of sleep in older adults. The use of acupressure in postoperative pain was investigated in a study published in the *Clinical Journal Of Pain* in 1996. In this study, which involved 40 knee surgery patients, one group received acupressure (15 acupoints were stimulated) while the control group received sham acupressure. Within an hour of treatment, members of the acupressure group reported less pain than those in the control group. The pain-relieving effects associated with acupressure lasted for 24 hours.

Shiatsu may benefit stroke victims. The results of at least one study (which did not include a control group) suggest that shiatsu may be useful during stroke rehabilitation when combined with other treatments.

Training and certification

A qualified shiatsu therapist must have completed courses in this form of therapy and should be nationally certified or licensed by the state (most are certified by the American Oriental Bodywork Therapy Association). Asking a medical doctor for a recommendation is a great place to start. It can also be helpful to consult friends and family members who have tried shiatsu. There are several massage-related organizations that offer information on locating a qualified therapist. These include the National Certification Board for Therapeutic Massage and Bodywork, the American Massage Therapy Association, the International School of Shiatsu, and the American Oriental Bodywork Therapy Association.

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American Massage Therapy Association. 820 Davis Street, Suite 100, Evanston, IL.

American Oriental Bodywork Therapy Association. 50 Maple Place, Manhasset, NY 11030.

International School of Shiatsu. 10 South Clinton Street, Doylestown, PA 18901.

National Certification Board for Therapeutic Massage and Bodywork. 8201 Greensboro Drive, Suite 300, McLean, VA 22102.

OTHER

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Greg Annussek

Shock

Definition

Shock occurs when the body's organs and tissues do not receive an adequate flow of **blood**. Inadequate blood flow deprives the organs and tissues of oxygen and allows the buildup of waste products. Shock is a medical emergency and can result in serious damage or even death.

Description

There are three stages of shock: Stage I (also called compensated, or nonprogressive), Stage II (also called decompensated or progressive), and Stage III (also called irreversible).

In Stage I of shock, when low blood flow (perfusion) is first detected, a number of systems are activated in order to maintain or restore perfusion. The result is that the **heart** beats faster, the **blood vessels** throughout the body become slightly smaller in diameter, and the kidney works to retain fluid in the circulatory system. All this serves to maximize blood flow to the most important organs and systems in the body. A person in this stage of shock has very few symptoms, and treatment can completely halt any progression.

In Stage II of shock, the body's standard methods of compensation begin to fail and are unable to improve perfusion any longer. Oxygen deprivation in the **brain** causes the person to become confused and disoriented, while oxygen deprivation in the heart may cause chest **pain**. With quick and appropriate treatment, this stage of shock can be reversed.

In Stage III of shock, the length of time that poor perfusion has existed begins to take a permanent toll on the body's organs and tissues. The heart's functioning continues to spiral downward, and the **kidneys** usually shut down completely. Cells in organs and tissues throughout the body are injured and dying. The endpoint of Stage III shock is death.

Causes and symptoms

Shock is caused by three major categories of problems: cardiogenic (problems associated with the heart's functioning); hypovolemic (total volume of blood available to circulate is low); and **septic shock** (overwhelming **infection**, usually by **bacteria**).

Cardiogenic shock can be caused by any disease or event which prevents the heart muscle from pumping strongly and consistently enough to circulate the blood in a normal fashion. Heart attack, conditions which cause inflammation of the heart muscle (myocarditis), disturbances of the electrical rhythm of the heart, and any kind of mass or fluid accumulation or blood clot which interferes with flow out of the heart can significantly affect the heart's ability to pump a normal quantity of blood.

Hypovolemic shock occurs when the total volume of blood in the body falls well below normal. This can occur when there is excess fluid loss, as in **dehydration** due to severe vomiting or **diarrhea**, diseases which cause excess urination (diabetes insipidus, **diabetes mellitus**,

and kidney failure), extensive **burns**, blockage in the intestine, inflammation of the **pancreas (pancreatitis)**, or severe bleeding of any kind.

Septic shock can occur when an untreated or inadequately treated infection (usually bacterial) is allowed to progress. Bacteria often produce poisonous chemicals (toxins) which can cause injury throughout the body. When large quantities of these bacteria and their toxins begin circulating in the bloodstream, every organ and tissue is at risk of their damaging effects. The most damaging consequences include poor functioning of the heart muscle; widening of the diameter of the blood vessels; a drop in **blood pressure**; activation of the blood clotting system, causing blood clots, followed by a risk of uncontrollable bleeding; damage to the **lungs**, causing acute **respiratory distress syndrome**; **liver** failure; kidney failure; and **coma**.

Initial symptoms of shock include cold, clammy hands and feet; pale or blue-tinged skin tone; weak, fast pulse rate; fast rate of breathing; low blood pressure. A variety of other symptoms may be present, but they are dependent on the underlying cause of shock.

Diagnosis

Diagnosis of shock is based on a person's symptoms, as well as criteria including a significant drop in blood pressure, extremely low urine output, and blood tests that reveal overly acidic blood with a low circulating concentration of carbon dioxide. Other tests are performed, as appropriate, to try to determine the underlying condition responsible for an individual's state of shock.

Treatment

The most important goals in treating shock include quickly diagnosing a person's state of shock; quickly intervening to halt the underlying condition (stopping bleeding, re-starting the heart, giving **antibiotics** to combat an infection, etc.); treating the effects of shock (low oxygen, increased acid in the blood, activation of the blood clotting system); and supporting vital functions (blood pressure, urine flow, heart function).

Treatment includes keeping a person warm, with legs raised and head down to improve blood flow to the brain, putting a needle in a vein in order to give fluids or blood transfusions, as necessary; giving a person extra oxygen to breathe and medications to improve the heart's functioning; and treating the underlying condition which led to shock.

KEY TERMS

Cardiogenic—Originating with the heart.

Deprivation—A condition of having too little of something.

Hypovolemic—Having a low volume.

Perfusion—Blood flow through an organ or tissue.

Sepsis—An overwhelming infection throughout the body, usually caused by bacteria in the bloodstream.

Prognosis

The prognosis of an individual in shock depends on the stage of shock when treatment was begun, the underlying condition causing shock, and the general medical state of the person.

Health care team roles

First aid is often given by appropriately trained individuals. Physicians supervise the treatment of shock in a hospital setting. Nurses provide bedside management and patient-family education.

Prevention

The most preventable type of shock is caused by dehydration during illnesses with severe vomiting or diarrhea. Shock can be avoided by recognizing that a person who is unable to drink in order to replace lost fluids needs to be given fluids intravenously (through a needle in a vein). Other types of shock are only preventable insofar as one can prevent their underlying conditions or can monitor and manage those conditions well enough so that they never progress to the point of shock.

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L. Fleming Fallon, Jr., MD, DrPH

Sickle cell disease

Definition

Sickle cell disease describes a group of inherited **blood** disorders characterized by chronic anemia, painful events, and various complications due to associated tissue and organ damage.

Description

The most common and well-known type of sickle cell disease is sickle cell anemia, also called SS disease. All types of sickle cell disease are caused by a genetic change in hemoglobin, the oxygen-carrying protein inside the red blood cells. The red blood cells of affected individuals contain a predominance of a structural variant of the usual adult hemoglobin. This variant hemoglobin, called sickle hemoglobin, has a tendency to polymerize into rod-like structures that alter the shape of the usually flexible red blood cells. The cells take on a shape that resembles the curved blade of a sickle, an agricultural tool. Sickle cells have a shorter life span than normally-shaped red blood cells. This results in chronic anemia characterized by low levels of hemoglobin and decreased numbers of red blood cells. Sickle cells are also less flexible and more sticky than normal red blood cells and can become trapped in small **blood vessels** preventing blood flow. This compromises the delivery of oxygen, which can result in **pain** and damage to associated tissues and organs. Sickle cell disease presents with marked variability, even within families.

Demographics

Carriers of the sickle cell gene are said to have sickle cell trait. Unlike sickle cell disease, sickle cell trait does not cause health problems. In fact, sickle cell trait is protective against **malaria**, a disease caused by blood-borne parasites transmitted through mosquito bites. According to a widely accepted theory, the genetic mutation associated with the sickle cell trait occurred thousands of years ago. Coincidentally, this mutation increased the likelihood that carriers would survive malaria **infection**. Survivors then passed the mutation on to their offspring, and the trait became established throughout areas where malaria was common. As populations migrated, so did the sickle cell trait. Today, approximately one in 12 African Americans has sickle cell trait.

Worldwide, it has been estimated that one in every 250,000 babies is born with sickle cell disease. Sickle cell disease primarily affects people with African, Mediterranean, Middle Eastern, and Asian Indian ances-

try. In the United States, sickle cell disease is most often seen in African Americans, in whom the disease occurs in one out of every 400 births. The disease has been described in individuals from several different ethnic backgrounds and is also seen with increased frequency in Latino Americans, particularly those of Caribbean, Central American, and South American ancestry. Approximately one in every 1,000–1,400 Latino births are affected.

Genetic profile

Humans normally make several types of the oxygen-carrying protein hemoglobin. An individual's stage in development determines whether primarily embryonic, fetal, or adult hemoglobins will be made. All types of hemoglobin are made of three components: heme, alpha (or alpha-like) globin, and beta (or beta-like) globin. Sickle hemoglobin is the result of a genetic change in the beta globin component of normal adult hemoglobin. The beta globin gene is located on chromosome 11. The sickle cell form of the beta globin gene results from the substitution of a single DNA nucleotide, or genetic building-block. The change from adenine to thymine at codon (position) 6 of the beta globin gene leads to insertion of the amino acid valine instead of glutamic acid at this same position in the beta globin protein. As a result of this change, sickle hemoglobin has unique properties in comparison to the usual type of adult hemoglobin.

Most individuals have two normal copies of the beta globin gene, which make normal beta globin that is incorporated into adult hemoglobin. Individuals who have sickle cell trait (called sickle cell carriers) have one normal beta globin gene and one sickle cell gene. These individuals make both the usual adult hemoglobin and sickle hemoglobin in roughly equal proportions, so they do not experience any health problems as a result of having the trait. Although traces of blood in the urine and difficulty in concentrating the urine can occur, neither represents a significant health problem due to sickle cell trait. Of the millions of people with sickle cell trait worldwide, a small handful of individuals have experienced acute symptoms. In these very rare cases, individuals were subject to very severe physical strain.

When both members of a couple are carriers of sickle cell trait, there is a 25% chance in each **pregnancy** for their baby to inherit two sickle cell genes and have sickle cell anemia, or SS disease. Correspondingly, there is a 50% chance their baby will have sickle cell trait and a 25% chance that the baby will have the usual type of hemoglobin. Other types of sickle cell disease include SC disease, SD disease, and S/beta thalassemia. These conditions are caused by the co-inheritance of the sickle cell

gene and another altered beta globin gene. For example, one parent may have sickle cell trait and the other parent may have hemoglobin C trait (another hemoglobin trait that does not cause health problems). For such a couple, there would be a 25% chance of SC disease in each pregnancy.

Causes and symptoms

Normal adult hemoglobin transports oxygen from the **lungs** to tissues throughout the body. Sickle hemoglobin can also transport oxygen. However, once the oxygen is released, sickle hemoglobin tends to polymerize (line-up) into rigid rods that alter the shape of the red blood cell. Sickling of the red blood cell can be triggered by low oxygen, such as occurs in organs with slow blood flow. It can also be triggered by cold temperatures and **dehydration**.

Sickle cells have a decreased life span in comparison to normal red blood cells. Normal red blood cells survive for approximately 120 days in the bloodstream; sickle cells last only 10–12 days. As a result, the bloodstream is chronically short of red blood cells and hemoglobin, and an affected individual develops anemia.

The sickle cells can create other complications. Due to their shape, they do not fit well through small blood vessels. As an aggravating factor, the outside surfaces of sickle cells may have altered chemical properties that increases their stickiness. These sticky sickle cells are more likely to adhere to the inside surfaces of small blood vessels, as well as to other blood cells. As a result of the sickle cells' shape and stickiness, blockages form in small blood vessels. Such blockages prevent oxygenated blood from reaching areas where it is needed, causing pain, as well as organ and tissue damage.

The severity of symptoms cannot be predicted based solely on the genetic inheritance. Some individuals with sickle cell disease may develop problems in infancy that affect their health or be life-threatening. Others may experience only mild symptoms throughout their lives. Individuals may experience varying degrees of health at different stages in the life cycle. For the most part, this clinical variability is unpredictable, and the reasons for the observed variability can not usually be determined. However, certain types of sickle cell disease (i.e., SC disease) tend to result in fewer and less severe symptoms on average than other types of sickle cell disease (i.e., SS disease). Some additional modifying factors are known. For example, elevated levels of fetal hemoglobin in a child or adult can decrease the quantity and severity of some symptoms and complications. Fetal hemoglobin is a normally occurring hemoglobin that usually decreases from over 90% of the total hemoglobin to under 1% dur-

ing the first year of life. This change is genetically determined, although some individuals may experience elevated levels of fetal hemoglobin due to variation in the genes that control fetal hemoglobin production. Such individuals often experience a reduction in their symptoms and complications due to the ability of fetal hemoglobin to prevent the polymerization of sickle hemoglobin, which leads to sickling of the red blood cell.

There are several symptoms that warrant immediate medical attention, including the following:

- signs of infection (**fever** above 101°F or 38.3°C, coughs frequently or breathing trouble, unusual crankiness, feeding difficulties)
- signs of severe anemia (pale skin or lips, yellowing of the skin or eyes, very tired, very weak)
- signs indicating possible dehydration (vomiting, **diarrhea**, fewer wet diapers)
- other signs (pain or swelling in the abdomen, swollen hands or feet, screams when touched)

The following can be signs of various complications that occur in sickle cell disease.

Infections and effects on the spleen

Children with sickle cell disease who are under age three are particularly prone to life-threatening bacterial infections. *Streptococcus pneumoniae* is the most common offending **bacteria**, and invasive infection from this organism leads to death in 15% of cases. The spleen, an organ that helps to fight bacterial infections, is particularly vulnerable to the effects of sickling. Sickle cells can impede blood flow through the spleen, causing organ damage, which usually results in the loss of spleen function by late childhood. The spleen can also become enlarged due to blockages and/or increased activity of the spleen. Rapid enlargement of the spleen may be a sign of another complication called splenic sequestration, which occurs mostly in young children and can be life-threatening. Widespread sickling in the spleen prevents adequate blood flow from the organ, removing increasing volumes of blood from the circulation and leading to accompanying signs of severe anemia.

Painful events

Painful events, also known as vaso-occlusive events, are a hallmark symptom of sickle cell disease. The frequency and duration of the pain can vary tremendously from person to person and over an individual's life cycle. Painful events are the most common cause of hospitalizations in sickle cell disease. However, only a small proportion of individuals with sickle cell disease experience frequent and severe painful events. Most painful events

can be managed at home. Pain results when small blood vessel blockages prevent oxygen from reaching tissues. Pain can affect any area of the body, although the extremities, chest, abdomen, and bones are frequently affected sites. There is some evidence that cold temperatures or infection can trigger a painful event, but most events occur for unknown reasons. The hand-foot syndrome, or dactylitis, is a particular type of painful event. Most common in toddlers, dactylitis results in pain and swelling in the hands and feet and is sometimes accompanied by a fever.

Anemia

Sickle cells have a high turnover rate, and there is a deficit of red blood cells in the bloodstream. Common symptoms of anemia include fatigue, paleness, and a shortness of breath. A particularly severe form of anemia called aplastic anemia may occur following infection with parvovirus. Parvovirus infection causes extensive destruction of the bone marrow, bringing production of new red blood cells to a halt. Bone marrow production resumes after seven to 10 days. However, given the short lives of sickle cells, even a brief shut-down in red blood cell production can cause a rapid decline in hemoglobin concentrations.

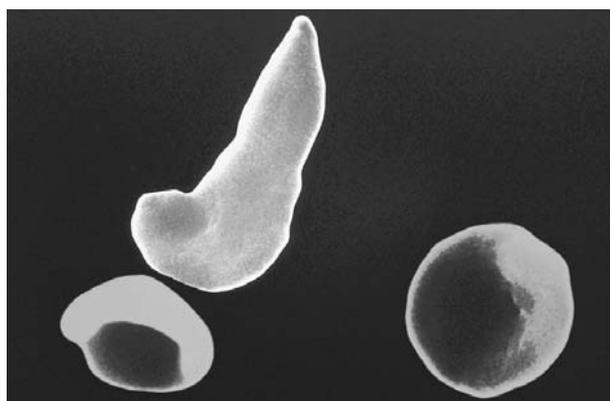
Delayed growth

The energy demands of the bone marrow for red blood cell production compete with the demands of a growing body. Children with sickle cell anemia may have delayed growth and reach **puberty** at a later age than normal. By early adulthood, they catch up on growth and attain normal height. However, their weight typically remains below average.

Stroke

Children with sickle cell disease have a significantly elevated risk of having a stroke, which can be one of the most serious complications of sickle cell disease. Approximately 11% of individuals with sickle cell disease will have a recognizable stroke by the age of 20. **Magnetic resonance imaging** (MRI) studies have found that 17% of children with sickle cell anemia have evidence of a previous stroke or clinically ‘silent’ stroke-like events called transient ischemic attacks. Stroke in sickle cell disease is usually caused by a blockage of a blood vessel. However, approximately one-fourth of the time they may be caused by a hemorrhage (or rupture) of a blood vessel.

Strokes result in compromised delivery of oxygen to an area of the **brain**. The consequences of stroke can



A scanning electron micrograph (SEM) of red blood cells taken from a person with sickle cell anemia. The blood cells at the right are normal; the diseased, sickle-shaped cells appear at the left. (Photograph by Dr. Gopal Murti, Photo Researchers, Inc. Reproduced by permission.)

range from life-threatening, to severe physical or cognitive impairments, to apparent or subtle learning disabilities, to undetectable effects. Common stroke symptoms include weakness or numbness that affects one side of the body, sudden behavioral changes, loss of **vision**, confusion, loss of speech or the ability to understand spoken words, dizziness, headache, seizures, vomiting, or even **coma**.

Approximately two-thirds of children who have a stroke will have at least one more. Transfusions have been shown to decrease the incidence of a second stroke. A recent study showed that children at highest risk to experience a first stroke were ten times more likely to stroke if untreated when compared to high-risk children treated with chronic blood **transfusion therapy**. High-risk children were identified using transcranial Doppler ultrasound technology to detect individuals with increased blood flow speeds due to constricted intracranial blood vessels.

Acute chest syndrome

Acute chest syndrome (ACS) is a leading cause of death for individuals with sickle cell disease, and recurrent attacks can lead to permanent lung damage. Therefore rapid diagnosis and treatment is of great importance. ACS can occur at any age and is similar but distinct from **pneumonia**. Affected persons may experience fever, cough, chest pain, and shortness of breath. ACS seems to have multiple causes including infection, sickling in the small blood vessels of the lungs, fat embolisms to the lungs, or a combination of factors.

Priapism

Males with sickle cell anemia may experience priapism, a condition characterized by a persistent and painful erection of the penis. Due to blood vessel blockage by sickle cells, blood is trapped in the tissue of the penis. Priapism may be short in duration or it may be prolonged. Priapism can be triggered by low oxygen (hypoxemia), alcohol consumption, or sexual intercourse. Since priapism can be extremely painful and can result in damage to this tissue (causing impotence), rapid treatment is essential.

Kidney disease

The internal environment of the kidney is particularly prone to damage from sickle cells. Signs of kidney damage can include blood in the urine, incontinence, and enlarged **kidneys**. Adults with sickle cell disease often experience insufficient functioning of the kidneys, which can progress to kidney failure in a small percentage of adults with sickle cell disease.

Jaundice and gallstones

Jaundice is indicated by a yellow tone in the skin and eyes, and alone it is not a health concern. Jaundice may occur if bilirubin levels increase, which can occur with high levels of red blood cell destruction. Bilirubin is the final product of hemoglobin degradation, and is typically removed from the bloodstream by the **liver**. Therefore, jaundice can also be a sign of a poorly functioning liver, which may also be evidenced by an enlarged liver hepatomegaly. Increased bilirubin also leads to increased chance for gallstones in children with sickle cell disease. Treatment, which may include removal of the gall bladder, may be selected if the gallstones start causing symptoms.

Retinopathy

The blood vessels that supply oxygen to the retina, the tissue at the back of the eye, may be blocked by sickle cells, leading to a condition called retinopathy. This is one of the only complications that is actually more common in SC disease as compared to SS disease. Retinopathy can be identified through regular ophthalmology evaluations and effectively treated in order to avoid damage to vision.

Joint problems

Avascular necrosis of the hip and shoulder joints, in which bone damage occurs due to compromised blood flow due to sickling, can occur later in childhood. This

complication can affect an individual's physical abilities and result in substantial pain.

Diagnosis

In the United States, African Americans and Latino Americans have the highest risk of having the disease or trait. Sickle cell is also common among individuals of Mediterranean, Middle Eastern, and Eastern Indian descent. Individuals from these areas of ethnic groups should consider screening for sickle cell disease.

A **complete blood count (CBC)** will describe several aspects of an individual's blood cells. A person with sickle cell disease will have a lower than normal hemoglobin level, together with other characteristic red blood cell abnormalities. Hemoglobin electrophoresis is a test that can help identify the types and quantities of hemoglobin made by an individual. This test uses an electric field applied across a slab of gel-like material. Hemoglobins migrate through this gel at various rates and go to specific locations, depending on their size, shape, and electrical charge. Although sickle hemoglobin (Hb S) and regular adult hemoglobin (called Hb A) differ by only one amino acid, they can be clearly separated using hemoglobin electrophoresis. Isoelectric focusing and high-performance liquid chromatography (HPLC) use similar principles to separate hemoglobins and can be used instead of or in various combinations with hemoglobin electrophoresis to determine the types of hemoglobin present.

Another test, called the 'sickledex' can help confirm the presence of sickle hemoglobin, although this test cannot provide accurate or reliable diagnosis when used alone. When Hb S is present, but there is an absence or only a trace of Hb A, sickle cell anemia is a likely diagnosis. Additional beta globin DNA test that directly assays the beta globin gene can be performed to help confirm the diagnosis and establish the exact genetic type of sickle cell disease. CBC and hemoglobin electrophoresis are also typically used to diagnosis sickle cell trait and various other types of beta globin traits.

Diagnosis of sickle cell disease can occur under various circumstances. If an individual has symptoms that are suggestive of this diagnosis, the above-described screening tests can be performed followed by DNA testing, if indicated. Screening at birth using HPLC or a related technique offers the opportunity for early intervention. More than 40 states include sickle cell screening as part of the usual battery of blood tests done for newborns. This allows for early identification and treatment. Hemoglobin trait screening is recommended for any individual of a high-risk ethnic background who may be considering having children. When both members of a cou-

ple are found to have sickle cell trait, or other related hemoglobin traits, they can receive **genetic counseling** regarding the risk of sickle cell disease in their future children and various testing options.

Sickle cell disease can be identified before birth through the use of prenatal diagnosis. **Chorionic villus sampling** (CVS) can be offered as early as 10 weeks of pregnancy and involves removing a sample of the placenta made by the baby and testing the cells. CVS carries a risk of causing a **miscarriage** that is between 0.5 and 1%.

Amniocentesis is generally offered between 15 and 22 weeks of pregnancy, but can sometimes be offered earlier. Two to three tablespoons of the fluid surrounding a baby are removed. This fluid contains fetal cells that can be tested. Although both tests carry a risk of causing a miscarriage, the risk is not greater than 1%. Pregnant woman and couples may choose prenatal testing in order to prepare for the birth of a baby that may have sickle cell disease. Alternately, knowing the diagnosis during pregnancy allows for the option of pregnancy termination.

Preimplantation genetic diagnosis (PGD) is a relatively new technique that involves in-vitro fertilization followed by **genetic testing** of one cell from each developing embryo. Only the embryos unaffected by sickle cell disease are transferred back into the uterus. PGD is currently available on a research basis only and is relatively expensive.

Treatment

There are several practices that are intended to prevent some of the symptoms and complications of sickle cell disease. These include preventative **antibiotics**, good hydration, immunizations, and access to comprehensive care. Maintaining good health through adequate **nutrition**, avoiding stresses and infection, and getting proper rest is also important. Following these guidelines usually improves the health of individuals with sickle cell disease.

Penicillin

Infants are typically started on a course of penicillin that extends from infancy to age six. Use of this antibiotic is meant to ward off potentially fatal infections. Infections at any age are treated aggressively with antibiotics. Vaccines for common infections, such as *pneumococcal pneumonia*, are also recommended.

Pain management

Pain is one of the primary symptoms of sickle cell anemia, and controlling it is an important concern. The

methods necessary for pain control are based on individual factors. Some people can gain adequate pain control through over-the-counter oral painkillers (**analgesics**). Others individuals or painful events may require stronger methods, which can include administration of narcotics. Alternative therapies may be useful in avoiding or controlling pain, including **relaxation**, hydration, avoiding extremes of temperature, and the application of local warmth.

Blood transfusions

Blood transfusions are not usually given on a regular basis but are used to treat individuals with frequent and severe painful events, severe anemia, and other emergencies. In some cases blood transfusions are given as preventive measures, for example to treat spleen enlargement (splenomegaly) or prevent a second stroke (or a first stroke in an individual shown to be at high risk).

Regular blood transfusions have the potential to decrease formation of hemoglobin S, and reduce associated symptoms. However, there are limitations and risks associated with regular blood transfusions, including the risk of blood-borne infection and sensitization to **proteins** in the transfused blood that can make future transfusions very difficult. Most importantly, chronic blood transfusions can lead to **iron** overload. The body tends to store excess iron, such as that received through transfusions, in various organs. Over time, this iron storage can cause damage to various tissues and organs, such as the **heart** and endocrine organs.

Some of this damage can be prevented by the administration of a medication called desferrioxamine that helps the body to eliminate excess iron through the urine. Alternately, some individuals receive a new, non-standard treatment called erythrocytapheresis. This involves the automated removal of sickle cells and is used in conjunction with a reduced number of regular transfusions. This treatment also helps to reduce iron overload.

Hydroxyurea

Emphasis is being placed on developing drugs that treat sickle cell anemia directly. The most promising of these drugs in the beginning of the twenty-first century is hydroxyurea, a drug that was originally designed for anti-cancer treatment. Hydroxyurea has been shown to reduce the frequency of painful crises and acute chest syndrome in adults, and to lessen the need for blood transfusions. Hydroxyurea, and other related medications, seem to work by inducing a higher production of fetal hemoglobin. The major side effects of the drug include decreased production of platelets, red blood cells, and certain white

KEY TERMS

Amino acid—A type of molecule used as a building block for protein construction.

Anemia—A condition in which the level of hemoglobin or the number of red blood cells falls below normal values. Common symptoms include paleness, fatigue, and shortness of breath.

Bilirubin—A yellow pigment that is the end result of hemoglobin breakdown. Bilirubin is cleared from the blood by action of liver enzymes and excreted from the body.

Bone marrow—A spongy tissue located in the hollow centers of certain bones, such as the skull and hip bones. Bone marrow is the site of blood cell generation.

Bone marrow transplantation—A medical procedure in which normal bone marrow is transferred from a healthy donor to an ailing recipient. An illness such as sickle cell anemia that prevents production of normal blood cells may be treated with a bone marrow transplant.

Globin—One of the component protein molecules found in hemoglobin. Normal adult hemoglobin has a pair each of alpha-globin and beta-globin molecules.

Heme—The iron-containing molecule in hemoglobin that serves as the site for oxygen binding.

Hemoglobin—The red pigment found within red blood cells that enables them to transport oxygen throughout the body. Hemoglobin is a large molecule composed of five components: a heme molecule and two pairs of globin molecules.

Hemoglobin A—Normal adult hemoglobin contains a heme molecule, two alpha-globin molecules, and two beta-globin molecules.

Hemoglobin electrophoresis—A laboratory test that separates molecules based on their size, shape, or electrical charge.

Hemoglobin S—Hemoglobin that is produced in association with the sickle cell trait. The beta-globin molecules of hemoglobin S are defective.

Hydroxyurea—A drug that has been shown to induce production of fetal hemoglobin. Fetal hemoglobin has a pair of gamma-globin molecules in place of the typical beta-globins of adult hemo-

globin. Higher-than-normal levels of fetal hemoglobin can prevent sickling from occurring.

Impotence—The inability to have a penile erection, which can be due to tissue damage resulting from sickling within the penis (priapism).

Iron overload—A side effect of frequent transfusions in which the body accumulates abnormally high levels of iron. Iron deposits can form in organs, particularly the heart, and cause life-threatening damage.

Jaundice—A condition characterized by higher-than-normal levels of bilirubin in the bloodstream and an accompanying yellowing of the skin and eyes.

Mutation—A change in a gene's DNA. Whether a mutation is harmful is determined by the effect on the product for which the gene codes.

Magnetic resonance imaging—A type of imaging technique that allows the visualization of internal structures, such as the brain.

Narcotic—Strong, prescription medication that can be effective in treating sickle cell pain. Narcotics have the potential to be habit-forming if their use is not adequately supervised.

Nucleic acid—A type of chemical that is used as a component for building DNA. The nucleic acids found in DNA are adenine, thymine, guanine, and cytosine.

Ophthalmology—The medical specialty of vision and the eye.

Placenta—The organ responsible for oxygen and nutrition exchange between a pregnant mother and her developing baby.

Red blood cell—Hemoglobin-containing blood cells that transport oxygen from the lungs to tissues. In the tissues, the red blood cells exchange their oxygen for carbon dioxide, which is brought back to the lungs to be exhaled.

Screening—Process through which carriers of a trait may be identified within a population.

Sickle cell—A red blood cell that has assumed a elongated shape due to the presence of hemoglobin S.

blood cells. The effects of long-term hydroxyurea treatment are unknown.

Bone marrow transplantation

Bone marrow transplantation has been shown to cure sickle cell anemia in some cases. This treatment is reserved primarily for severely affected children with a healthy donor whose marrow proteins match those of the recipient, namely a brother or sister who has inherited the same tissue type. Indications for a bone marrow transplant are stroke, recurrent acute chest syndrome, and chronic unrelieved pain.

Bone marrow transplantations tend to be the most successful in children. Adults have a higher rate of transplant rejection and other complications. There is approximately a 10% fatality rate associated with bone marrow transplants performed for sickle cell disease. Survivors face potential long-term complications, such as chronic graft-versus-host disease (an immune-mediated attack by the donor marrow against the recipient's tissues), **infertility**, and development of some forms of **cancer**. A relatively recent advance in transplantation involves the use of donor stem cells obtained from cord blood, the blood from the placenta that is otherwise discarded following the birth of a new baby. Cord blood cells, as opposed to fully mature bone marrow cells, appear to be less likely to result in graft-versus-host disease in a recipient. This increases the safety and efficacy of the transplant procedure.

Surgery

Certain surgical interventions are utilized in the treatment of specific sickle cell-related complications. Removal of a dysfunctional **gallbladder** (cholecystectomy) or spleen (splenectomy) can often lead to improvements in health. Investigations are currently underway to establish the efficacy of hip coring surgery, in which a portion of affected bone is removed to treat avascular necrosis of the hip. The hope is that this may provide an effective treatment to alleviate some pain and restore function in an affected hip.

Psychosocial support

As in any lifelong, chronic disease, comprehensive care is important. Assistance in coping with the emotional, social, family-planning, economic, vocational, and other consequences of sickle cell disease can enable affected individuals to better access and benefit from their medical care providers.

Prognosis

Sickle cell disease is characteristically variable between and within affected individuals. Predicting the course of the disorder based solely on genes is not possible. Several factors aside from genetic inheritance determine the prognosis for affected individuals, including the frequency, severity, and nature of specific complications in any given individual. The availability and access of comprehensive medical care also plays an important role in preventing and treating serious, acute complications that cause the majority of sickle cell-related deaths. For those individuals who do not experience such acute events, life-expectancy is probably substantially greater than the average for all people with sickle cell disease. The impact of recent medical advances supports the hypothesis that current life-expectancies may be significantly greater than those estimated in the early 1990s. At that time, individuals with SS disease lived, on average, to their early- to mid-40s, and those with SC disease lived into the upper 50s. With early detection and comprehensive medical care, most people with sickle cell disease enjoy fairly good health throughout most of their lives. Most individuals can be expected to live well into adulthood, enjoying an improved quality of life including the ability to choose a variety of education, career, and family-planning options for themselves.

Health care team roles

Sickle cell disease is often initially identified as a result of a screening test. This may be ordered by a pediatrician, obstetrician or family physician. A phlebotomist or nurse often obtains a sample of blood. A laboratory technician processes the sample. A pathologist or hematologist analyzes the results of a test. A family doctor may return results to individuals who have been tested. A genetic counselor or other person with training in test interpretation and ethics must be available to assist tested persons to accurately assess their options in the future.

Prevention

Inheritance of sickle cell disease or trait cannot be prevented, but it may be predicted. Screening is recommended for individuals in high-risk populations.

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- American Society of Hematology. 1900 M Street NW, Suite 200, Washington, DC 20036. (202) 776-0544. Fax: (202) 776-0545. <<http://www.hematology.org>>. ash@hematology.org.
- Sickle Cell Disease Association of America, Inc. 200 Corporate Pointe, Suite 495, Culver City, California 90230-8727. (310) 216-6363 or (310) 215-3722. Fax: (800) 421-8453. <www.sicklecelldisease.org>. scdaa@sicklecelldisease.org.

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L. Fleming Fallon, Jr., MD, DrPH

Sigmoidoscopy

Definition

Sigmoidoscopy is a diagnostic and screening procedure in which a rigid or flexible tube with a camera on the end (a sigmoidoscope) is inserted into the anus to examine the rectum and lower colon (bowel) for bowel disease, **cancer**, precancerous conditions, or causes of bleeding and **pain**.

Purpose

Sigmoidoscopy is used most often in screening for **colorectal cancer** or to determine the cause of rectal bleeding. It is also used in diagnosis of inflammatory bowel disease, microscopic and ulcerative colitis, and **Crohn's disease**.

Cancer of the rectum and colon is the second most common cancer in the United States. About 155,000 cases are diagnosed annually. About 55,000–60,000 Americans die each year of colorectal cancer.

A number of studies have suggested, and it is now recommended by cancer authorities that people over 50 be screened for colorectal cancer using endoscopy every three to five years. Individuals with inflammatory bowel disease, such as Crohn's disease or ulcerative colitis, who are at increased risk for colorectal cancer, may begin their screenings at a younger age, depending on when their disease was diagnosed. Many physicians screen such patients more often than every three to five years. Screening should also be done in patients who have a

family history of colon or rectal cancer or small growths in the colon (polyps).

Some physicians do this screening with a colonoscope, which allows them to see the entire colon. However, most physicians prefer sigmoidoscopy, which is less time consuming, less uncomfortable, and less costly.

Studies have shown that one quarter to one-third of all precancerous or small cancerous growths can be seen with a sigmoidoscope. About one-half are found with a 1 ft (30 cm) scope, and two-thirds to three-quarters can be seen using a 2 ft (60 cm) scope.

In some cases, the sigmoidoscope can be used therapeutically in conjunction with other equipment, such as electrosurgical devices, to remove polyps and other lesions found during the sigmoidoscopy.

Precautions

Sigmoidoscopy can usually be conducted in a physician's office or an outpatient clinic. However, some individuals should have the procedure done in a hospital day-surgery facility. Those with rectal bleeding may need full **colonoscopy** in a hospital setting. Patients whose **blood** does not clot well (possibly as a result of blood thinning medications) may need the procedure performed in a hospital setting as well.

Individuals with renal insufficiency or congestive **heart failure** need to be prepared in an alternative way, and must be carefully monitored during the procedure.

Sigmoidoscopy may be contraindicated in patients with severe active colitis or toxic megacolon (an extremely dilated colon). In general, patients on continuous ambulatory **peritoneal dialysis** are not candidates due to a high risk of developing intraperitoneal bleeding.

Description

Sigmoidoscopy may be performed using either a rigid or flexible sigmoidoscope, a thin tube with fiberoptics, electronics, a light source, and camera. The physician inserts the sigmoidoscope into the anus to examine the rectum (the first 1 ft/30 cm of the colon) and its interior walls. If a 2 ft/60 cm scope is used, the next portion of the colon can also be examined for any irregularities. The sigmoidoscope's camera is connected to a viewing monitor (television screen), so the rectum and colon are enlarged and viewed on a monitor. Images can then be recorded as still pictures for hard copy or the entire procedure can be videotaped.

If polyps, lesions, or other suspicious areas are found, the physician biopsies them for analysis. During the sigmoidoscopy, the physician may also use forceps,

KEY TERMS

Biopsy—The removal a small portion of tissue during sigmoidoscopy to perform laboratory tests to determine if the tissue is cancerous.

Colonoscopy—A diagnostic endoscopic procedure that uses a long flexible tube called a colonoscope to examine the inner lining of the entire colon; used for colorectal cancer screening and more thorough examination of the colon.

Colorectal cancer—Cancer of the large intestine, or colon, including the rectum (the last 16 in of the large intestine before the anus).

Congestive heart failure—Excess fluid accumulation in the lungs and surrounding tissues due to the weakness of the heart muscle and the inability to pump sufficiently.

Electrosurgical device—A medical device that uses electrical current to cauterize or coagulate tissue during surgical procedures, often used in conjunction with laparoscopy.

Inflammatory bowel disease—Ulcerative colitis or Crohn's disease; chronic conditions characterized by periods of diarrhea, bloating, abdominal cramps, and pain, sometimes accompanied by weight loss and malnutrition because of the inability to absorb nutrients.

Pathologist—A doctor who specializes in the diagnosis of disease by studying cells and tissues under a microscope.

Polyp—A small growth, usually not cancerous, but often precancerous when it appears in the colon.

Renal insufficiency—The inability of the kidneys to process fluid fast enough to flush the body of impurities.

graspers, snares, or electrosurgical devices to remove polyps, lesions, or tumors.

The sigmoidoscopy procedure takes five to 20 minutes. Preparation begins one day before the procedure. There is some discomfort when the scope is inserted and throughout the procedure, similar to that experienced when a physician performs a rectal exam using a finger to test for occult blood in the stool (another major colorectal cancer screening test). The patient may also feel some minor cramping pain. There is rarely severe pain,

except for individuals with active inflammatory bowel disease.

Private insurance plans almost always cover the \$150 to \$200 cost of sigmoidoscopy for screening in healthy individuals over 50, or for diagnostic purposes. **Medicare** covers the cost for diagnostic exams, and may cover the costs for screening exams. **Medicaid** varies by state, but does not cover the procedure in most states. Some community health clinics offer the procedure at reduced cost, but this can only be done if a local gastroenterologist (a physician who specializes in treating **stomach** and intestinal disorders) is willing to donate his or her time.

Preparation

The purpose of preparation for sigmoidoscopy is to cleanse the lower bowel of stool so the physician can see the lining. Preparation begins 24 hours before the procedure, when the individual must begin a clear liquid diet. Preparation kits are available in drug stores. In normal preparation, about 20 hours before the exam, the patient begins taking a series of **laxatives**, which may be oral tablets or liquid. The individual must stop drinking four hours before the exam. An hour or two prior to the exam, the patient uses an enema or laxative suppository to finish cleansing the lower bowel.

Individuals need to be careful about medication before having sigmoidoscopy. They should not take aspirin, products containing aspirin, or ibuprofen products (Nuprin, Advil, or Motrin) for one week prior to the exam, because these medications can exacerbate bleeding during the procedure. They should not take any **iron** or **vitamins** with iron for one week prior to the exam, since iron can cause color changes in the bowel lining that interfere with the examination. They should take any routine prescription medication, but may need to stop certain medications; the physician should be consulted regarding routine prescriptions and their possible effect on sigmoidoscopy.

Aftercare

There is no specific aftercare necessary following sigmoidoscopy. If a biopsy was taken, a small amount of blood may appear in the next stool. Patients should be encouraged to pass gas following the procedure to relieve any bloating and cramping that may occur after the procedure. In addition, an **infection** may develop following sigmoidoscopy, and patients should be instructed to call their physician if a **fever** or pain in the abdomen develops over the few days after the procedure.

Complications

There is a slight risk of bleeding from the procedure. This risk is heightened in individuals whose blood does not clot well, either due to disease or medication, and in those with active inflammatory bowel disease. Rarely, trauma to the bowel or other organs can occur, resulting in an injury (perforation) that needs to be repaired or peritonitis, which must be treated with medication.

Results

A normal exam shows a smooth colon wall, with sufficient **blood vessels** for good blood flow.

For a cancer screening sigmoidoscopy, an abnormal result is one or more noncancerous or precancerous polyps, or clearly cancerous polyps. People with polyps have an increased risk of developing colorectal cancer in the future and may be required to undergo additional procedures, such as colonoscopy, or more frequent examinations.

Small polyps can be completely removed. Larger polyps may require the physician to remove a portion of the growth for laboratory biopsy. Depending on the laboratory results, the patient is then scheduled to have the polyp removed surgically, either as an “urgent” matter if it is cancerous or as an elective surgery within a few months if it is noncancerous.

In a diagnostic sigmoidoscopy, an abnormal result shows signs of active inflammatory bowel disease, either a thickening of the intestinal lining consistent with ulcerative colitis, or ulcerations or fissures consistent with Crohn’s disease.

Health care team roles

Sigmoidoscopy is performed by an experienced family physician or gastroenterologist. Nurses or physician assistants may be present during the procedure to assist the physician and monitor the patient. Biopsy specimens taken during the sigmoidoscopy are analyzed in the clinical laboratory by a pathologist. Sigmoidoscopes and procedural accessories must be sterilized or disinfected by clinical staff trained in proper scope reprocessing techniques.

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Sinus endoscopy

Definition

Sinus endoscopy is a procedure used to examine, diagnose, and treat disorders of the nose, sinuses, or throat. During sinus endoscopy, an endoscope—a narrow, flexible tube fitted with a fiber-optic device such as a telescope or magnifying lens—is inserted into the nose, the interior of the nasal passages, sinuses, and throat.

Purpose

Sinus endoscopy is used diagnostically to evaluate structural defects, **infection** or damage to the sinuses, or structures in the nose and throat. It may be used to view polyps (growths) in the sinuses and to investigate causes of recurrent sinusitis (infection of the sinuses). During treatment, an **endoscope** may be used to view the affected area before, during, and after surgical procedures to correct anatomical malformations, sinus-drainage problems, or to remove polyps from the nose and throat.

Precautions

Insertion of the endoscope may cause a gag reflex and some discomfort, however, no special precautions are required to prepare for nasal endoscopy. Before the procedure begins, the nurse generally describes this and any other discomfort the patient may experience.

Description

This procedure is usually performed in a physician's office or other outpatient setting, such as a clinic or ambulatory surgical center. The endoscope is inserted into a nostril and threaded through the sinus passages to the throat. To visualize these areas more easily, and to record the areas being examined, the endoscope is fitted with a camera, monitor, or other viewing device.

Preparation

During the procedure, the patient is usually awake and seated upright in a chair. A local anesthetic spray or liquid may be applied to the throat to ease insertion of the endoscope and minimize discomfort.

Aftercare

Following sinus endoscopy procedures, most patients may immediately resume normal activities. If anesthetic was used, the patient may have to wait until the numbness wears off before eating or drinking.

Complications

The insertion and removal of the endoscope may trigger a gag reflex and can cause some discomfort. The procedure may also irritate the tissues of the nose and throat, causing a nosebleed or coughing.

Results

Under normal conditions, no polyps are found in the sinuses. There should also be no evidence of infection, swelling, injury, or an anatomical or structural defect that would prevent normal draining of the sinuses.

Polyps, growths, infections, or structural defects of the nasal passages are considered abnormal.

Health care team roles

Sinus endoscopy is usually performed by an otolaryngologist (a physician specializing in disorders of the ear, nose and throat). Before the procedure, some patients may undergo computed tomography (CT) scans or other imaging studies performed by radiological technologists.

KEY TERMS

Fiber-optic—Relating to the transmission of light through very fine, flexible glass or plastic fibers.

Polyp—A usually nonmalignant growth or tumor protruding from the mucous lining of an organ such as the nose, bladder, or intestine, often causing obstruction.

Patient education

Generally, the procedure is explained by the physician who will perform it. Since the procedure is generally performed in the physician's office or other outpatient setting, **patient education** also may be provided by nurses, nursing assistants, or certified medical assistants working in the medical office.

Resources

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ORGANIZATIONS

American Academy of Otolaryngology—Head and Neck Surgery. One Prince St, Alexandria, VA 22314. (703) 836-4444.

Ear Foundation. 2000 Church St., Box 111, Nashville, TN 37236. (615) 329-7807, (800) 545-HEAR.

Barbara Wexler

Skeletal muscles

Definition

Skeletal muscles have transverse striations and are under conscious or voluntary control by the **somatic nervous system**.

Description

Macroscopic

Skeletal muscles are often attached to bone, although this is not always the case. Tendons are a common means of attaching skeletal muscle to bone; they are

composed of collagen, a structurally strong yet flexible substance. A muscle's origin is the end that moves least on contraction; the other end is referred to as the insertion. There is a large range of muscle sizes, types, and functions. Most human muscles have muscle fibers arranged parallel to a tendon. A unipennate muscle, however, has all of its muscle fibers inserted at an angle into one side of a tendon.

Microscopic

Skeletal muscles are made up of bundles (called fascicles) of individual muscle fibers lined with connective tissue. Each muscle fiber is a giant multinucleated cell, formed by the fusion of myoblasts (muscle cell precursors) during development. Muscle fibers contain approximately one thousand myofibrils, tubular organelles that appear striated under a **microscope**; each myofibril is surrounded by a system of vesicles called the sarcoplasmic reticulum. The striations are due to alternating bands of light and dark regions called bands. The light regions are called I-bands, while the dark regions are called A-bands. A dividing line that runs through the A-band is called the Z-line, and the region between successive Z-lines is called the sarcomere.

The sarcomere is the functional unit of skeletal muscle and is associated with **muscle contraction**. It is composed primarily of two different contractile **proteins**: actin (or thin filaments) and myosin (or thick filaments). The filaments are arranged in an organized array so that their overlapping pattern produces the striations visible from under a microscope. The light I-bands are formed by actin filaments that are rooted at the Z-line, while the dark A-bands are composed of myosin filaments that overlap the actin filaments to varying degrees based on the extent of muscle contraction. The region in which there is no overlap (i.e., groups of actin filaments) in the center part of the A-band is called the H-band.

Function

Contraction

In a resting muscle, opposing actin filaments overlap myosin filaments only partially, resulting in the characteristic H-band. When a muscle contracts, however, the opposing actin filaments slide along the myosin filaments and are pushed together so that the H-bands (and I-bands) become narrower, while the A-bands remain the same length. The result is that the Z-lines come closer together without the actual length of the filaments changing. This mode of action is called the sliding filament mechanism.

The sliding filament mechanism is regulated by the binding of adenosine triphosphate (ATP) to myosin. ATP is a molecule present in all living cells that acts as an energy source. When ATP is not bound to myosin, projections along the myosin filaments called heads remain tightly bound to actin and therefore no sliding takes place (and subsequently, no muscle contraction). When ATP binds to myosin, however, a series of steps causes the myosin head to temporarily dissociate and change its conformation so that the actin and myosin filaments move relative to one another. This process, actively repeated in the many sarcomeres in a muscle fiber, results in muscle contraction.

Muscle contraction is also regulated by the **calcium** ion. A nerve impulse results in calcium being released from the sarcoplasmic reticulum. The calcium binds to various proteins that in turn cause conformational changes that expose the myosin-binding sites on the actin filaments so that contraction may occur.

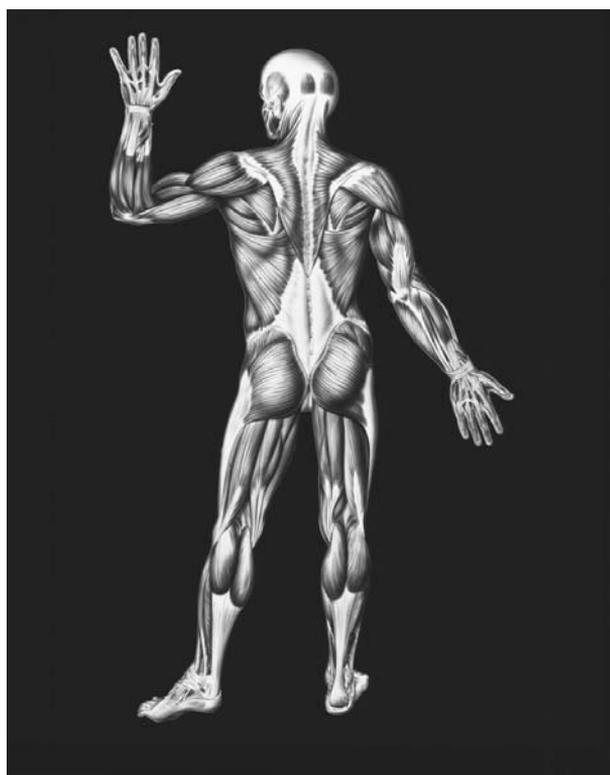
Lactic acid fermentation

Glucose is a major fuel for most organisms; when energy is needed, glucose can be quickly released from the body's stores and processed metabolically to produce ATP. This metabolic process occurs optimally under high-oxygen (aerobic) conditions. When oxygen cannot be replenished to the muscles as fast as it is being used (as in short bursts of extreme activity), glucose can be broken down anaerobically (under no- or low-oxygen conditions). Use of this pathway, however, leads to a buildup of the byproduct lactic acid in the muscles; this buildup causes muscle **pain** and cramps—uncontrollable shortening and hardening of muscle tissue—and limits the period of intense activity.

Role in human health

Neuromuscular disorders typically manifest themselves with one of four classes of symptoms (or any combination of the four):

- **Weakness:** Muscle weakness may be specific to a particular part of the body (i.e., neck, shoulder, arm, hand, leg, hip, etc.) or it may be generalized. Weakness may be caused by **brain** damage from a stroke or tumor, damage to the **spinal cord**, damage to a single nerve, or psychological problems.
- **Fatigue:** Individuals may suffer from chronic fatigue because of major depression, **multiple sclerosis**, stroke, neuromuscular transmission failure, or psychosomatic illness.
- **Pain:** Like muscle weakness, muscle pain may be specific (e.g., due to an muscle **abscess**) or general; it may



Skeletal muscles. (Photograph by John Bavosi. Science Photo Library. Photo Researchers, Inc. Reproduced by permission.)

also have a psychosomatic origin (i.e., associated with **anxiety** or depression).

- **Cramps:** Muscle pain caused by cramps is distinct from general muscle pain in that it often occurs in healthy individuals and causes intense pain.

Common diseases and disorders

- **Spasmodic torticollis:** This disease is characterized by painful spasms of the neck muscles that force the head to rotate and/or tilt. Its cause is usually unknown although occasionally conditions such as infections of the nervous system, tumors of the neck, or hyperthyroidism cause spasmodic torticollis.
- **Fibromyalgia:** Syndromes associated with fibromyalgia are characterized by localized or general pain or stiffness in muscles, tendons, and ligaments. There is no known cause for fibromyalgia but **stress**, inadequate sleep, injury, infections, and other conditions have been associated.
- **Muscular dystrophy:** The most common dystrophies (Duchenne's and Becker's) cause weakness in the muscles in or around the torso. In the case of Duchenne's muscular dystrophy (DMD), joint and muscle contrac-

KEY TERMS

Actin—A contractile protein that forms thin filaments in myofibrils; forms the I-band of the sarcomere.

Adenosine triphosphate (ATP)—A molecule present in all living organisms that acts as an energy source.

Fascicle—Bundles of muscle fibers surrounded by connective tissue.

Muscle fibers—Tubular multinucleated cells containing approximately one thousand contracting myofibrils.

Myofibrils—Tubular organelles found in muscle fibers that appear striated under a microscope; they are surrounded by a system of vesicles called the sarcoplasmic reticulum, important in the regulation of muscle contraction.

Myosin—A contractile protein that forms thick filaments in myofibrils; forms the A-band of the sarcomere with some overlap with actin filaments.

Sarcomere—The functional unit of muscle contraction; composed of striated bands of contractile proteins (actin and myosin).

tures develop in the form of cramps and amassment of fibrous tissue (including progressive destruction of muscle fibers).

- Tetanus: The bacillus *Clostridium tetani* produces a toxin called tetanospasmin that causes persistent spasms in the muscles of the jaw (hence the name “lockjaw”), the back, and/or the site of infection.
- Sports injuries: Muscle, ligament, and tendon injuries can be caused by inaccurate training advice, abnormalities in body structures, and overexertion. Common muscular injuries include ankle sprains, shin splints, hamstring injuries, and weightlifter’s back. Such injuries can often be prevented by warming up before **exercise**, cooling down after exercise, performing strengthening and stretching exercises, and wearing protective gear.

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ORGANIZATIONS

Muscular Dystrophy Association. 3300 E. Sunrise Drive, Tucson, AZ 85718. (800) 572-1717. <<http://www.mdaua.org>>.

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Stéphanie Islane Dionne

Skeletal system

Definition

The skeletal system is a living, dynamic, bony framework of the body, with networks of infiltrating **blood vessels**.

Description

Inside every person is a skeleton, a sturdy framework of about 206 bones that protects the body’s organs, supports the body, provides attachment points for muscles to enable body movement, functions as a storage site for **minerals** such as **calcium** and **phosphorus**, and produces **blood** cells. Living mature bone is about 60% calcium compounds and about 40% collagen. Hence, bone is strong, hard, and slightly elastic. Humans are born with over 300 bones but some bones, such as those in the **skull** and lower spine, fuse during growth, thereby reducing the number. Although mature bones consist largely of calcium—70% calcium salts and about 30% organic matrix, mostly collagen fibers—most bones in the skeleton of vertebrates, including humans, began as cartilage. Cartilage is a type of connective tissue, and contains collagen and elastin fibers. The hard outer part of bones are comprised mostly of a **proteins** such as collagen, in addition to a substance called hydroxyapatite. This substance is composed primarily of calcium and other minerals, and stores much of the body’s calcium; it is primarily responsible for the strength of bones. At the center of each bone is the marrow, which is softer and less dense than the rest of the bone. The marrow contains specialized cells that

produce blood cells that run through a bone, with nerves surrounding it.

Individual bones meet at areas called joints and are held in place by connective tissue. Most joints, such as the elbow, are called synovial joints, for the synovial membrane which envelops the joint and secretes a lubricating fluid. Cartilage lines the surface of many joints and helps reduce friction between bones. The connective tissues linking the skeleton together at the joints are tendons and ligaments. Ligaments and tendons are both made up of collagen, but serve different functions. Ligaments link bones together and help prevent dislocated joints. Tendons link bone to muscle.

Because the bones making up the human skeleton are inside the body, the skeleton is called an endoskeleton. Some animals, such as the crab, have an external skeleton called an exoskeleton.

Types of bone

Bones may be classified according to their various traits, such as shape, origin, and texture. Four types are recognized based on shape. These are long bones, short bones, flat bones, and irregular bones. Long bones have a long central shaft, called the diaphysis, and two knobby ends, called the epiphysis. In growing long bones, the diaphysis and epiphysis are separated by a thin sheet of cartilage. Examples of long bones include bones of the arms and legs, the metacarpals of the hand, metatarsals of the foot, and the clavicle. Short bones are about as long as wide. The patella, carpels of the wrist, and tarsals of the ankle are short bones. Flat bones take several shapes, but are characterized by being relatively thin and flat. Examples include the sternum, ribs, hip bones, scapula, and cranial bones. Irregular bones are the odd-shaped bones of the skull, such as the sphenoid, the sacrum, and the vertebrae. The common characteristic of irregular bones is not that they are similar to each other in appearance, but that they cannot be placed in any of the other bone categories.

Bones may also be classified based on their origin. All bone (as well as muscles and connective tissue) originates from an embryonic connective tissue called mesenchyme, which makes mesoderm, also an embryonic tissue. Some mesoderm forms the cartilaginous skeleton of the fetus, the precursor for the bony skeleton. However, some bones, such as the clavicle and some of the facial and cranial bones of the skull, develop directly from mesenchyme, thereby bypassing the cartilaginous stage. These types of bone are called membrane bone (or dermal bone). Bone which originates from cartilage is called endochondral bone.

Finally, bones are classified based on texture. Smooth, hard bone called compact bone forms the outer layer of bones. Inside the outer compact bone is cancellous bone, sometimes called the bone marrow. Cancellous bone appears open and spongy, but is actually very strong, like compact bone. Together, the two types of bone produce a light, but strong, skeleton.

Structure

The human skeletal system is divided into two main groups: the axial skeleton and the appendicular skeleton. The axial skeleton includes bones associated with the body's main axis including:

- the skull
- the spine or **vertebral column**
- the ribs

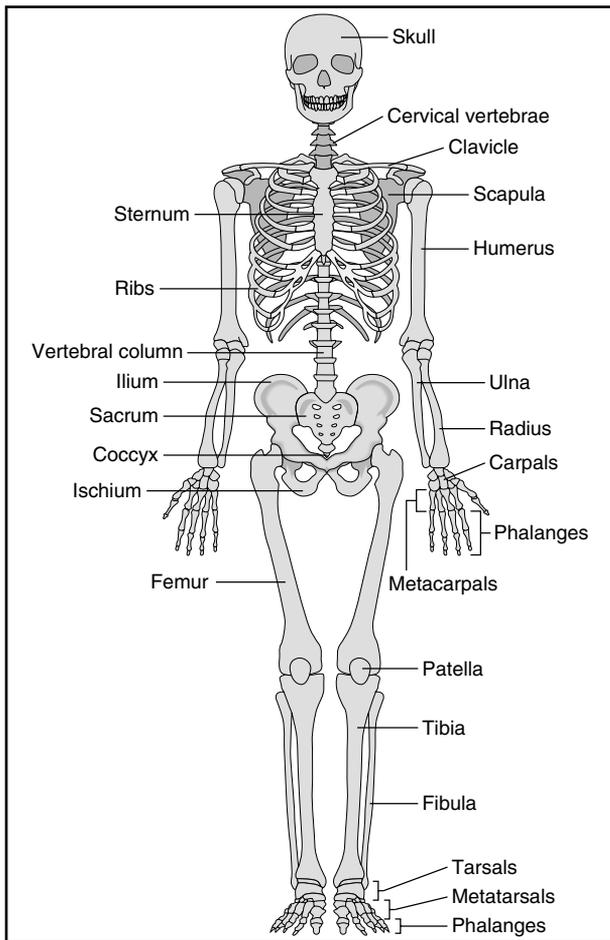
The appendicular skeleton consists of the bones that anchor the body's appendages to the axial skeleton including:

- the pectoral girdle (shoulder area)
- the pelvic girdle (hip area)
- the upper extremities (arms)
- the lower extremities (legs)

AXIAL SKELETON. There are 28 bones in the skull. Of these, eight bones comprise the cranium and provide protection for the **brain**. In adults, these bones are flat and interlocking at their joints, making the cranium immobile. Fibrous joints, or sutures occur where the bony plates of the cranium meet and interlock. Cartilage-filled spaces between the cranial bones of infants, known as soft spots or fontanelles, allow their skull bones to move slightly during birth. This makes birth easier and helps prevent skull **fractures**, but may leave the infant with an odd-shaped head temporarily while the skull regains its shape. Eventually, the fontanelles in an infant's head are replaced by bone, and fibrous joints develop. In addition to protecting the brain, skull bones also support and protect the sensory organs responsible for sight, **hearing**, **smell** and **taste**.

The eight bones of the cranium are:

- frontal
- parietal (2)
- temporal (2)
- ethmoid
- sphenoid
- occipital



Frontal view of the adult human skeleton. (Delmar Publishers, Inc. Reproduced by permission.)

The frontal bone forms the forehead and eyebrows. Behind the frontal bone are the two parietal bones. Parietal bones form the roof of the cranium and curve down to form the sides of the cranium. Also forming the sides of the cranium are the two temporal bones, located behind the eyes. Each temporal bone encloses the cochlea and labyrinth of the inner ear, and the ossicles, three tiny bones of the middle ear which are not part of the cranium. The ossicles are the malleus (hammer), incus (anvil), and stapes (stirrups). The temporal bones also attach to the lower jaw, and this is the only moveable joint in the skull. Between the temporal bones is the irregular shaped sphenoid bone, which provides protection for the **pituitary gland**. The small ethmoid bone forms part of the eye socket next to the nose. Olfactory nerves, or sense of smell nerves, pass through the ethmoid bone on their way to the brain. Forming the base and rear of the cranium is the occipital bone. The occipital bone has a hole, called the foramen magnum, through which the **spinal cord** passes and connects to the brain.

Fourteen bones shape the cheeks, eyes, nose, and mouth. These include:

- the nasal (2)
- zygomatic (2)
- maxillae (2)
- mandible

The upper, bony bridge of the nose is formed by the nasal bones and provides an attachment site for the cartilage making up the softer part of the nose. The zygomatic bones form the cheeks and part of the eye sockets. Two bones fuse to form the maxillae, the upper jaw of the mouth. These bones also form the hard palate of the mouth. The mandible forms the lower jaw of the mouth and is moveable, enabling chewing of food and speech. The mandible is the bone which connects to the temporal bones.

Located behind these facial bones are other bones which shape the interior portions of the eyes, nose, and mouth. These include:

- lacrimal (2)
- palatine (2)
- conchae (2)
- vomer bones

In addition to these 28 skull bones is the hyoid bone, located at the base of the tongue. Technically, the hyoid bone is not part of the skull but it is often included with the skull bones. It provides an attachment site for the tongue and some neck muscles.

Several of the facial and cranial bones contain sinuses, or cavities, that connect to the nasal cavity and drain into it. These are the frontal, ethmoid, sphenoid, and maxillae bones, all located near the nose. Painful sinus headaches result from the build up of pressure in these cavities. Membranes that line these cavities may secrete mucous or become infected, causing additional aggravation for humans.

The skull rests atop of the spine, which encases and protects the spinal cord. The spine, also called the vertebral column or backbone, consists of 33 stacked vertebrae, the lower ones fused. Vertebra are flat with two main features. The main oval shaped, bony mass of the vertebra is called the centrum. From the centrum arises a bony ring called the neural arch which forms the neural canal (also called a vertebral foramen), a hole for the spinal cord to pass through. Short, bony projections (neural spines) arise from the neural arch and provide attachment points for muscles. Some of these projections (called transverse processes) also provide attachment points for the ribs. There are also small openings in the

neural arch for the spinal nerves, which extend from the spinal cord throughout the body. Injury to the column of vertebrae may cause serious damage to the spinal cord and the spinal nerves, and could result in **paralysis** if the spinal cord or nerves are severed.

There are seven cervical, or neck, vertebrae. The first one, the atlas, supports the skull and allows the head to nod up and down. The atlas forms a condylar joint (a type of synovial joint) with the occipital bone of the skull. The second vertebra, the axis, allows the head to rotate from side to side. This rotating synovial joint is called a **pivot joint**. Together, these two vertebrae make possible a wide range of head motions.

Below the cervical vertebrae are the 12 thoracic, or upper back, vertebrae. The ribs are attached to these vertebrae. Thoracic vertebrae are followed by five lumbar, or lower back, vertebrae. Last is the sacrum, composed of five fused vertebrae, and the coccyx, or tail bone, composed of four fused bones.

The vertebral column helps to support the weight of the body and protects the spinal cord. Cartilaginous joints rather than synovial joints occur in the spine. Disks of cartilage lie between the bony vertebrae of the back and provide cushioning, like shock absorbers. The vertebrae of the spine are capable of only limited movement, such bending and some twisting.

A pair of ribs extends forward from each of the 12 thoracic vertebrae, for a total of 24 ribs. Occasionally, a person is born with an extra set of ribs. The joint between the ribs and vertebrae is a gliding (or plane) joint, a type of synovial joint, as ribs do move, expanding and contracting with breathing. Most of the ribs (the first seven pair) attach in the front of the body via cartilage to the long, flat breastbone, or sternum. These ribs are called true ribs. The next three pair of ribs are false ribs. False ribs attach to another rib in front instead of the sternum, and are connected by cartilage. The lower two pair of ribs which do not attach anteriorly are called floating ribs. Ribs give shape to the chest and support and protect the body's major organs, such as the **heart** and **lungs**. The rib cage also provides attachment points for connective tissue, to help hold organs in place. In adult humans, the sternum also produces red blood cells as well as providing an attachment site for ribs.

APPENDICULAR SKELETON. The appendicular skeleton joins with the axial skeleton at the shoulders and hips. Forming a loose attachment with the sternum is the pectoral girdle, or shoulder. Two bones, the clavicle (collar bone) and scapula (shoulder blade), form one shoulder. The scapula rest on top of the ribs in the back of the body. It connects to the clavicle, the bone which attaches the entire shoulder structure to the skeleton at the sternum.

The clavicle is a slender bone that is easily broken. Because the scapula is so loosely attached, it is easily dislocated from the clavicle, hence the dislocated shoulder injuries commonly suffered by persons playing sports. The major advantage to the loose attachment of the pectoral girdle is that it allows for a wide range of shoulder motions and greater overall freedom of movement.

Unlike the pectoral girdle, the pelvic girdle, or hips, is strong and dense. Each hip, left and right, consists of three fused bones, the ilium, ischium, and pubic. Collectively, these three bones are known as the innominate bone.

The innominates fuse with the sacrum to form the pelvic girdle. Specifically, the iliums shape the hips and the two ischial bones support the body when a person sits. The two pubic bones meet anteriorly at a cartilaginous joint. The pelvic girdle is bowl-shaped, with an opening at the bottom. In a pregnant woman, this bony opening is a passageway through which her baby must pass during birth. To facilitate the baby's passage, the body secretes a hormone called relaxin which loosens the joint between the pubic bones. In addition, the pelvic girdle of women is generally wider than that of men. This also helps to facilitate birth, but is a slight impediment for walking and running. Hence, men, with their narrower hips, are better adapted for such activities. The pelvic girdle protects the lower abdominal organs, such as the intestines, and helps supports the weight of the body above it.

The arms and legs, the upper and lower appendages of the body, are very similar in form. Each attaches to the girdle, pectoral or pelvic, via a **ball and socket joint**, a special type of synovial joint. In the shoulder, the socket, called the glenoid cavity, is shallow. The shallowness of the glenoid cavity allows for great freedom of movement. The hip socket, or acetabulum, is larger and deeper. This deep socket, combined with the rigid and massive structure of the hips, give the legs much less mobility and flexibility than the arms.

The humerus, or upper arm bone, is the long bone between the elbow and the shoulder. It connects the arm to the pectoral girdle. In the leg the femur, or thigh bone, is the long bone between the knee and hip which connects the leg to the pelvic girdle. The humerus and femur are sturdy bones, especially the femur, which is a weight bearing bone. Since the arms and legs are jointed, the humerus and femur are connected to other bones at the end opposite the ball and socket joint. In the elbow, this second joint is a type of synovial joint called a **hinge joint**. Two types of synovial joints occur in the knee region, a condylar joint (like the condylar joint in the first

vertebra) which connects the leg bones, and a plane, or **gliding joint**, between the patella (knee cap) and femur.

At the elbow the humerus attaches to a set of parallel bones, the ulna and radius, bones of the forearm. The radius is the bone below the thumb that rotates when the hand is turned over and back. The ulna and radius then attach to the carpal bones of the wrist. Eight small carpal bones make up the wrist and connect to the hand. The hand is made up of five long, slender metacarpal bones (the palms) and 14 phalanges of the hand (fingers and thumb). Some phalanges form joints with each other, giving the human hand great dexterity.

Similarly, in the leg, the femur forms a joint with the patella and with the fibula and tibia bones of the lower leg. The tibia, or shin bone, is larger than the fibula and forms the joint behind the patella with the femur. Like the femur, the tibia is also a weight bearing bone. At the ankle joint, the fibula and tibia connect to the tarsals of the upper foot. There are seven tarsals of the upper foot, forming the ankle and the heel. The tarsals in turn connect to five long, slender metatarsals of the lower foot. The metatarsals form the foot's arch and sole and connect to the phalanges of the feet (toes). The 14 foot phalanges are shorter and less agile than the hand phalanges. Several types of synovial joints occur in the hands and feet, including plane, ellipsoid and saddle. Plane joints occur between toe bones, allowing limited movement. Ellipsoid joints between the finger and palm bones give the fingers circular mobility, unlike the toes. The saddle joint at the base of the thumb helps make the hands the most important part of the body in terms of dexterity and manipulation. A saddle joint also occurs at the ankles.

Bone development and growth

Since most bone begins as cartilage, it must be converted to bone through a process called ossification. The key players in bone development are cartilage cells (chondrocytes), bone precursor cells (osteoprogenitor cells), bone deposition cells (osteoblasts), bone resorption cells (osteoclasts), and mature bone cells (osteocytes).

During ossification, blood vessels invade the cartilage and transport osteoprogenitor cells to a region called the center of ossification. At this site, the cartilage cells die, leaving behind small cavities. Osteoblast cells form from the progenitor cells and begin depositing bone tissue, spreading out from the center. Through this process, both the spongy textured cancellous bone and the smooth outer compact bone forms. Two types of bone marrow, red and yellow, occupy the spaces in cancellous bone. Red marrow produces red blood cells while yellow marrow stores fat in addition to producing blood cells.

Eventually, in compact bone, osteoblast cells become trapped in their bony cavities, called lacunae, and become osteocytes. Neighboring osteocytes form connections with each other and thus are able to transfer materials between cells. The osteocytes are part of a larger system called the Haversian system. These systems are like long tubes, squeezed tightly together in compact bone. Blood vessel, lymph vessels, and nerves run through the center of the tube, called the Haversian canal, and are surrounded by layers of bone, called lamellae, which house the osteocytes. Blood vessels are connected to each other by lateral canals called Volkmann's canals. Blood vessels are also found in spongy bone, without the Haversian system. A protective membrane called the periosteum surrounds all bones.

Bone development is a complex process, but it is only half the story. Bones must grow, and they do so via a process called remodeling. Remodeling involves resorption of existing bone inside the bone (enlarging the marrow cavities) and deposition of new bone on the exterior. The resorptive cells are the osteoclasts and osteoblast cells lay down the new bone material. As remodeling progresses in long bones, a new center of ossification develops, this one at the swollen ends of the bone, called the epiphysis. A thin layer of cartilage called the epiphyseal plate separates the epiphysis from the shaft and is the site of bone deposition. When growth is complete, this cartilage plate disappears, so that the only cartilage remaining is that which lines the joints, called hyaline cartilage. Remodeling does not end when growth ends. Osteocytes, responding to the body's need for calcium, resorb bone in adults to maintain a calcium balance.

Function

The skeletal system has several important functions:

- It provides shape and form to the body, while allowing for body movement.
- It supports and protects vital organs and muscles.
- It produces red blood cells for the body in the bone marrow. Each second, an average of 2.6 million red blood cells are to replace worn out blood cells and those destroyed by the **liver**.
- It stores minerals including calcium and phosphorus. When excess are present in the blood, the bones will store minerals. When the supply in the blood runs low, minerals will be withdrawn from the bones to replenish the blood supply.

Common diseases and disorders

Even though bones are very strong, they may be broken. Most fractures do heal. The healing process may be stymied if bones are not reset properly or if the injured person is the victim of malnutrition. Osteoprogenitor cells migrate to the site of the fracture and begin the process of making new bone (osteoblasts) and reabsorbing the injured bone (osteoclasts). With proper care, the fracture will fully heal, and in children, often without a trace.

The joint between the mandible and the temporal bones, called the temporomandibular joint, is the source of the painful condition known as temporomandibular joint dysfunction, or TMJ dysfunction. Sufferers of TMJ dysfunction experience a variety of symptoms including headaches, a sore jaw, and a snapping sensation when moving the jaw. There are several causes of the dysfunction. The cartilage disk between the bones may shift, or the connective tissue between the bones may be situated in a manner that causes misalignment of the jaw. Sometimes braces on the teeth can aggravate TMJ dysfunction. The condition may be corrected with **exercise**, or in severe cases, surgery. Another condition, cleft palate, is due to the failure of the maxillary bones in the jaw to completely fuse in the fetus.

Bones are affected by poor diet and are also subject to a number of diseases and disorders. Some examples include scurvy, rickets, **osteoporosis**, arthritis, and bone tumors. Scurvy results from the lack of **vitamin C**. In infants, scurvy causes poor bone development. It also causes membranes surrounding the bone to bleed, forming clots which are eventually ossified, and thin bones which break easy. In addition, adults are affected by bleeding gums and loss of teeth. Before modern times, sailors were often the victims of scurvy, due to extended periods of time at sea with limited food. They consequently tried to keep a good supply of citrus fruits, such as oranges and limes, on board because these fruits supply vitamin C. By the twenty-first century, scurvy had become extremely rare in Western societies.

Rickets is a children's disease resulting from a deficiency of **vitamin D**. This vitamin enables the body to absorb calcium and phosphorus; without it, bones become soft and weak and actually bend, or bow out, under the body's weight. Vitamin D is found in milk, eggs and liver, and may also be produced by exposing the skin to sunlight. Pregnant women can also suffer from a vitamin D deficiency, osteomalacia, resulting in soft bones. The elderly, especially women who had several children in succession, sometimes suffer from osteoporosis, a condition in which a significant amount of calcium from bones is dissolved into the blood to maintain the body's calcium balance. Weak, brittle bones dotted with

KEY TERMS

Bone—Composed primarily of a non-living matrix of calcium salts and a living matrix of collagen fibers, bone is the major component that makes up the human skeleton. Bone produces blood cells and functions as a storage site for elements such as calcium and phosphorus.

Calcium—A naturally occurring element which combines primarily with phosphate to form the nonliving matrix of bones.

Cartilage—A type of connective tissue that takes three forms: elastic cartilage, fibrocartilage, and hyaline cartilage. Hyaline cartilage forms the embryonic skeleton and lines the joints of bones.

Haversian system—Tubular systems in compact bone with a central Haversian canal which houses blood and lymph vessels surrounded by circular layers of calcium salts and collagen, called lamellae, in which reside osteocytes.

Marrow—A type of connective tissue which fills the spaces of most cancellous bone and which functions to produce blood cells and store fat.

Ossification—The process of replacing connective tissue such as cartilage and mesenchyme with bone.

Osteoblast—The bone cell which deposits calcium salts and collagen during bone growth, bone remodeling and bone repair.

Osteoclast—The bone cell responsible for reabsorbing bone tissue in bone remodeling and repair.

Osteocyte—Mature bone cell which functions mainly to regulate the levels of calcium and phosphate in the body.

Skeleton—Consists of bones and cartilage which are linked together by ligaments. The skeleton protects vital organs of the body and enables body movement.

Synovial joint—One of three types of joints in the skeleton and by far the most common. Synovial joints are lined with a membrane which secretes a lubricating fluid. Includes ball and socket, pivot, plane, hinge, saddle, condylar, and ellipsoid joints.

Vertebrates—Includes all animals with a vertebral column protecting the spinal cord such as humans, dogs, birds, lizards, and fish.

pits and pores are the result. Osteoporosis occurs most often in older people and in women after **menopause**. It affects nearly half of all those, men and women, over the age of 75. Women, however, are five times more likely than men to develop the disease. They have smaller, thinner bones than men to begin with, and they lose bone mass more rapidly after menopause (usually around age 50), when they stop producing a bone-protecting hormone called estrogen. In the five to seven years following menopause, women can lose about 20% of their bone mass. By age 65 or 70, though, men and women lose bone mass at the same rate. As an increasing number of men reach an older age, they are becoming more aware that osteoporosis is an important health issue for them as well.

Arthritis is another condition commonly afflicting the elderly. This is an often painful inflammation of the joints. Arthritis is not restricted to the elderly, and even young people can suffer from this condition. There are several types of arthritis, such as rheumatoid, rheumatic, and degenerative. Arthritis basically involves the inflammation and deterioration of cartilage and bone at the joint surface. In some cases, bony protuberances around the rim of the joint may develop. Most people will probably develop arthritis if they live to a significant older age. Degenerative arthritis is the type that commonly occurs with age. The knee, hip, shoulder, and elbow are the major targets of degenerative arthritis. A number of different types of tumors, some harmless and others more serious, may also affect bones.

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ORGANIZATIONS

- Arthritis Foundation. 1330 W. Peachtree St., PO Box 7669, Atlanta, GA 30357-0669. (800) 283-7800. <<http://www.arthritis.org>>.
- National Center for Complementary and Alternative Medicine (NCCAM), 31 Center Dr., Room #5B-58, Bethesda, MD 20892-2182. (800) NIH-NCAM, Fax (301) 495-4957. <<http://nccam.nih.gov>>.
- National Osteoporosis Foundation. 1150 17th Street, Suite 500 NW, Washington, DC 20036-4603. (800) 223-9994. <<http://www.nof.org>>.
- Osteoporosis and Related Bone Diseases-National Resource Center. 1150 17th St., NW, Ste. 500, Washington, DC 20036-4603. (800) 624-BONE. <<http://www.osteoo.org>>.

Crystal Heather Kaczowski, MSc.

Skin allergy tests see **Allergy tests**

Skin cancer see **Malignant melanoma**

Skin culture

Definition

A skin culture is a laboratory test used to isolate and identify the microorganism (bacterium, fungus, or virus) causing a skin **infection**, so the most effective antibiotic or other treatment for the infection can be determined.

Purpose

Skin infections are contagious and, if left untreated, can lead to serious complications. A skin culture helps the physician to diagnose and treat a skin infection.

Precautions

To avoid spreading pathogenic organisms to patients or other individuals, health care professionals should be cautious in the collection and handling of skin culture specimens.

Description

Skin infections may involve the superficial layer (epidermis) only or may involve the deeper dermis,

including the sweat glands, oil glands, lymphatics, and hair follicles within. Microorganisms can infect healthy skin, but more often they infect skin already damaged by an injury or an abrasion. The lesion produced by the infection is an early indication of which type of microorganism is causing the infection. For example, pustules are associated with impetigo (pyoderma) the most common bacterial skin infection. Pyoderma is most often caused by group A *Streptococcus*. Vesicular skin rashes are commonly caused by herpesviruses as in chickenpox. Scaly rashes are most commonly caused by dermatophytes, **fungi** that infect the keratinized skin (epidermis). Bacterial skin infections are the most common, and can result in ulcers, cellulitis, rashes, **boils**, abscesses, and other types of lesions.

The following types of microorganisms cause most skin infections and can be isolated by performing a skin culture:

- **Bacteria:** Aerobic gram positive cocci, *Streptococcus pyrogenes*, and *Staphylococcus aureus* are the most common isolates and are responsible for pyoderma. However many other bacteria cause skin infections less frequently. Usually, these are introduced through a wound in the skin caused by a bite, decubitus ulcer, burn, trauma, or puncture. Some notable genera are anaerobic bacteria such as *Bacteroides* and *Clostridium* from soils, gram negative rods such as *Aeromonas*, *Plesiomones*, and *Vibrio* from water. Organisms that live in the mouth of dogs and cats such as *Pasteurella multocida* can infect bite **wounds**.
- **Fungi** (molds and yeast): Three genera of fungi commonly cause ringworm of the skin, hair, and nails and are the most common fungi isolated from skin. These are *Trichophyton*, *Epidermophyton*, and *Microsporum*. *Candida* can colonize the epidermis as part of the normal flora but will infect burned skin and skin folds of newborns. Several other fungi may cause subcutaneous infection.
- **Viruses:** Rubella (German measles), rubeola, roseola, and herpes varicella zoster (chickenpox) are common causes of viral rashes in children. Herpes simplex 1 and cytomegalovirus may cause more complex infections in immunosuppressed adults. In addition, skin infections can be caused by enteroviruses, poxviruses and several others.
- Skin infections can also be caused by mycobacteria such as *Mycobacterium tuberculosis* and *M. leprae* the cause of leprosy, and skin lesions can be caused by some parasites when the larva enter the skin.

Based on the appearance of the lesion, the physician orders one or more types of skin cultures. Using **aseptic technique**, the physician, nurse, or other health care pro-

fessional collects a specimen. For open epidermal infections a sample of the lesion such as skin cells, pus, or fluid can be collected using a swab. For crusted or closed lesions, the surface of the vesicle or pustule should be removed with a scalpel blade in order to expose the infected skin before swabbing. Ringworm should be scraped using a scalpel blade to collect the keratinized skin. Deeper infections should be sampled by aspiration. Swabs for bacterial culture are placed in a sterile container (often containing transport medium such as Stuart or Cary-Blair) before being sent to the laboratory for culture. If anaerobic culture is requested the specimen is immediately placed in prerduced oxygen-free transport medium.

Bacterial skin cultures

A **Gram stain** is prepared by rolling the smear across the center of a glass slide or dropping a liquid specimen onto the center and allowing it to air dry. Gram-positive cells retain the crystal violet stain and appear dark purple, while gram-negative cells do not. Gram-negative bacteria are counterstained by the safranin and appear pink. In addition to classifying the bacteria seen, the Gram stain can identify yeast, hyphal elements, and organisms that require special culture media. For example, the presence of large gram-positive spore forming rods indicates the possible presence of *Clostridium spp.* and the need for anaerobic culture.

A routine bacterial skin culture involves inoculating (spreading a portion of the specimen on) several culture plates containing general-use enrichment media and selective media. Commonly used media include sheep blood agar plates, chocolate (heated blood) agar plates, MacConkey agar for isolation of gram-negative rods, and either phenylethyl alcohol (PEA) or colistin-naladixic acid (CNA) blood agar for isolation of gram positive cocci. Plates are incubated in air or 5–10% carbon dioxide and examined for growth daily for at least two days. Bacteria present in the specimen multiply and appear on the plates as visible colonies. These are Gram stained and subcultured (transferred) to other media in order to identify the organism. Complete identification usually requires one to two days following isolation of a pure culture. It is standard practice to perform an antibiotic sensitivity test on any bacterial pathogen isolated from a routine skin culture, except group A *Streptococcus*, which is susceptible to penicillin and related **antibiotics**. An antibiotic sensitivity test, also called an antibiotic susceptibility test, grows the bacteria in the presence of different antibiotics to determine which ones will effectively treat the infection by killing the bacteria.

Fungal skin cultures

Physicians request fungal skin cultures less frequently. A group of fungi called dermatophytes cause skin infections such as ringworm and athlete's foot. Yeast infections caused by *Candida* can thrive on moist skin, such as in diaper areas and in the folds of skin in the groin. Yeast infections can cause significant problems for newborns and patients with **AIDS** or depressed immune systems. Yeast infections are cultured on sheep blood agar and grow in one to two days. Dermatophytes are usually identified by a **KOH test**. In this test, a sample of skin scraped with a scalpel blade and transferred to a slide. After adding KOH, the slide is allowed to stand for five minutes in order to dissolve skin cells, hair, and debris. Lactophenol cotton blue stain can be added to make the fungi easier to see, or if a fluorescent **microscope** is available, calcofluor white stain may be added to the KOH preparation. This will cause the fungi to become fluorescent making them easier to identify. Dermatophytes are easily recognized under the microscope by their long branch-like tubular structures called hyphae. Fungi causing ringworm infections produce septate (segmented) hyphae. Some show the presence of spores formed directly from the hyphae (arthroconidia). Yeast infections of the skin can also be identified by the KOH test. Yeast cells appear round or oval, and budding forms may be seen.

A culture is requested only when specific identification of the fungus is necessary. For a routine **fungal culture**, the specimen is spread on a culture plate or tube containing nutrient media designed to grow fungi, incubated for up to four weeks, and observed for growth at regular intervals. Stains and biochemical tests are usually used to identify yeast and other fungi. Dermatophytes may be cultured on a medium called dermatophyte test medium (DTM). This is an agar slant containing phytone, dextrose, phenol red, cycloheximide, gentamicin, and chlortetracycline. The antibiotics inhibit the growth of normal skin flora. Skin scrapings, hair, or nail samples are added to the medium and allowed to grow at room temperature. Cultures are held for 14 days. Dermatophytes will turn the medium from yellow to red as they grow. Other fungi, called systemic fungi can enter the skin through puncture wounds, abrasions or cuts and cause subcutaneous infection. A common cause of systemic mycosis in the United States among gardeners and farmers is *Sporothrix schenckii*. Such fungi are cultured from skin aspirates on growth medium for fungi containing antibiotics to inhibit bacterial growth. Most commonly used are Sabouraud dextrose agar with antibiotics and mycosel agar with cycloheximide and chloramphenicol. Cultures are incubated at both 77°F and 96.8°F (25°C and 36°C). *Sporothrix schenckii* grows in about

four days but other fungi grow more slowly, and plates should be held for 30 days before reporting as negative.

Viral skin cultures

Viruses, such as herpes, can also cause skin infections. A specimen for viral culture is mixed with commercially prepared animal cells usually grown on a coverslip in a shell vial. Characteristic changes to the animal cells caused by the growing virus help to identify the virus. For rapid diagnosis, some laboratories use an electron microscope to identify viruses on the basis of morphology. For example, the herpes virus can be cultured from a vesicle (blister) which has been removed carefully with a scalpel blade. The base of the vesicle is swabbed with a sterile cotton applicator, and the virus taken to the laboratory in a tube of viral transport medium. Herpes can be cultured in several cell lines including human diploid fibroblasts (HDF), HEp2 cells (epithelial **cancer** cells from the larynx), primary monkey kidney cells (PMK), and rabbit kidney cells (RK). Cell cultures are inoculated and allowed to grow for one to three days at 96.8°F (36°C) in 5–10% carbon dioxide. Usually by the end of the first day of culture the cytopathic effect (CPE), formation of giant cells, can be seen by observing the cells under a microscope.

Preparation

Before ordering a skin culture, the physician will ask the patient for a complete medical history and perform a **physical examination** to determine possible causes of the skin infection and whether a skin culture is appropriate. For acute skin infections, immediate treatment is sometimes necessary.

All healthcare professionals who participate in collecting a skin culture specimen should be trained in aseptic technique. Before collecting the specimen, they should scrub their hands thoroughly with an antimicrobial soap and, in some cases, put on sterile gowns, masks, and gloves. Sterile instruments and containers should be assembled near the patient. If appropriate, a sterile drape can be placed around the site of the infection. After cleaning the infected area with alcohol and sterile saline, the physician, nurse, or other healthcare professional uses a sterile blade, swab, needle, syringe, or other instruments to collect a sample of skin cells, pus, or fluid from the lesion. It might be necessary to open the lesion before collecting the specimen.

Aftercare

Collection of the specimen could cause some slight bleeding at the infection site, which might require some

attention. Otherwise, no special aftercare is necessary for the patient following a skin culture.

The health care professionals who collect the specimen should ensure that any drapes, gowns, gloves, or instruments used for the collection are placed in the proper containers for disposal or sterilization. Then they should again scrub their hands thoroughly with an antimicrobial soap before leaving the area.

Complications

If aseptic technique is not used to collect the specimen, the patient or the healthcare professionals could develop postprocedure infections. The infection could also be transmitted to other individuals by contaminated hands or objects.

Results

Results for bacterial cultures are usually available in one to three days. Cultures for fungi and viruses may take longer—up to three or more weeks.

Many microorganisms that are found on a person's skin are normally considered to be harmless. When these microorganisms grow on a skin culture, they are reported as "normal flora." One of the most common of these microorganisms is *Staphylococcus epidermidis*. Other bacteria that live in the high salt environment of the skin include *Propionibacterium acnes*, *Corynebacterium xerosis*, and some yeasts.

Besides normal flora, any microorganism that grows on a skin culture is considered to be the cause of the infection if it is the only microorganism or the predominant microorganism; if it grows in large numbers; or if it is known to produce infection. *Staphylococcus aureus* and group A *Streptococcus* cause most bacterial skin infections. *Candida albicans* causes most yeast skin infections, and *Herpes simplex* is the most frequent cause of viral skin infections.

Health care team roles

The physician determines whether a skin culture is needed to diagnose a skin infection, and orders the test when appropriate. Then the physician, nurse, or other healthcare professional trained in aseptic technique collects the specimen and sends it to the laboratory. The clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) assumes responsibility for correct handling, culture, identification, and reporting of the results.

KEY TERMS

Antimicrobial—A substance or action that kills or inhibits the growth of microorganisms.

Aseptic technique—Practices performed before, during, and after a clinical procedure to prevent or reduce contamination and postprocedural infection.

Pathogen—An organism that causes disease.

Pyoderma—A pus-containing bacterial skin infection.

Selective media—Media designed to enhance the growth of one type of microorganism by inhibiting the growth of other types with antibiotics or other substances.

Sensitivity test—A laboratory test that shows which antibiotics will treat an infection by killing the bacteria.

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- American Society of Microbiology. 1752 N Street NW, Washington DC 20036. (202) 737-3600. <<http://www.asmsa.org>>.
- UTMB The University of Texas Medical Branch. 301 University Blvd., Galveston, TX 77555. (409) 772-1011. <<http://www.utmb.edu>>.
- Yale University School of Medicine. 367 Cedar Street, New Haven, CT 06510. (203) 785-2643. <<http://www.info.med.yale.edu/ysm/ysminfo/index.html>>.

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Skull

Definition

The skull—or cranium—is the skeleton of the head. It includes the **brain** case and the bones of the face and jaw.

Description

The skull is the bony part of the head. It rests on the first vertebra of the spine, called the atlas. It belongs to the axial skeleton, meaning the skeleton associated with the **central nervous system**. That includes the skull, all the bones of the spine, the ribs, and the breastbone.

At birth, the skull of a baby is large when compared to the rest of the body. It is fairly compressible, with soft spots (fontanelles) that eventually harden around the age of eighteen months. In the adult, some bones of the skull are paired, meaning that there is a left and a right, while others are unpaired. They are connected by sutures, saw-like bony edges that serve as joints. Bones of the skull are usually classified as cranial bones, facial bones (splanchnocranium), or as bones that form the braincase (neurocranium). There are eight cranial bones and 14 facial bones. The facial bone assembly also includes air-filled spaces located all around the nose and called the paranasal sinuses.

Paired cranial bones

The paired cranial bones include parietal bones and the temporal bones.

The parietal bones are paired. Shaped like curved plates, they form the bulging sides and roof of the cranium. Fused in the middle along the sagittal suture, they meet the frontal bone along the coronal suture in the front of the skull. The point at which the two sutures meet is called the bregma. In the back of the skull, the parietals connect with the occipital bone along the lambdoid suture. The intersection of the lambdoid and sagittal sutures is called the lambda. The parietals meet the temporal bones in the lower portion of the skull along the squamosal and parieto-mastoid sutures. On the external surface near the center of the bone is the parietal eminence, or bulge. Slightly behind the bulge is found the parietal foramen (a foramen is an opening through bone that serves as a passageway for **blood vessels** and nerves). The parietals make contact with the following bones: occipital, frontal, temporal, sphenoid, and parietal.

The temporals form parts of the sides and base of the cranium. They are also paired left and right. Each temporal bone consists of two major sections, the squamous

portion, or flat section, and a very thick and rugged part, the petrosal portion. The petrosal portion contains the cavity of the middle ear and the three smallest bones of the body. The smallest bones are the bones of the ear: the malleus, the incus and the stapes. Located near the lower edge is a gap, the external auditory meatus, that leads inward to the ear. At the lower end of the petrosal portion is the slender styloid process. A process is a bony extension or projection on a bone and the styloid is of variable length, it serves as a muscle attachment for various thin muscles to the tongue and other structures in the throat. Another projection, the mastoid process, provides an attachment for some of the muscles of the neck. The temporals also house the internal structures of the ear and have depressions, called mandibular fossae, that assist in forming the shallow socket of the jawbone joint. A zygomatic process projects from the front of the temporal bone where it joins the zygomatic bone to help form the prominence of the cheek. The temporals make contact with the following bones: the zygomatics, parietals, mandible, occipital, and sphenoid.

Unpaired cranial bones

The unpaired cranial bones include the frontal bone, occipital bone, sphenoid bone, and ethmoid bone.

The frontal bone consists of two major sections, a vertical squamous portion that connects with the paired parietals along the coronal suture and forms the forehead, and two orbital plates, which form the left and right eye sockets (orbits). On its external surface, the squamous portion very often displays a left and right frontal eminence, or bulge. Additionally, the frontal bone has two supra-orbital ridges, which are bumps above each of the eye sockets. The frontal and nasal bones connect along the fronto-nasal suture. The frontal bone makes contact with the following bones: lacrimals, nasals, zygomatics, sphenoid, maxillae, parietals, and ethmoid.

The occipital bone forms the back of the skull and the base of the cranium. It consists of a large flattened section separated from a small thick portion by the foramen magnum—a large opening through which cranial nerves from the brain pass and enter the spine to become part of the **spinal cord**. On both sides of the foramen, there is a left and a right occipital condyle. A condyle is a rounded enlargement that has an articulating surface, or joint. The occipital condyles articulate with the first vertebra of the neck, the atlas (also known as the first cervical vertebra, or C1). The occipital makes contact with the following bones: parietals, temporals, sphenoid, and the atlas.

The sphenoid is a single bone that assists in connecting the cranial bones to the facial bones. It consists of

a hollow part, which contains the sphenoidal sinus, and three pairs of bony projections. The first projections are called the lesser wings and they contain the optic foramen, through which the optic (or second) cranial nerve passes before reaching the eye. The second pair are called the greater wings, they assist in forming the orbital plates for each of the eye sockets. The third pair are the pterygoid processes that run along the back section of the nasal passages toward the palate and provide muscle attachments for the jawbones. The sphenoid makes contact with the following bones: vomer, ethmoid, frontal, occipital, parietals, temporals, zygomatics, and palatines.

Like the sphenoid, the ethmoid is a single bone that helps to connect the cranial bones to the facial bones. It consists of various plates and paired projections. The upper projections are the crista galli that assist in dividing the left and right frontal lobes of the brain. Side projections from the crista galli are the left and right cribriform plates which provide a seat for the olfactory nerves. The nerves go through these plates into the nasal cavity below. Directly under the crista galli is the perpendicular plate which connects with the vomer bone and helps to separate the left and right nasal passages. The ethmoid makes contact with the following bones: sphenoid, frontal, maxillae, palatines, vomer, and lacrimals.

Paired facial bones

Paired facial bones include the lacrimals, nasals, zygomatics, maxillae, palatines, and inferior nasal conchae.

The lacrimal bones are the smallest and most fragile of the facial bones and they are paired left and right. They help form the back portion of each eye socket, and are rectangular in shape with two surfaces and four borders. The lacrimals contain a feature, called the lacrimal sulcus, which helps to form the lacrimal fossa. The lacrimal fossa is an opening for the lacrimal ducts that connects the corner of the eye to the nasal passage, and allows the tears from the eye to be channeled into the nose. The lacrimals make contact with the following bones: frontal, ethmoid, and maxillae.

Each nasal bone is a small rectangular bone. Together they form the bridge of the nose above the nasal cavity. They join with each other along the internasal suture and with the frontal bone above along the frontonasal suture. The point of intersection of both sutures is called the nasion. Nasal bones make contact with the following bones: frontal, maxilla, and other nasals.

The zygomatics are the cheek bones. They have three major features that connect them with surrounding bones. The first is the frontal process. The frontal process forms the wall of the eye socket and connects above with

the zygomatic process of the frontal bone. This section separates the eye orbit from the temporal fossa and has a projection called the marginal process. The third feature is the temporal process, and it connects with the zygomatic process of the temporal bone. Together these processes help to form the zygomatic arch which is the attachment for the masseter muscle, one of the major muscles used for chewing (mastication). The zygomatics make contact with the following bones: frontal, sphenoid, maxillae, and temporals.

The maxillae are also paired facial bones. They seat the upper teeth and form the upper jaw. In the upper part of the bone, the frontal process helps to form the nasal opening and ends by connecting with the frontal bone. A maxilla makes contact with the following bones: frontal, ethmoid, zygomatic, vomer, lacrimal, maxilla, nasal, palatine, mandible, and inferior nasal concha.

The palatines are paired left and right and connect with each other along the interpalatine suture. Both bones help form the back section of the hard palate as well as a portion of the nasal cavity. A palatine bone makes contact with the following bones: sphenoid, ethmoid, maxilla, vomer, and the other palatine bone.

The inferior nasal conchae are very thin and delicate paired bones that are elongated with curled-up ends. They are attached to the sides of the nasal cavity and connect to the maxilla and the bones that form the side wall of the nasal cavity. An inferior nasal concha makes contact with the following bones: ethmoid, lacrimal, maxilla, and palatines.

Unpaired facial bones

The unpaired facial bones include the vomer, mandible, and hyoid.

The vomer is a single flat bone. The upper part connects with the perpendicular plate of the ethmoid to form the nasal septum, the dividing wall that runs down the middle of the nose. The vomer makes contact with the following bones: sphenoid, ethmoid, palatines, and maxillae.

The largest facial bone is the mandible. It is the only bone of the skull that contains a movable joint. It is a strong, curved-shaped bone that encases the lower teeth in the alveolar process. It has rounded projections, called mandibular condyles on each end. The condyles link it to the temporal bone by hinges called the temporomandibular joints. The mandible makes contact with the following bones: temporals and maxillae.

The hyoid is a single small U-shaped bone that does not join with any other bone. It hangs from the styloid process of each temporal bone by means of ligaments.

KEY TERMS

Atlas—The atlas is not part of the skull. It is the first of the seven vertebrae of the neck and the one upon which the base of the skull rests. It is also the bone around which the skull rotates.

Axial skeleton—The skeleton associated with the central nervous system—the cranium, all the bones of the vertebral column, the ribs, and the sternum.

Brain—One of the two components of the central nervous system (CNS), the brain is the center of higher thought and emotion. It is responsible for the coordination and control of all body activities and for the perception and the interpretation of sense information.

Bregma—The point where the coronal and sagittal sutures of the skull meet.

Calvaria—The skull cap, roof of the skull, or cranium without the facial bones attached.

Condyle—A rounded enlargement that has an articulating surface.

Coronal suture—The suture between the two parietal bones and the frontal bone in the skull.

Cranial bones—The eight bones of the skull that form the braincase, which encloses the brain. They are the parietals, the temporals, the frontal, the occipital, the sphenoid, and the ethmoid bones.

Cranial nerve—In humans, there are 12 cranial nerves. They are connected to the brain stem and basically ‘run’ the head as well as help regulate the organs of the thoracic and abdominal cavities.

Cranium—The bones of the head.

Ethmoid bone—Skull bone located behind the nose.

External auditory meatus—The passage or canal in the skull for the tissues involved in hearing.

Facial bones—The 14 bones of the skull that form the face and jaw. The paired facial bones are the lacrimals, nasals, zygomatics, maxillae, palatines, and inferior nasal conchae. The unpaired facial bones are the vomer, mandible and hyoid.

Foramen—A hole in a bone, usually for the passage of blood vessels and/or nerves.

Foramen magnum—The large opening at the base of the skull that allows passage of the spinal cord.

Fossa—A pit, depression, or concavity, on a bone or formed from several bones.

Lambda—The point where the sagittal and lambdoid sutures of the skull meet.

Lambdoid suture—The suture between the two parietal bones and the occipital bone in the skull.

Mandible—The lower jaw bone.

Maxillae—The upper jaw bones, connected to the orbit, hard palate and nasal cavity.

Neurocranium—The braincase of the skull.

Process—A general term describing any marked projection or prominence on a bone.

Sagittal suture—The suture between the two parietal bones in the top of the skull.

Sinuses—Air-filled cavities of the skull. The ethmoid sinus is in the ethmoid bone, the maxillary sinus in the maxilla, the frontal sinus in the frontal bones and the sphenoid sinus in the sphenoid bone.

Skull—All of the bones of the head.

Sphenoid bone—An irregularly shaped bone located in front of the occipital bone in the base of the skull.

Spinal cord—The elongated part of the central nervous system (CNS) that lies in the vertebral canal of the spine from which the spinal nerves emerge.

Squamosal suture—The suture between a temporal bone and a parietal bone in the skull.

Squamous—Adjective meaning scaly, flat, and plate-like.

Splanchocranium—The facial bones of the skull.

Suture—The saw-like edge of a cranial bone that serves as joint between bones of the skull.

Vertebrae—The flat bones that make up the spine or vertebral column. The spine has 33 vertebrae.

Function

The skull encloses and protects the brain, provides a base for the attachments of the muscles of the head and

neck, and provides a structural element to form the first sections of the respiratory and digestive tracts. The bones of the skull are very hard, and protection of the brain is undoubtedly their most important function.

Common diseases and disorders

Disorders and conditions that affect the skull can be divided into two broad categories—craniofacial anomalies and trauma-related injuries. The most serious injury is a skull fracture, meaning a break or rupture in any of the skull bones. Craniofacial anomaly is a general term that includes malformations diagnosed at birth (congenital anomalies) and developmental anomalies that result from the abnormal growth of the skull and face after birth.

- **Basal skull fractures:** These are most commonly extensions of fractures of the roof of the skull. The usual locations are the temporal bone, the orbital surface of the frontal bone, and the occipital bone.
- **Jaw fractures:** These include mandibular fractures and maxillary fractures.
- **Facial fractures:** These can range from the fracture of one facial bone, for example a zygomatic fracture, to more severe trauma such as facial smash, which involves multiple fractures and extensive disruption of the bony architecture of the head.
- **Hemifacial microsomia:** Hemifacial Microsomia is a condition that affects the growth of the face on one or both sides. The severity of this disorder can vary from mild to severe. Although different facial structures can be affected, the most common areas include the ear, the oral cavity, and the mandible.
- **Goldenhar syndrome:** This syndrome is a variant of hemifacial microsomia. The symptoms of this disorder match those of hemifacial microsomia with the addition of epibulbar dermoids, which are benign tumors located just inside the opening of the eye orbit.
- **Treacher-Collins syndrome:** Also known as mandibulo-facial synostosis. The syndrome affects the size and shape of the ears, cheekbones, and upper and lower jaws.

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World Craniofacial Foundation. 7777 Forest Lane, Suite C-621, P.O. Box 515838, Dallas, TX, 75251-5838. (972) 566-6669. (800) 533-3315. <<http://www.worldcf.org/index.html>>.

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Monique Laberge, PhD

Skull x rays

Definition

Skull x rays are performed to examine the nose, sinuses, and facial bones. These studies may also be referred to as sinus or maxillofacial x rays. X-ray studies produce films, also known as radiographs, by aiming x rays at bones and soft tissues of the body. X-ray beams are similar to light waves, except their shorter wavelength allows them to penetrate dense substances, producing images and shadows on film.

Purpose

Doctors may order skull x rays to aid in the diagnosis of a variety of diseases or injuries, such as:

Sinusitis

Sinus x rays may be ordered to confirm a diagnosis of sinusitis, or sinus **infection**.

Fractures

A skull x ray may detect bone **fractures**, resulting from injury or other disease. The skull x ray should clearly show the top of the skull, jaw bones (mandible), and facial bones. In larger facilities the computed tomography scan (CT) has begun to replace the skull x-ray as a screening tool, since a CT scan can offer more information about craniofacial injuries.

Tumors

Skull radiographs may indicate tumors in facial bones, tissues, or the sinuses. Tumors may be benign (not cancerous) or malignant (cancerous). If a tumor is suspected the patient will then be referred to another imaging modality (MRI or CT) for a more thorough examination.



Skull x rays may be used to help diagnose a number of injuries and conditions, including sinusitis, fractures, tumors, birth defects, and other diseases that result in changes in bone structure or other tissues and glands in the skull. (K. Beebe/Custom Medical Stock Photo. Reproduced by permission.)

Other

Birth defects (referred to as congenital anomalies) may be detected on a skull x ray by changes in bone structure. Abnormal tissues or glands resulting from various conditions or diseases may also be shown on a skull radiograph.

Precautions

As with any x-ray procedure, women who may be pregnant are advised against having a skull x ray if it is not absolutely necessary. However, a lead apron may be worn across the abdomen during the procedure to protect the fetus. Children are also more sensitive to x-ray exposure. Children of both sexes should wear a protective covering (a lead apron) in the genital/reproductive area. In general, skull x-ray exposure is minimal and x-ray equipment and procedures are monitored to ensure radiation safety.

Description

In many instances, particularly for sinus views, the patient will sit upright in a chair, perhaps with the head held stable by a foam sponge. Sitting upright helps demonstrate air-fluid levels within the sinuses. (Air-fluid levels indicate acute disease, such as acute sinusitis or hemorrhage.) A film cassette is located behind the patient. The x-ray tube is in front of the patient and may be moved to allow for different positions and views. A patient may also be asked to move his or her head at various angles and positions.

In some cases, the technologist will ask the patient to lie on a table and will place the head and neck at various angles. In routine skull x rays, as many as five different views may be taken to allow a clear picture of various bones and tissues. The radiologist may request additional views to help better demonstrate pathology. The length of the test will vary depending on the number of views taken, but in general, it should last about 10 minutes. The technologist will usually ask a patient to wait while the films are being developed to ensure that they are clear before going to the radiologist.

Preparation

There is no preparation for the patient prior to arriving at the radiology facility. Patients will be asked to remove jewelry, dentures, or other metal objects that may produce artifacts on the film. The referring doctor or x-ray technologist can answer any questions regarding the procedure. Any woman who is, or may be, pregnant should inform the technologist.

Aftercare

There is no aftercare required following skull or sinus x-ray procedures.

Complications

There are no common side effects from skull or sinus x ray. The patient may feel some discomfort in the positioning of the head and neck, but will have no complications. Any x-ray procedure carries minimal radiation risk, and children and pregnant women should be protected from radiation exposure to the abdominal or genital areas.

Results

Normal results should indicate sinuses, bones, tissues, and other observed areas are of normal size, shape, and thickness for the patient's age and medical history. Results, whether normal or abnormal, will be provided to the referring physician in a written report.

Abnormal results may include:

Sinusitis

Air in sinuses will show up on a radiograph as black, but fluid will be cloudy or white (opaque). This helps the radiologist to identify fluid in the sinuses. In chronic sinusitis, the radiologist may also note thickening or hardening of the bony wall of an infected sinus.

Fractures

Radiologists may recognize facial bone fractures as a line of defect.

Tumors

Tumors may be visible if the bony sinus wall or other bones are distorted or destroyed. Abnormal findings may result in follow-up imaging studies, such as **magnetic resonance imaging** (MRI) and computed tomography (CT).

Other

Skull x rays may also detect disorders that show up as changes in bone structure, such as Paget's disease of the bone or acromegaly (a disorder associated with excess growth hormone from the **pituitary gland**). Areas of calcification (a gathering of **calcium** deposits), depending on their appearance and distribution, may indicate a condition such as an infection of bone or bone marrow (osteomyelitis).

Health care team roles

Skull or sinus x rays may be performed in a doctor's office that has x-ray equipment. A radiologic technologist performs the procedure, and a physician interprets the results. The exam may also be performed in an outpatient radiology facility or a hospital radiology department.

Resources

BOOKS

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ORGANIZATIONS

Cancer Information Clearinghouse, National Cancer Institute. Building 31, Room 10A24, 9000 Rockville Pike, Bethesda, MD 20892. (800) 4-Cancer. <<http://www.nci.nih.gov>>.

The National Head Injury Foundation, Inc. 1140 Connecticut Ave. NW, Suite 812, Washington, DC 20036. (800) 444-NHIF.

KEY TERMS

Radiograph—Images produced with ionizing radiation that can be displayed on photographic film or on a high resolution computer monitor that can aid in diagnosing a variety of symptoms.

X ray—A form of electromagnetic radiation with shorter wavelengths than normal light. X rays can penetrate most structures.

Radiological Society of North America. 2021 Spring Rd., Suite 600, Oak Brook, IL 60521-1860. (708) 571-2670. <<http://www.rsna.org>>.

J. Paul Dow, Jr.

Sleep and wakefulness

Definition

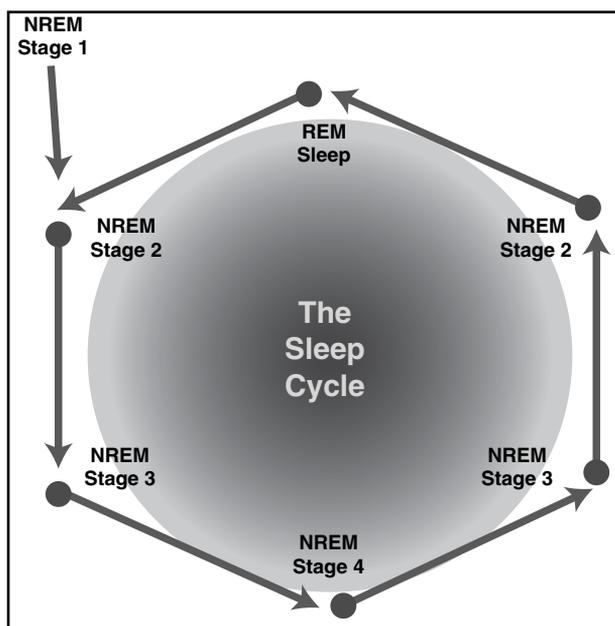
Sleep is a normal state of rest that is characterized by unconsciousness, reduced activity, and limited sensory responsiveness. Sleep differs from other states of reduced consciousness, such as drug intoxication or **coma**, because it is spontaneous, periodic, and readily reversible. Sleep is usually described by contrasting it with wakefulness, which is characterized by consciousness, sensory responsiveness, and purposeful activity.

Description

Sleep is one of the least understood aspects of human and animal behavior. It occurs in virtually every vertebrate species and seems to be necessary to healthy functioning, but science has been slow to discover how and why sleep occurs. The biological events that take place during sleep are subtle, and many seem to occur at a cellular level within the **brain**. These events are difficult to observe, and as a consequence our understanding of sleep has developed slowly.

Stages of sleep

Although the sleeping person seems inactive, the sleeping brain exhibits variations in activity throughout the sleep period. Recordings of brain activity, known as electroencephalograms (EEGs), show patterns that occur in a regular cycle lasting about 90 to 100 minutes. This cycle includes relatively brief periods of rapid-eye-



The sleep cycle. (Delmar Publishers, Inc. Reproduced by permission.)

movement (REM) sleep, characterized by back-and-forth movement of the eyes and changes in **autonomic nervous system** activity. REM is absent in the other phases of the sleep cycle, which are characterized as non-REM (NREM) sleep. Sleep can be divided into five distinct stages based on EEG and REM activity:

- Stage 1 NREM sleep: This lightest stage of sleep occurs as the person is just falling asleep. Stage 1 accounts for about 5% of a normal sleep period.
- Stage 2 NREM sleep: During this period the EEG exhibits characteristic patterns known as “sleep spindles” and K-complexes. This stage accounts for about 50% of a normal sleep period.
- Stage 3 NREM sleep: This stage is characterized by “slow wave” EEG activity, which is associated with deep sleep.
- Stage 4 NREM sleep This stage is very similar to Stage 3, the only difference being the amount of slow wave sleep that occurs. Together, Stages 3 and 4 account for about 20% of a normal sleep period.
- REM sleep. The EEG pattern of this stage is similar to that of Stage 1 NREM sleep. The sleeping person exhibits rapid eye movements and autonomic changes, as well as inactivity of the **skeletal muscles**. Most dreaming occurs during this stage of sleep. This stage accounts for about 20 to 25% of a normal sleep period.

The first 90-minute sleep cycle of the night begins with Stage 1 NREM sleep and progresses through Stages

2, 3, and 4, ending with a period of REM sleep. Subsequent cycles usually replace Stage 1 with the REM period. In a typical night of sleep, the earlier cycles tend to include more Stage 3 and 4 NREM sleep, with briefer REM periods. As the night progresses, the REM periods tend to get longer while the NREM periods get shorter.

Sleep and biological rhythms

Sleep is one of several biological processes that exhibit a pattern known as a circadian rhythm. A circadian rhythm recurs spontaneously on about a 24-hour cycle. Humans tend to sleep and wake up according to internal circadian rhythms, which seem to be part of our self-regulatory systems.

Circadian rhythms are regulated by a structure in the brain called the superchiasmatic nucleus, which is influenced by exposure to light. Damage to the superchiasmatic nucleus may result in loss of circadian rhythms, however, the individual still exhibits periodic tendencies to fall asleep. This is because a second, homeostatic process also regulates sleep. The individual seems to need sleep after periods of being awake, and the longer the period of wakefulness, the greater the likelihood that the person will fall asleep.

Sleep and the life cycle

The duration and patterning of sleep shows developmental changes throughout the life cycle. Newborns tend to sleep about 16 hours each day, with sleep occurring in relatively brief two to four-hour periods. As children grow, they sleep for longer periods at a time, with fewer sleep periods in a day, until they achieve the adult pattern of a single sleep period each day. The total amount of sleep also declines during childhood, until reaching the adult average of seven to nine hours per night.

In most adults, the amount of nightly sleep remains fairly stable until old age. Adults over 65 years of age tend to sleep less and report more frequent awakenings than younger adults. More than half of adults over 65 report some difficulty with sleep, although these sleep disturbances are often related to other problems, such as poor health or depression.

The patterns of REM and NREM sleep also show developmental changes. REM sleep tends to be much more prevalent in infants, with as much as 50% of their sleep time taken up by REM activity. This percentage declines throughout childhood and stabilizes at 20 to 25% in adolescence. In old age the percentage of sleep time devoted to REM declines to about 20%. Older adults also show a sharp decline in Stage 3 and Stage 4 NREM sleep.

Function

Experience suggests that sleep has some sort of restorative function. Humans feel refreshed and energized after a good night's sleep, and feel tired and ineffectual when they don't sleep well. But science has had difficulty going beyond this common-sense understanding of sleep. The physiological purpose of sleep continues to be something of a mystery.

The most common way to look for the purpose of sleep is to study people who have been deprived of sleep and measure the degree of impairment in their functioning. A large number of such studies have been done, with surprisingly slim results. Lack of sleep seems to have very little impact on functions such as motor coordination, sensory perception, or reflex activity, and most cognitive functions seem relatively unaffected as well. The biggest impact seems to be on short-term **memory** and sustained attention, both of which are impaired somewhat by sleep deprivation. This impairment may be due to the subjects' marked tendency to fall asleep for short periods as sleep deprivation is increased. By far, the most common outcome of sleep deprivation is increased sleepiness. As deprivation increases, the pressure to fall asleep intensifies to the point where it is almost impossible to keep subjects awake unless they are monitored constantly.

Role in human health

The quality and quantity of sleep are important indicators of overall health. Sleep is often affected by physical or emotional **stress**, and sleep disturbances are good indicators that something is amiss with a person. Although the majority of sleep complaints can be traced to psychosocial stress, sleep disturbance can be an important feature of many serious physical or psychological problems as well.

Sleep disturbance occurs in a wide variety of medical problems, including endocrine disturbances, gastrointestinal disorders, and **hypertension**. Chronic **pain** disorders such as arthritis and **fibromyalgia** also produce sleep disturbances, and sleep disruption is a common feature of a number of neurological disorders. Complaints about sleep are also very common with psychiatric illnesses, especially **anxiety** disorders and mood disorders, and they also occur in some forms of psychosis. Sleep disruption can be an important indicator of substance abuse. The most obvious case is the abuse of stimulants, such as **caffeine** or amphetamines, but alcohol abuse can also interfere with sleep, as can the abuse of sedatives.

Inadequate sleep is also a **public health** issue in its own right. A recent poll indicated that 63% of American

adults fail to get the recommended amount of sleep at night, and 69% report frequent sleep problems. Chronic lack of sleep causes daytime sleepiness, which increases the risk of accidents of all types, especially automobile accidents. One estimate suggests that driver sleepiness plays a role in 10% of serious automobile accidents. Lack of sleep also impairs work performance and may contribute to industrial accidents.

Common diseases and disorders

Sleep disorders can be classified as primary or secondary, depending on the presumed cause of the disorder. Primary sleep disorders are those that arise in the absence of other medical or psychiatric conditions, while secondary sleep disorders are likely caused by some other condition.

Some of the more common primary sleep disturbances include the following:

- **Primary insomnia:** This disorder is defined as difficulty getting to sleep or staying asleep that lasts for over one month. Primary insomnia is often triggered by psychological stress, but it may persist long after a stressful event occurs. It is often related to anxiety about sleep, as well as poor sleep hygiene.
- **Narcolepsy:** Narcolepsy is characterized by periodic attacks of uncontrollable sleepiness, sometimes triggered by strong emotions. Patients with narcolepsy often experience cataplexy, a sudden loss of muscle tone, which can result in falling and injuries. Other symptoms of narcolepsy include hallucinations and sleep **paralysis**. Narcolepsy occurs in around 0.04% of the general population.
- **Breathing-related sleep disorders:** This is a group of disorders that are all characterized by disturbed sleep due to periodic disruptions in breathing. The most common form is obstructive sleep apnea (OSA) syndrome, in which sleep is marked by periodic blockage of the upper airway. This disorder may affect 2 to 4% of the general population.
- **Nocturnal myoclonus and restless leg syndrome:** These are characterized by night-time discomfort and movement of the lower extremities. In nocturnal myoclonus, the person may be awakened by twitching or cramps in the legs. In restless leg syndrome, patients usually report a "crawly" feeling and the urge to move their legs. Both disorders interfere with sleep, and patients may complain of insomnia or daytime sleepiness.
- **Circadian rhythm sleep disorders:** In these disorders the timing of sleep is disturbed, so that the person's sleep schedule does not fit with external social demands. Shift work and long-distance travel can contribute to

KEY TERMS

Cataplexy—An abrupt and reversible loss of muscle tone. Cataplexy is one of the key symptoms of narcolepsy.

Circadian rhythm—A body rhythm that occurs in a 24-hour cycle. Sleep, body temperature, and some endocrine functions exhibit circadian rhythms.

Electroencephalogram (EEG)—A recording of electrical activity in the brain.

Insomnia—Difficulty falling asleep or staying asleep.

Narcolepsy—A sleep disorder characterized by sudden attacks of sleep. Key symptoms include cataplexy, hallucinations, and sleep paralysis.

Nocturnal myoclonus—A sleep disorder in which sleep is disturbed by twitching or cramps in the leg muscles. Nocturnal myoclonus is also known as periodic limb movements in sleep (PMLS).

Non-rapid eye movement (NREM) sleep—Stages of sleep during which rapid eye movements do not occur. The majority of sleep consists of the four stages of NREM sleep.

Rapid eye movement (REM) sleep—A stage of sleep during which the sleeper's eyes move back and forth rapidly. Most dreams occur during REM sleep.

Restless leg syndrome (RLS)—A sleep disorder in which the person is awakened by uncomfortable "crawly" feelings in the legs.

Sleep apnea—Temporary cessation of breathing during sleep.

Sleep hygiene—A set of behaviors associated with the timing and conditions of sleep. Good sleep hygiene involves setting a regular sleep schedule, avoiding bedtime stress, and restricting activities so that the bed becomes a place for sleeping.

Sleep paralysis—A sudden inability to move that occurs at the point of falling asleep or awakening.

these disorders, but they are also common in elderly people. Often these disorders are treated by light exposure and other efforts to "reset" the patient's internal clock.

- **Sleep terror disorder:** This is a disorder in which the patient wakes up physically aroused and screaming or

crying. Although these episodes resemble nightmares, they usually occur during NREM sleep rather than during the normal dreaming of REM sleep. The patient often cannot recall the episode the next morning. Sleepwalking disorder is a similar condition, involving complex movements and activities during sleep. It also occurs during NREM sleep. Both disorders are more common in children than adults.

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ORGANIZATIONS

National Sleep Foundation. 1522 K Street NW. Suite 500, Washington, DC 20005.
<<http://www.sleepfoundation.org>>.

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<http://www.sleepfoundation.org/PressArchives/lessfun_1esssleep.html>.

Denise L. Schmutte, Ph.D.

Sleep disorders

Definition

Sleep disorders are a group of syndromes characterized by disturbance in a person's amount of sleep, quality or timing of sleep, or in behaviors or physiological conditions associated with sleep. There are about 70 different sleep disorders. To qualify for the diagnosis of

sleep disorder, the condition must be a persistent problem, cause an individual significant emotional distress, and interfere with social or occupational functioning. The text revision of the fourth edition (2000) of the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR)* specifically excludes temporary disruptions of sleeping patterns caused by travel or other short-term stresses.

Although sleep is a basic behavior in animals as well as humans, researchers still do not completely understand all of its functions in maintaining health. In the past 30 years, however, laboratory studies on human volunteers have yielded new information about the different types of sleep. Researchers have learned about the cyclical patterns of different types of sleep and their relationships to breathing, **heart** rate, **brain** waves, and other physical functions. These measurements are obtained by a technique called **polysomnography**.

There are five stages of human sleep. Four stages have non-rapid eye movement (NREM) sleep, with unique brain wave patterns and physical changes occurring. Dreaming occurs in the fifth stage, during rapid eye movement (REM) sleep.

- Stage 1 NREM sleep. This stage occurs while a person is falling asleep. It represents about 5% of a normal adult's sleep time.
- Stage 2 NREM sleep. In this stage, (the beginning of "true" sleep), the person's electroencephalogram (EEG) will show distinctive wave forms called sleep spindles and K complexes. About 50% of sleep time is stage 2 NREM sleep.
- Stages 3 and 4 NREM sleep. Also called delta or slow wave sleep, these are the deepest levels of human sleep and represent 10-20% of sleep time. They usually occur during the first 30-50% of the sleeping period.
- REM sleep. REM sleep accounts for 20-25% of total sleep time. It usually begins about 90 minutes after a person falls asleep, an important measure called REM latency. It alternates with NREM sleep about every hour and a half throughout the night. REM periods increase in length over the course of the night.

Sleep cycles vary with a person's age. Children and adolescents have longer periods of stage 3 and stage 4 NREM sleep than do middle aged or elderly adults. Because of this difference, a doctor will need to take a person's age into account when evaluating a sleep disorder. Total REM sleep also declines with age.

The average length of nighttime sleep varies among people. Most individuals sleep between seven and nine hours a night. This population average appears to be constant throughout the world. In temperate climates, how-

ever, people often notice that sleep time varies with the seasons. It is not unusual for people in North America and Europe to sleep about 40 minutes longer per night during the winter.

Description

The *DSM-IV-TR* classifies sleep disorders based on their causes. Primary sleep disorders are distinguished from those that are not caused by other mental disorders, prescription medications, substance abuse, or medical conditions. The two major categories of primary sleep disorders are the dyssomnias and the parasomnias.

Dyssomnias

Dyssomnias are primary sleep disorders in which a person suffers from changes in the amount, restfulness, and timing of sleep. The most important dyssomnia is primary insomnia, which is defined as difficulty in falling asleep or remaining asleep that lasts for at least one month. It is estimated that 35% of adults in the United States experience insomnia during any given year, but the number of these adults who are experiencing true primary insomnia is unknown. Primary insomnia can be caused by a traumatic event related to sleep or bedtime, and it is often associated with increased physical or psychological arousal at night. People who experience primary insomnia are often anxious about not being able to sleep. Individuals may then associate all sleep-related things (their bed, bedtime, etc.) with frustration, making the problem worse. They then become more stressed about not sleeping. Primary insomnia often begins in young adulthood or in middle age.

Hypersomnia is a condition marked by excessive sleepiness during normal waking hours. Affected persons either have lengthy episodes of daytime sleep or episodes of daytime sleep on a daily basis even though they are sleeping normally at night. In some cases, persons with primary hypersomnia have difficulty waking in the morning and may appear confused or angry. This condition is sometimes called sleep drunkenness and is more common in males. The number of people with primary hypersomnia is unknown, although 5-10% of people in sleep disorder clinics have the disorder. Primary hypersomnia usually affects young adults between the ages of 15 and 30.

Nocturnal myoclonus and restless legs syndrome (RLS) can cause either insomnia or hypersomnia in adults. Individuals with nocturnal myoclonus wake up because of cramps or twitches in the calves. These people feel sleepy the next day. Nocturnal myoclonus is sometimes called periodic limb movement disorder. RLS patients have a crawly or aching feeling in their calves that can be relieved by moving or rubbing the legs. RLS

often prevents people from falling asleep until the early hours of the morning, when the condition is less intense.

Kleine-Levin syndrome is a recurrent form of hypersomnia that affects a person three or four times a year. Doctors do not know the cause of this syndrome. It is marked by two to three days of sleeping 18–20 hours per day, hypersexual behavior, compulsive eating, and irritability. Men are three times more likely than women to have the syndrome. As of 2001, there is no cure for this disorder.

Narcolepsy is a dyssomnia characterized by recurrent “sleep attacks” that a person cannot fight. The sleep attacks are about 10–20 minutes long. A person feels refreshed by the sleep, but typically feels sleepy again several hours later. Narcolepsy has three major symptoms in addition to sleep attacks: cataplexy, hallucinations, and sleep **paralysis**. Cataplexy is the sudden loss of muscle tone and stability (“drop attacks”). Hallucinations may occur just before falling asleep (hypnagogic) or right after waking up (hypnopompic) and are associated with an episode of REM sleep. Sleep paralysis occurs during the transition from being asleep to waking up. About 40% of patients with narcolepsy have or have had another mental disorder. Although narcolepsy is often regarded as an adult disorder, it has been reported in children as young as three years old. Almost 18% of people with narcolepsy are 10 years old or younger. It is estimated that 0.02–0.16% of the general population suffers from narcolepsy. Men and women are equally affected.

Breathing-related sleep disorders are syndromes in which a person’s sleep is interrupted by problems with breathing. There are three types of breathing-related sleep disorders:

- **Obstructive sleep apnea syndrome.** This is the most common form of breathing-related sleep disorder, marked by episodes of blockage in the upper airway during sleep. It is found primarily in obese people. Persons with this disorder typically alternate between periods of snoring or gasping (when their airway is partly open) and periods of silence (when their airway is blocked). Very loud snoring is a clue to this disorder.
- **Central sleep apnea syndrome.** This disorder is primarily found in elderly people with heart or neurological conditions that affect their ability to breathe properly. It is not associated with airway blockage and may be related to brain disease.
- **Central alveolar hypoventilation syndrome.** This disorder is found most often in extremely obese people. Their airway is not blocked, but **blood** oxygen level is too low.

- **Mixed-type sleep apnea syndrome.** This disorder combines symptoms of both obstructive and central sleep apnea.

Circadian rhythm sleep disorders are dyssomnias resulting from a discrepancy between a person’s daily sleep and wake patterns and demands of social activities, shift work, or travel. The term circadian comes from a Latin word meaning daily. There are three circadian rhythm sleep disorders. Delayed sleep phase type is characterized by going to bed and arising later than most people. Jet lag type is caused by travel to a new time zone. Shift work type is caused by the schedule of a person’s job. People who are ordinarily early risers appear to be more vulnerable to jet lag and shift work-related circadian rhythm disorders than people who are “night owls.” There are some individuals who do not fit the pattern of these three disorders and appear to be the opposite of the delayed sleep phase type. These people have an advanced sleep phase pattern and cannot stay awake in the evening, but wake up on their own in the early morning.

PARASOMNIAS. Parasomnias are primary sleep disorders in which a person’s behavior is affected by specific sleep stages or transitions between sleeping and waking. They are sometimes described as disorders of physiological arousal during sleep.

Nightmare disorder is a parasomnia in which a person is repeatedly awakened from sleep by frightening dreams and is fully alert on awakening. The actual rate of occurrence of nightmare disorder is unknown. Approximately 10–50% of children between three and five years old experience nightmares. They occur during REM sleep, usually in the second half of the night. A child is usually able to remember the content of the nightmare and may be afraid to go back to sleep. More females than males have this disorder, but it is not known whether the gender difference reflects a difference in occurrence or a difference in reporting. Nightmare disorder is most likely to occur in children or adults under severe or traumatic **stress**.

Sleep terror disorder is a parasomnia in which a person awakens screaming or crying. The individual also has physical signs of arousal, like sweating, shaking, etc. It is sometimes referred to as pavor nocturnus. Unlike nightmares, sleep terrors typically occur in stage 3 or stage 4 NREM sleep during the first third of the night. A person may be confused or disoriented for several minutes and cannot recall the content of the dream. There is usually a return to sleep without being able to remember the episode the next morning. Sleep terror disorder is most common in children four to 12 years old and is outgrown in adolescence. It affects about 3% of children. Fewer than 1% of adults have the disorder. In adults, it



A patient suffering from acute sleep apnea is hooked up to monitors in preparation for a night's sleep at a Stanford University lab. (Photograph by Russell D. Curtis, Photo Researchers, Inc. Reproduced by permission.)

usually begins between the ages of 20 and 30. In children, more males than females have the disorder. In adults, men and women are equally affected.

Sleepwalking disorder, which is sometimes called somnambulism, occurs when a person is capable of complex movements during sleep, including walking. Like sleep terror disorder, sleepwalking occurs during stage 3 and stage 4 NREM sleep during the first part of the night. If individuals are awakened during a sleepwalking episode, they may be disoriented and have no **memory** of the behavior. In addition to walking around, persons with sleepwalking disorder have been reported to eat, use the bathroom, unlock doors, or talk to others. It is estimated that 10–30% of children have at least one episode of sleepwalking. However, only 1–5% meet the criteria for sleepwalking disorder. The disorder is most common in children eight to 12 years old. It is unusual for sleepwalking to occur for the first time in adults.

Unlike sleepwalking, REM sleep behavior disorder occurs later in the night and people can remember what they were dreaming. The physical activities of such persons are often violent.

Sleep disorders related to other conditions

In addition to the primary sleep disorders, the *DSM-IV-TR* specifies three categories of sleep disorders that are caused by or related to substance use or other physical or mental disorders.

Many mental disorders, especially depression or one of the **anxiety** disorders, can cause sleep disturbances. Psychiatric disorders are the most common cause of chronic insomnia.

Some people with chronic neurological conditions like **Parkinson's disease** or Huntington's disease may develop sleep disorders. Sleep disorders have also been associated with viral encephalitis, brain disease, and hypo- or hyperthyroidism.

The use of drugs, alcohol, and **caffeine** frequently produce disturbances in sleep patterns. Alcohol abuse is associated with insomnia. A person may initially feel sleepy after drinking, but wakes up or sleeps fitfully during the second half of the night. Alcohol can also increase the severity of breathing-related sleep disorders. With amphetamines or cocaine, a person typically suffers from insomnia during drug use and hypersomnia during drug

withdrawal. Opioids usually make short-term users sleepy. However, long-term users develop tolerance and may suffer from insomnia.

In addition to alcohol and drugs that are abused, a variety of prescription medications can affect sleep patterns. These medications include **antihistamines, corticosteroids, asthma** medicines, and drugs that affect the **central nervous system**.

Sleep disorders in children and adolescents

Pediatricians estimate that 20–30% of children have difficulties with sleep that are serious enough to disturb their families. Although sleepwalking and night terror disorder occur more frequently in children than in adults, children can also suffer from narcolepsy and sleep apnea syndrome.

Causes and symptoms

The causes of sleep disorders have already been discussed with respect to the *DSM-IV-TR* classification of these disorders.

The most important symptoms of sleep disorders are insomnia and sleepiness during waking hours. Insomnia is by far the more common of the two symptoms. It covers a number of different patterns of sleep disturbance. These patterns include inability to fall asleep at bedtime, repeated awakening during the night, and/or inability to go back to sleep once awakened.

Diagnosis

Diagnosis of sleep disorders usually requires a psychological history as well as a medical history. With the exception of sleep apnea syndromes, physical examinations are not usually revealing. A person's gender and age are useful starting points in assessing the problem. A doctor may also talk to other family members to obtain information about a person's symptoms. A family's observations are particularly important to evaluate sleepwalking, kicking in bed, snoring loudly, or other behaviors that an individual cannot remember.

Sleep logs

Many doctors ask people to keep a sleep diary or sleep log for a minimum of one to two weeks in order to evaluate the severity and characteristics of the sleep disturbance. An individual records medications taken as well as the length of time spent in bed, the quality of the sleep, and similar information. Some sleep logs are designed to indicate circadian sleep patterns as well as simple duration or restfulness of sleep.

Psychological testing

A physician may use **psychological tests** or inventories to evaluate insomnia because it is frequently associated with mood or affective disorders. The Minnesota Multiphasic Personality Inventory (MMPI), the Millon Clinical Multiaxial Inventory (MCMI), the Beck Depression Inventory, and the Zung Depression Scale are the tests most commonly used in evaluating this symptom.

Self-report tests

The Epworth Sleepiness Scale, a self-rating form recently developed in Australia, consists of eight questions used to assess daytime sleepiness. Scores range from 0–24, with scores higher than 16 indicating severe daytime sleepiness.

Laboratory studies

If a doctor is considering breathing-related sleep disorders, myoclonus, or narcolepsy as possible diagnoses, an affected person may be tested in a sleep laboratory or at home with portable instruments.

POLYSOMNOGRAPHY. Polysomnography can be used to help diagnose sleep disorders as well as conduct research into sleep. In some cases a person is tested in a special sleep laboratory. The advantage of this testing is the availability and expertise of trained technologists, but it is expensive. As of 2001, however, portable equipment is available for home recording of certain specific physiological functions.

MULTIPLE SLEEP LATENCY TEST. The multiple sleep latency test (MSLT) is frequently used to measure the severity of a person's daytime sleepiness. The test measures sleep latency (the speed with which an individual falls asleep) during a series of planned naps during the day. The test also measures the amount of REM sleep that occurs. Two or more episodes of REM sleep under these conditions indicates narcolepsy. This test can also be used to help diagnose primary hypersomnia.

REPEATED TEST OF SUSTAINED WAKEFULNESS. The repeated test of sustained wakefulness (RTSW) measures sleep latency by challenging a person's ability to stay awake. In the RTSW, a person is placed in a quiet room with dim lighting and is asked to stay awake. As with the MSLT, the testing pattern is repeated at intervals during the day.

Treatment

Treatment for a sleep disorder depends on what is causing the disorder. For example, if major depression is

the cause of insomnia, then treatment of the depression with antidepressants should resolve the insomnia.

Medications

Sedative or hypnotic medications are generally recommended only for insomnia related to a temporary stress (such as surgery or grief) because of the potential for addiction or **overdose**. Trazodone, a sedating antidepressant, is often used for chronic insomnia that does not respond to other treatments. Sleep medications may also cause problems for elderly persons because of possible interactions with their other prescription medications. Among the safer hypnotic agents are lorazepam, temazepam, and zolpidem. Chloral hydrate is often preferred for short-term treatment in elderly people because of its mildness. Short-term treatment is recommended because this drug may be habit forming.

Narcolepsy is treated with stimulants such as dextroamphetamine sulfate or methylphenidate. Nocturnal myoclonus has been successfully treated with clonazepam.

Children with sleep terror disorder or sleepwalking are usually treated with benzodiazepines because this type of medication suppresses stage 3 and stage 4 NREM sleep.

Psychotherapy

Psychotherapy is recommended for persons with sleep disorders associated with other mental disorders. In many cases an individual's scores on the Beck or Zung inventories will suggest the appropriate direction of treatment.

Sleep education

"Sleep hygiene" or sleep education for sleep disorders often includes instructing a person in methods to enhance sleep. People are advised to:

- Wait until they feel sleepy before going to bed.
- Avoid using the bedroom for work, reading, or watching television.
- Get up at the same time every morning no matter how much or how little they have slept.
- Avoid smoking and avoid drinking liquids with caffeine.
- Get some physical **exercise** on a daily basis, early in the day.
- Limit fluid intake after dinner; in particular, avoid alcohol because it frequently causes interrupted sleep.
- Learn to meditate or practice **relaxation** techniques.

- Avoid tossing and turning in bed; instead, people should get up and listen to relaxing music or read.

Lifestyle changes

People with sleep apnea or hypopnea are encouraged to stop smoking, avoid alcohol or drugs of abuse, and lose weight in order to improve the stability of the upper airway.

In some cases, individuals with sleep disorders related to jet lag or shift work may need to change employment or travel patterns. They may need to avoid rapid changes in shifts at work.

Children with nightmare disorder may benefit from limits on television or movies. Violent scenes or frightening science fiction stories appear to influence the frequency and intensity of children's nightmares.

Surgery

Although making a surgical opening into the windpipe (a tracheostomy) for sleep apnea or hypopnea in adults is a treatment of last resort, it is occasionally performed if a person's disorder is life threatening and cannot be treated by other methods. In children and adolescents, surgical removal of the tonsils and adenoids is a fairly common and successful treatment for sleep apnea. Most people with sleep apnea are treated with continuous positive airway pressure (CPAP). Sometimes an oral prosthesis is used for mild sleep apnea.

Alternative treatment

Some alternative approaches may be effective in treating insomnia caused by anxiety or emotional stress. **Meditation** practice, breathing exercises, and **yoga** can break the vicious cycle of sleeplessness, worry about inability to sleep, and further sleeplessness for some people. Yoga can help some people to relax muscular tension in a direct fashion. The breathing exercises and meditation can keep them from obsessing about sleep.

Homeopathic practitioners recommend that people with chronic insomnia see a professional homeopath. They do, however, prescribe specific remedies for at-home treatment of temporary insomnia: *Nux vomica* for alcohol or substance-related insomnia, *Ignatia* for insomnia caused by grief, *Arsenicum* for insomnia caused by fear or anxiety, and *Passiflora* for insomnia related to mental stress.

Melatonin has also been used as an alternative treatment for sleep disorders. Melatonin is produced in the body by the pineal gland at the base of the brain. This substance is thought to be related to the body's circadian rhythms.

KEY TERMS

Apnea—The temporary absence of breathing. Sleep apnea consists of repeated episodes of temporary suspension of breathing during sleep.

Cataplexy—Sudden loss of muscle tone (often causing a person to fall), usually triggered by intense emotion. It is regarded as a diagnostic sign of narcolepsy.

Circadian rhythm—Any body rhythm that recurs in 24-hour cycles. The sleep-wake cycle is an example of a circadian rhythm.

Dyssomnia—A primary sleep disorder in which the patient suffers from changes in the quantity, quality, or timing of sleep.

Electroencephalogram (EEG)—The record obtained by a device that measures electrical impulses in the brain.

Hypersomnia—An abnormal increase of 25% or more in time spent sleeping. Patients usually have excessive daytime sleepiness.

Hypnotic—A medication that makes a person sleep.

Hypopnea—Shallow or excessively slow breathing usually caused by partial closure of the upper airway during sleep, leading to disruption of sleep.

Insomnia—Difficulty in falling asleep or remaining asleep.

Jet lag—A temporary disruption of the body's sleep-wake rhythm following high-speed air travel across several time zones. Jet lag is most severe in people who have crossed eight or more time zones in 24 hours.

Kleine-Levin syndrome—A disorder that occurs primarily in young males, three or four times a year. The syndrome is marked by episodes of hypersomnia, hypersexual behavior, and excessive eating.

Narcolepsy—A life-long sleep disorder marked by four symptoms: sudden brief sleep attacks, cataplexy, temporary paralysis, and hallucinations. The hallucinations are associated with falling asleep or the transition from sleeping to waking.

Nocturnal myoclonus—A disorder in which the

patient is awakened repeatedly during the night by cramps or twitches in the calf muscles. Nocturnal myoclonus is sometimes called periodic limb movement disorder (PLMD).

Non-rapid eye movement (NREM) sleep—A type of sleep that differs from rapid eye movement (REM) sleep. The four stages of NREM sleep account for 75–80% of total sleeping time.

Parasomnia—A primary sleep disorder in which a person's physiology or behaviors are affected by sleep, the sleep stage, or the transition from sleeping to waking.

Pavor nocturnus—Another term for sleep terror disorder.

Polysomnography—Laboratory measurement of a person's basic physiological processes during sleep. Polysomnography usually measures eye movement, brain waves, and muscular tension.

Primary sleep disorder—A sleep disorder that cannot be attributed to a medical condition, another mental disorder, or prescription medications or other substances.

Rapid eye movement (REM) sleep—A phase of sleep during which a person's eyes move rapidly beneath the lids. It accounts for 20–25% of sleep time. Dreaming occurs during REM sleep.

REM latency—After a person falls asleep, the amount of time it takes for the first onset of REM sleep.

Restless legs syndrome (RLS)—A disorder in which a person experiences crawling, aching, or other disagreeable sensations in the calves that can be relieved by movement. RLS is a frequent cause of difficulty falling asleep at night.

Sedative—A medication given to calm agitated individuals; sometimes used as a synonym for hypnotic.

Sleep latency—The amount of time that it takes to fall asleep. Sleep latency is measured in minutes and is important in diagnosing depression.

Somnambulism—Another term for sleepwalking.

Practitioners of Chinese medicine usually treat insomnia as a symptom of excess yang energy. Cinnabar is recommended for chronic nightmares. Either magnetic

magnetite or “dragon bones” is recommended for insomnia associated with hysteria or fear. If the insomnia appears to be associated with excess yang energy arising

from the **liver**, a practitioner will suggest oyster shells. Acupuncture treatments can help bring about balance and facilitate sleep.

Dietary changes such as eliminating stimulant foods (coffee, cola, chocolate) and late-night meals or snacks can be effective in treating some sleep disorders. Nutritional supplementation with magnesium, as well as botanical medicines that calm the nervous system, can also be helpful. Among the botanical remedies that may be effective for sleep disorders are valerian (*Valeriana officinalis*), passionflower (*Passiflora incarnata*), and skullcap (*Scutellaria lateriflora*).

Prognosis

Prognosis depends on the specific disorder. Children usually outgrow sleep disorders. People with Kleine-Levin syndrome usually get better by age 40. Narcolepsy is a life-long disorder. The prognosis for sleep disorders related to other conditions depends on successful treatment of the substance abuse, medical condition, or other mental disorder. The prognosis for primary sleep disorders is affected by many things, including a person's age, gender, occupation, personality characteristics, family circumstances, neighborhood environment, and similar factors.

Health care team roles

Sleep experts are often trained in physiology, medicine or psychology. Such professionals often administer tests and make initial diagnoses. Physicians prescribe drugs for some forms of sleep disorders. Surgeons are occasionally called upon for surgical intervention. Nurses take part in any testing as well as providing pre-test **patient education**. Family members are often key members of a health care team when they provide information and help to make changes in the home. An affected person may become a member of the health care team when making dietary modifications, seeking alternative employment or deciding to undertake a course of therapy.

Prevention

Sleep disorders are difficult to prevent. Recognition of potential causes and avoidance of such situations or substances can prevent many forms of sleep disorders. Since many sleep disorders are relatively common and transitory, a good attitude about occasional problems with sleep is very helpful. This can prevent worrying.

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- American Academy of Sleep Medicine. 6301 Bandel Road NW, Suite 101, Rochester, MN 55901. (507) 287-6006, Fax: (507) 287-6008. <<http://www.asda.org/>>. info@aasmnet.org.
- American Psychiatric Association. 1400 K Street NW, Washington, DC 20005. (888) 357-7924, Fax: (202) 682-6850. <<http://www.psych.org/>>. apa@psych.org.

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Sleep study see **Polysomnography**

Sleepwalking see **Sleep disorders**

Slipped disk see **Herniated disk**

Slightly movable joint

Definition

A slightly movable joint (amphiarthrosis) is an articulation between bones in which the motion is limited due to either fibrous tissue or cartilage.

Description

Joints are classified as either fibrous or cartilaginous. Only one type of fibrous joint is slightly movable. It is known as a syndesmosis. In a syndesmosis, bones are separated by a substantial space and united by fibrous connective tissue.

In another classification of joints, cartilaginous also has only one type that is considered slightly movable. It is known as a symphysis. In a symphysis, bony surfaces are united by fibrocartilage.

Function

The function of a syndesmosis and symphysis is to bind two bones together, thus holding portions of the **skeletal system** intact. Also, the limited motion available in either of these two types of joints allows certain movements to take place.

Role in human health

A syndesmosis connects two bones by connective tissue and is found throughout the human body. An example is the tibio-fibular syndesmosis, or the connective

tive tissue that binds the distal ends of the fibula and tibia. A syndesmosis allows the fibula and tibia to work in unison as part of the lower leg. The limited motion available at this joint allows the tibia and fibula to move about each other yet still remain as a unit. This available movement is extremely important in the actions of the foot and ankle complex. This example describes how a syndesmosis provides stability as well as slight mobility.

A symphysis is a cartilaginous joint in which the uniting entity is fibrocartilage. Similar to the syndesmosis, the symphysis is stable but there is limited motion. In the syndesmosis, the bones are separated by a large space, unlike the symphysis, in which the articular surfaces are closer together. An example of a symphysis in the human body is the attachment of one vertebral body to another by way of an intervertebral disk. The intervertebral disk is a fibrocartilage ring that unites individual vertebral bodies. The sum attachment of many vertebrae gives rise to the **vertebral column**. The importance of this symphysis is that minimal motion occurs between vertebrae, thus maintaining stability. The combination of small movements between each successive vertebral attachment is what allows the vertebral column to move as a unit, that is, to flex and extend.

Common diseases and disorders

In the human body, a syndesmosis provides a stable environment between two bones and also allows for limited but important motion. In the example previously cited, the disorder that can affect a syndesmosis is primarily orthopedic. The tibio-fibular syndesmosis plays an integral role in stabilizing and allowing motion of the lower leg, foot, and ankle. Clearly, injury to this structure such as tearing would impair the stability and mobility of the lower leg, foot, and ankle. Thus, an injury to a syndesmosis described in this example could lead to impaired function such as walking.

A symphysis binds two bones by fibrocartilage. As cited previously, a good example of a symphysis in the human body is the attachment of one vertebra to another by a fibrocartilaginous disk. One of the most common and obvious disorders that can affect this joint is injury to the fibrocartilaginous disk. Injury to this fibrocartilage can be due to trauma, tumor, or **osteoarthritis**. Depending on which fibrocartilaginous disk is injured in the spine, associated problems could be **pain**, weakness, numbness, or tingling in the limbs, trunk, or both. Problems associated with an injured disk could affect overall human function and limit movement.

The syndesmosis and symphysis play important roles in human health. Moreover, injury to these joints could lead to reduced function and possible disability.

KEY TERMS

Connective tissue—Tissue that has pliable fibers, which provide strength to the tissue and thus support to the structures it attaches to.

Fibrocartilage—Connective tissue made up of collagen fibers that unites two bones together as a joint.

Fibula—The outer or lateral bone of the lower leg.

Intervertebral disk—A fibrocartilaginous structure that attaches one vertebra to another. An intervertebral disk provides force attenuation in the spine and aids in the overall movement of the spine.

Tibia—The larger weight-bearing bone of the lower leg.

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Slit lamp examination *see* **Eye examination**

Small bowel follow-through (SBFT) *see*
Upper GI exam

Small intestine *see* **Intestine, small**

Small intestine radiography and fluoroscopy *see* **Upper GI exam**

Smell

Definition

Smell is the ability of an organism to sense and identify a substance by detecting trace amounts of the sub-

stance that evaporate. Researchers have noted similarities in the sense of smell between widely differing species that reveal some of the details of how the chemical signal of an odor is detected and processed.

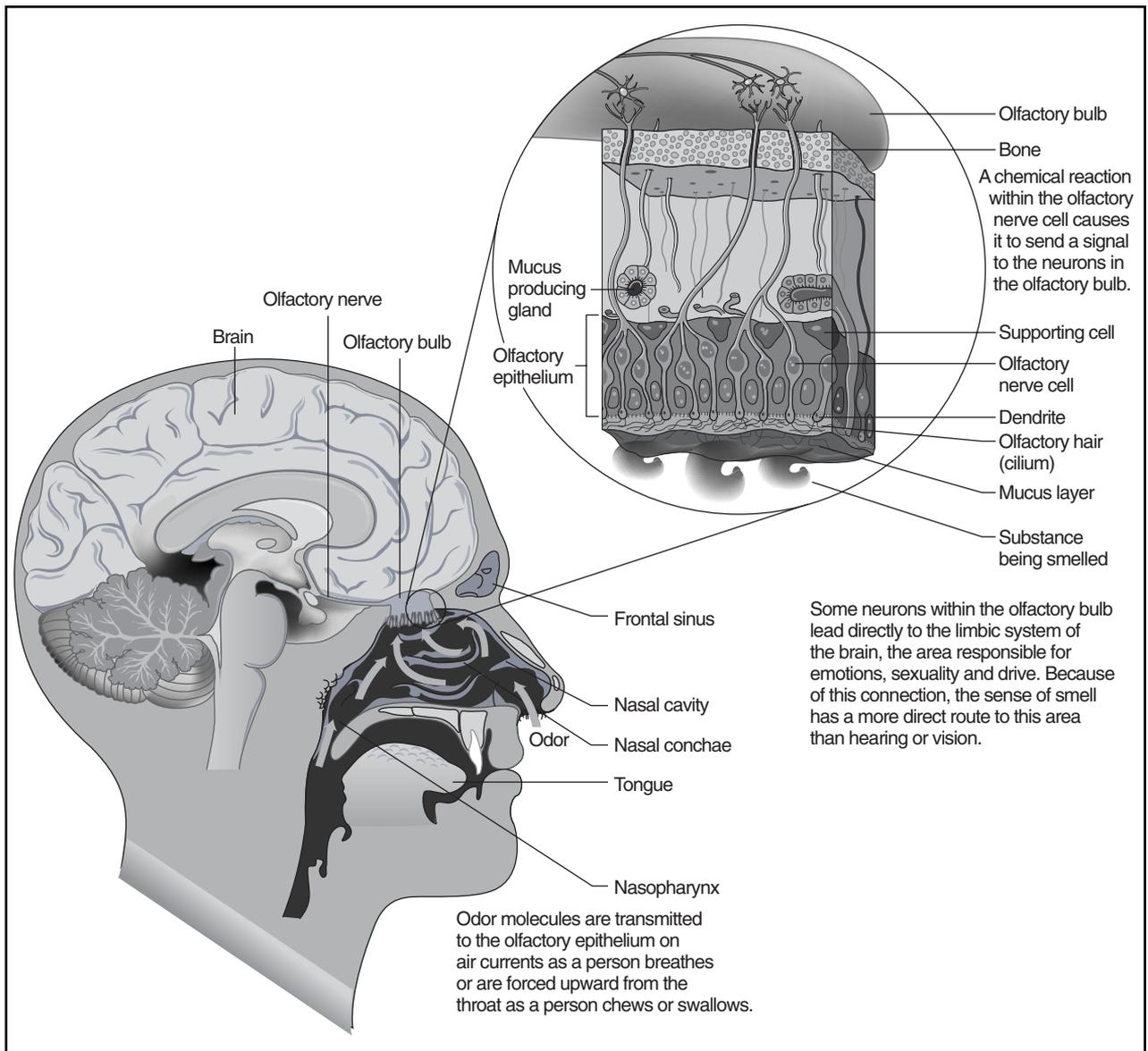
Description

The sense of smell has been a topic of debate from humankind's earliest days. The Greek philosopher Democritus of Abdera (460–360 B.C.), speculated that humans smell “atoms” of different size and shape that come from objects. His countryman Aristotle (384–322 B.C.), on the other hand, guessed that odors are detected when the “cold” sense of smell meets “hot” smoke or steam from the object being smelled. It was not until the late eighteenth century that most scientists and philosophers reached agreement that Democritus was basically right: the smell of an object is due to volatile, or easily evaporated, molecules that emanate from it.

In 1821, the French anatomist Hippolyte Cloquet (1787–1840) rightly noted the importance of smell for animal survival and reproduction; but his theorizing about the role of smell in human sex, as well as mental disorders, proved controversial. Many theories of the nineteenth century seem irrational or even malignant today. Many European scientists of that period fell into the trap of an essentially circular argument, that held that non-Europeans were more primitive, and therefore had a more developed sense of smell. The first half of the twentieth century saw progress in making the study of smell more rational. A Spanish neuroanatomist traced the architecture of the nerves leading from the nose to and through the **brain**. Other scientists carried out the first methodical investigations of how the nose detects scent molecules, the sensitivity of the human nose, and the differences between human and animal olfaction. But the most recent progress in studying the sense of smell and how it affects humans was made with the application of molecular science to the odor-sensitive cells of the nasal cavity.

The sense of smell is the most important sense for most organisms. A wide variety of species use their sense of smell to locate prey, navigate, recognize and perhaps communicate with kin, and mark territory. In a broad sense, the workings of smell in animals as different as mammals, reptiles, fish, and even insects are remarkably similar.

The sense of smell differs from most other senses in its directness; humans and other mammals actually smell microscopic bits of a substance that have evaporated and made their way to the olfactory epithelium, a section of the mucus membrane in the roof of the olfactory cavity. The olfactory epithelium contains the smell-sensitive ending of the olfactory nerve cells, also known as the



Sense of smell. (Illustration by Hans & Cassidy. Courtesy of Gale Group.)

olfactory epithelial cells. These cells detect odors through receptor **proteins** on the cell surface that bind to odor-carrying molecules. A specific odorant docks with an olfactory receptor protein in much the same way as a key fits in a lock; this in turn excites the nerve cell, causing it to send a signal to the brain. This is known as the stereospecific theory of smell.

Recently, molecular scientists have cloned the genes for the human olfactory receptor proteins. Although there are perhaps tens of thousands or more of odor-carrying molecules in the world, there are only hundreds, or at most about 1,000, kinds of specific receptors in any species of animal, including humans. Because of this,

scientists do not believe that each receptor recognizes a unique odorant; rather, similar odorants can all bind to the same receptor. It appears that a few loose-fitting odorant “keys” of broadly similar shape can turn the same receptor “lock.” Researchers do not yet know how many specific receptor proteins each olfactory nerve cell carries, but recent work suggests that the cells specialize just as the receptors do, and any one olfactory nerve cell has only one or a few receptors rather than many.

Function

It is the combined pattern of receptors that are tweaked by an odorant that allow the brain to identify it,

much as yellow and red light together are interpreted by the brain as orange. (In fact, just as people can be color-blind to red or green, some can be “odor-blind” to certain simple molecules because they lack the receptor for that molecule.) In addition, real objects produce multiple odor-carrying molecules, so that the brain must analyze a complex mixture of odorants to recognize a smell.

Just as the sense of smell is direct in detecting fragments of the objects, it is also direct in the way the signals transmitted to the brain. In most senses, such as **vision**, this task is accomplished in several steps: a receptor cell detects light and passes the signal to a nerve cell, which passes it on to another nerve cell in the **central nervous system**, which then relays it to the visual center of the brain. But in olfaction, all these jobs are performed by the olfactory nerve cell. In a very real sense, the olfactory epithelium is a direct outgrowth of the brain.

Role in human health

In humans, the olfactory nerve cell takes the scent message directly to the nerve cells of the olfactory bulb of the brain. There multiple signals from different olfactory cells with different odor sensitivities are organized and processed. The signal then goes to the brain’s olfactory cortex, where higher functions such as **memory** and emotion are coordinated with the sense of smell.

There is no doubt that many animals have a sense of smell far superior than humans. This is why, even today, humans use dogs to find lost persons, hidden drugs, and explosives although research on “artificial noses” than can detect scent even more reliably than dogs continues.

Because of their humble abilities of olfaction, humans are called microsmatic, rather than macrosmatic. Still, the human nose is capable of detecting over 10,000 different odors, some in the range of parts per trillion of air; and many researchers suspect that smell plays a greater role in human behavior and biology than has been previously thought. For instance, research has shown that human mothers can smell the difference between a vest worn by their baby and one worn by another baby only days after the child’s birth.

Yet some olfactory abilities of animals are probably beyond humans. Most vertebrates have many more olfactory nerve cells in a proportionately larger olfactory epithelium than humans, which probably gives them much more sensitivity to odors. The olfactory bulb in these animals takes up a much larger portion of the brain than it does in humans, giving the animal more ability to process and analyze olfactory information. In addition, most land vertebrates have a specialized scent organ in the roof of the mouth called vomeronasal organ. This

KEY TERMS

Anosmia—A disorder in which one is able to detect no odors.

Olfactory bulb—The primitive part of the brain that first processes olfactory information.

Olfactory cortex—The cerebral cortex that makes use of information from the olfactory bulb.

Olfactory epithelium—The patch of mucus membrane at the top of the nasal cavity that is sensitive to odor.

Olfactory nerve cell—The cell in the olfactory epithelium that detects odor and transmits the information to the olfactory bulb of the brain.

Pheromones—Scent molecules made by the body that attract a mate and help initiate mating behaviors.

Receptor protein—A protein in a cell that sticks to a specific odorant or other signal molecule.

Stereospecific theory—The theory that the nose recognizes odorants when they bind to receptor proteins that recognize the odorants’ molecular shape.

Volatile—Easily evaporated.

Vomeronasal—A pit on the roof of the mouth in most vertebrates that serves to detect odor molecules that are not as volatile as those detected by the nose.

organ, believed to be vestigial in humans, is a pit lined by a layer of cells with a similar structure to the olfactory epithelium, which feeds into its own processing part of the brain, called accessory olfactory bulb, an area of the brain that is absent in humans.

Researchers have learned a lot about how the olfactory nerve cells detect odorants. However, they have not yet learned how this information is coded by the olfactory cell. Scientists are only beginning to understand the role that smell plays in animal and human behavior. The vomeronasal sense of animals is still largely not understood and some researchers have even suggested that the human vomeronasal organ might retain some function, and that humans may have pheromones that play a role in sexual attraction and mating. However, this hypothesis is still very controversial.

Detailed study of the biology of the olfactory system may yield gains in other fields. For instance, olfactory

nerve cells are the only nerve cells that are derived from the central nervous system that can regenerate, possibly because the **stress** of their exposure to the outside world gives them a limited life span. Some researchers hope that studying regeneration in olfactory nerve cells or even transplanting them elsewhere in the body can lead to treatments for as yet irreversible damage to the spine and brain.

Common diseases and disorders

The most common complaint registered by patients is the loss of the sense of smell (anosmia). Smell disorders usually develop after an illness or an injury. Loss of the sense of smell is commonly caused by upper respiratory illnesses or a **head injury**. It can result from polyps in the nose or nasal cavity, sinus infections, hormonal fluctuations, or dental problems.

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Social work in health care

Definition

Social work in health care helps people who are dealing with a medical problem to function within their situation. The social worker who specializes in health care works with clients and their families to provide services necessary to make their lives easier for the duration of the client's illness, and to help them deal with the consequences directly related to that illness.

Description

According to the code of ethics of the National Association of Social Workers (NASW), the profession of social work is dedicated to a set of core values. These values include social justice, service, dignity and worth of the person, importance of human relationships, integrity, and competence, and they form the foundation of social work. Social workers in the medical field provide a wide variety of services to clients who are going through a short-term medical crisis, suffering from chronic illnesses, facing a life-threatening disease, or in need of long-term care or rehabilitation.

The main concern of the social worker is to assist the client and the client's family in coping with their health care situation. Clients are faced with many problems when they have an accident, contract a sudden and debilitating illness, or are diagnosed with a chronic or life-threatening disease. Social workers help them assess these problems, identify their immediate and long term needs, and find resources to supply the needs.

Within the health care setting, the social worker has many responsibilities. The services provided by the social worker depend on the needs of the client. The worker acts as an advocate to secure the client's rights, directly counsels the client and the client's family, and refers the client to other social agencies, community resources, or facilities that can meet the client's immediate and long-term needs. The services provided by the social worker always depend upon the client's needs and the health care setting.

If the social worker is working in a hospital, these duties may include setting up home health care services after the client's discharge, arranging for meals to be delivered to the client's home, and setting appointments for follow-up care. The worker may also make arrangements for transportation to doctor's appointments and community social service agencies, and for long-term care within another facility.

Work settings

Duties of the social worker vary with the health care setting. Medical social workers may work in a hospital, hospice, assisted living center, nursing home, physical rehabilitation center, clinic, home health care agency, or drug rehabilitation or mental health center. Social workers may work in the health care facility or make home visits to work with their clients. They often work with other agencies and have to travel short distances for meetings with the agency members. Social workers confer with other agency workers or with health care team

members to assess client needs and to make plans for the client's care.

Hours of work vary for the social worker, depending upon the facility or agency within which he is employed. Usually the work hours are between 8 AM and 5 PM Monday through Friday, but the worker may be required to work hours as needed for emergencies. In larger urban areas or rural areas, the social worker may also be required to work during evening hours and on weekends to better serve the clients.

Education and training

Education, training, and licensing requirements may vary from state to state, but the NASW states that the minimum educational requirement for social workers is a baccalaureate degree in social work (BSW). However, people who hold a bachelor's degree in another discipline such as psychology, sociology, or urban studies may also qualify for entrance level jobs.

BSW programs prepare students for direct care of clients. Students who choose to major in social work must complete courses in social work practice, social work policies, human behavior and social environment, research methods, social work values and ethics, study of populations at risk, and the promotion of social justice. They must also complete 400 hours of supervised field work.

An advanced degree is the standard for many positions in social work including positions within the field of health care. A master's degree in social (MSW) allows the social worker to be certified for clinical and supervisory work.

Advanced education and training

A master's degree in social work qualifies the social worker to make clinical assessments, choose an area of specialization, manage large caseloads, and supervise social workers with lesser degrees. In addition to courses of specialization and assessment, the MSW candidate must complete 900 hours of supervised field work, or an internship.

Social workers may also acquire a Ph.D. or DSW in social work. This is required if they want to teach in an accredited program at a university or to work in a supervisory position as the head of a social service program.

The National Association of Social Workers requires social workers to complete 90 hours of continuing education classes every three years to continue their certification in the profession. Licensed professionals with

KEY TERMS

BSW—Baccalaureate degree in social work.

Long-term care—Placement of client in a facility that provides nursing and basic needs care when client is no longer able to provide that care at home.

MSW—Master's degree in social work.

NASW—National Association of Social Workers.

Needs assessment—Social worker conducts an interview with client and family, reviews charts, interviews other health workers to determine what specific services are required by client.

Urban studies—Course work in the sociology of urban areas.

advanced degrees may be required to complete more than 90 hours of continuing education classes.

Future outlook

Social work is a growing profession. The occupational outlook is optimistic. The national Bureau of Labor Statistics predicts that growth will continue at a rate exceeding that of other occupations until at least 2008. There are several reasons why the field of social work in health care continues to grow:

- the aging population of "baby boomers"
- advanced medical treatment
- longer life expectancy
- growth of home health care due to growing trend of early release of patients from hospitals
- replacement of workers seeking career change
- stress and burnout among social workers causing them to leave profession
- increase in population of people living with AIDS

Resources

BOOKS

Occupation Outlook Handbook, 2000-01 Ed. Washington, D.C.: Department of Labor, 2000.

ORGANIZATIONS

National Association of Social Workers. 750 First Street NE, Suite 700, Washington, D.C. 20002-4241.
<<http://www.naswdc.org>>.

Peggy Elaine Browning

Sodium bicarbonate see **Antacids**

Sodium test see **Electrolyte tests**

Soft tissue mobilization see **Massage therapy**

Somatization disorder see **Somatoform disorders**

Somatoform disorders

Definition

Somatoform disorders is the umbrella term developed by the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* in 1980 to describe a group of conditions characterized by the presence of physical symptoms without evidence of a physiologic cause. *DSM-IV* divides these conditions into six separate psychiatric disorders.

- somatization disorder
- undifferentiated somatoform disorder
- conversion disorder
- **pain** disorder
- hypochondriasis
- body dysmorphic disorder

Description

It is helpful to understand that the present classification of these disorders reflects recent historical changes in the practice of medicine and psychiatry. When psychiatry first became a separate branch of medicine at the end of the nineteenth century, the term hysteria was commonly used to describe mental disorders characterized by altered states of consciousness (for example, sleepwalking or trance states) or physical symptoms (for example, a “paralyzed” arm or leg with no neurologic cause) that could not be fully explained by a medical disease. The term dissociation was used for the psychological mechanism that allows the mind to split off uncomfortable feelings, memories, or ideas so that they are lost to conscious recall. Sigmund Freud and other pioneering psychoanalysts thought that the hysterical patient’s symptoms resulted from dissociated thoughts or memories reemerging through bodily functions or trance states. Prior to the fourth edition of *DSM* in 1980, all mental disorders that were considered to be forms of hysteria were grouped together on the basis of this theory about their cause.

Since 1980, however, the somatoform disorders and the so-called dissociative disorders have been placed in separate categories on the basis of their chief symptoms. In general, the somatoform disorders are characterized by disturbances in the patient’s physical sensations or ability to move the limbs or walk, while the dissociative disorders are marked by disturbances in the patient’s sense of identity or **memory**.

Somatization disorder

Somatization disorder was formerly called Briquet’s syndrome, after the French physician who first recognized it. Z. J. Lipowski defined somatization in the *American Journal of Psychiatry* as “the tendency to experience and communicate somatic distress and symptoms not accounted for by pathologic findings, to attribute them to physical illness and to seek medical help for them.”

Somatization disorder typically begins before the age of 30. It is estimated that worldwide, between 0.2% and 2% of the population will develop this disorder in their lifetime. In the United States, it is nearly twice as common in women, but in other cultures, it is believed to be more widespread in men. Some psychiatrists think that the high female-to-male ratio in this disorder in North America reflects the cultural pressures on women and the social expectation that women are generally physically weak or sickly. It is also likely to run in families. As many as 20% of the mothers, sisters, or daughters of somatization disorder patients have the same illness. Their male first-degree relatives are more apt to have anti-social personality disorder or addiction problems. When asked to self-assess health, somatization disorder patients usually rate their well-being as worse than people suffering from actual long-term illness do. Physical complaints normally develop or increase during times of **stress**, and though these people look for help frequently, it is highly unusual for them to find relief.

Undifferentiated somatoform disorder

Undifferentiated somatoform disorder is generally less specific than somatization disorder, and requires only the presence of one symptom to be consistently present. But patients suffering from undifferentiated somatoform disorder often complain of fatigue, loss of appetite, or difficulty swallowing. Symptoms commonly develop when the person is under stress or is depressed, and to meet *DSM-IV* criteria, must have no physical basis and remain for more than six months.

Conversion disorder

In conversion disorders, people typically report a loss or change in the function of some part of their body that does not correlate with what medical science knows today of anatomy or physiology. Symptoms are often neurological in nature, such as seizures that are not seen on EEG, or an inability to move an arm or leg, or walk. The disorder gets its name from the notion that the patient is converting a psychological conflict or problem into an inability to move specific parts of the body or to use the senses normally. An example of a conversion reaction would be a patient who loses his or her voice in a situation in which he or she is afraid to speak. The symptom simultaneously contains the **anxiety** and serves to get the patient out of the threatening situation. The resolution of the emotion that underlies the physical symptom is called the patient's primary gain, and the change in the patient's social, occupational, or family situation that results from the symptom is called a secondary gain. Doctors sometimes use these terms when they discuss the aftereffects of conversion disorder or of other somatoform disorders on the patient's emotional adjustment and lifestyle.

Unlike somatization disorder, the symptoms of conversion disorder typically occur in adolescence or early adulthood, when the person is under extreme stress. It does not appear to run in families. It is estimated that as many as one in four people admitted to a general hospital have experienced conversion symptoms, but that the disorder is more likely to occur among less educated or sophisticated people. Females are at least twice as likely to develop conversion disorder symptoms, and men are more likely to develop such symptoms in occupational settings or military service.

Pain disorder

Pain disorder is marked by the experience of severe pain in the absence of physical cause for the pain, or markedly unwarranted complaint of pain from an actual illness. *DSM-IV* requirements include duration of a minimum of six months, a curtailment of normal activities such as work or school, and relationship problems. Prescription drug dependency often accompanies somatoform pain disorder, but drug-seeking does not cause it. Somatoform pain disorder is not deliberately put on. This category of somatoform disorder covers a range of patients with a variety of ailments, including chronic headaches, back problems, arthritis, muscle aches and cramps, or pelvic pain. In some cases the patient's pain appears to be largely due to psychological factors, but in other cases the pain is derived from a medical condition as well.

Pain disorder is frequently accompanied by what are termed the Five D's. These are:

- depressed mood
- disturbed sleep pattern
- dysfunction in social situations
- decreased activity level
- decreased physical activity

Because pain is such an individual experience, the incidence of somatoform pain disorder is unclear. It is known that between 10–15% of all of the population that suffer from back pain eventually become work-disabled. What percent of these people suffer from somatoform pain disorder is unclear.

Hypochondriasis

Hypochondriasis is a somatoform disorder marked by excessive fear of or preoccupation with having a serious illness that persists in spite of medical testing and reassurance. It was formerly called hypochondriacal neurosis.

Although hypochondriasis is usually considered a disorder of young adults, it is now increasingly recognized in children and adolescents. It may also develop in elderly people without previous histories of health-related fears. The disorder accounts for about 5% of psychiatric patients, and is equally common in men and women. Patients typically are abnormally attentive to normal bodily functions such as heartbeat or perspiring. *DSM-IV* criteria include the presence of unrealistic fears or beliefs for at least six months. During any six month period, between 4% and 6% of the population suffers from hypochondria. Episodes can last anywhere from months to years, and it is a persistent, relapsing condition. Chronic stress is believed to play a large role in its occurrence.

Body dysmorphic disorder

Body dysmorphic disorder is a new category in *DSM-IV*. It is defined as a preoccupation with an imagined or exaggerated defect in appearance. Most cases involve features on the patient's face or head, but other body parts—especially those associated with sexual attractiveness, such as the breasts or genitals—may also be the focus of concern. Patients with this disorder are often found in plastic surgery clinics. They frequently have histories of seeking or obtaining plastic surgery or other procedures to repair or treat supposed defects, but it seldom if ever provides them with long-term relief.

Though the average age of body dysmorphic disorder patients is thirty, it is regarded as a chronic condition that usually begins in the patient's late teens and fluctu-

ates over the course of time. It was initially considered to be a relatively unusual disorder, but it is now estimated that two percent of those seeking plastic surgery may be dysmorphic disorder patients. It appears to affect men and women with equal frequency. Some may even meet the criteria for a delusional disorder of the somatic type.

Somatoform disorders in children and adolescents

In children and adolescents, the most common somatoform disorder is conversion disorder, though body dysmorphic disorders are being reported more frequently. Conversion reactions in this age group usually reflect stress in the family or problems with school, rather than long-term psychiatric disturbances. Some psychiatrists speculate that adolescents with conversion disorders frequently have overprotective or over-involved parents with a subconscious need to see their child as sick. In many cases the son or daughter's symptoms become the center of family attention. The rise in incidence of body dysmorphic disorder in adolescents is thought to reflect the increased influence of media preoccupation with physical perfection.

Causes and symptoms

In somatoform disorders, the patient's reported symptoms are considered to be the unconscious manifestation of very real emotional suffering. In classic psychoanalytic theories, unconscious conflicts are the result of painful early-life events that are re-awakened in adult life by similar stressors. Because the person is unable to express the re-awakened emotion because of fear or guilt, their emotions are repressed and changed into physical symptoms.

Because *DSM-IV* groups the somatoform disorders into their present category on the basis of symptom patterns, their causes as presently understood include several different factors.

Family stress

Family stress is believed to be one of the most common causes of somatoform disorders in children and adolescents. Conversion disorders in this age group may also be connected with physical or sexual abuse within the family of origin.

Parental modeling

Somatization disorder and hypochondriasis may result in part from the patient's unconscious reflection or imitation of parental behaviors. This "copycat" behavior is particularly likely if the patient's parent derived considerable secondary gain from his or her symptoms.

Cultural influences

Cultural influences appear to affect the gender ratios and body locations of somatoform disorders, as well as their frequency in a specific population. Some cultures (for example, Greek and Puerto Rican) report higher rates of somatization disorder among men than is the case for the United States. In addition, researchers found lower levels of somatization disorder among people with higher levels of education. People in Asia and Africa are more likely to report certain types of physical sensations (for example, burning hands or feet, or the feeling of ants crawling under the skin) than are Westerners.

Biological factors

Genetic or biological factors may also play a role. For example, people who suffer from somatization disorder may also differ in how they perceive and process pain.

Diagnosis

Accurate diagnosis of somatoform disorders is important to prevent unnecessary surgery, laboratory tests, or other treatments or procedures. But it is equally important for physicians and all healthcare staff to carefully evaluate the person to assure that an actual physical cause for the somatoform-appearing symptom is not being missed. Diagnosis of somatoform disorders requires a thorough physical workup. Pain disorder patients have, on occasion, later been discovered to actually have **cancer**, and a detailed examination is especially necessary when conversion disorder is a possible diagnosis, because some neurological conditions, including **multiple sclerosis** and myasthenia gravis, have been misdiagnosed as conversion disorder. Some patients who receive a diagnosis of somatoform disorder ultimately go on to develop neurologic disorders.

In addition to ruling out medical causes for the patient's symptoms, a doctor who is evaluating a patient for a somatization disorder will consider the possibility of other psychiatric diagnoses or of overlapping psychiatric disorders. Somatoform disorders often coexist with **personality disorders** because of the chicken-and-egg relationship between physical illness and certain types of character structure or personality traits. At one time, the influence of Freud's theory of hysteria led doctors to assume that the patient's hidden emotional needs cause the illness. But in many instances, the patient's personality may have changed over time due to the stresses of adjusting to a chronic disease. This gradual transformation is particularly likely in patients with pain disorder. Patients with somatization disorder often develop panic

attacks or agoraphobia together with their physical symptoms. In addition to anxiety or personality disorders, the doctor will usually consider major depression as a possible diagnosis when evaluating a patient with symptoms of a somatoform disorder. Pain disorders may be associated with depression, and body dysmorphic disorder may be associated with obsessive-compulsive disorder.

Treatment

Psychiatric therapies

Patients with somatoform disorders are not considered good candidates for psychoanalysis or other forms of insight-oriented **psychotherapy**. They can benefit, however, from supportive approaches aimed at symptom reduction and stabilization of the patient's personality. Some patients with pain disorder benefit from group therapy or support groups, particularly if their social network has been limited by their pain symptoms. Cognitive-behavioral therapy is also used sometimes to treat pain disorder.

Family therapy is usually recommended for children or adolescents with somatoform disorders, particularly if the parents seem to be using the child as a focus to divert attention from other difficulties. Working with families of chronic pain patients also helps avoid reinforcing dependency within the family setting.

Medications

Patients with somatoform disorders are sometimes given anti-anxiety drugs or **antidepressant drugs** if they have been diagnosed with a coexisting mood or anxiety disorder. In general, though, it is considered better practice to avoid prescribing medications for these patients since they run the risk of becoming psychologically dependent on them.

Hypnosis is a time-honored technique used since Freud's time as part of a general psychotherapeutic approach to conversion disorder. It may allow patients to recover memories or thoughts connected with the onset of the physical symptoms.

Alternative treatment

Patients with somatization or pain disorders may be helped by a variety of alternative therapies including acupuncture, **hydrotherapy**, therapeutic massage, **yoga**, **meditation**, botanical medicine, and homeopathic treatment. These are often available through both pain and stress reduction clinics that many general hospitals now have.

Prognosis

Somatization disorder is considered to be a chronic disturbance that tends to persist throughout the patient's life, but a recent three year follow-up study reported in *Caring For The Mind: The Comprehensive Guide to Mental Health* showed that a consistent approach using education and reassurance resulted in noticeable improvement.

The prognosis for conversion disorder is considered to be good. Ninety percent of patients recover within a month, and only one in five will ever have a recurrence.

People suffering from hypochondriasis have a more optimistic outlook if treatment is initiated early, before they have gotten themselves into a cycle of medical tests and procedures. There has been very little research regarding the effectiveness of treatment in body dysmorphic disorder.

Health care team roles

In many cases a somatoform disorder diagnosis is made in a general medical clinic by a primary care practitioner, rather than by a psychiatrist. Children and adolescents with somatoform disorders are most likely to be diagnosed by their primary care physician, or pediatrician.

Primary care practitioner (PCP)

A PCP is typically a licensed medical doctor. Because somatoform disorders are associated with physical symptoms, patients are much more apt to be seen by primary care physicians. Their lengthy medical histories make a long-term relationship with a trusted PCP a safeguard against unnecessary treatments as well as being a comfort to the patient. Many PCPs prefer to schedule brief appointments on a regular basis with the patient and keep referrals to specialists to a minimum. This practice also allows them to monitor the patient for any new physical symptoms or diseases. However, some PCPs work with a psychiatric consultant.

Psychiatrist

Psychiatrists are licensed medical doctors that have undergone a three year psychiatric residency. They are often the providers of both education and support for patients with somatoform disorders.

Registered nurse (RN), psychiatric nurse, or licensed practical nurse (LPN)

Both RNs and LPNs must complete a prescribed course in nursing and pass a state examination. RNs typ-

KEY TERMS

Briquet's syndrome—Another name for somatization disorder.

Conversion disorder—A somatoform disorder characterized by the transformation of a psychological feeling or impulse into a physical symptom. Conversion disorder was previously called hysterical neurosis, conversion type.

CT scan—Computerized Tomography Scanning. A diagnostic technique in which the combined use of a computer and x rays passed through the body at different angles produces clear, cross-sectional images.

Dissociation—A psychological mechanism in which the mind splits off certain aspects of a traumatic event from conscious awareness. Dissociation can affect the patient's memory, sense of reality, and sense of identity.

Hysteria—The earliest term for a psychoneurotic disturbance marked by emotional outbursts and/or disturbances of movement and sense perception. Some forms of hysteria are now classified as somatoform disorders and others are grouped with the dissociative disorders.

Hysterical neurosis—An older term for conversion disorder or dissociative disorder.

MRI—Magnetic Resonance Imaging. A diagnostic technique that provides very clear cross-sectional images of organs and structures in the human body without x rays or other radiation.

Primary gain—The immediate relief from guilt, anxiety, or other unpleasant feelings that a patient derives from a symptom.

Repression—A unconscious psychological mechanism in which painful or unacceptable ideas, memories, or feelings are removed from conscious awareness or recall.

Secondary gain—The social, occupational, or interpersonal advantages that a patient derives from symptoms. A patient's being relieved of his or her share of household chores by other family members would be an example of secondary gain.

Somatoform disorder—A category of psychiatric disorder characterized by physical complaints that appear to be medical in origin but that cannot be explained in terms of a physical disease, the results of substance abuse, or by another mental disorder.

Stressor—Any interference that disturbs a person's healthy mental and physical well-being.

ically have a degree in nursing, and psychiatric nurses have additional training specific to psychiatry. Both RNs and LPNs are often the people who deal the most with patients with somatoform disorders in general hospitals, clinics and on psychiatric units. An open mind and non-judgmental attitude toward the patient and careful, detailed observation of symptoms can be highly useful. The provision of education about the nature of these illnesses will typically come from both physicians and nurses.

Clinical laboratory scientist

Clinical laboratory scientists have specialized training and must pass a state examination. They draw **blood** samples or test urine or other specimens that are ordered by the physician to help in making a correct diagnosis.

Radiologic technologist

Radiologic technologists have specialized training and must pass a state examination. They take x rays or

other imaging such as MRIs or **CT scans** that are ordered by the physician to help in making a correct diagnosis.

Social workers

Social workers are usually either certified (CSW) or licensed clinical social workers (LCSW). A two-year graduate program degree and specialized training including supervised clinical work in working with the mentally ill, and state licensure are typical requirements. Social workers often conduct supportive groups or programs that help people vent feelings or work on ways to better be able to cope.

Specialized therapists

Stress reduction therapists are a good example of this category. They are not necessarily licensed in all states, but typically have a degree in one of the human service fields such as social work, psychology or nursing. They are often certified in a specific stress reduction program such as the now-nationwide one that was developed

at University of Massachusetts Medical Center by Dr. Jon Kabat-Zinn. Most of these stress reduction programs incorporate standard supportive group therapy techniques with alternative medicine areas such as yoga and meditation.

Prevention

Generalizations regarding prevention of somatoform disorders are difficult because these syndromes affect different age groups, vary in their symptom patterns and persistence, and result from different problems of adjustment to the surrounding culture. In theory, allowing expression of emotional pain in children, rather than regarding it as a weakness, might reduce the secondary gain of physical symptoms that draw the care or attention of parents.

Resources

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Joan M. Schonbeck

Somatosensory evoked potential study see
Evoked potential studies

Sonogram unit see **Ultrasound unit**

Sore throat

Definition

Sore throat is an upper respiratory **infection** that may be caused by inflammation of the pharynx, larynx,

or tonsils. Thus, it is a symptom of many conditions, but most often is associated with **common cold** or **influenza**. Sore throat may be caused by either a virus or **bacteria** in addition to certain environmental conditions. Most sore throats heal without complications, but they should not be ignored because some develop into serious illnesses.

Description

Almost everyone gets a sore throat at one time or another. Sore throat and cold are more prevalent among children in daycare centers or schools and seem to be related to their lack of resistance as compared to the adolescents and adults. It is interesting to note that women in the age of 20–30 are affected by more cold attacks than men, which may be attributed to their contact with children. Sore throats are most common during the winter months when upper respiratory infections (colds) are more frequent. The National Center for Health Statistics has estimated that common cold symptoms (which include sore throat) amounted to 62 million cases, in 1996, that needed medical attention.

Sore throats can be either acute or chronic. Acute sore throats are more common. They last from three to seven days. A chronic sore throat lasts much longer and is a symptom of an unresolved underlying condition or disease, such as a sinus infection.

Causes and symptoms

Sore throats have many different causes, and may or may not be accompanied by cold symptoms, **fever**, or swollen lymph glands. Proper treatment depends on understanding the cause of the sore throat.

Viral sore throat

Viruses cause 90-95% of all sore throats. Cold and flu viruses are the main culprits although about 200 different viruses are known to cause the symptoms of sore throat. Rhinoviruses cause 30-35% of all adult colds in fall, spring, and summer. Coronaviruses cause the infections in winter and spring. These viruses cause an inflammation in the throat and occasionally the tonsils (tonsillitis). The causative agents of viral tonsillitis are Epstein-Barr virus, influenza virus, enterovirus, or adenoviruses. Cold symptoms almost always accompany a viral sore throat. These can include a runny nose, cough, congestion, hoarseness, conjunctivitis, and fever. The level of throat **pain** varies from uncomfortable to excruciating, when it is painful for the patient to eat, breathe, swallow, or speak.

Another group of viruses that cause sore throat are the adenoviruses. These may also cause infections of the **lungs** and ears. In addition to a sore throat, symptoms that accompany an adenovirus infection include cough, runny nose, white bumps on the tonsils and throat, mild **diarrhea**, vomiting, and a rash. The sore throat lasts about one week.

A third type of virus that can cause severe sore throat is the coxsackie virus. It can cause a disease called herpangina. Although anyone can get herpangina, it is most common in children up to age ten and is more prevalent in the summer or early autumn. Herpangina is sometimes called summer sore throat.

Three to six days after being exposed to the virus, an infected person develops a sudden sore throat that is accompanied by a substantial fever usually between 102-104°F (38.9-40°C). Tiny grayish-white blisters form on the throat that turn into ulcerative lesions. Throat pain is often severe, interfering with swallowing. Children may become dehydrated if they are reluctant to eat or drink because of the pain. In addition, people with herpangina may vomit, have abdominal pain, and generally feel ill and miserable.

One other common cause of a viral sore throat is mononucleosis. An estimated 90% of mononucleosis cases are caused by the Epstein-Barr virus (EBV), while the remaining cases may be attributed to the cytomegalovirus. EBV is known to infect B lymphocytes (a subset of white **blood** cells). The infection spreads to the **lymphatic system, respiratory system, liver, spleen, throat** and salivary glands. Symptoms appear 30-50 days after exposure.

Mononucleosis, sometimes called the “kissing disease,” is extremely common. It is estimated that by the age of 35-40, 80-95% of Americans will have had mononucleosis. Often, symptoms are mild, especially in young children, and are diagnosed as a cold. Since symptoms are more severe in adolescents and adults, more cases are diagnosed as mononucleosis in this age group. One of the main symptoms of mononucleosis is severe sore throat.

Although a runny nose and cough are much more likely to accompany a sore throat caused by a virus than one caused by a bacteria, there is no absolute way to tell what is causing the sore throat without a laboratory test. Viral sore throats are contagious and are passed directly from person to person by coughing and sneezing.

Bacterial sore throat

About 5-10% of sore throats are caused by bacteria. The most common bacterial sore throat results from an infection by group A *Streptococcus*. This type of infec-

tion is commonly called **strep throat**. Anyone can get strep throat. This organism may also cause laryngitis, which is predominantly marked by hoarseness of voice, sore throat, dry and persistent cough, and fever. Yet another ailment caused by *Streptococcus* is pharyngitis, which is inflammation of pharynx leading to fever, tenderness in the neck glands, sore throat, abdominal pain, headache, cough, hoarseness, and skin rash. Other bacteria that are known to cause pharyngitis are groups C and G *Streptococcus*, *Yersinia enterocolitica*, and rarely *Corynebacterium diphtheriae*. Untreated streptococcal pharyngitis may lead to peritonsillar **abscess** that is accompanied by severe sore throat and hoarseness of voice. In these cases, immediate intervention by otolaryngologists is required to aspirate the abscess.

Pharyngeal gonorrhea, a sexually transmitted bacterial disease, causes severe sore throat. Gonorrhea in the throat is transmitted by having oral sex with an infected person.

Noninfectious sore throat

Not all sore throats are caused by infection. Postnasal drip can irritate the throat and make it sore. It can be caused by hay fever and other **allergies** that are irritating to the sinuses. Environmental and other conditions, such as heavy smoking or breathing secondhand smoke, heavy alcohol consumption, breathing polluted air or chemical fumes, or swallowing substances that burn or scratch the throat can also cause pharyngitis. Dry air, like that in airplanes or from forced hot air furnaces, can make the throat sore. People who breathe through their mouths at night because of nasal congestion often get sore throats that improve as the day progresses. Sore throat caused by environmental conditions is not contagious.

Diagnosis

It is easy for people to tell if they have a sore throat, but difficult to know what has caused it without laboratory tests. Most sore throats are minor and heal without any complications. A small number of bacterial sore throats do develop into serious diseases. Because of this, it is advisable to see a doctor if a sore throat lasts more than a few days or is accompanied by fever, nausea, or abdominal pain.

Diagnosis of a sore throat begins with a **physical examination** of the throat and chest. The examiner will also look for signs of other illness, such as a sinus infection or bronchitis. Since both bacterial and viral sore throat are contagious and pass easily from person to person, the health care provider will seek information about whether the patient has been around other people with

flu, sore throat, colds, or strep throat. If it appears that the patient may have strep throat, laboratory Tests will be performed.

If mononucleosis is suspected, the doctor may do a mono spot test to look for antibodies indicating the presence of the Epstein-Barr virus. The test is inexpensive, takes only a few minutes, and can be done in a physician's office. An inexpensive blood test can also determine increased lymphocytes and the presence of specific antibodies to the mononucleosis virus.

Treatment

Effective treatment varies depending on the cause of the sore throat. As frustrating as it may be to the patient, viral sore throat is best left to run its course without drug treatment. **Antibiotics** are ineffective against viruses. They do not shorten the length of the illness, nor do they lessen the symptoms.

Sore throat caused by a streptococci or another bacteria must be treated with antibiotics. Penicillin is the preferred medication. Oral penicillin must be taken for ten days. Patients need to take the entire course of antibiotic prescribed, even after symptoms of the sore throat improve. Incomplete treatment may lead to the relapse of the symptoms. Occasionally a single **intramuscular injection** of long-acting penicillin G is administered instead of ten days of oral treatment. In cases of penicillin allergy, cephalexin, cefuroxime, or cefprozil are the preferred alternative antibiotics that are recommended. These medications generally cost under fifteen dollars.

Mononucleosis, being a viral infection, is self-limiting with no means of therapeutic control. Rest, a healthy diet, plenty of fluids, avoiding strenuous exercises and competitive sports are recommended. The acute phase of infection is treated with acetaminophen (Datril, Tylenol, Panadol) or ibuprofen (Advil, Nuprin, Motrin, Medipren). Nearly 90% of mononucleosis infections are mild. The infected person does not normally get the disease again.

In the case of chronic sore throat, it is necessary to treat the underlying disease to heal the sore throat. If sore throat is caused by environmental factors, the aggravating stimulus should be eliminated from the sufferer's environment.

Home care for sore throat

Regardless of the cause of a sore throat, there are some **home care** steps that can be taken to ease discomfort. These include:

- Taking acetaminophen or ibuprofen for pain. Aspirin should not be given to children because of its associa-

tion with increased risk for Reye's syndrome, a serious disease.

- Gargling with warm double strength tea or warm salt water made by adding one teaspoon of salt to eight ounces of water.
- Drinking plenty of fluids, but avoiding acid juices like orange juice, which can irritate the throat. Sucking on popsicles is a good way to get fluids into children.
- Eating soft, nutritious foods like noodle soup and avoiding spicy foods.
- Refraining from smoking.
- Resting until the fever is gone, then resuming strenuous activities gradually.
- Often minimizing the dryness by using room humidifier may improve the symptoms of sore throat, especially in pediatric population.
- Antiseptic lozenges and sprays may aggravate the sore throat rather than improve it.

Alternative treatment

Alternative treatment focuses on easing the symptoms of sore throat using herbs and botanical medicines.

- Aromatherapists recommend inhaling the fragrances of essential oils of lavender (*Lavandula officinalis*), thyme (*Thymus vulgaris*), eucalyptus (*Eucalyptus globulus*), sage (*Salvia officinalis*), and sandalwood.
- Ayurvedic practitioners suggest gargling with a mixture of water, salt, and turmeric (*Curcuma longa*) powder or astringents such as alum, sumac, sage, and bayberry (*Myrica* spp.).
- Herbalists recommend taking osha root (*Ligusticum porteri*) internally for infection or drinking ginger (*Zingiber officinale*), slippery elm (*Ulmus fulva*), sage or marshmallow tea for pain. Also fresh juice of *Echinacea* along with the root of goldenseal may have a soothing effect on the throat. The tannins found in blueberries, blackberries and red raspberries have also been shown to be effective for sore throats
- Homeopaths may treat sore throats with superdilute solutions of *Lachesis*, *Belladonna*, *Phytolacca*, or yellow jasmine (*Gelsemium*).
- Nutritional recommendations include **zinc** lozenges every two hours along with **vitamin C** with bioflavonoids, **vitamin A**, and beta-carotene supplements.

KEY TERMS

Antigen—A foreign protein to which the body reacts by making antibodies.

Conjunctivitis—An inflammation of the membrane surrounding the eye; also known as pink-eye.

Lymphocyte—A type of white blood cell. Lymphocytes play an important role in fighting disease.

Pharynx—The pharynx is the part of the throat that lies between the mouth and the larynx or voice box.

Tonsils—Fleshy tissues located on either side of the back of the throat.

Toxin—A poison. In the case of scarlet fever, the toxin is secreted as a byproduct of the growth of the streptococcus bacteria and causes a rash.

Prognosis

Sore throat caused by a viral infection generally clears up on its own within one week with no complications. The exception is mononucleosis. Ninety percent of cases of mononucleosis clear up without medical intervention or complications, so long as **dehydration** does not occur. In young children the symptoms may last only a week, but in adolescents the symptoms last longer. Adults over age 30 have the most severe and long lasting symptoms. Adults may take up to six months to recover. In all age groups fatigue and weakness may continue for up to six weeks after other symptoms disappear.

In rare cases of mononucleosis, breathing may be obstructed because of swollen tonsils, adenoids, and lymph glands. If this happens, the patient should immediately seek emergency medical care.

Patients with bacterial sore throat begin feeling better about 24 hours after starting antibiotics. If left untreated strep throat may lead to scarlet fever, rheumatic fever resulting in rheumatic **heart** disease or glomerulonephritis. Scarlet fever is a combination of sore throat with rash of sand paper consistency that may appear in the lower abdomen and gradually spread to the trunk. Rheumatic fever is marked by inflammation and pain in the joints. In severe cases, inflammation of the heart valves can lead to **heart failure**. Glomerulonephritis is inflammation of glomeruli that serve as filters in the kidney. The damaged filters result in red urine due to the release of red blood cells. The treatment for this disorder is aimed at control-

ling the symptoms. Taking antibiotics within the first week of a strep infection will prevent these complications. People with strep throat remain contagious until after they have been taking antibiotics for 24 hours.

Health care team roles

Sore throat may not always need medical intervention, but persistent sore throats and accompanying symptoms should not be ignored. A general physician helps in determining whether the sore throat is a result of a viral or bacterial infection. A thorough physical examination followed by laboratory tests in cases of a doubtful bacterial infection is performed. If a bacterial sore throat is diagnosed by the physician, antibiotics are prescribed. Health care professionals, including the pharmacists, play a key role in cautioning the patient regarding the potential allergic reactions associated with the intake of antibiotics. Some of these reactions may be serious and need immediate medical intervention.

There may be lingering symptoms or changes in the symptoms after visiting the doctor. Some of the concerns will be:

- persistent fever
- continuing and severe sore throat
- discomfort in opening the mouth wide
- dizziness

In such cases, a doctor's advice is highly recommended. In addition, health care professionals will provide the best resources for **nutrition**, suggestions for pain relievers and effective home remedies for viral sore throats.

Prevention

There is no way to prevent a sore throat; however, the risk of getting one or passing one on to another person can be minimized by:

- Washing hands well and frequently.
- Avoiding close contact with someone who has a sore throat.
- Not sharing food and eating utensils with anyone.
- Cleaning the environmental surfaces with a disinfectant.
- Not smoking.
- Avoiding polluted air.
- Using a room humidifier at home during the winter months when the dryness is maximum.

- Avoiding exposures to sudden and frequent changes in temperatures (in winter, being exposed to severe cold outside and heated room within the home).

Resources

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Tish Davidson
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Speech disorders

Definition

A speech disorder is a communication disorder characterized by an impaired ability to produce speech sounds or normal voice, or to speak fluently.

Description

Speech disorders belong to a broad category of disorders called communication disorders that also include language and **hearing** disorders. Communication disorders affect one person out of every ten in the United States. Speech disorders refer to difficulties producing speech sounds or problems with voice quality. They may be characterized by an interruption in the flow or rhythm of speech such as **stuttering**, or by problems with the way sounds are formed, also called articulation or phonological disorders, or they may involve voice problems such as pitch, intensity, or quality. Often, there is a combination of several different problems.

Speech disorders can either be present at birth or acquired as a result of stroke, **head injury**, or illness. The production of intelligible speech is the result of very complex interactions originating in the **brain**. When the brain sends a series of speech signals to the speech muscles, the muscles need to produce the series of sounds that will convey the intended message. Major speech disorders that can impair this process include:

- **Articulation disorders:** Articulation is the production of speech sounds, and persons affected by articulation disorders experience difficulty in being understood because they produce incorrect speech sounds. As a result, their speech is not intelligible. They may substitute one sound for another or may distort the sound with the result that it sounds incorrect, even though still recognizable, or omit one or more sounds in a word.
- **Phonological disorders:** Phonology is the science of speech sounds and sound patterns and of the language rules that dictate how sounds may be combined to produce language. Persons affected by phonological disorders do not use the conventional rules for their native language but substitute their own variants. This affects classes of sounds, as opposed to single sounds. Sounds are characterized by where in the mouth they are produced, how they are produced, and by how the larynx (voice box) is used. Any unusual deviation in these features is called a phonological process. Fronting and backing are examples of phonological processes, characterized by the production of sounds at the front or at the back of the mouth when they should be produced the other way around. For example, the word "go," produced at the back of the mouth, might be used instead of "doe," which is produced in the front.
- **Stuttering:** Normal speech is fluent, in that it is spoken effortlessly and without hesitation. A break in fluent speech is called a dysfluency. Although some degree of dysfluency occurs in normal speech from time to time, stuttering has more dysfluencies than is considered average. Normally developing preschool children often demonstrate dysfluencies that are effortless and last for brief periods of time. However, changes in the types of dysfluency behavior and the frequency of occurrence may signal the development of a problem. Normal dysfluencies consist of word or sentence repetitions, fillers ("um," "ah"), or interjections. Stuttering behavior includes sound or syllable repetition, prolongations (the unnatural stretching out of sounds), and blocks, which refers to an inability to produce the sound, as if it gets stuck and cannot come out. Stuttering dysfluencies are also often accompanied by tension and anxiety.
- **Voice disorders:** There are two types of voice disorders: organic voice and functional voice disorders.

Organic voice disorders are associated with disease and require medical intervention. Functional voice disorders are the result of abuse or misuse of the larynx. Sounds are produced when the vocal cords of the throat come close together and vibrate with air coming from the **lungs**. These vibrations produce a series of pulses that then cause the air to resonate and produce voice sounds. People have unique voice characteristics and it is therefore difficult to define a normal voice. Generally speaking, a normal voice is pleasant sounding and has appropriate pitch and loudness for the age and gender of the speaker. A voice disorder is therefore present when the voice is not pleasant sounding, or when it is too loud or too soft or too high-pitched or low-pitched for the speaker's gender.

- **Apraxia:** This is a speech disorder in which voluntary muscle movement is impaired without muscle weakness. There are two main types of apraxias: buccofacial apraxia and verbal apraxia. Buccofacial apraxia impairs the ability to move the muscles of the mouth for non-speech purposes such as coughing, swallowing, and wiggling of the tongue. Verbal apraxia impairs the proper sequencing of speech sounds. Apraxias can either be acquired or developmental and have different degrees of severity, ranging from the inability to initiate speech to mild difficulties with the pronunciation of multi-syllabic words.
- **Dysarthria:** This is a speech disorder that affects the muscles involved in the production of speech. As a result, speech is slow, weak, inaccurate, and hesitant. The production of clear speech requires that several muscle systems work together. First, the lungs must provide the air required to activate speech. Then, the larynx must allow the air to vibrate. The soft palate that separates the oral and nasal cavities must also direct the air to one or both cavities to produce the different sounds. Finally, the lips, tongue, teeth, and jaw then must all move in a concerted way to shape the sounds into the various vowels, consonants, and syllables that make up the sounds of language. Dysarthria results from a weakness in any one of these elements or in the absence of proper coordination between them. If, for example, the lungs are weak, then speech will be too quiet or produced one word at a time. Childhood dysarthria can be present at birth or acquired as a result of disease or accident, as is the case for adult dysarthria.

Causes and symptoms

The causes of articulation and phonological disorders are unclear, although it has been observed that they tend to develop in children before age four and run in

families. The symptoms vary, depending on whether other disorders are present, but typically involve difficulty in making specific speech sounds. Articulation is considered a disorder when it is unintelligible or draws negative attention to the speaker. For example, the word "super" is pronounced as "thuper."

The causes of stuttering are not very well understood. There is some evidence that stuttering has a genetic cause since it has been observed to run in some families. According to the National Stuttering Association (NSA), current research suggests a connection between stuttering and the brain's ability to coordinate speech. The major symptom of stuttering, found in preschoolers but not adults, is persistent dysfluency of language that exceeds 10%.

The main causes of organic voice disorders include neuromuscular disorder, **cancer**, vocal cord **paralysis**, endocrine changes, various benign tumors such as inflammatory growths (granulomas), or consisting of a mass of **blood vessels** (hemangiomas) or occurring on mucous membranes (papillomas). Functional voice disorders are caused by abuse or misuse of the larynx. Misuse of the voice includes talking for excessively long periods of time or yelling. Abuse occurs as a result of excessive throat clearing, laughing, crying, coughing, or smoking. Both abuse and misuse of the voice can damage the vocal cords, or may result in nodules, polyps, contact ulcers, or **edema**.

Acquired apraxias occur as a result of brain damage and can often be linked to specific lesion sites on the brain. They can result from stroke, head injury, brain tumors, toxins, or infections. In the case of developmental apraxia of speech (DAS), it is usually present at birth. There are no specific lesion sites in the brain associated with DAS, and no direct cause has been identified. However, since young children only use a few words, it has been proposed that delays in language expression can impair a child's ability to gain control over the speech muscles.

Childhood dysarthria can be present at birth or acquired with diseases such as **cerebral palsy**, Duchenne **muscular dystrophy**, or myotonic dystrophy. Adult dysarthria may be caused by stroke, degenerative diseases such as Parkinson's or Huntington's disease, amyotrophic lateral sclerosis, **multiple sclerosis**, myasthenia gravis, **meningitis**, brain tumors, toxins, drug or alcohol abuse, or lead **poisoning**.

Diagnosis

Speech disorders are usually identified using a combination of hearing tests and physical exams. Physicians

then recommend specialized evaluation by speech-language pathologists, who can best establish an accurate diagnosis.

A stuttering diagnosis is established on the basis of the type, frequency, and duration of speech dysfluency. The number of dysfluencies occurring in 100 words is counted to determine the dysfluency percentage. One half a stuttered word per minute is the usual criterion. Determining the type of stuttering behavior, either overt or covert, is the most important factor in diagnosing stuttering.

Organic and functional voice disorders are diagnosed with the assistance of an ear, nose, and throat specialist, a otolaryngologist, who can identify the organic cause of the voice disorder, if present. Several tests can be used to screen for possible tumors in the throat or laryngeal box area. Only in the absence of an organic cause will the voice disorder be diagnosed as functional, indicating that it is due to abuse or misuse of the voice.

A diagnosis of apraxia is not easy to establish but is usually indicated when children do not develop speech normally and are unable to produce consonant sounds.

Treatment

Speech pathologists have designed approaches for treating speech disorders with the type of treatment depending upon the type of impairment. A wide variety of treatment techniques are available for treating affected children, adolescents, and adults. A thorough assessment is normally conducted with the aim of determining the most effective and acceptable treatment approach for each disorder on an individual basis. A common treatment for many patients involves increasing sensory motor awareness of selected aspects of speech and systematically shaping the target speech behaviors.

Treatment for articulation/phonological disorders is usually based on increasing the affected person's awareness about how speech sounds make the meaning of words different. As a result, therapy often involves pronunciation exercises designed to teach how to produce sounds and words more clearly to increase understanding of the differences between the various speech sounds and words.

Treatment plans for stuttering depend on the severity of the dysfluency and may include seeing a speech-language pathologist. Most treatment plans include breathing techniques, **relaxation** strategies to help relax speech-associated muscles, posture control, and other exercises designed to help develop fluency.

Speech-language pathologists use many different approaches to treat voice problems. Functional voice dis-

orders can often be successfully treated by voice therapy. Voice therapy involves identifying voice abuses and misuses and designing a course of treatment aimed at eliminating them. Voice disorders may require surgery if cancer is present.

Treatment of apraxia depends on the extent of the impairment. For individuals diagnosed with moderate to severe apraxia, therapy may be for them to start saying individual sounds and contrasting them, thinking about how the lips and tongue should be placed. Other specialized drills use the natural rhythm of speech to increase understanding. Individuals affected with mild apraxia are taught strategies to help them produce the words that give them difficulty. Several treatment programs have been developed for developmental apraxias. Some feature the use of touching cues, others modify traditional articulation therapies.

Treatment of dysarthria usually aims at maximizing the function of all speech systems with the use of compensatory strategies. Patients may be advised to take frequent pauses for breath, or to exaggerate articulation, or to pause before important words to emphasize them. If there is muscle weakness, oro-facial exercises may also be prescribed to strengthen the muscles of the face and mouth that are used for speech.

Prognosis

The prognosis depends on the cause of the disorder; many speech disorders can be improved with speech therapy. In the case of childhood speech disorders, prognosis also significantly improves with early diagnosis and intervention. Children who do not receive speech therapy and do not outgrow their speech difficulties will continue to have the disorder as adults.

Health care team roles

The treatment of speech disorders belongs to the field of speech-language pathology. Speech-language pathologists assist individuals who have speech disorders and collaborate with families, teachers, and physicians to design an appropriate course of treatment, which depends on the specific nature of the disorder. They also provide individual therapy to affected persons, consult with teachers about effective classroom strategies to help children with speech disorders, and work closely with families to develop effective therapies.

Prevention

Prevention of speech disorders is centered on identifying at-risk infants. The following conditions are con-

KEY TERMS

Apraxia—Motor disorder in which voluntary movement is impaired without muscle weakness.

Articulation disorder—Also called phonological disorder; type of speech disorder characterized by the way sounds are formed.

Communication disorder—Disorder characterized by an impaired ability to communicate, including language, speech, and hearing disorders.

Dysarthria—Speech disorder due to a weakness or lack of coordination of the speech muscles.

Dysfluency—Any break or interruption in speech.

Language disorder—Communication disorder characterized by an impaired ability to understand and/or use words in their proper context, whether verbal or nonverbal.

Phonological process—Any unusual change in the place, manner, or larynx characteristics of a produced sound.

Phonology—The science of speech sounds and sound patterns.

Speech disorder—Communication disorder characterized by an impaired ability to produce speech sounds or by problems with voice quality.

Speech-language pathology—This field, formerly known as speech therapy, is concerned with disorders of speech and language.

Stuttering—Speech disorder characterized by speech that has more dysfluencies than is considered average.

Vocal cords—Either of the two pairs of folds of mucous membrane located in the throat and projecting into the cavity of the larynx.

sidered to represent high-risk factors, and children exposed to them should be tested early and regularly:

- diagnosed medical conditions such as chronic ear infections
- biological factors such as fetal alcohol syndrome
- genetic defects such as Down syndrome
- neurological defects such as cerebral palsy
- family history such as family incidence of literacy difficulties

Stuttering can be prevented by parents avoiding undue corrections of dysfluency in their children. As young children begin to speak, some dysfluency is normal because they have a limited vocabulary and have difficulty expressing themselves. This results in dysfluent speech, and if parents place excessive attention on the dysfluency, a pattern of stuttering may develop. Speech therapy with children at risk for stuttering may prevent the development of a stuttering speech disorder.

Resources

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ORGANIZATIONS

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- Autism Society of America. 7910 Woodmont Avenue, Suite 300, Bethesda, Maryland 20814-3067. (301) 657-0881. (800) 3AUTISM. <<http://www.autism-society.org/>>.
- The Hanen Program for Parents of Children with Language Delays. The Hanen Center, Suite 403, 1075 Bay Street, Toronto, Ont M5S 2B1, Canada. (416) 921-1073. <<http://www.hanen.org/>>.
- National Institute on Deafness and Other Communication Disorders (NIDCD). National Institute on Deafness and Other Communication Disorders, National Institutes of Health, 31 Center Drive, MSC 2320, Bethesda, MD USA 20892-2320. <<http://www.nidcd.nih.gov/>>.

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Speech reading

Definition

Speech reading, also called lipreading, is ‘reading’ the visual clues of a spoken message, meaning the movements of the lips, the tongue, the lower jaw, the eyes, the eyebrows, and the facial expression and gestures of the speaker, in an effort to process all of the available visible, situational, and auditory cues.

Purpose

Speech reading is intended for people affected by a **hearing loss** or who are close to someone affected by a **hearing loss**. Speech readers mostly use their eyes to supplement the verbal information received through their ears. It is a technique available to any person having lost hearing during adult life, whether the loss is mild or severe, and its purpose is to support or replace hearing.

Description

Speech produces not only sounds but visible movements of the lips, tongue, and jaw of the speaker as well. These movements are called articulators of speech. Because of the physical constraints imposed by the muscles involved in the articulation of speech sounds, the same speech sounds are produced with a consistent pattern of physical movements and these movements are then associated with specific sounds. Speech reading is based on this principle, that many of the sounds produced during speech may be “seen” by paying attention to the articulators of speech.

Preparation

Speech reading is taught by special educators. In typical classes, the speech educator and the students usually sit in a horseshoe seating arrangement so as to ensure that everyone present can see whoever is speaking. Teachers use a variety of exercises, focused on presenting material without using voice so as to develop the visual perception of the speech articulators in the participants, who can learn how to recognize sounds that are visible, sounds that are less visible, and sounds that can not be seen. Sounds that look like each other are differentiated, and explanations are provided as to why some words can get mixed up during speech reading. The exercises help students use what they can see, as well as the partial sounds that they can hear.

There is no special preparation required for speech reading, except the motivation to learn. However, the following recommendations are found helpful:

- **Position.** Speech readers are asked to position themselves with their back to the light so as to see the speaker’s face clearly.
- **Relaxation.** A relaxed atmosphere favors speech reading.
- **Recollection of speech sounds.** Speech readers are encouraged to watch the speaker’s face closely and to try to recall how their voice sounded.
- **Speech movement.** They are also encouraged to pay attention to the movements made by the lips, tongue and jaw as the person speaks, so as to learn how to differentiate the articulators, some being more recognizable than others.
- **Facial expression.** The facial expression of speakers is very important in speech reading, as it conveys a lot of information about the topic and the speaker’s mood and feelings.
- **Gestures.** Gestures such as nodding and pointing also provide a lot of clues about what the speaker is saying.

Results

Speech reading recognizes that speech comprehension is an integrated process by which a listener, whether hearing-impaired or not, uses all possible information to understand a spoken message. In speech reading, the focus is on the overall meaning of the message as opposed to its specific spoken details. The result is that **vision** can then supplement the information obtained through the ears, by including all aspects of non-verbal communication as well, such as facial expressions and body language.

Health care team roles

Speech reading is taught by speech pathologists specialized in hearing disorders.

Resources

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ORGANIZATIONS

Self Help for Hard of Hearing People, Inc., 7910 Woodmont Ave - Suite 1200, Bethesda, Maryland 20814. Phone: (301) 657-2248. <<http://www.shhh.org/>>

OTHER

Speechreading challenges Website, Bloomsburg University. <<http://www.bloomu.edu/speechreading.html>>.

Monique Laberge, Ph.D.

Speech pathology

Definition

The field of speech pathology, formerly known as speech therapy, is concerned with disorders of speech and language. A speech-language pathologist is a professional trained to diagnose and treat language and **speech disorders**.

Description

Speech pathology addresses the pathology of speech and language, meaning the “diseases” of speech and language and their functional effects on the affected person. Speech and language delays and disorders cover a wide range, from simple word substitutions in sentences to the inability to understand or use language for functional communication. The causes of speech and **language disorders** are wide and varied, including **hearing loss**, neurological disorders, traumatic **brain** injury, mental retardation, drug abuse, physical disabilities, and emotional abuse. Frequently, the cause is also unknown. In 1997-98, more than one million students were enrolled in spe-

cial education programs designed by speech-language pathologists as a result of speech or language disorders.

Work settings

Speech-language pathologists work in a wide variety of settings ranging from private practice to the public sector and with agencies treating specific disabilities. Some examples are:

- kindergartens
- primary schools
- high schools
- nursing homes
- hospitals
- universities
- rehabilitation centers
- mental health centers
- community health centers
- private practice

In any of these work settings, a speech-language pathologists’s typical workload may include:

- advising a mother on feeding a baby with a cleft palate
- helping a high school student who stutters
- helping a stroke victim to regain communication skills
- providing special training for teachers, doctors, or parents
- advising parents on the prevention of language disorders
- helping children and adults to learn to read
- treating people with brain injuries to regain language
- assisting people to develop control of vocal and respiratory systems for correct voice production

Due to the wide implications of speech and language disorders, speech-language pathologists usually work in close collaboration with other professionals such as medical specialists, educators, engineers, scientists, and other allied health professionals and technicians.

For example, in the vocational school context, speech-language pathologists collaborate with teachers and counselors in establishing communication goals related to the work experiences of students and propose strategies that are designed for the important transition from school to employment.



A speech therapist works with a young boy with dyspraxia, a difficulty in expressing language. (Photograph by Hattie Young. Science Source/Photo Researchers. Reproduced by permission.)

Education and training

Speech-language pathologists first complete a bachelor's degree which covers all aspects of communication development and disorders, followed by a master's degree. Many universities integrate both degrees into one sequence of training with the bachelor's degree providing the required background in theoretical and clinical areas and the master's program providing professional training for speech-language pathology careers.

A typical master's program in Speech-Language Pathology will usually include courses such as: Research Methods in Communication Disorders, Neuromotor Disorders of Speech Production, Disorders of Phonology, Neurologic Communication Disorders in Adults, Disorders of Speech Fluency, Language Intervention: from birth to age 21, **Voice Disorders**, Language

Assessment from Childhood to Adulthood, and Augmentative and Alternative Communication (AAC).

Employment in speech-language pathology requires both a master's degree in a program of study accredited by the American Speech-Language-Hearing Association (ASHA) and a credential or license. These requirements vary from state to state. Completion of the master's program provides the training required for students to qualify for a state license as a speech-language pathologist and the state credential for working as a speech-language pathologist in the public school system. The ASHA issues the Certificate of Clinical Competence (CCC) in speech-language pathology.

In the United States, ASHA is the professional, scientific, and certification association for speech-language pathologists, audiologists, and speech, language, and hearing scientists. The Association holds that academic studies are not sufficient to prepare an individual to func-

KEY TERMS

Aphasia—Acquired language disorder caused by damage to the areas of the brain responsible for language function.

ASHA—The American Speech-Language-Hearing Association. In the United States, the association that regulates and provides credentials for speech-language pathologists, audiologists, and speech, language, and hearing scientists.

Communication disorder—Disorder characterized by an impaired ability to communicate. Communication disorders include language, speech, and hearing disorders. They are associated with a wide variety of physical and psychological causes.

Language disorder—Communication disorder characterized by an impaired ability to understand and/or use words in their proper context, whether verbal or nonverbal. The disorder can be either developmental or acquired.

Phonology—The science of speech sounds and sound patterns.

Speech disorder—Communication disorder characterized by an impaired ability to produce speech sounds or by problems with voice quality.

Speech pathology—The field of speech pathology, formerly known as speech therapy, is concerned with disorders of speech and language. A speech pathologist is a professional trained to diagnose and treat language and speech disorders.

tion as a fully competent professional able to provide high quality care in speech-language pathology. All applicants for the CCC are accordingly required to successfully complete a clinical fellowship as well as the national examination in speech-language pathology. The clinical fellowship is intended to enable individuals to obtain supervised professional clinical experience in order to qualify for the CCC. Professional experience includes direct patient contact, consultations, record keeping, and all other duties associated with clinical work. All nonpublic school work settings require ASHA-CCC and/or state license or certification. Each state's guidelines may require ASHA certification as well as state license in addition to educational certification for employment in public schools for speech-language pathology.

Advanced education and training

The ASHA sponsors continuing education programs for speech-language pathologists. The courses of advanced study are conducted by leaders in the field of speech pathology and designed to keep speech-language pathologists abreast of new research findings, clinical techniques, and treatment models. Recognized experts also lead discussions on important ethical and regulatory issues that affect speech pathology. Alternatively, speech-language pathologists may elect to pursue doctorate work at a university and further specialize in those areas of basic research that contribute directly or indirectly to the identification, treatment, and prevention of speech and language disorders. For example, they may conduct advanced research on how people communicate. Others may design and develop equipment or techniques for diagnosing and treating speech problems.

Future outlook

The outlook for the field of speech pathology is very promising due mainly to the extraordinary advances in computer technology. Computers are being used for a wide variety of speech-language pathology applications. For example, computer programs are available for articulation and voice therapy that provide visual displays of speech: voicing, loudness, pitch, and articulation. Speech capture programs are being developed to assist the evaluation of speech/language patterns and for use in the treatment of disorders. Speech-language pathologists can use such programs, adjusting settings to provide visual reinforcement of the patient's attempts to correctly produce the target sound. Increasingly, programs and software are becoming available for testing and monitoring all major speech elements such as articulation, pitch, rhythm, duration, volume, and stress. This improved and greater use of computer technology has enabled speech-language pathologists to better serve those with speech-language disorders. There are improved augmentative devices for those with neuromuscular diseases and head injuries. For those with difficulty comprehending spoken language, the technology exists and is being used to modify the human speech signal and improve listening and comprehending skills which are fundamental for learning to read and write. For both children and adults, computer-based treatment programs exist for home use, making treatment more efficient.

Major areas of speech-language pathology software development include:

- Word-retrieval programs. These programs are mainly used to treat people affected by **aphasia**, a language disorder caused by damage to the areas of the brain

responsible for language function. Speech-language pathologists use them to treat aphasia at the word or sentence level.

- **Speech production software.** This type of software is being developed for teaching purposes, for example to teach the proper sounds of vowels, and also for voice analysis purposes in the clinical setting.
- **Reading comprehension programs.** These are programs that can teach word relationships interactively and monitor the level of functional reading.
- **Cognitive exercises software.** This type of software is used to test logic and deduction patterns, the ability to follow directions, and the understanding of traffic signs or of word associations.

Speech-language pathology is a very dynamic field. According to the U.S. Department of Labor, employment of speech-language pathologists is expected to grow at a much faster rate than the average for all occupations up to year 2008.

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ORGANIZATIONS

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10801 Rockville Pike, Rockville, MD 20852.
(800)638-8255. <<http://www.asha.org/>>.

OTHER

- National Center for Voice and Speech Website*.
<<http://www2.shc.uiowa.edu/>>.
- Net Connections for Communication Disorders and Sciences
A guide to communication disorders and science sources on the Internet.

<<http://www.mankato.msus.edu/dept/comdis/kuster2/welcome.html>>.

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Monique Laberge, Ph.D.

Sperm count test see **Semen analysis**

Sphygmomanometer

Definition

A sphygmomanometer is a device for monitoring **blood pressure**.

Purpose

The sphygmomanometer is designed to monitor the **blood** pressure by measuring the force of the blood in the **heart** where the pressure is greatest, during the contraction of the ventricles as blood is pumped from the heart to the rest of the body (systolic pressure), and during the period when the heart is relaxed between beats and pressure is lowest (diastolic pressure).

The device is used to establish a baseline at a health-care encounter and on admission to the hospital. Checking blood pressure is also performed to monitor the effectiveness of medication and other methods to control **hypertension**, and as a diagnostic aid to detect various diseases and abnormalities.

Description

The sphygmomanometer consists of a hand bulb pump, a unit that displays the blood pressure reading, and an inflatable cuff that is wrapped around the patient's upper arm. Care should be taken to ensure the cuff is the correct size to give an accurate reading. Children and adults with smaller or larger than average-sized arms require special sized cuffs appropriate for their needs. A **stethoscope** is also used in conjunction with the sphygmomanometer to hear the blood pressure sounds. Some devices have the stethoscope already built in.

The sphygmomanometer can be used in a variety of settings:

- home



The gauge on an aneroid sphygmomanometer shows the blood pressure reading as the inflatable cuff deflates.
(Custom Medical Stock Photo. Reproduced by permission.)

- hospital
- primary care, clinic, or clinician's office
- ambulance
- dental office

There are three types of equipment for monitoring blood pressure.

The mercury-based unit has a manually inflatable cuff attached by tubing to the unit that is calibrated in millimeters of mercury. During **blood pressure measurement**, the unit must be kept upright on a flat surface and the gauge read at eye level. Breakage of the unit may cause dangerous mercury contamination and would require specialist removal for disposal.

The aneroid unit is mercury free and consists of a cuff that can be applied with one hand for self-testing, a stethoscope that is built in or attached, and a valve that inflates and deflates automatically with the data displayed on an easy-to-read gauge that will function in any position. The unit is sensitive and if dropped, may require recalibration.

The automatic unit is also mercury free and is battery operated. It has a cuff that can be applied with one hand for self-testing, and a valve that inflates and deflates automatically. (Units with manual inflation are also available.) The reading is displayed digitally and a stethoscope is not required, therefore, the unit is useful for someone who is **hearing** impaired. A wrist monitor is also available for home testing. Some more expensive models also remember and print out recordings. The automatic units may be more portable than the bulkier mercury devices.

Blood pressure can be measured with any of the units, although mercury units are becoming less common due to the hazards of mercury.

Operation

The flow, resistance, quality, and quantity of blood circulating through the heart and the condition of the arterial walls are all factors that influence the blood pressure. If blood flow in the arteries is restricted, the reading will be higher.

Blood pressure should be routinely checked every one to two years. It can be checked at any time but is best performed when the patient has been resting for at least five minutes, so that exertion prior to the test will not unduly influence the outcome of the reading.

To record blood pressure, the patient should be seated with his left arm bent slightly, and the arm bare or with the sleeve loosely rolled up. With an aneroid or automatic unit, the cuff is placed level with the heart and wrapped around the upper arm, one inch above the elbow. Following the manufacturer's guidelines, the cuff is inflated and then deflated and the nurse records the reading.

If the blood pressure is monitored manually, a cuff is placed level with the heart and wrapped firmly but not tightly around the arm one inch above the elbow over the brachial artery, with creases in the cuff smoothed out. With a stethoscope over the brachial artery in front of the elbow with one hand and listening through the earpiece, the cuff is inflated well above normal levels (to about 200mm Hg), or until no sound is heard. The cuff is then inflated a further 10mm Hg above the last sound heard. The valve in the pump is slowly opened no faster than 5mm Hg per second to deflate the pressure in the cuff to the point where a tapping sound is heard over the brachial artery. This point is noted as the systolic pressure. The sounds continue as the pressure in the cuff is released and the artery is no longer occluded. At this point, the noises are no longer heard and this is noted as the diastolic pressure.

With children, the tapping noise changes to a soft muffled sound. That point is noted as the diastolic pressure, since sounds continue to be heard as the cuff deflates to zero.

Blood pressure results are recorded with the systolic pressure first, then the diastolic pressure (e.g. 120/70).

Maintenance

Devices should be checked and calibrated annually by a qualified technician to ensure accurate readings.

Health care team roles

The appropriate sized cuff should be used to give an accurate reading. Repeated measurements may be required if hypertension is suspected. One elevated reading does not mean that hypertension is present. The blood

KEY TERMS

Aneroid monitor—A monitor that works without fluids, i.e. without mercury.

Blood pressure—The tension of the blood in the arteries measured in millimeters of mercury by a sphygmomanometer or by an electronic device.

Diastolic—Minimum arterial blood pressure during ventricular rest.

Systolic—Maximum arterial blood pressure during ventricular contraction.

pressure measurement is recorded and compared with normal ranges for the patient's age and medical condition and a decision made on whether any further medical intervention is required.

Training

The method of recording blood pressure should be consistent, especially the diastolic pressure, as a different reading will be obtained if it is measured when the sounds change or when they disappear. All healthcare professionals should be aware of the normal values for blood pressure measurement based on age and medical history.

Resources

PERIODICALS

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ORGANIZATIONS

American College of Nurse Practitioners, 503 Capitol Ct. NE 300, Washington, D.C. 20002. (202) 546-4825. acnp@nurse.org

OTHER

"About Blood Pressure." American Heart Association, National Center, 7272 Greenville Avenue, Dallas, TX 752311. (800) AHA-USA1.

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Margaret A. Stockley

Sphygmomanometry see **Blood pressure measurement**

Spina bifida see **Neural tube defect**

Spinal column see **Vertebral column**

Spinal cord

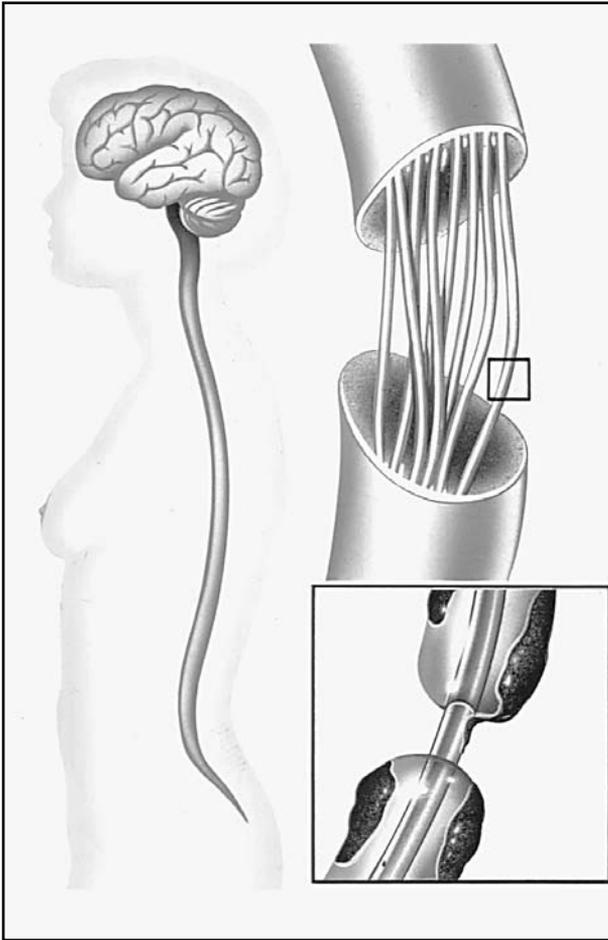
Definition

The spinal cord is the elongated bundle of nervous tissue that carries nerve impulses between the **brain** and the rest of the body. It lies in the vertebral canal of the **vertebral column**.

Description

The spinal cord lies within the vertebral canal, which is the hollow part of the vertebral column, or spine, that consists of 33 bones called vertebrae. The canal is formed by the stacked vertebrae which all contain a central vertebral foramen, or hole. The spinal cord extends from the lowest part of the brain, called the brainstem, through a hole located at the base of the **skull**, the foramen magnum, and continues down the vertebral canal to the twenty-first vertebra of the spine.

Like the brain, the spinal cord is protected by three layers of membranes, called meninges. The inner meninge that makes direct contact with the spinal cord is called the pia mater. It is separated from the second layer by a space called the subarachnoid space. This space is filled with cerebrospinal fluid (CSF), the colorless fluid that bathes the entire brain and spinal cord. The second layer is the thin and spider web-like arachnoid mater and it is separated from the outermost layer by a space called the subdural space. The outermost layer is the dura mater, a protective sheath made of tough fiber. Between the dura mater and the bone of the vertebral canal is a space, called the epidural space, which contains a small amount of fatty tissue and **blood vessels**. The spinal dura mater



The brain and spinal cord comprise the central nervous system. At the right is a magnified view of the spinal cord showing the individual nerves. The inset shows an individual axon covered with a myelin sheath. (Photo Researchers, Inc. Reproduced by permission.)

prolongs the dura mater that lines the skull cavity and extends to the sacrum, the second to last bone of the vertebral column. It also covers each of the spinal nerves as they leave the vertebral canal. Both the arachnoid and pia mater also prolong the arachnoid and pia surrounding the brain, but unlike the arachnoid, which continuously follows the dura mater, the pia ends where the spinal cord ends. A stringy extension of the pia mater, called the filum terminale joins the end of the spinal cord to the end of the dura mater. Additionally, the pia mater contains thin projections called denticulate ligaments, that connect the spinal cord to the dura mater.

Function

The major function of the spinal cord is to carry nerve impulses between the brain and the rest of the body. Together, the brain and the spinal cord constitute

the **central nervous system (CNS)**. The other nerves of the nervous system, that is the motor and sensory nerves, constitute the peripheral nervous system (PNS).

The spinal cord consists of a core of grey nervous tissue surrounded by a thicker section of white tissue. The grey matter looks like a butterfly with outspread wings and the upper and lower sections of these wings are called the posterior and anterior horns. The tissues of the spinal cord are full of nerve cells, also called neurons. **Neurons** with large cell bodies that are located in the anterior horns give rise to motor nerve fibers that connect to spinal nerves which pass out of the cord to skeletal muscle. The grey matter of the spinal cord also contains other neurons that connect together to form nerve pathways and the white matter contains nerves that are wrapped in myelin sheaths and form nerve tracts. The tracts that conduct sensory impulses from the body to the brain are called ascending tracts and those that conduct motor impulses from the brain to muscles and glands are called descending tracts.

Thirty-one pairs of spinal nerves emerge from the spinal cord. They are all mixed nerves, meaning that they provide a two-way communication system for sensory and motor information exchange between the spinal cord and the rest of the body. Spinal nerves are numbered according to the vertebral column level from which they stem. There are eight pairs of cervical nerves, C1 to C8, twelve pairs of thoracic nerves, T1 to T12, five pairs of lumbar nerves, L1 to L5, five pairs of sacral nerves, S1 to S5, and one pair of coccygeal nerves.

Role in human health

The spinal cord is an extremely important component of the CNS because it provides the crucial link between the brain and the spinal nerves that connect to the individual muscles and organs of the body. The role of the spinal cord in human health however, is not only to carry this sensory and motor information. It also carries a great deal of other crucial information as well, having to do with involuntary and automatic body functions. For example, the regulation of the chemical contents of the **blood** and body fluids is carried out by an automatic feedback control system that involves the spinal cord and its attached network of peripheral nerves. The regulation the **heart, stomach,** and intestines are other examples. These are all vital body functions of which we are unaware of and that all proceed with the involvement of the spinal cord nervous tissues.

KEY TERMS

Arachnoid mater—One of three meninges covering the central nervous system (CNS) the others are the dura and pia maters. The dura mater encloses the arachnoid which in turn covers the pia mater.

Brain stem—Lowest part of the brain that connects with the spinal cord. It is a complicated neural center with several neuronal pathways between the cerebrum, spinal cord, cerebellum, and motor and sensory functions of the head and neck. It consists of the medulla oblongata, the part responsible for cardiac and respiratory control, the midbrain, which is involved in basic, involuntary body functions, and the pons, where some cranial nerves originate.

Central nervous system (CNS)—One of two major divisions of the nervous system. The CNS consists of the brain, the cranial nerves and the spinal cord.

Cerebrospinal fluid (CSF)—A clear colorless fluid that circulates in the brain and in the subarachnoid spaces surrounding the brain and spinal cord. The CSF lies between the spinal cord and the arachnoid mater thereby suspending the spinal cord in fluid.

Cervical vertebrae—Vertebrae of the neck.

Epidural space—This space lies between the dura mater and the walls of the vertebral canal, it contains loose connective tissue, blood vessels and some fatty tissue.

Foramen—A hole in a bone usually for the passage of blood vessels and/or nerves.

Foramen magnum—Large opening at the base of the skull that allows passage of the spinal cord.

Intervertebral disk—Disk-shaped pads of fibrous cartilage interposed between the vertebrae of the vertebral column that provide cushioning and join the vertebrae together.

Meninges—The membranes that surround and protect the brain and spinal cord. There are three layers: the dura mater (outermost), arachnoid membrane (middle) and the pia mater (innermost).

Nervous system—The entire system of nerve tissue in the body. It includes the brain, the brainstem, the

spinal cord, the nerves and the ganglia and is divided into the peripheral nervous system (PNS) and the central nervous system (CNS).

Paraplegia—Paraplegia is permanent paralysis of the trunk and lower limbs. It is caused by injury or disease affecting the spinal cord below the chest or waist.

Peripheral nerves—The nerves outside of the brain and spinal cord, including the autonomic, cranial, and spinal nerves. These nerves contain cells other than neurons and connective tissue as well as axons.

Peripheral nervous system (PNS)—One of the two major divisions of the nervous system. The PNS consists of the somatic nervous system (SNS), that controls voluntary activities and of the autonomic nervous system (ANS), that controls regulatory activities. The ANS is further divided into sympathetic and parasympathetic systems.

Quadraplegia—Quadraplegia is permanent paralysis of the trunk, lower and upper limbs. It is caused by injury or disease affecting the spinal cord at the neck level.

Sacrum—The triangular-shaped bone found between the fifth lumbar vertebra and the coccyx. It consists of five fused vertebrae and it articulates on each side with the bones of the pelvis (ilium), forming the sacroiliac joints.

Sensory nerve—A nerve that receives input from sensory cells, such as the skin or muscle receptors.

Skull—All of the bones of the head.

Spinal cord—Elongated part of the central nervous system (CNS) that lies in the vertebral canal of the spine and from which the spinal nerves emerge.

Vertebra—Flat bones that make up the vertebral column. The spine has 33 vertebrae.

Vertebral canal—Hollow part of the vertebral column formed by the vertebral foramina of the stacked vertebrae. It encloses the spinal cord.

Vertebral foramen—The opening formed in vertebrae that allows passage of the spinal cord.

Common diseases and disorders

Spinal cord injuries are usually the result of trauma to the vertebral column. When dislocations and frac-

tures of the spine occur, the vertebrae may press on the spinal cord, thus compressing the nerves. Pressure applied to the spinal cord may result in muscle weakness or **paralysis**. It could also cause abnormal sensations,

such as **pain**, tingling, or burning. In severe cases, the cord might even be torn or severed, and the function of the spinal cord risks being seriously impaired if not altogether destroyed. A damaged spinal cord results in loss of sensation and/or motor function below the level of the injury. Thus, injuries to the cord at the chest or waist level may result in paraplegia, which is paralysis of the legs and/or part of the trunk. Damage to the cord in the neck region may result in paralysis of all four limbs and the trunk, a condition called quadriplegia, and it can be fatal. Other disorders of the spinal cord include:

- Epidural abscesses. Infections that occur in the epidural space around the dura mater. These create pockets of infected fluid that affect the spinal nerve roots and generate enough pressure to impair neurological function.
- Foraminal stenosis. Normally, nerve roots have enough room to easily slip through the foramina of the spine. However, with age and disease, they may become clogged and blocked, thus trapping and compressing the nerves.
- Pinched nerve. The two nerves most commonly pinched in the spinal cord are L5 and S1. The L5 nerve supplies the nerves to the muscles that raise the foot and big toe, and a pinched L5 may lead to weakness in these muscles. Likewise, a pinched S1 may lead to weakness with the large muscle in the back of the calf.
- Sciatica. The compression of the spinal roots of the sciatic nerve. It is characterized by pain in the low back region that radiates down the back of the thigh, the leg and into the foot. It results from diseased sciatic nerve roots or can be caused by a tumor, or intervertebral disc displacement resulting from injury or inflammation.
- Spinal stenosis. A narrowing of spaces in the spine that results in pressure on the spinal cord and nerve roots. This disorder usually involves the narrowing of one or more of three areas of the spine: the vertebral canal, the canals at the base or roots of nerves branching out from the spinal cord, and the vertebral foramina. It is usually a degenerative disorder caused by old age, but may also be an inherited disease.

Resources

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- Palmer, S., Harris, K., and J. Kriegsman. *Spinal Cord Injury: A Guide for Living (Johns Hopkins Press Health Book)*. Baltimore: Johns Hopkins University Press, 2000.

Reeves, C. *Still Me*. New York: Ballantine Books, 1999.

ORGANIZATIONS

- American Paraplegia Society (APS) 75-20 Astoria Blvd., Jackson Heights, NY 11370. (718) 803-3782. <<http://www.apssci.org/contactAPS.htm>>.
- National Spinal Cord Injury Association 701 Democracy Boulevard, Suite 300-9, Bethesda, MD 20817. (301) 588-6959; (800) 352-9424. <<http://www.spinalcord.org/>>.
- Spinal Cord Society 19051 County Highway 1, Fergus Falls, MN 56537-7609. (218) 739-5252; (218)739-5261. <<http://members.aol.com/scsweb>>.

OTHER

- The Spinal Cord Injury Resource Center. <<http://www.spinal-injury.net/>>.
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Monique Laberge, Ph.D.

Spinal cord injury

Definition

Spinal cord injury is damage to the spinal cord that causes loss of sensation and motor control.

Description

Approximately 11,000 new spinal cord injuries (SCIs) occur each year in the United States. About 200,000 people are currently affected. Spinal cord injuries can happen to anyone at any time of life. The typical patient, however, is a man between the ages of 19 and 26, injured in a motor vehicle accident (about 35% of all SCIs), a fall (20%), an act of violence (15%), most often related to firearms use, or a sporting accident (14%). According to the Centers for Disease Control, violence-related SCIs have been steadily increasing since 1980, and in 2001, violence is associated with 30% of all SCI cases.

Most SCI patients are white, but the nonwhite fraction of SCI patients is larger than the nonwhite fraction of the general population. In fact, the SCI rate among blacks, who are at higher risk for SCI than whites, has been rising in recent years. Alcohol or other drug abuse plays an important role in a large percentage of all spinal cord injuries. Six percent of people who receive injuries to the lumbar spine die within a year, and 40% of people

who sustain the more frequent higher, or rostral injuries, also die within a year.

Short-term costs for hospitalization, equipment, and home modifications are approximately \$140,000 for an SCI patient capable of independent living. Lifetime costs may exceed one million dollars. Costs may be three to four times higher for the SCI patient who needs long-term institutional care. Overall costs to the American economy in direct payments and lost productivity are more than \$10 billion per year.

Causes and symptoms

Causes

The spinal cord descends from the **brain** down the back through the spinal canal that lies within the bony spinal column. The spinal cord is composed of **neurons** and axons (nerve cells). The neurons carry sensory data from the areas outside the spinal cord (periphery) to the brain, and convey motor commands from brain to periphery. Peripheral neurons are bundled together to comprise the 31 pairs of peripheral nerve roots. The peripheral nerve roots enter and exit the spinal cord by passing through the spaces between the stacked vertebrae (the neural foramen). Each pair of nerves is named for the vertebra from which it exits. These are known as:

- C1-8. These nerves enter from the seven cervical or neck vertebrae.
- T1-12. These nerves enter from the thoracic or chest vertebrae.
- L1-5. These nerves enter from the lumbar vertebrae of the lower back.
- S1-5. These nerves enter through the sacral, or pelvic vertebrae.
- Coccygeal. These nerves enter through the coccyx, or tailbone.

Peripheral nerves carry motor commands to the muscles and internal organs, and transmit sensations from these areas and from the body's surface. (Sensory data from the head, including sight, sound, **smell**, and **taste**, do not pass through the spinal cord and are not affected by most SCIs. These nerves, called the cranial nerves, pass through the brain stem.) Damage to the spinal cord interrupts these signals. The interruption damages motor functions that enable the muscles to move, sensory functions (e.g., feeling heat and cold, and autonomic functions (e.g., urination, sexual function, sweating, and **blood pressure**)).

Spinal cord injuries most often occur where the spine is most flexible, in the regions of C5–C7 of the neck, and T10–L2 at the base of the rib cage.

Several physically distinct types of damage are recognized. Sudden and violent jolts to nearby tissues can jar the cord. This jarring causes a transient neurological deficit, known as temporary spinal **concussion**. Concussion symptoms usually disappear completely within several hours of injury. A spinal contusion, or bruise, is bleeding within the spinal column. The pressure from the excess fluid may kill spinal cord neurons. Spinal compression is caused by an object, such as a tumor, pressing on the cord. Lacerations, or tears, cause direct damage to cord neurons. Lacerations may be caused by bone fragments or missiles, such as bullets. Spinal transection describes the complete severing of the cord. Most spinal cord injuries involve two or more of these types of damage.

Symptoms

PARALYSIS AND LOSS OF SENSATION. The extent to which movement and sensation are damaged depends on the level of the spinal cord injury. Nerves leaving the spinal cord at different levels control sensation and movement in different parts of the body. The distribution is roughly as follows:

- C1–C4: head and neck
- C3–C5: diaphragm (chest and breathing)
- C5–T1: shoulders, arms and hands
- T2–T12: chest and abdomen (excluding internal organs)
- L1–L4: abdomen (excluding internal organs), buttocks, genitals, and upper legs
- L4–S1: legs
- S2–S4: genitals and muscles of the perineum

Damage below T1, which lies at the top of the rib cage, causes **paralysis** and loss of sensation in the legs and trunk below the injury. Injury at this level usually does no damage to the arms and hands. Paralysis of the legs is called paraplegia. Damage above T1 involves the arms as well as the legs. Paralysis of all four limbs is called quadriplegia.

Cervical, or neck injuries, not only cause quadriplegia, but also may cause difficulty in breathing. Damage in the lower part of the neck may leave enough diaphragm control to allow unassisted breathing. Patients with damage at C3 or above, just below the base of the **skull**, require mechanical assistance from a ventilator or a diaphragmatic nerve stimulation to breathe.

Symptoms also depend on the extent of the SCI. A completely severed cord causes paralysis and loss of sensation below the wound. If the cord is only partially severed, some function will remain below the injury.

Damage limited to the front portion of the cord causes paralysis and loss of sensations of **pain** and temperature. Other sensation may be preserved. Damage to the center of the cord may spare the legs, but paralyze the arms. Damage to the right or left half causes loss of position sense, paralysis on the side of the injury, and loss of pain and temperature sensation on the opposite side.

AUTONOMIC DYSREFLEXIA. Body organs that self-regulate, such as the **heart**, gastrointestinal tract, and glands, are controlled by autonomic nerves. Autonomic nerves emerge from three different places: above the spinal column, in the lower back from vertebrae T1-L4, and from the lowest regions of the sacrum at the base of the spine. In general, these three groups of autonomic nerves operate in balance. Spinal cord injury can disrupt this balance, a condition called autonomic dysreflexia or autonomic hyperreflexia. Patients with injuries at T6 or above are at greatest risk.

SPASTICITY AND CONTRACTURE. A paralyzed limb is incapable of active movement, but the muscle still has tone, a constant low level of contraction. Normal muscle tone requires communication between the muscle and the brain. Spinal cord injury prevents the brain from telling the muscle to relax. The result is prolonged **muscle contraction** or spasticity. Since the muscles that extend and those that bend a joint are not usually equal in strength, the involved joint is bent, often severely. This constant pressure causes deformity. As the muscle remains in the shortened position over several weeks or months, the tendons remodel and cause permanent muscle shortening or contracture. When muscles have permanently shortened, the inner surfaces of joints, such as armpits or palms, cannot be cleaned and the skin breaks down in that area.

HETEROTOPIC OSSIFICATION. Heterotopic ossification is an abnormal deposit of bone in muscles and tendons that may occur after injury. It is most common in the hips and knees. Initially heterotopic ossification causes localized swelling, warmth, redness, and stiffness of the muscle. It usually begins one to four months after the injury and is rare after one year.

In autonomic dysreflexia, irritation of the skin, bowel, or bladder causes a highly exaggerated response from autonomic nerves. This response is caused by the uncontrolled release of norepinephrine, a hormone similar to adrenaline. Uncontrolled release of norepinephrine causes a rapid rise in **blood** pressure and a slowing of the heart rate. These symptoms are accompanied by throbbing headache, nausea, **anxiety**, sweating, and goose bumps below the level of the injury. The elevated blood pressure can rapidly cause loss of consciousness, seizures, cerebral hemorrhage, and death. Autonomic dysreflexia is most often caused by an over-full bladder

or bladder **infection**, impaction or hard, impassable fecal mass in the bowel, or skin irritation from tight clothing, sunburn, or other irritant. Inability to sense these irritants before the autonomic reaction begins is a major cause of dysreflexia.

LOSS OF BLADDER AND BOWEL CONTROL. Bladder and bowel control require both motor nerves and the **autonomic nervous system** (ANS). Both of these systems may be damaged by SCI. When the ANS triggers an urge to urinate or defecate, continence is maintained by contracting the anal or urethral sphincter, respectively. The sphincter is a ring of muscle that contracts to close off a passage or opening in the body. When the neural connections to these muscles are severed, conscious control is lost. In addition, loss of feeling may prevent sensations of fullness from reaching the brain. To compensate, the patient may help empty the bowel or bladder by using physical maneuvers that stimulate autonomic contractions before they would otherwise begin. The patient may not, however, be able to relax the sphincters. If the sphincters cannot be relaxed, the patient will retain urine or feces.

Retention of urine may cause muscular changes in the bladder and urethral sphincter that make the problem worse. Urinary tract infection is common. Retention of feces can cause impaction. Symptoms of impaction include loss of appetite and nausea. Untreated impaction may cause perforation of the **large intestine** and sepsis (rapid overwhelming infection).

Complications

DEEP VENOUS THROMBOSIS. Blood does not flow normally through a paralyzed limb that is inactive for long periods. The blood pools in the deep veins and forms clots, a condition known as deep vein thrombosis. A clot, or thrombus, can break free and lodge in smaller arteries in the brain (causing a stroke), or in the **lungs** (causing pulmonary embolism).

DECUBITUS ULCERS (PRESSURE ULCERS). Inability to move may also lead to decubitus ulcers (pressure ulcers or bedsores). Decubitus ulcers form where skin remains in contact with a bed or chair for a long time. The most common sites of pressure ulcers are the buttocks, hips, and heels. Decubitus ulcers can cause sepsis (infection) and may seriously jeopardize recovery.

Diagnosis

The location and extent of SCI is determined by obtaining a history, performing a **physical examination**, and ordering appropriate imaging studies. Imaging studies usually include a combination of computed tomogra-

phy (CT) scans, **magnetic resonance imaging** (MRI) scans, and traditional x rays. Computed tomography or MRI scans may be enhanced with an injected contrast dye. These diagnostic imaging studies are explained to patients by nurses and radiologic technicians. The studies are usually performed by these technicians, and are read, or interpreted, by a radiologist and/or a neuroradiologist.

Treatment

Acute care of SCI

Onlookers should not move a person who may have sustained SCI. Emergency medical personnel are best equipped to transport the injured patient. Treatment of SCI begins with immobilization. This strategy prevents partial injuries of the cord from severing it completely. Since the early 1980s, the use of splints to completely immobilize suspected SCI at the scene of the injury has helped reduce the severity of spinal cord injuries. Intravenous methylprednisolone, a steroidal anti-inflammatory drug, is given during the first 24 hours to reduce inflammation and limit tissue destruction.

Restoration of function and mobility

Rehabilitation after SCI seeks to prevent complications, promote recovery, and make the most of remaining function. Rehabilitation is a complex and long-term process; it requires a team of professionals, including a neurologist, physiatrist (or rehabilitation specialist), physical therapist, and occupational therapist. Other specialists who may be needed include a respiratory therapist, vocational rehabilitation counselor, social worker, speech-language pathologist, nutritionist, special education teacher, recreation therapist, and clinical psychologist. Support groups provide a critical source of information, advice, and support for SCI patients and their families.

While the possibility of using functional electrical stimulation (FES) for ambulation (outside of the laboratory) remains distant, the use of FES to deal with other aspects of SCI (such as loss of grasp capabilities in quadriplegia) is actually more advanced and more likely to be in common use in the foreseeable future.

Instruction in activities of daily living

Physical therapy focuses on mobility to maintain range of motion of affected limbs and reduce contracture and deformity. Additionally, it helps to compensate for lost skills by using those muscles that are still functional, and helps to increase any residual strength and control in affected muscles. Adaptive equipment such as braces,

canes, or wheelchairs can be suggested by a physical therapist.

The goal of **occupational therapy** is to restore the ability to perform the activities of daily living, such as eating and grooming, with tools and new techniques. Modifications of the home and workplace to accommodate and address the individual impairment are also addressed by the occupational therapist.

Treatment of sexual dysfunction

Men who have sustained SCI may be unable to achieve an erection or ejaculate. Sperm formation may be abnormal and fertility may be compromised. Fertility and the ability to achieve orgasm are less impaired for women. Women may still be able to become pregnant and deliver vaginally.

Prevention of complications

DECUBITUS ULCERS (PRESSURE ULCERS). Turning the patient in bed at least every two hours prevents the formation of decubitus ulcers. The patient should be turned more frequently when redness begins to develop in sensitive areas. Special mattresses and chair cushions can distribute weight more evenly to reduce pressure. Skin should be carefully attended to by nurses and other caregivers in order to maintain skin integrity and prevent ulcers from developing. Electrical stimulation is sometimes used to promote muscle movement to prevent decubitus ulcers.

SPASTICITY AND CONTRACTURE. Range of motion (ROM) exercises help to prevent contracture. Chemicals can be used to prevent contractures from becoming fixed when ROM **exercise** is inadequate. Phenol or alcohol can be injected into the nerve, or botulinum toxin can be injected directly into the muscle. Botulinum toxin is associated with fewer complications, but it is more expensive than phenol and alcohol. Contractures can be released by cutting the shortened tendon or transferring it surgically to a different site on the bone, where deformity will be lessened by its pull. Such tendon transfers may also be used to increase strength in partially functional extremities.

DEEP VENOUS THROMBOSIS. Deep venous thrombosis may be prevented by using passive ROM exercises, sequential compression stockings, intermittent pneumatic compression devices, and kinetic (movement) therapies. Heparin and aspirin may also be administered to prevent deep venous thrombosis.

HETEROTOPIC OSSIFICATION. Etidronate disodium (Didronel), a drug that regulates the body's use of **calcium**, is used to prevent heterotopic ossification.

KEY TERMS

Autonomic nervous system—The part of the nervous system that controls involuntary functions such as sweating and blood pressure.

Botulinum toxin—Any of a group of potent bacterial toxins or poisons produced by different strains of the bacterium *Clostridium botulinum*.

Computed tomography (CT)—An imaging technique in which cross-sectional x rays of the body are compiled to create a three-dimensional image of the body's internal structures.

Magnetic resonance imaging (MRI)—An imaging technique that uses a large circular magnet and radio waves to generate signals from atoms in the body. These signals are used to construct images of internal structures.

Motor—Of or pertaining to motion, the body apparatus involved in movement, or the brain functions that direct purposeful activity.

Motor nerve—Motor or efferent nerve cells carry impulses from the brain to muscle or organ tissue.

Peripheral nervous system—The part of the nervous system that is outside the brain and spinal cord. Sensory, motor, and autonomic nerves are included.

Postural drainage—The use of positioning to drain secretions from the bronchial tubes and lungs into the trachea or windpipe.

Range of motion (ROM)—The range of motion of a joint from full extension to full flexion (bending) measured in degrees like a circle.

Sensory nerves—Sensory or afferent nerves carry impulses of sensation from the periphery or outward parts of the body to the brain. Sensations include feelings, impressions, and awareness of the state of the body.

Voluntary—An action or thought undertaken or controlled by a person's free will or choice.

Treatment begins three weeks after the injury and continues for 12 weeks. Surgical removal of ossified tissue is possible.

AUTONOMIC DYSREFLEXIA. Bowel and bladder care and attention to potential irritants prevent autonomic dysreflexia. It is treated by prompt removal of the irritant. Drugs to lower blood pressure are used when necessary. Patients and friends and families of the patient should

be educated about the symptoms and treatment of dysreflexia, because immediate intervention is usually necessary.

LOSS OF BLADDER AND BOWEL CONTROL. Normal bowel function is promoted through adequate fluid intake and a diet rich in fiber. Evacuation is stimulated by deliberately increasing the abdominal pressure, either voluntarily or by using an abdominal binder.

Bladder care involves continual or intermittent catheterization. The full bladder may be detected by feeling its bulge against the abdominal wall. Urinary tract infection is a significant complication of catheterization and requires frequent monitoring.

SEXUAL DYSFUNCTION. Counseling can help patients to adjust to changes in sexual function after SCI. Erection may be enhanced through the same means used to treat erectile dysfunction in the general population.

Prognosis

The prognosis for SCI depends on the site and extent of injury. Injuries of the neck above C4 with significant involvement of the diaphragm hold the gravest prognosis. Respiratory infection is one of the leading causes of death in long-term SCI. Overall, 85% of SCI patients who survive the first 24 hours are alive ten years after their injuries. Recovery of function is impossible to predict. Partial recovery is more likely after an incomplete wound than after the spinal cord has been completely severed.

Health care team roles

Initial medical management, including immobilization and transport of SCI patients, is usually provided by emergency medical personnel. Upon arrival, the physicians and nurses in the hospital emergency department assess the nature and extent of the injury. Imaging studies are performed by radiologic technicians and interpreted by radiologists and neuroradiologists. Consultation with a neurosurgeon determines whether surgical intervention will be beneficial in treating the injury.

Following emergency treatment, assessment and completion of the diagnostic work-up, critical care vigilant monitoring of SCI patients is provided by the nurses. The aim of monitoring is to identify the decreased cardiac output that may result from sympathetic nerve blockade; excessive autonomic nerve responses (i.e., distended bladder or bowel); problems associated with breathing, and the risk of aspiration.

Nurses, social workers, physical and occupational therapists, pastoral counselors, and other medical and mental health professionals may be called upon to help patients and families manage their emotional responses to the injury. Feelings of anxiety, anger, denial may be experienced by hopeless patients and families.

Patient education

Patient education is an essential part of the rehabilitation process. Every member of the treatment team is involved in patient education. Patients and families are taught by nurses to recognize symptoms requiring immediate medical attention, and to provide selected care (e.g., a bowel program to prevent impaction). They may be instructed by physical and occupational therapists to use adaptive devices and equipment. Education may help to reduce feelings of powerlessness and hopelessness, and can assist in the creation of realistic expectations about recovery.

Many SCI patients also benefit from participation in peer support groups. They are enabled by the groups to meet others with comparable conditions, thereby reducing feelings of isolation, and allowing them to share experience-tested coping strategies.

Prevention

Risk of spinal cord injury can be reduced through prevention of the accidents that lead to it. Chances of injury from automobile accidents, the major cause of SCIs, can be significantly reduced by driving at safe speeds, avoiding alcohol while driving, not talking on mobile phones while driving, and using seat belts.

Paralysis and loss of sensation

Some limited mobility and sensation may be recovered, but the extent and speed of recovery cannot be predicted with any accuracy. Experimental electrical stimulation has been demonstrated to allow some control of muscle contraction in paraplegia. This experimental technique offers the possibility of unaided walking. Further development of current control systems will be needed before useful movement is possible outside the laboratory.

A pulmonologist, or respiratory therapist, can promote airway hygiene through instruction in assisted coughing techniques and postural drainage. **Ventilators**, facial or nasal masks, and tracheostomy equipment, where necessary, can also be prescribed by the respiratory professional. He or she can provide instruction in their use, as well.

Resources

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Barbara Wexler

Spinal fluid analysis see **Cerebrospinal fluid (CSF) analysis**

Spinal manipulation see **Joint mobilization and manipulation**

Spinal meningitis see **Meningitis**

Spinal orthoses

Definition

Spinal orthoses, also known as braces, are devices worn on the body to treat conditions such as **scoliosis**, back **pain**, and injury.

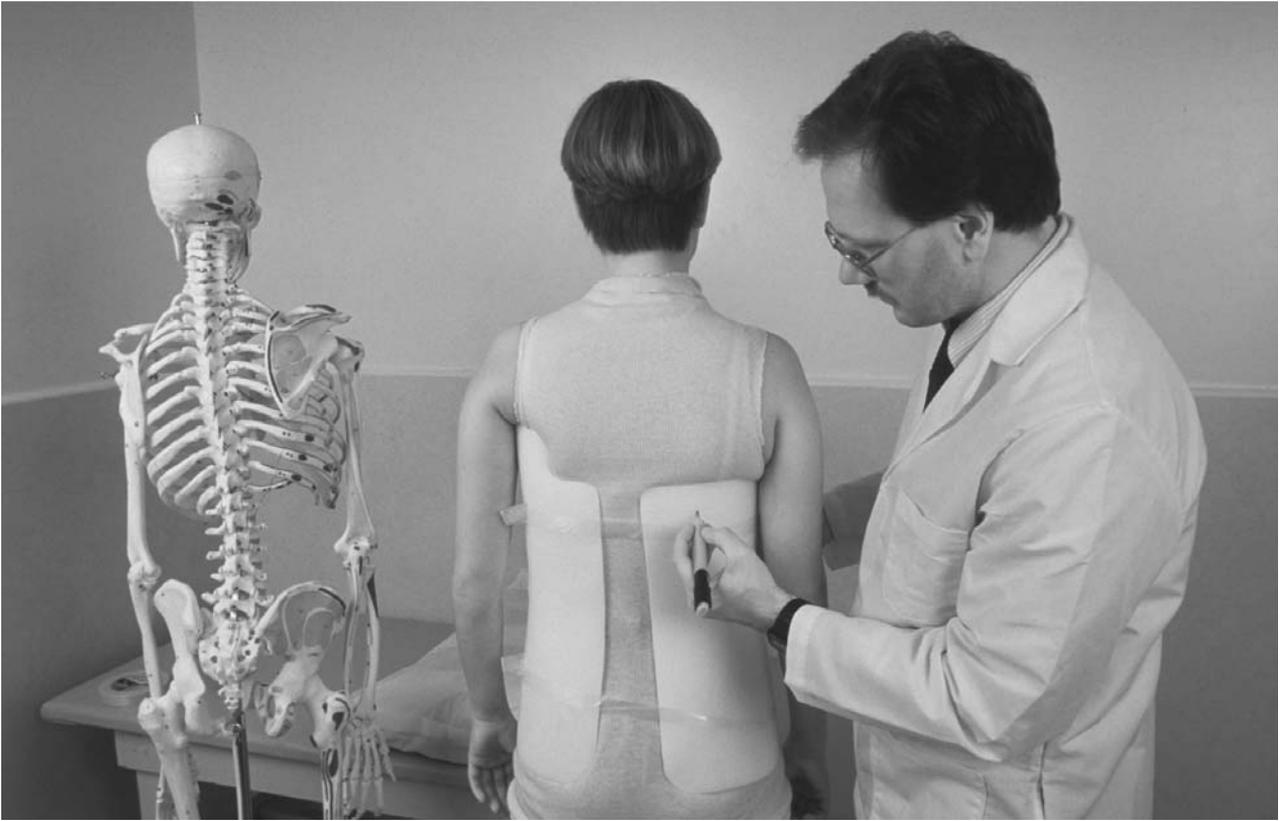
Purpose

Most spinal orthoses are designed to adjust skeletal alignment, limit torso movement, and compress the **stomach**.

Scoliosis

Spinal orthoses are used to treat longterm spinal conditions such as scoliosis. The brace is worn to stop the progression of scoliosis, which is the lateral (side-to-side) curvature of the spine. This condition progresses as a person grows and is primarily seen in children and adolescents. In general, scoliosis can not be reversed. Therefore, the goal of treatment is stop the progression of scoliosis.

Orthopedists usually diagnosis this condition based on an x ray showing curves of 10 degrees or more. Treatment is usually indicated when curves measure 25 degrees or more. Scoliosis progresses more slowly as



A patient with scoliosis is fitted with a brace. (Photograph by Aaron Haupt. Science Source/Photo Researchers. Reproduced by permission.)

patients reach skeletal maturity, so use of spinal orthosis is prescribed for patients with at least 18 months of growing left. In older patients, scoliosis is treated with surgery.

Back pain

Spinal orthoses are worn to relieve back pain and to provide back support after an injury or to treat conditions such as degenerative disc disorder. Other uses of spinal orthoses include protecting the back after surgery and the stabilization and support of a weak back.

Description

For more than two thousands years, doctors have tried to treat scoliosis by having patients wear devices to keep their spines rigid. Equipment used throughout the centuries included bandages bolstered by splints, leather appliances, and plaster casts. During the Middle Ages, the craftsmen who made armor for knights also produced bulky metal corsets to stop the progression of scoliosis.

Today, braces made of materials ranging from cotton to plastic are used to treat conditions related to the back and spine. Spinal orthoses vary in size from the cloth belts worn

for back support to the rigid full-torso Milwaukee brace used to stop the progression of scoliosis. Braces used to treat scoliosis are prescribed by an orthopedist. The orthosis may be custom-made or fitted from a prefabricated brace.

Corsets and belts

Cloth corsets and belts are generally made of cotton, nylon, or rayon. These flexible orthoses are used to relieve back pain and to restrict movement.

Rigid and semi-rigid spinal orthoses

The braces worn to treat scoliosis or during rehabilitation from spinal surgery are generally classified as rigid or semi-rigid orthoses. The rigid orthosis immobilizes the spine and prevents spinal motion. It is designed to apply force in every direction, distributing pressure over a broad area. A semi-rigid brace combines the support of a rigid brace with the flexibility of a cloth orthosis.

Orthoses for scoliosis

Orthoses prescribed for the treatment of scoliosis generally fall into three categories, with model variations in each group.

THE MILWAUKEE BRACE. The Milwaukee brace is a full-torso orthosis developed during the late 1940s. Named for the location of the doctors who developed it, the orthosis consists of pressure pads held in place by three vertical metal bars. The bars extend from a neck ring, a type of collar worn around the neck. The bars are secured at the neck ring and anchored to a plastic pelvic girdle. The rear vertical bar extends down the back. There are two shorter bars in front.

The neck ring centers the head and straightens the spine. The pads apply pressure to the spinal curve to keep it from worsening. Patients wear the brace under clothing, and it is worn for much of the day. While it effectively stops the progression of scoliosis, wearing the brace with the visible neck ring can be embarrassing for patients.

LOW-PROFILE BRACES. During the 1970s, doctors in Boston developed a brace that extends from under the arms to the hips. Variations of this brace are known as thoracolumbar-sacral orthoses (TLSOs), the Boston brace, the low-profile brace, and the underarm brace. The orthosis consists of a plastic corset with pressure pads attached to the inside. The original braces opened from the back. Current models open in the front or back. However, the back-opening orthosis generally keeps the pelvis in place. This reduces the flattening of the lower back that can occur when scoliosis is treated with an orthosis.

Patients wear the underarm brace for much of the day. This orthosis is regarded as low-profile because it is not visible when worn under clothes.

THE CHARLESTON NIGHTTIME BENDING BRACE. This orthosis developed in 1979 forces the spine to one side. It is held in place away from the direction of the spinal curve. The bending brace is curved and is designed to be worn only at night when the patient sleeps. Most patients have no trouble sleeping in this brace once they have adjusted to wearing it. In addition, many young patients appreciate the option of wearing the brace only at home and going to school without wearing a brace.

Operation

The overall length of time for wearing a spinal orthosis depends on the patient's age and condition. If the brace stops the progression of scoliosis, the patient wears an orthosis until reaching skeletal maturity (around age 15 or 16). The orthopedist or other health professional will determine the amount of wearing time when a brace is used to treat other conditions. While daily wearing times will also vary by the patients, there are set times for

how long orthoses should be worn during treatment for scoliosis.

Scoliosis treatment

Orthopedists are divided about how long some spinal orthoses should be worn each day to treat scoliosis. While some doctors believe that the brace must be worn fulltime, others maintain that part-time bracing can be effective. In some cases, this recommendation is based on the patient's condition and age. In other cases, the health care team realizes that young patients embarrassed by the awkward Milwaukee brace may stop wearing it. In these situations, doctors believe that a shorter wearing time or a split schedule could be more effective.

For fulltime bracing to stop the progression of scoliosis, the daily wearing time is:

- 22-23 hours for the Milwaukee brace. The patient can remove the orthosis when bathing. Some doctors allow the patient to remove the brace when exercising; others say that it can be worn while doing some exercises.
- 20 hours for the Boston brace. Daily wearing time of 16 hours may be effective. However, reduced time could increase the risk of curve progression.
- During the eight to nine hours of sleep for the Charleston bending brace.

Precautions

Patients should be told that it takes time to adjust to wearing an orthosis. A light shirt or other article of clothing should be worn under the brace because the appliance should not touch the skin. The health care team should realize that patient compliance is a crucial part of treatment, especially during treatment of scoliosis. Younger patients should be counseled about the importance of their treatment. They should be consulted about the type of orthosis chosen and advised about how to make adjustments to wardrobe so that they feel they fit in.

Furthermore, the patient should be advised to **exercise** regularly. Exercise helps to preserve spinal motion and keeping adjacent muscles strong.

Maintenance

For scoliosis braces, adjusting the tension on chest straps may be necessary. In addition, the spinal orthosis will need to be adjusted as the patient grows. Generally, a brace needs to be replaced after 15 months.

KEY TERMS

Disc—A circle of cartilage located between vertebrae in the spine.

Torso—The trunk of the human body, the area exclusive of the head and limbs.

Vertebrae—The back bones that form the spinal column. The bones are connected by discs and facet joints.

Health care team roles

Patients are seen by an orthopedist, a physician specializing in the treatment of musculoskeletal disorders. This specialty is concerned with deformities, diseases and injuries of the arms, legs, spine, and associated structures. The physician examines the patient, interprets x-rays, and establishes a treatment plan.

If a brace is needed, the patient is sent to an orthotist, an allied health professional who measures, designs, and fits orthopedic equipment like spinal orthoses. Orthotists may supervise several staff members. In some workplaces, the orthotics assistant assists the orthotist and may fabricate, repair, and maintain braces. However, orthoses may be made by the orthotics technician, an allied health worker who takes direction from the orthotist and the orthotics assistant. The technician also repairs and maintains braces. In some settings, the technician may have no contact with patients. Physical therapists will help the patient set up an exercise or rehabilitation program. In addition, a nurse may help plan treatment.

When a patient begins treatment for scoliosis, the orthopedist generally sees the patient several times annually. These appointments are scheduled every four to six months to allow the health care team to assess the patient's growth. The orthotist and orthotic technician may need to adjust a brace or fit a new orthosis. Once the patient is skeletally mature and bracing treatment ends, the patient usually returns a year later for a follow-up assessment that includes an x ray. The patient may be asked to return in five years. Patients are urged to return if a problem develops or they become pregnant.

Training

Members of the health care team receive training in the use of spinal orthoses while studying for their respective professions. For the orthopedist, this training is part

of medical school. For the orthopedic nurse, this training comes during nursing school.

Orthotists earn a four-year bachelor of science degree and finish with specialized orthotic training. They also serve a clinical residency. Orthotics technicians complete programs that last from six months to one year. In addition, people working in these allied health professions can receive certification through the American Academy of Orthotics and **Prosthetics**. Board certification is based on factors including education, employment, continuing education courses, and membership in the academy.

The name of the academy reflects the relationship between the fields of orthotics and prosthetics. While orthotics usually focuses on temporary treatment with a brace, prosthetics involves permanent replacement of a body part with an artificial appliance. However, some patients will require both prosthetics and orthotics, so schools offer degrees and certificates in both disciplines.

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ORGANIZATIONS

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- American Board for Certification of Orthotics and Prosthetics. 330 John Carlyle Street, Suite 200, Alexandria, VA 22314. (703) 836-7114. <<http://www.opoffice.org>>.
- American Orthopaedic Association, 6300 N. River Road, Suite 505, Rosemont, IL 60018. (847) 318-7330. <<http://www.aoassn.org>>.
- National Association of Orthopaedic Nurses, P.O. Box 56, Pitman, NJ 08071. (856) 256-2310. <<http://www.naon.nurse.com>>.

Liz Swain

Spinal tap see **Cerebrospinal fluid (CSF) analysis**

Spinal traction

Definition

Spinal traction is the process of applying force through body weight, weights, and/or pulleys to draw apart the vertebrae of the spine.

Purpose

Spinal traction may be indicated when a patient complains of cervical, low back, or radiating **pain** that is likely caused by a vertebral disc protrusion or degenerative changes. It is used to accomplish one or more of the following purposes: distract (pull apart) vertebral bodies, distract and glide the facet joints, widen the intervertebral foramen (openings to the spinal canal formed by the vertebrae), or stretch spinal musculature. Release of discal pressure and widening of intervertebral space can reduce discal pain and pain caused by impingement of nerves exiting the **spinal cord**.

Precautions

In general, traction should not be applied when there is a disease process that reduces the body's tolerance to force. Traction is contraindicated when there is a tumor, **infection**, vascular disorder, ligamentous instability, **osteoporosis**, or claustrophobia.

Description

Types of spinal traction include: sustained, intermittent mechanical, manual, positional, auto-traction, and gravity traction. Sustained traction is applied with heavy weights or a mechanical device that apply the force to maintain a constant traction for a time period of one to 30 minutes. Intermittent mechanical traction is more widely used in the United States; it involves the use of a split table and a mechanical device to apply and withdraw force every few seconds. In manual traction, the physical therapist may use the weight of his or her body in applying a traction force to the spine. Manual traction is often used to assess a patient's response to traction, or when adjustment of the position or amount of force may be needed. Positional traction allows the patient to be positioned to maximize the effect of traction on the suspected causative structure, or to allow the patient to remain in a preferred posture until pain is relieved. Self-traction allows the patient to position him or herself to provide traction with the assistance of gravity. Gravity lumbar traction is administered in one of two ways. Either the rib cage is grasped in a vest, allowing the weight of the legs to provide a traction force; or the ankles or pelvis are grasped, allowing the upper body to exert the traction force.

In order for traction to be effective, the force must be great enough to cause separation at the target spinal segment(s). A wide range of forces, from 30–300% of body weight, has been shown to be effective in studies of lumbar traction; however, a traction force of such large magnitude as 300% may cause damage to the vertebral structures. Thirty percent of body weight has been shown to be effective in reduction of symptoms. For cervical traction, research has shown that 20–45 lb (7.4–16.8 kg) is an effective range for producing separation.

With mechanical lumbar traction, traction harnesses are placed around the patient's pelvis and thorax. The patient then lies on a split table on his or her back, **stomach**, or side, depending upon the position thought to be optimal for the specific symptoms being treated. The split table allows for minimizing of friction forces. The straps of the harness are hooked to the motorized traction unit that is programmed for the traction force, overall time, and hold/rest periods desired.

For cervical traction, it has been found that patients are able to relax better and forces of gravity interfere less in the supine versus sitting position. To straighten out the normal lordosis and provide a more longitudinal pull, the neck often is flexed to approximately 20–30°, unless treating the joints of the first and second cervical vertebrae. Several types of head halters and devices are available to connect to the traction source.

Preparation

Before traction is applied, a full evaluation should be done to determine the possible causes of the patient's symptoms and uncover potential contraindications to traction. Physical therapists often use manual traction as part of the evaluation to assess the effects it has on symptoms. It is important that the patient is able to relax when traction is applied, so that muscle guarding does not take place. Modalities such as heat may be used to help with **relaxation**.

Aftercare

Traction usually is one part of a patient's plan of care. The physical therapist may teach a patient exercises, body mechanics, self-traction, and **pain management** techniques that should be performed at home between treatment times and after the course of **physical therapy** is finished.

Complications

It is important that the patient reports any adverse reactions or increase in pain after each treatment. Adverse reactions can be more easily avoided by keeping

the initial treatment times short (less than 10 minutes) with low force to allow the patient to become accustomed to the procedure.

Results

The desired outcome of traction is the reduction of neurological signs and pain in the neck, back and/or extremities, allowing for return to functional activities. Although clinicians often find favorable results with the use of traction, research with randomized, controlled trials showing statistically significant positive results is still sparse. This may be due in part to lack of good research design and the many factors involved in back pain.

Health care team roles

The physician usually refers the patient to physical therapy for conservative treatment of neck or back pain. The physical therapist examines the patient and makes decisions regarding the appropriate plan of care, which may include traction. The physical therapist determines the specifications for traction and sets up the patient on the apparatus for the first few times, being sure to monitor the patient intermittently. The physical therapist assistant may set up the patient for future treatments, with guidance from the physical therapist regarding duration and force specifications.

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Spirometry tests

Definition

Spirometry is the measurement of airflow into and out of the **lungs**. The patient is given instructions on how to perform the breathing maneuvers. To perform the procedure the nose is pinched off, and the patient breathes as instructed through a mouthpiece attached to the spirometer. The three breathing maneuvers are practiced before recording the procedure, and the highest of three trials is used for evaluation of breathing. The instrument measures air flow by electronic or mechanical displacement principles and uses a microprocessor and recorder to calculate and plot air flow.

The test produces a recording of the patient's ventilation under conditions involving both normal and maximal effort. The recording, called a spirogram, shows the volume of air moved and the rate at which it is moved into and out of the lungs. There are several lung capacities that are measured by spirometry. Accurate measurement of these are dependent upon the patient performing the appropriate maneuver properly. The most common are described below:

- **Vital capacity (VC):** This is the amount of air in liters that is moved out of the lung during normal breathing. The patient is instructed to breathe in and out normally to full expiration for this maneuver. Vital capacity is normally about 80% of the total lung capacity. Because of the elastic nature of the lungs and surrounding thorax, a small volume of air will remain in the lungs after full exhalation. This volume is called the residual volume (RV).
- **Forced vital capacity (FVC):** After breathing out normally to full expiration the patient is instructed to breath in with a maximal effort and then exhale as forcefully and rapidly as possible. The FVC is the volume of air that is expelled into the spirometer following a maximum inhalation effort.
- **Forced expiratory volume (FEV):** At the start of the FVC maneuver, the spirometer measures volume of air that is delivered through the mouthpiece at timed intervals of 0.5, 1.0, 2.0, and 3.0 seconds. The sum of these measurements normally constitutes about 97% of the FVC measurement. The most commonly used FEV measurement is FEV-1, which is the volume of air exhaled into the mouthpiece in one second. The FEV-1 should be at least 70% of the FVC.
- **Forced expiratory flow 25-75% (FEF 25-75):** This is a calculation of the average flow rate over the center portion of the forced expiratory volume recording. It is determined from the time in seconds at which 25% and

75% of the vital capacity is reached. The volume of air exhaled in liters per second between these two times is the FEF 25-75. This value reflects the status of the medium and small sized airways.

- **Maximal voluntary ventilation (MVV):** A maneuver in which the patient breathes as deeply and as fast as possible for 15 seconds. The average airflow (liters per second) indicates the strength and endurance of the respiratory muscles.

Normal values for FVC, FEV, FEF, and MVV are dependent on the patient's age, gender and size (height).

Purpose

Spirometry is the most commonly performed **pulmonary function test (PFT)**. The test can be performed at the bedside, in a physician's office, or pulmonary laboratory. It is often the first test performed when a problem with lung function is suspected. Spirometry may also be suggested by an abnormal x ray, arterial **blood gas analysis**, or other diagnostic pulmonary test result. In March 2000, the National Lung Health Education Program recommended that regular spirometry tests be performed on persons over 45 years old who have a history of smoking. Spirometry tests are also recommended for persons having a family history of lung disease, chronic respiratory ailments, and persons of advanced age. Spirometry measures ventilation, the movement of air into and out of the lungs. The spirogram will identify two different types of abnormal ventilation patterns, obstructive and restrictive. Common causes of an obstructive pattern are **cystic fibrosis, asthma**, broniectasis, bronchitis, and **emphysema**. These conditions may be collectively referred to using the acronym CABBE. Chronic bronchitis, emphysema, and asthma result in dyspnea and ventilation deficiency, a condition known as chronic obstructive pulmonary disease (COPD). As of 2001, COPD is the fourth leading cause of death among Americans. Common causes of a restrictive pattern are **pneumonia, heart** disease, **pregnancy**, lung fibrosis, pneumothorax (collapsed lung), and pleural effusion (compression caused by chest fluid).

Obstructive and restrictive patterns can be identified on spirographs. Volume (liters) is plotted on the y-axis versus time (seconds) on the x-axis. A restrictive pattern is characterized by a normal shape showing reduced volumes for all parameters. The reduction in volumes indicates the severity of the disease. An obstructive pattern produces a spirogram with an abnormal shape. Inspiration volume is reduced. The volume of air expelled is normal, but the air flowrate is slower causing an elongated tail to the FVC.

A flow-volume loop spirogram is another way of displaying spirometry measurements. This requires a FVC maneuver followed by a forced inspiratory volume (FIV). Flow rate in liters per second is plotted on the y-axis and volume (liters) is plotted on the x-axis. The expiration phase is shown on top and the inspiration phase on the bottom. The flow-volume loop spirogram is helpful in diagnosing upper airway obstruction and can differentiate some types of restrictive patterns.

Some conditions produce specific signs on the spirogram. Irregular inspirations with rapid frequency are caused by hyperventilation associated with **stress**. Diffuse fibrosis of the lung causes rapid breathing of reduced volume that produces a repetitive pattern known as the penmanship sign. Serial reduction in the FVC peaks indicates trapped air inside the lung. A notch and reduced volume in the early segments of the FVC is consistent with airway collapse. A rise at the end of the expiration is associated with airway resistance.

Spirometry is used to assess lung function over time and is often used to evaluate the efficacy of bronchodilator inhalers such as albuterol. It is important that the patient not use a bronchodilator prior to the evaluation. Spirometry is performed before and after inhaling the bronchodilator. In general, a 12% or greater improvement in both FVC and FEV-1 and/or an increase in FVC by 0.2 liters is considered a significant improvement in an adult patient.

Precautions

The physician ordering the test should be aware of any medications and medical conditions which may affect the validity of the test. The patient's smoking habits and history should be documented thoroughly. The subject must be able to understand and respond to instructions for the breathing maneuvers. Therefore, the test may not be appropriate for very young, unresponsive, or physically impaired persons. Spirometry is contraindicated in patients whose condition will be aggravated by forced breathing. Hemoptysis, pneumothorax, recent heart attack, unstable angina, aneurysm (cranial, thoracic, or abdominal), thrombotic condition, recent thoracic or abdominal surgery, nausea or vomiting are conditions that may contraindicate spirometry. The test should be terminated, if the patient shows signs of significant head, chest, or abdominal **pain** while the test is in progress.

Spirometry is dependent upon the patient's full compliance with breathing instructions especially his or her willingness to extend a maximal effort at forceful breathing. Therefore, the patient's emotional state needs to be considered when performing the procedure.

KEY TERMS

Bronchodilator—A drug, usually self-administered by inhalation, that dilates the airways.

Forced expiratory volume (FEV)—The volume of air exhaled from the beginning of expiration to a set time (usually 0.5, 1, 2, and 3 seconds).

Forced vital capacity (FVC)—The volume of air that can be exhaled forcefully after a maximal inspiration.

Vital capacity (VC)—The volume of air that can be exhaled following a full inspiration.

Preparation

The patient's age, sex, and race are recorded, and height and weight are measured before starting the procedure. The patient should not have eaten heavily within three hours of the test. He or she should be instructed to wear clothing that is loose fitting over the chest and abdominal area. The respiratory therapist or other testing personnel should explain and demonstrate the breathing maneuvers to the patient. The patient should practice breathing into the mouthpiece until he or she is able to duplicate the maneuvers successfully on two consecutive tries.

Aftercare

No special care is usually required following spirometry. The occasional patient may become light-headed or dizzy. Such patients should be asked to rest or lie down, and they should not be discharged until after the symptoms subside. In rare cases, the patient may experience pneumothorax, intracranial **hypertension**, vertigo, chest pain, or uncontrolled coughing. In such cases, additional care directed by a physician may be required.

Results

The results of spirometry tests are compared to predicted values based on the patient's age, gender, and height. For example, a young adult in good health is expected to have the following FEV values:

- FEV-0.5 50-60% of FVC
- FEV-1 75-85% of FVC
- FEV-2 95% of FVC
- FEV-3 97% of FVC

In general, any value falling between 80% and 100% of the predicted value is considered normal. Values between 60% and 79% indicate mild lung dysfunction. Values between 40% and 59% indicate moderate lung dysfunction, and values below 40% indicate severe dysfunction.

Health care team roles

Spirometry tests are ordered by a physician, and results are evaluated by a pulmonologist, a physician with special training in pulmonary function. Spirometry testing is performed most often by a registered respiratory therapist (RRT), certified respiratory technician (CRTT), certified pulmonary function technologist (CPFT), or registered pulmonary function technologist (RPFT).

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Robert Harr
Paul Johnson

Spontaneous abortion see **Miscarriage**

Sports injuries

Definition

A sports injury is any bodily damage sustained during participation in competitive or non-competitive ath-

letic activity. Sports injuries can affect bones or soft tissue (i.e., muscles, ligaments, tendons).

Description

Sports injuries are identified as either acute or chronic. Acute sports injuries are characterized by the sudden appearance of symptoms, usually associated with a single traumatic incident. Signs and symptoms of acute sports injuries include **pain**, swelling, and deformity in the affected area, and in the case of joint injuries, limited ability to move the joint. Common acute sports injuries include **sprains and strains**, contusions (i.e., serious bruises), joint dislocations, bone **fractures**, and concussions.

Chronic sports injuries, also called overuse injuries, are identified with more gradual onset and are caused by repetitive light trauma to soft tissue or bone. Typically, pain and swelling worsen during athletic activity but decrease after the activity is stopped. Overuse injuries include tendonitis, **bursitis**, shin splints, and stress fractures.

The United States Consumer Product Safety Commission (CPSC) estimates that, in 1998, there were over one million sports injuries among persons 35–54 years old. Moreover, the number of sports injuries in this age group increased by one-third between 1991 and 1998. The CPSC believes that the rise in injuries is because of increased sports participation among baby boomers.

The CPSC National Electronic Injury Surveillance System also reports that over 3.5 million sports injuries in children younger than age 15 are treated at hospitals and clinics annually. Children are particularly vulnerable to sports injuries because their bones, muscles, and connective tissue have not fully matured, and because they have not yet developed mature neuromuscular coordination.

Causes and symptoms

Acute sports injuries are caused by excessive force applied to bone or soft tissue during sports activity. These injuries are commonly associated with **falls** and high-speed collisions. Specific signs and symptoms depend on the nature of the impact and the body region affected.

Acute sports injuries

SOFT TISSUE INJURIES. Soft tissue injuries occur typically in the knee, shoulder, and ankle. In the knee, tears of the anterior cruciate ligament (ACL) and of the meniscus (i.e., cartilage in the knee) are common. A twisted knee, a sudden directional change, or a misaligned landing from a jump can cause these knee injuries. With the

ACL tear, a “pop” in the knee is frequently felt at the time of the injury. This popping sensation is accompanied by pain and weakness in the knee. A tear of the meniscal cartilage is identified by pain over the area of the meniscus area underneath the edge of the patella, or kneecap), and the pain intensifies if a finger is gently pushed on the edge of the kneecap. The athlete is also often unable to fully extend the knee. With both ACL and meniscus tears, there is swelling several hours after the injury occurs.

In the shoulder, strains of the rotator cuff tendons and dislocation of the shoulder are frequently seen. Tendon strains are associated with overly vigorous throwing movements, and are characterized by the patient complaining of pain if the arm is rotated against resistance. Shoulder dislocations are identified by deformity in the shoulder joint, and pain and lack of mobility in the joint area.

Ankle sprains are the most common injury in sports that require running and jumping. Ankle sprains occur when ligaments in the ankle have been stretched or torn. There is typically swelling and tenderness, and in more serious cases, the athlete is unable to put much weight on the foot of the injured ankle.

SKELETAL INJURIES. Fractures are breaks in the bone due to collisions or falls, and commonly appear in the leg and arm. Symptoms include pain, swelling, and bruising at the site of the fracture. There is also weakness in the limb and an inability to bear weight on the limb. With open fractures, bone fragments protrude through the skin.

BRAIN INJURIES. Brain injuries cause more deaths than any other type of sports injuries. A common brain injury is the **concussion**, an injury caused by the impact of the brain against the interior surface of the **skull**. Concussions often follow a blow to the head or a very rapid acceleration of the head. Loss of consciousness is an important symptom in brain injuries. Other signs and symptoms of concussion include headache, vomiting, delayed motor or verbal responses, partial loss of **vision**, **memory** loss, lack of coordination, or erratic and inappropriate behavior.

Chronic sports injuries

Chronic or overuse injuries are caused by repetitive stress to soft tissue or bone and typically result from a sudden increase in the duration or intensity of athletic activity. In some cases, chronic injuries can be a precipitating factor in acute injuries such as strains and sprains.

SOFT TISSUE INJURIES. Tendonitis, or inflammation of the tendon, is one of the most common overuse injuries and often affects the joints at the elbow, knee, shoulder, and foot. In the elbow joint, tendonitis is known



This man has ruptured his biceps from weight lifting. (NMSB/Custom Medical Stock Photo. Reproduced by permission.)

as golfer's elbow or tennis elbow, and is often caused by poor technique. Shoulder tendonitis is caused by repetitive overhead motions and is common in swimming and in sports requiring throwing motions. In the foot, inflammation of the Achilles tendon (i.e., in the heel area) is caused by biomechanical misalignments, inadequate stretching, sudden increases in training, and athletic play on hard or banked surfaces. Symptoms of tendonitis include pain, redness, swelling, and warmth of the affected area. These symptoms diminish when athletic activity is stopped. Bursitis, an inflammation of the connective tissue of joints, is also common in the knee.

SKELETAL INJURIES. Stress fractures are tiny breaks in the bone caused by repetitive forces. Stress fractures frequently affect the leg, foot, and ankle after training has been suddenly intensified or the sport has been played on hard surfaces. Other risk factors of stress fractures are **osteoporosis** and eating disorders, which tend to weaken bone. Symptoms of stress fractures include pain when weight is placed on the leg or foot, with pain increasing after athletic activity. There may be swelling and point tenderness (i.e., pain when a small region of the affected area is lightly pushed).

Diagnosis

Acute injuries are usually self-evident, as they are associated with a specific traumatic event. After the trauma, the physician performs a **physical examination** of the athlete to identify the specific injury. In the case of suspected joint or skeletal injuries, a radiological technician will take x rays, and the radiologist will confirm or rule out a dislocation, bone fracture, or soft tissue injury.

With overuse injuries, the physician conducts a physical examination and uses signs, symptoms, and training history to diagnose the injury. If a stress fracture is suspected, a bone scan or **magnetic resonance imaging** (MRI) of the area may be performed.

Treatment

For sports injuries, Protection-Rest-Ice-Compression-Elevation (PRICE) is the standard of treatment. PRICE specifies the elements of first-line treatment. Depending on the type of injury, protection may mean immobilizing the affected area with a brace, tape, or wrap, or simply avoiding activities that aggravate the injury. Rest means refraining from activities that prevent recovery from injury; in many cases, cross-training is considered rest

because it exercises areas that do not affect the injury. Ice should be used to relieve pain and swelling. Compression, with tape or elastic wraps, is used to limit swelling and stabilize the area. Elevation, where the injured body part is placed above the level of the **heart**, is also used to prevent swelling.

Some clinicians use the extended PRICE-MM (i.e., Medication and Modalities) regimen, which includes therapeutic use of medication and modalities (i.e., rehabilitation). Nonsteroidal anti-inflammatory medicines such as ibuprofen (e.g., Advil, Motrin) and naproxen (e.g., Naprosyn) have traditionally been used for **pain management** with sports injuries. Injections of **corticosteroids** are sometimes used to control inflammation and pain, but since these injections reduce the strength and flexibility of soft tissue, corticosteroids are used sparingly, primarily for specific overuse syndromes.

The goal of modalities, as in modes of rehabilitation therapies, is to return the athlete to the sport as quickly and as safely as possible. Rehabilitation can begin as soon as the physician permits, typically after internal bleeding has stopped. Modalities include cold and heat therapies, therapeutic ultrasound, range of motion exercises, and resistance exercises.

In serious cases of acute and overuse injuries, PRICE-MM may not be sufficient, and surgery may be required to repair injuries.

Prognosis

For most sports injuries, the PRICE-MM regimen should be sufficient to restore the athlete to the previous level of performance. The prognosis is good as long as the rehabilitation has successfully restored the strength and flexibility of the injured area, and the athlete takes care to prevent recurrence of the injury, suspending activity and undertaking appropriate therapy if pain recurs. With some serious injuries, the athlete will not be able to return to the sport or return to the previous level of activity in that sport.

Health care team roles

In school and youth sports, the nurse is often the first health care provider to evaluate acute injuries and is often responsible for some **first aid of wounds** and injuries until a physician can attend to the athlete. In school settings, since the nurse is in more frequent contact with children, he or she can advise on general measures to prevent injuries such as warm-up and stretching. In clinical settings, the nurse takes a detailed medical and training history that can help the physician diagnose the injury.

The athletic trainer is often on call for emergency care of acute sports injuries and performs first aid on the injured athlete. He or she specializes in sports activities and can give more specific advice for overall conditioning, training, and treatment of the athlete. The athletic trainer also serves as a liaison between the athlete and coaches, parents, and physicians.

Prior to student participation in athletic activity, the the preparticipation physical examination is performed by the physician to assess the patient's fitness for the sport. If the athlete is injured, a diagnosis of the injury is made by the physician and a prescription for appropriate treatment is given. Medical and radiological tests are conducted by technologists. The results assist in determination of the physician's diagnosis. For rehabilitation, the patient may be referred to a physical therapist. For serious injuries requiring surgery, the patient may be referred to an orthopedic surgeon.

Prevention

Many acute and overuse sports injuries are caused by increases in training intensity that put too much physical stress on the athlete's body. This often happens for in amateur athletes who do not sustain regular training regimens and overdo their workouts when they do train. These injuries can be prevented with a variety of training and educational regimens.

For youths and adults, the physical exam can be used to identify weaknesses that may predispose the athlete to injury, and that should be developed prior to engaging in athletic activity. Pre-season conditioning programs that slowly increase intensity level are useful in developing the athlete's level of fitness in preparation for the sports season. Flexibility training, strength training, and cross training have also been shown to prevent injuries by improving the body's resilience.

Finally, education can be effective in preventing certain common sports injuries. The athlete can be shown how to wear protective gear correctly, how to perform the correct throwing, swinging, blocking, or tackling motion to prevent injury, and how to adjust body biomechanics in the event of an unpreventable fall. Although not all sports injuries can be prevented, the damage from many injuries can be minimized with appropriate training.

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Genevieve Pham-Kanter

Sports nutrition

Definition

Sports **nutrition** consists of the nutritional guidelines involving primarily carbohydrate, protein and fluid intake that are used to improve athletic performance.

Purpose

Optimal nutrition improves physical activity, athletic performance and recovery from **exercise**, whether one exercises recreationally or trains as a competition athlete. Consuming adequate food and fluid during, before, and after exercise does several things: maintains **blood** glucose, maximizes performance, and improves recovery time.

Precautions

Athletes who do not consume enough food to make the energy their bodies need risk nutrient deficiencies, loss of muscle mass and increase risk of injury and illness. In particular, female athletes who undereat put themselves at risk for low bone mass and amenorrhea. Athletes who desire weight loss should seek professional help to assure a slow weight loss before competition begins.

Description

Athletes do not need a diet substantially different from the U.S. Recommended Dietary Guidelines. However, the intake and timing of **carbohydrates**, protein, and fluids all affect athletic performance. The following guidelines are advised.

Meeting energy needs is the first priority for athletes, with caloric requirements influenced by many factors such as age, sex, lean body mass, and frequency and intensity of the exercise. Great variation among individuals exists in the energy needed to maintain weight and body composition. Men and women aged 19-50 years who are slightly to moderately active were established by the 1989 Recommended Daily Allowances as 2,200 and 2,900 kcal per day, respectively. However, the male endurance athlete may need as high as 5,000 kcal per day.

The body prefers carbohydrates as an energy source, using blood glucose during the first minutes of exercise. Then the stored carbohydrate form called glycogen becomes depleted to some extent, with a slow walk using up less glycogen than a one-hour jog. In endurance exercise, the energy source shifts to circulating blood glucose provided from the breakdown of **fats**. A diet consisting of 55%-60% carbohydrate is sufficient for most athletes, with daily recommendations ranging from 6-10 gm/kg body weight, depending on the type of sport, energy expended, sex and environmental conditions.

A practice called carbohydrate loading, which first depletes glycogen stores and then restores them with a 70% carbohydrate intake, is sometimes used in athletes performing exhausting events lasting at least 90 minutes. However, it entails weeks worth of preparation to adjust exercise and diet.

Protein and fat both contribute to the energy pool but in much less amounts. Protein needs of athletes receive a lot of attention but a balanced diet usually meets requirements. Endurance athletes and strength-training athletes do need more protein, 1.2 gm up to 1.6 gm/kg for strength training, versus the usual 0.8 to 1 gm/kg. Few athletes are protein-deficient, because the extra calories eaten due to exercise needs provide adequate protein. Research on individual amino acids supplementation is inconsistent and their use is not advocated.

As for fat, diets containing 20-25% energy from fat are recommended to ensure adequate carbohydrate intake. Because of negative effects on some people's blood **lipids**, fat intake should not be decreased below 15% of calories.

Vitamin and mineral supplementation is not required if a variety of foods are eaten. **Calcium**, **iron** and **zinc** can be low in the diets of athletes, particularly females. Of these, iron depletion is the most common, and occurs most often in female athletes, long-distance runners and vegetarians.

Fluid intake is probably the most neglected aspect of an athlete's diet. Muscle activity during exercise produces heat, which the body gets rid of through sweat. It is very important that water be replaced to prevent **dehydration**.

Fluid losses can exceed 2 qts (1.8 L) per hour, especially in humid environments or in sports where padding blocks effective sweating. Performance becomes impaired in dehydration. The amount of fluid needed depends on how much sweat is lost during exercise.

The use of ergogenic aids, products that claim to increase performance or work output, is controversial. Athletes should carefully evaluate products before use.

During exercise

During exercise, the following guidelines should replace fluid losses and maintain carbohydrate levels. These are especially important for endurance events lasting longer than an hour or in extreme environment.

- Drink small amounts (6-12 oz) of plain, cool water every 15-20 minutes during workouts, as tolerated, particularly if it is hot or humid or during longer exercise.
- For exercise lasting over one hour or in high humidity, a sports drink like Gatorade or PowerAde, which contain 6% carbohydrate (15–20 gm or 8 oz), can maintain blood glucose levels, preserve glycogen stores, and improve performance. Beverages such as undiluted fruit juice contain greater than 8% carbohydrate and may cause intestinal upset.

Preparation

Before exercise

The following is recommended one to two hours before exercise:

- Exercisers should eat a carbohydrate snack, such as yogurt, cereal, or a bagel one or more hours before exercise if it has been several hours since a meal. Grains, fruits and dairy products all contain high amounts of carbohydrates and help keep a steady blood sugar. People who experience **stomach** upset or drops in blood sugar called hypoglycemia should avoid carbohydrates immediately before exercise.
- Drink about two cups (14-22 oz) of fluid before exercise.

Aftercare

After exercise

The following tips help after exercise:

- The athlete should drink adequate fluids to replace sweat losses. The best measurement of fluid loss is weighing before and after exercise. Drinking 16–24 oz of fluid (non-caffeinated, non-alcoholic) for every

KEY TERMS

Carbohydrates—Sugars or starches composed of long sugar chains, which serve as a main energy source.

Endurance athlete—An athlete who trains continuously, for long durations and over an extended period of time.

Glycogen—The main storage form of carbohydrate, which occurs primarily in the muscle and liver

pound (0.45 kg) of body weight lost during exercise is recommended. If the previous meal included sodium, there is no need for an electrolyte drink after a session of moderate duration.

- Eat a high carbohydrate snack or drink some juice, when muscles are geared up to replace expended glycogen. Especially after strenuous competition or training, a snack that also contains some protein will help build and repair muscle tissue.

Complications

Vegetarian athletes may be at risk for inadequate energy, protein, and micronutrients intakes, particularly if they eliminate dairy from their diet. Consultation with a registered dietitian is recommended.

While incorrect carbohydrate or fluid intake usually leads to reduced performance, too much dehydration can be deadly. A loss of 5% of body weight due to sweating can result in heat stroke, a severe condition characterized by high **fever**, collapse, cessation of sweating, and sometimes **coma**. Hypohydration occurs when athletes dehydrate themselves before competing, such as for a weight category. Hyponatremia (low blood sodium concentrations) can develop from prolonged heavy sweating and failure to replace sodium, or when excess water is retained in the body.

Results

Research over the past 20 years shows good nutrition affects exercise performance. Optimal sport nutrition increases glycogen stores prior to exercise, supplies carbohydrate during prolonged exercise, and assures adequate hydration before, during and after exercise.

Health care team roles

- The training of exercise physiologists includes sports nutrition. Also, athletes can seek consultations with a licensed nutrition specialist or registered dietitian trained in sport nutrition.
- Nursing and other allied health professionals should ask patients about their exercise and nutrition habits, particularly when patients present with unexplained weight loss, bone **fractures** or nutrient deficiencies.

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(317) 637-9200. <<http://www.acsm.org>>.

American Dietetic Association (ADA). 216 W. Jackson Blvd., Chicago, IL 60606-6995. 800/366-1655.
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Gatorade Sports Science Institute (GSSI). 617 West Main Street, Barrington, IL 60010, 800-616-GSSI (4774).
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Sports participation in children

Definition

Sports participation in children involves the issue of children playing or competing in sports and the related concerns regarding **nutrition**, growth, injury and psychosocial factors.

Description

As more and more children participate in recreational or competitive sports activities, the issue of sports participation has increasingly become a topic of discussion. It is estimated that 25% of girls and 50% of boys aged

eight to 16 participate in sports in the United States. Even more participate in sports in the United Kingdom. These numbers have increased the discussion and research on the effects of early athletic training on children's growing bodies. Specific areas of concern include the cardiovascular and musculoskeletal systems, nutrition, sexual maturation, psychosocial implications, and injury prevention and treatment.

Viewpoints

Studies have shown that, in general, childhood activity is on the decline and childhood **obesity** is on the rise. Requirements for physical education in schools have become less stringent. One survey sponsored by the Centers for Disease Control reports that 50% of high school students are not enrolled in physical education, and more than 80% of high school students do not participate in 20 minutes of physical activity three times per week. There is clearly a need for the encouragement of physical activity in children and adolescents. At the other end of the spectrum, however, injuries and other ramifications of intense athletic participation cannot be ignored.

One of the major concerns related to sports participation is the incidence of injury. Thirty to 40 percent of all pediatric accidents occur during athletics, with 10% of all childhood head injuries being related to sports participation. An estimated three million children and adolescents visit emergency rooms each year for sports-related injuries, while another five million require a visit to their physicians. Some parents and professionals view these statistics as viable reasons to keep children away from organized sports participation, however, a large number of injuries occur during unsupervised activities as well, such as diving and skiing. In any case, excessive stress to the body can cause tissue injuries; particularly concerning being those to the epiphyseal plates, as they can result in growth disturbances.

Research studies have identified several factors contributing to **sports injuries**, including but not limited to inadequate equipment, intensity of competition, and poor playing technique. Preventative measures can address many of these contributors in order to help reduce risk, but some researchers opine that increased surveillance is still required to determine which preventative measures would be most effective. Surveillance would include determination of the most prevalent types of injuries, who is affected and why they occur.

Another area of concern related to early sports participation is nutrition. Proper nutrition is important for all youth, and vital for young athletes. Opponents of early sports participation may point out that children who

engage in activities requiring slim figures, such as ballet or gymnastics, may place their growth at risk through inadequate nutrition and even pathologic eating behaviors. One study of rhythmic gymnasts noted that while gymnasts did not have adequate caloric intake for their energy expenditure, the composition of their diets reflected better nutritional practices than those of non-athletes.

Other areas of concern include: cardiac implications, sexual maturation, and psychosocial aspects of sports participation. The research on cardiac function with intense **exercise** has not demonstrated adverse effects, although opponents may point to research indicating that myocardial function can be depressed after intense exercise. In relation to sexual maturation, athletic girls tend to have a later onset of menstruation than do those not participating in sports. In addition, amenorrhea, or cessation of menstrual period, is common with intense training. Opponents of childhood athletics also point to psychosocial problems caused by **anxiety** and stress of competition. Research studies have shown that these problems do occur in a small minority of youth athletes due to burnout, inability to participate in other activities, and parental demands. Proponents of sports participation recommend that psychosocial problems can be limited with participation in a variety of sports as opposed to early specialization.

Professional implications

Allied health professionals, including nurses, physical therapists, exercise physiologists and athletic trainers, play important roles in client education, injury prevention and treatment. These professionals may assist clients and their families by:

- Providing general information regarding benefits and risks to youth athletics so that clients and families can make informed decisions regarding level of participation.
- Encouraging children to participate in activities consistent with their abilities and interests, while discouraging early specialization, parental pressure and emphasis only on winning.
- Providing education regarding proper coaching, early identification of signs related to overuse injuries, and importance of rest.
- Monitoring body composition, height, weight, cardiac function, nutrition, and stress level regularly.
- Emphasizing the importance of general fitness versus training only sports-specific skills, and the importance of warm-up, cool-down and flexibility.



Sports participation impacts children physically, socially, and emotionally. Children can be impacted positively or negatively, so parents should watch for problems in any of these areas. (Photograph by Richard Cummins. Corbis. Reproduced by permission.)

- Identifying individual risk factors to injury (e.g., malalignment, muscle-tendon imbalance, disease, improper footwear) and provide education regarding these factors.
- Recommending and providing pre-participation physical examinations that include: medical history; screening of body systems; orthopedic evaluation; flexibility, strength, speed, agility, power, endurance, balance, and coordination assessment; and clearance for sports participation by a physician.

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Sprains and strains

Definition

A sprain is an injury to ligaments and/or the joint capsule that occurs in response to large stresses. A strain is disruption of the contractile elements in muscle and/or tendon. An easy way to remember the difference between sprain and strain is that strain is spelled with a "t," which can infer the associated word tendon.

Description

Sprains

Sprains are categorized into three levels of severity. In a mild sprain, or first degree sprain, few ligamentous fibers have been torn, and the ligament is not significantly weakened. There may have been some slight bleeding. In a moderate sprain, also known as a second degree sprain, there is more disruption of the ligamentous fibers (40%–50% of the fibers are torn) and ligamentous weakness is present. Moderate bleeding occurs. In a severe sprain, also named a third degree sprain, there is complete disruption of the ligamentous fibers or joint capsule and there is no strength of the ligamentous tissue. Marked swelling, secondary to bleeding, is present. Many athletes have suffered a complete tear, or third degree sprain, of the anterior cruciate ligament (ACL) of their knee.

Strains

Strains are also referred to as first degree, second degree or third degree strains. In a first degree strain there is usually mild damage to the muscle or tendon with only a few fibers torn. There is minimal bleeding. A second degree strain presents with moderate weakness as the contractile components are torn. There is more bleeding

and swelling. In a third degree strain there is complete rupture of the muscle or tendon. A third degree strain is considered a complete tear, accompanied by bleeding, swelling, and loss of function of the associated muscle. An example of a third degree strain would be a rupture of the biceps tendon.

Causes and symptoms

Both sprains and strains are due to increased demand or large stresses placed on the involved structures, i.e., ligament, muscle, or tendon.

Sprains

In a first degree or mild sprain, there is minor weakness, minimal disability, and no muscle spasms of the surrounding musculature. In a second degree sprain, the individual may complain of moderate disability and report instability. For example, in a second degree sprain of the lateral ankle, the individual may report, "the ankle feels like giving way." In a third degree sprain the individual will complain of **pain** secondary to swelling. Furthermore, the individual will report having major impairment in function, i.e., weight bearing activities.

Strains

An individual with a mild strain may complain of mild irritation of the affected area with no appreciable change in function. A secondary strain will cause the individual to complain about swelling, some minimal stiffening, moderate disability, and moderate pain. In a severe strain, the individual will report a marked loss of function, swelling of the affected area, muscle spasms secondary to guarding, and significant weakness. Interestingly, because of the complete rupture in severe strains, there will be little or no pain on stretching or with movement. Any pain present is probably due to the severe swelling secondary to bleeding.

Diagnosis

Sprains

Functional testing and clinical observation are often sufficient to establish a diagnosis of sprain. In addition to the above symptoms, a variety of tests can be performed in an effort to evaluate the integrity and stability of the joint. For example, a clinician might test an injured knee by applying medial and lateral stress to the knee.

Four ligaments are important for the stability of the knee joint: the lateral collateral ligament, the medial collateral ligament, the anterior cruciate ligament and the posterior cruciate ligament. The collateral ligaments are

largely responsible for the stability of the knee joint in response to lateral and medial stress. Lateral force (also known as a valgus stress) pressures the medial ligament and medial force (also known as varus) pressures the lateral ligament. If a patient has sprained either ligament, the joint should be abnormally mobile—the more mobile, the more severe the sprain. Other tests to determine the status of the cruciate ligaments, such as the Lachman test and the posterior drawer test, may also be performed. Some of the more common knee injuries associated with football are tears of the medial collateral ligament (MCL) and/or the anterior cruciate ligament (ACL). Sometimes the forces that caused the injury are so severe that the MCL, ACL, and medial meniscus (cartilage) are all disrupted. This is termed an “unhappy triad.”

Depending on factors like the severity of the sprain, the nature of the injury, and the severity of the sprain, x rays may also be indicated. X rays do not indicate the severity of the sprain, merely whether a fracture has occurred or not. Ultrasonography and **magnetic resonance imaging** (MRI) may be used to determine the severity of a sprain. MRI has the additional benefit of offering multiple types of information. For example, in cases of suspected neck sprain, MRI can show whether the injury is truly a sprain, a strain, or originates from abnormalities in the cervical (intervertebral) disks.

Strains

MRI is also an important tool in the evaluation of strain. Although not indicated in the majority of cases, MRI provides the most accurate diagnostic information of the imaging techniques currently available (as of 2001). Other imaging techniques include ultrasound and computerized axial tomography (CAT scan), but their use is limited. In most cases, however, diagnosis is obtained from clinical observation and functional testing.

When evaluating a first degree strain, findings will show a mild loss of strength during resistance testing, a decreased range of motion, and minimal muscle guarding. In a second degree strain, the strength test will indicate moderate weakness, decreased range of motion, and moderate pain when stretching the tendon or muscle. In a third degree strain, findings will be more pronounced with significant swelling and major weakness compared to the uninvolved side. There will be marked loss of function and significant disability.

One common example of a strain is a hamstring strain, known more commonly as a pulled hamstring. In baseball, when a batter has just hit the ball in the infield, she or he will need to run quickly to first base. On approaching the first base bag, the batter may reach out and extend with the leg to touch the base. A common

injury at the point of extension is a tear of one of the following muscles (more commonly known as the hamstrings): biceps femoris, semimembranosus, or semitendinosus (tearing of all three is rare). When the hamstrings are over-extended, such as when the baseball player over extends the leg, a muscle or tendon tear may occur.

Treatment

Sprains

In a mild sprain the goal in treatment is to decrease any swelling that is present and prevent loss of motion secondary to stiffness. Ice, elevation, and compression should be used before and after treatment sessions. **Therapeutic exercise** should include range of motion, stretching, and strengthening of the surrounding musculature. In a moderate sprain, treatment is more conservative and the clinician must minimize the risk of further injury. Modalities should be continued to decrease swelling and pain. The RICE (rest, ice, compression, and elevation) principle should continue throughout treatment. A general rehabilitation pathway of strengthening, range of motion, and flexibility all need to continue and progress as tolerated. In a severe sprain, there are usually two options: surgical and non-surgical. In the surgical option, the ligament is re-attached by the physician. The non-surgical approach relies on bracing to minimize motion and allow for healing. The rehabilitation plan is complex in either of these approaches, but the goal is to initially minimize motion followed by slow progression into range of motion and strengthening.

Strains

Treatment of first and second degree strains is similar to treatment of sprains. It consists of utilizing the RICE principle and protecting the affected area from overstretching or overuse. Rehabilitation should focus on range of motion, decreasing swelling and pain, and gradual introduction of a strengthening program. Severe strains may require surgical repair, and protocols of rehabilitation are different for each affected area. Initial treatment could be immobilization followed by guarded range of motion, flexibility, and strengthening therapies.

Prognosis

Sprains

In a mild sprain, the individual can usually engage in normal activities within three to six weeks. In a moderate sprain, normal activities can usually resume in approximately eight to 12 weeks—ligamentous tissue requires approximately eight to 10 weeks to heal. By the third or

KEY TERMS

Immobilization—To keep a limb or joint free from movement and to maintain position. Movement is stopped by either bracing or casting.

Irritation—Minimal disruption of a structure that may cause bleeding. An irritation can present with minimal swelling and a feeling of discomfort to the individual. Usually, function is not impaired secondary to an irritation. An irritation can progress to a more severe impairment if healing is not allowed to appropriately take place.

Modalities—A term used to describe treatment modes that are applied to the individual. In rehabilitation, a few examples of a modality could be heat, ice, ultrasound, electrical stimulation, and traction.

Range of motion—The amount of motion that a joint has. There is active range of motion and passive range of motion. Active range of motion is the range the joint can traverse under voluntary contraction. The individual moves the limb using their muscle power. Passive range of motion is the range that the joint moves though while either a machine or individual moves the limb. In passive range of motion the limb is usually moved for the individual with no muscle contraction.

Therapeutic exercise—A general term to describe a multitude of exercises, stretching and general rehabilitation. Can include range of motion, resistive exercises such as weight training, postural correction exercises, and exercises that incorporate coordination and balance training.

fourth week, however, the individual with a moderate sprain will usually have a normal range of motion and be free of pain. Therefore, the key to recovery from a moderate strain is to prevent the patient from returning to normal activity before the ligament heals.

The prognosis for a complete rupture (severe sprain) varies. Success depends on the management of the injury, and the subsequent level of desired activity. A return to normal activity may require from six months to one year.

Strains

The prognosis for treating first or second degree strains is good. The major problem is stressing the affected area too soon. Overstressing the affected area too early in recovery may cause the strain to become chronic. A

chronic strain could lead to further complications such as muscle spasm and possible myositis.

Health care team roles

It is appropriate that physicians, nurses, therapists, and other allied health partners be familiar with the prevention and care of sprains and strains. Moreover, nurses and allied health partners should be involved in **patient education** that focuses on minimizing the risk of over-use injuries.

Prevention

The best prevention for sprains and strains is to have optimal muscular strength, muscular flexibility, and endurance. Appropriate warm-up exercises before an activity may further minimize the potential for injury. Sprains may also be prevented by the use of a brace.

Sprains are caused by excessive stress to a ligament or capsule. Optimal strength, flexibility and endurance help the muscles to accept and distribute forces that might otherwise be placed on the joint. If muscles are weak and not flexible, increased demand placed on the area will need to be absorbed by the ligaments or joint capsule. Increased demand on these structures will put them at greater risk for failure, i.e. tearing. Braces may absorb some of this extra demand. For example, persons wishing to avoid ankle injury may choose to tape their ankle or wear a lacing brace before engaging in activities with injury potential. Persons with prior ankle injuries may utilize an air stirrup.

Surfaces may also play a role in sprains and strains. A controversial example is the comparison of football injuries on natural grass and artificial turf. One study found an increased rate of anterior cruciate ligament sprains in football players playing on artificial turf compared to sprains on natural grass. A less controversial example might be the comparison of a manicured lawn to a field of wild prairie grass. The prairie grass might hide many dips in the field that would be apparent in a manicured lawn. Such a field would provide a greater likelihood of injury due to the unpredictability and unevenness of the surface (there is a greater chance for unexpected excessive forces on a joint).

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Sputum analysis

Definition

Sputum is a substance comprised of mucous, foreign matter, and saliva that is found in the **lungs** or bronchial tree. A sputum analysis is a group of tests performed in a laboratory on a sputum specimen obtained from a sick patient. A portion of the sputum specimen is stained and put on a slide for examination of cells and organisms. Another portion of the specimen is put on an agar plate to see if infectious organisms grow and can be identified. Some of the sputum may be placed in special solutions to test for specific diseases.

Sputum

Term	Description	Associated with
Fetid	Foul-smelling, typical of anaerobic infection	Bronchiectasis, lung abscess, or cystic fibrosis
Frothy	White or pink-tinged, foamy, thin sputum	Pulmonary edema
Hemoptysis	Expectoration of blood or bloody sputum; amount may range from blood-streaked to massive hemorrhage	A variety of pathologies
Mucoid	White or clear, not generally associated with bronchopulmonary infection	Chronic cough (acute or chronic bronchitis, cystic fibrosis)
Purulent	Pus, yellow or greenish sputum, often copious and thick	Acute and chronic infection
Rusty	Descriptive of the color of sputum (also called prune juice)	Pneumococcal pneumonia

SOURCE: Rothstein, J.M., S.H. Roy, and S.L. Wolf. *The Rehabilitation Specialist's Handbook*. 2nd ed. Philadelphia: F.A. Davis Co., 1998.

Purpose

The purpose of a sputum analysis is to help identify microorganisms that are causing respiratory disease or **infection**. The most common reason for obtaining a sputum specimen is to test for infectious **tuberculosis**. A sputum analysis, however, is also used to identify disease-producing organisms that may be causing **pneumonia**, bronchitis, lung **abscess**, or other respiratory disease. A sputum analysis may be used to identify conditions such as: aspiration pneumonia, histoplasmosis, cryptococcosis, blastomycosis, mycoplasma pneumonia, plague, mycobacterial infection, and pneumocystic pneumonia.

Precautions

A sputum specimen should not be collected immediately following a meal because the sputum or the process of collecting the sputum may cause gagging and vomiting.

Good hand washing and the use of gloves are necessary when collecting a sputum specimen. A disposable gown and filter-mask should be worn if reactivated infectious tuberculosis is suspected.

About 1 teaspoon (3-5 cc) of sputum should be collected to have a sufficient quantity for proper testing. The specimen cup should not be left at the bedside for the client to randomly spit into. Specimens must be fresh and taken immediately to the laboratory for effective analysis.

KEY TERMS

Agar—A gelatinous culture media used in laboratories to grow microorganisms such as bacteria.

Bronchoscopy—The examination of the inside of a client's airway and bronchus by a physician using a flexible scope connected to a light source and video camera.

Sputum—A substance coughed up from the airway, bronchi or lungs comprised of saliva, foreign matter, and mucous.

The specimen must be coughed up from the lungs or bronchial tree. It can be mixed with saliva, but a specimen that is only saliva is not adequate for proper testing.

An infant or young child cannot cough up sputum on command. Sputum specimens must be obtained with a nasal-pharyngeal aspirator connected to a mucous trap or by bronchial washings performed during a **bronchoscopy**. If using a nasal-pharyngeal aspirator, the tubing must have a one way valve on the testers side of the tubing to prevent the inhalation of infected droplets from the patient or a trap that connects directly to a suction apparatus.

The use of **antibiotics**, anti-inflammatory drugs, or steroids may affect the test results. If the patient is receiving any of these medications, the physician should be notified, and it should be notified on the laboratory slip.

Description

The patient should take three slow deep breaths and cough forcefully with the exhalation of the third breath. Sputum that is coughed up should be spit directly into the sterile specimen cup. The process is repeated until the required amount of sputum is collected. The cap is then placed on the specimen cup.

If the patient has difficulty raising sputum, the physician should be notified. Some patients may require postural drainage and cupping to loosen and drain secretions. Others may require an aerosol treatment with saline or medications to open the air sacs and allow drainage of the sputum before it can be collected. In certain cases the physician may elect to perform a bronchoscopy to collect the sputum for analysis. A bronchoscopy is performed in a special setting where the client can be sedated and monitored during the procedure.

A nasal-pharyngeal mucous trap is used to collect sputum from an infant or young child that cannot under-

stand instructions. A small tube is inserted through the nasal passage and into the pharynx. This process usually stimulates the infant to cough. As the child coughs up sputum, it is pulled through the tubing and into a mucous trap. The mucous trap is placed in a plastic biohazard specimen bag that is sealed, labeled, and sent to the lab for analysis. If a specimen from an infant can not be collected, the physician should be notified. The sputum may need to be collected through a bronchoscope by the physician.

Special testing may require variance in the sputum collection procedure. For example, sputum for viral studies may require that the client gargles and expectorates with a nutrient broth. The medical setting's lab manual should be consulted for instructions to collect sputum for special testing.

Preparation

The procedure is explained to the patient. Fluid intake should be encouraged the night before the test. The specimen should be obtained in the morning before meals. The patient should abstain from smoking, eating, or chewing gum before the specimen collection. If the patient has dentures, they should be removed. The patient rinses his mouth with plain water before the test to clear debris from the mouth. The patient is seated in an upright position. A capped sterile specimen cup is placed near the patient. Good handwashing and the use of gloves is necessary for this procedure. Other protective gear is used as instructed (i.e., for known tuberculosis client with potentially reactivated tuberculosis). The laboratory manual of the medical setting should be consulted for specific specimen directions.

Aftercare

The patient should be allowed to relax and breathe quietly. The specimen cup is labeled with the patient's name, doctor, time, date, and type of specimen. The specimen cup is placed in a biohazard labeled plastic sealed bag. The specimen does not need to be refrigerated but should be transported to the lab immediately for testing. Good handwashing is necessary after the procedure. Used tissues and gloves should be placed in a contaminated trash bag that can be sealed and discarded.

Complications

There are no complications to obtaining a non-invasive sputum specimen. Complications of obtaining a specimen by nasal tracheal aspiration or bronchoscopy are rare but may include trauma to the throat or tracheal tissue and/or secondary infection.

Results

A sputum analysis, when used in conjunction with other tests such as chest x rays or **blood** cultures, is an important diagnostic tool. It is an effective method for identifying unknown organisms that are causing respiratory infections or disease. Identification of the organism allows proper selection of antibiotic or other drug therapy to treat specific respiratory disease and provide a positive outcome for the client. Improper collection or handling of a sputum specimen may invalidate the test results.

Health care team roles

A sputum specimen is usually collected by a licensed nurse or respiratory therapist in the medical setting. Other medical personnel, however, such as medical office technicians or other non-professional staff can be taught the correct method for obtaining a sputum specimen. A patient or patient's family can be trained to collect a sputum specimen in the home. The specimen should be taken promptly to a lab for analysis. A laboratory technician will prepare the specimen for analysis, and a pathologist will ultimately be responsible for analyzing the sputum specimen.

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Sputum culture

Definition

A sputum culture is a microbiology test performed to isolate and identify microorganisms causing an **infection** of the lower respiratory tract.

Purpose

Infections of the **lungs** and bronchial tubes are caused by several pathogenic microorganisms, including **bacteria, fungi, viruses**, and parasites which are responsible for a variety of diseases including pulmonary **tuberculosis**, bacterial **pneumonia**, viral and mycoplasma (atypical) pneumonia, chronic bronchitis and bronchiectasis. A chest x-ray provides visual evidence suggestive of a respiratory infection; a culture identifies the microorganism causing the infection.

Precautions

For best results, the specimen should be obtained prior to initiating any therapy. The health care worker should wear a mask to avoid inhalation of airborne pathogens that may be introduced into the air during the collection process. The specimen should be taken to the laboratory within 30 minutes of collection.

Description

Sputum collection

Based on the clinical condition of the patient, the physician determines what group of microorganism is likely to be causing the infection, and then orders one or more bacterial, viral, or fungal cultures. For all culture types, the sputum must be collected into a sterile container and care must be taken to minimize specimen contamination by the normal flora of the mouth and throat. Once in the laboratory, each culture type is handled differently.

Sputum must be expectorated from the bronchi by deep forceful coughing. The recovery of sputum is best in the early morning. The patient should rinse his or her mouth by gargling with water prior to coughing. Taking deep breaths and lowering the head helps bring up the sputum. Sputum must not be held in the mouth but immediately spat into a sterile container. For tuberculosis, the physician may request sputum samples from the patient on three consecutive mornings. In some cases the patient will be unable to produce the sputum, and an aerosol of saline will be needed to loosen the congestion. In such cases the sputum can be aspirated using a suction device.

In some cases sputum will be collected during a **bronchoscopy** or endotracheal procedure. These specimens, like coughed-up sputum, will be contaminated with normal flora from the mouth or throat and are not suitable for anaerobic culture. When anaerobic infection is suspected, the physician will collect the sample by transtracheal aspiration. These specimens and those collected by **thoracentesis** (removal of pleural fluid via chest wall puncture) are not contaminated by upper respiratory flora and are suitable for both aerobic and anaerobic culture.

Gram stain

The **Gram stain** is always performed when sputum is submitted for culture. Additional stains such as the acid-fast stain for tuberculosis are performed only upon request. The Gram stain is used to determine the acceptability of the specimen for culture, and aids the technologist in selecting special growth media that might be needed. Almost all bacteria are described by their Gram stain characteristics: color (purple or pink), shape (cocci or bacilli), and size; arrangement, presence, or absence of spores.

The Gram stain is performed by the following method:

- A portion of the sputum is smeared onto a glass **microscope** slide, air dried, and heat-fixed.
- The slide is flooded with crystal violet stain, which is allowed to set for 30-60 seconds.
- The crystal violet is rinsed off with a gentle stream of water.
- The slide is flooded with Gram's iodine, which is allowed to set for 60 seconds.
- The iodine is removed with a gentle stream of water.
- The slide is decolorized by rinsing with 95% ethanol, drop by drop, until the alcohol rinses clear.
- The slide is flooded with safranin, which is allowed to set for 30 seconds.
- The safranin is rinsed off with a stream of water.
- The excess water is removed by blotting with bibulous paper.
- The slide is allowed to air dry.
- The slide is observed under the microscope using both low power and oil immersion lenses.

Gram-positive cells retain the crystal violet stain and appear dark purple, while gram-negative cells do not. Gram-negative bacteria are counterstained by the safranin and appear pink. Gram staining also helps determine the integrity of the sputum specimen. The presence of many epithelial cells and few white **blood** cells indicates a con-

taminated sample, one not adequate for culture. The presence of many white blood cells and bacteria in the specimen signifies an acceptable sample for culture, and provides a preliminary indication of infection.

Bacterial culture

Streptococcus pneumoniae is the most common pathogen causing bacterial pneumonia, but almost any organism can be implicated. Other bacterial isolates include *Staphylococcus aureus*, *Haemophilus influenzae*, *E. coli*, *Enterobacter spp.*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Legionella pneumophila*, *Mycoplasma pneumoniae*, and *Mycobacterium tuberculosis*.

Using a sterile swab, a portion of the sputum sample is transferred to each plate and then streaked for isolation using a sterilized inoculating loop. Cultures should be performed using sheep blood agar, chocolate (heated blood) agar, and MacConkey agar. All plates are incubated in 5-10% carbon dioxide at 36°C for 24 hours. Plates are examined for growth and colonies are Gram stained and subcultured (transferred) to appropriate media for biochemical identification. Plates showing normal flora are incubated for an additional day. If *L. pneumophila* is suspected, the sputum should be plated on BCYE-alpha agar (buffered charcoal-yeast extract with alpha-ketoglutarate). Plates are cultured in air or 2.5% carbon dioxide for three to five days at 36°C. Small convex gray colonies are stained with fluorescent-labeled antibody specific for *L. pneumophila*. If atypical pneumonia is suspected, the sputum is plated on a medium that supports the growth of *Mycoplasma pneumoniae* such as SP4. The plates are incubated in air at 36°C. Colonies grow slowly and are almost microscopic. They are identified by cutting a block of agar, and staining it with Dienes stain. *M. pneumoniae* demonstrate their typical fried egg appearance. Alternatively, the colonies can be identified using a fluorescent-labeled antibody specific for *M. pneumoniae*. Plates showing no growth are held up to four weeks before reporting as negative. Because of the long culture time, *Mycoplasma pneumoniae* is not usually cultured. Infections with this organism are diagnosed by enzyme immunoassay for IgM antibodies produced against the organism. A high concentration of these antibodies indicates acute infection.

The results of the initial Gram stain are available the same day, or in less than an hour if requested by the physician. A preliminary report on the status of the culture is usually available after one day. This report notes the presence or absence of bacterial growth, the Gram stain of any organism isolated, and presumptive identification (if possible). The final report, usually available in

one to three days, includes organism identification, an estimate of the quantity of the bacteria, and the results of the antibiotic sensitivity testing.

Fungal culture

Fungal cultures of sputum are used primarily to identify the presence or *Histoplasma capsulatum*, *Coccidioides immitis*, *Cryptococcus neoformans*, *Blastomyces dermatitidis*, and *Paracoccidioides brasiliensis*. However, opportunistic yeast or fungi such as *Candida spp.*, *Aspergillus spp.*, and *Fusarium spp.* can cause pneumonia in immunocompromised patients. Definitive diagnosis depends upon the presence of clinical signs of pulmonary infection, a positive chest x-ray, and laboratory identification of the organism. In addition, histological results of open **lung biopsy** may reveal the organisms by microscopic examination of stained tissue. For the laboratory identification, the sputum is first examined microscopically via a direct smear using one or more of the following methods:

- 10% KOH preparation
- India ink preparation
- calcofluor white stain
- Gram stain
- Kinyoun's acid fast stain
- lactophenol cotton/aniline blue wet mount

In many cases, direct smears are sufficient to establish a preliminary diagnosis based upon the appearance of the yeast seen or the characteristic spores and hyphae produced by the fungus. If a **fungal culture** is ordered or suspected from direct smear, a portion of the sputum is transferred to an appropriate growth medium such as Sabauroad-dextrose agar or brain-heart infusion-blood agar. When infection with a dimorphic fungus is suspected (i.e., infection by *Histoplasma capsulatum*, *Coccidioides immitis*, *Blastomyces dermatitidis*, *Paracoccidioides brasiliensis*), the cultures are incubated at both 25°C and at 36°C in order to demonstrate conversion of the mold form at 25°C to the yeast form at 36°C. Rapidly growing fungi such as *Coccidioides immitis* may appear in three to four days, while slow growing fungi such as *Histoplasma capsulatum* may require several weeks. For this reason cultures are held for four weeks before signing out as negative. Identification is made on the basis of growth rate, appearance and color of colonies, and microscopic appearance demonstrating characteristic hyphae and/or spores. Microscopic evaluation is performed by transferring a loop or drop of the fungal culture onto a glass slide, adding one to two drops of lactophenol cotton blue stain, placing a coverglass over the material, and examining under the microscope.

In some cases, a culture filtrate is prepared and tested using antibodies to the exoantigens produced by the dimorphic fungi. This is done by the double immunodiffusion technique that permits direct comparison of precipitation reactions for the cultures and known fungal antigens controls.

Viral culture

Viruses that are a common cause of respiratory tract infection include adenoviruses, rhinoviruses, **influenza**, parainfluenza, enteroviruses, respiratory syncytial virus, retroviruses, herpes simplex, and cytomegalovirus. Because viruses need host DNA to replicate, they will not grow on artificial media. Therefore, viral cultures are inoculated onto cell cultures. These may be **cancer** cells grown in monolayers in the laboratory or cells taken from animal tissues and used to prepare a monolayer. Cell types commonly used for viral isolation are human diploid fibroblasts (HDF), HEp2 cells (epithelial cancer cells from the larynx), A549 cells (human **lung cancer** cells); primary monkey kidney cells (PMK), and rabbit kidney cells (RK). Cell cultures are inoculated and allowed to grow for one to three days at 36°C in 5-10% carbon dioxide. Within one to three days a characteristic cytopathic effect (CPE) can be seen by observing the cells under a microscope.

Mycobacterial culture

Mycobacterium tuberculosis is a respiratory infection commonly transmitted via the air to the lungs, where it thrives, causing **fever**, cough, and blood spitting. Pneumonia can also be caused by *M. bovis*, *M. avium* complex, and *M. kansasii*.

Most mycobacteria that cause pneumonia such as *Mycobacterium tuberculosis* grow very slowly requiring from two to six weeks for culture. *Mycobacterium tuberculosis* stains very poorly with Gram stain; therefore, acid-fast (light microscopy) and fluorescent staining methods are used to identify mycobacteria by direct microscopic examination of sputum. A smear can provide a presumptive diagnosis of mycobacterial disease; confirm that cultures growing on media are acid-fast; and demonstrate a patient's response to antibiotic therapy from post-treatment sputum cultures.

There are three staining methods commonly employed to test for mycobacteria. Two acid-fast stains, Ziehl-Neelsen and Kinyoun use light microscopy; the third method uses auramine or a combination of auramine and rhodamine and requires a fluorescent microscope. The advantage of fluorescent staining resides in the ability to examine much larger areas of the smear in a shorter period of time. Fluorescent staining is

more sensitive and detects approximately 18% more cases. Its disadvantage is that the stain also detects organisms that are non-viable. While a positive finding provides a basis for initiating antibiotic treatment, the sensitivity of the direct smear is highly variable. Therefore, when **acid-fast culture** is requested, all sputum samples (meeting the laboratory's criteria for sputum) are cultured, even when the direct smear exam shows no evidence of acid-fast bacteria.

Sputum for culture of mycobacteria must be decontaminated. This is commonly done by adding a mucolytic agent such as N-acetyl-L-cysteine and a clearing agent, sodium hydroxide, to an equal amount of the sputum. The suspension is mixed and allowed to stand for 15 minutes, then phosphate buffered saline is added and the sample is centrifuged. The supernatant is decanted and the remaining sample is resuspended with bovine albumin and used for culture.

An acid-fast culture can detect as few as 10 to 100 CFU/mL of sputum. Culture media may be enriched with egg, albumin, or a mixture of salts, **vitamins**, cofactors, fatty acids, glucose, and other nutrients. Media also contain malachite green or **antibiotics** to retard the growth of other bacteria and yeast. The sputum should be inoculated on at least one solid medium such as American Thoracic Society or Lowenstein-Jensen and one liquid medium such as Middlebrook 7H9. Cultures are set up at several different temperatures and examined daily for several weeks to characterize the rate of growth. Colonies are subcultured and transferred to appropriate media for biochemical identification. This process can take several more weeks and therefore, other identification methods are often performed concurrently. These include analysis of cell wall fatty acids by either gas or high-performance liquid chromatography (HPLC) and DNA probe testing. High-performance liquid chromatography can rapidly identify the species of mycobacteria from cultures, but according to the CDC, laboratories that use HPLC report that the method requires a highly experienced technologist and usually takes a long time (about six months) for initial incorporation into their laboratories. DNA probe testing can be done on as little as a single colony and demonstrates a far more rapid turnaround time than biochemical testing. Probes are available for many species but not all mycobacterium, and may be falsely negative (i.e., a low hybridization rate) if contaminating organisms are present. For these reasons, this method is used in conjunction with biochemical testing.

Other microorganisms that cause various types of lower respiratory tract infections also require special culture or staining procedures to grow and identify. For example, *Pneumocystis carinii* in bronchial lavage, sputum, or lung biopsy samples is detected by observing the

organisms with special stains such as methenamine silver stain or a fluorescent monoclonal antibody stain. *Pneumocystis carinii* causes pneumonia in people with weakened immune systems, such as people with **AIDS**, and does not grow in culture. The diagnosis is based on the results of these stains, the patient's symptoms, and medical history.

Antibiotic susceptibility testing

With the exception of *Streptococcus pneumoniae* or other strep which are sensitive to penicillin and related antibiotics, antibiotic susceptibility testing is performed on all isolates. Susceptibility testing is performed for most other organisms by the microtube broth dilution or Kirby Bauer method. The selection of antibiotics for testing depends upon the organism isolated (i.e., gram-negative, gram-positive, aerobe, anaerobe, mycobacteria, or yeast).

The Kirby-Bauer antibiotic susceptibility test method is commonly used for gram-positive and gram-negative aerobic bacteria. Antibiotic disks are placed on a plate containing a clear medium such as Mueller-Hinton agar that has been swabbed uniformly with a standardized broth suspension of a pure culture of the bacteria to be tested. The plate is then incubated at 36°C for 18-24 hours. The zone of no growth (zone of inhibition) around each disk is measured, and compared to predetermined cutoffs for each antibiotic concentration used. If the zone size equals or exceeds the cutoff, the organism is susceptible. If not, the organism is resistant. The results are reported as sensitive (organism inhibited by antibiotic), intermediate (inconclusive effect of antibiotic on organism), or resistant (organism not inhibited by the antibiotic).

Preparation

The specimen for culture should be collected before antibiotics are begun as the antibiotics may prevent microorganisms present in the sputum from growing in culture. The best time to collect a sputum sample is early in the morning, before the patient has had anything to eat or drink. The patient should first rinse his or her mouth with water to decrease mouth bacteria and dilute saliva.

If coughing up sputum is difficult, a nurse or respiratory therapist can have the patient breathe in sterile saline produced by a nebulizer. This nebulized saline coats the respiratory tract, loosening the sputum, and making it easier to cough up.

It is also useful to obtain information concerning travel to foreign countries, exposure to animals, and diagnosed or suspected immunosuppressive disease.

Aftercare

There are no specific requirements for care after obtaining the specimen. However, if the patient is found to have tuberculosis, several measures will be taken to prevent the spread of this airborne disease.

Complications

There are no complications associated with this test.

Results

Sputum from a healthy person will have no growth on culture. However, a mixture of microorganisms, typically found in a person's mouth and throat often contaminates the culture. In such cases the report will indicate the presence of normal flora contamination.

The preliminary report will note the presence of bacteria and white blood cells on the Gram stain and describe the appearance of the bacteria and the number of cells seen. Preliminary culture results will identify the Gram stain or presumptive identification of any organisms recovered.

Health care team roles

Sputum culture is requested by a physician. A nurse or respiratory therapist will provide instructions to the patient for collecting a sputum sample. Bronchoscopy, transtracheal aspiration, bronchial lavage or brushing, and thoracentesis are performed by a physician. Clinical laboratory scientists/medical technologists who specialize in microbiology will perform the culture and antibiotic sensitivity tests.

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KEY TERMS

Cocci—Spherical shape bacterium.

Bacilli—Rod-shaped bacterium.

Bronchiectasis—A chronic dilation of one or more bronchi.

Epithelial cells—Skin cells.

Mycobacterium—A slender acid-fast organism resembling *Mycobacterium tuberculosis*.

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Victoria E. DeMoranville

Sputum specimen collection

Definition

Sputum specimen collection is a procedure designed to collect expectorated secretions from a patient's respiratory tract.

Purpose

Sputum is collected to be used as a laboratory specimen for the isolation of organisms that might be causing abnormalities of the respiratory tract.

Precautions

This procedure should not be performed if the patient is unable to take several deep breaths or cough deeply from the **lungs**.

KEY TERMS

Expectorate—To cough up excessive secretions from the respiratory tract.

Haemoptysis—The presence of blood in the sputum.

Hypertonic saline—Saline that has a higher osmotic pressure than normal saline.

Inhalation—A medicinal substance for inhaling.

Mucoid—Resembling the thick liquid secreted by the mucous glands.

Mucopurulent sputum—Sputum containing mucus and pus.

Pulmonary embolism—A clot in the lungs.

Description

When secretions from the respiratory tract are expectorated, the secretions are called sputum. A **sputum culture** is a sample of expectorated sputum.

Induced sputum is a procedure to assist patients who have difficulty expectorating sputum. The patient inhales nebulized saline to loosen the sputum. To collect an induced sputum sample, the patient's mouth should be rinsed thoroughly with water to reduce the amount of oral **bacteria** that are normally present from contaminating the sputum. The patient then inhales 20–30 ml of hypertonic saline from an ultrasonic nebuliser. The sputum is loosened and collected in a sterile sputum container.

The patient should be supervised during the collection of the sputum to ensure the expectorated product has come from the lungs rather than saliva from the oral cavity. The sample is best taken first thing in the morning when the production of sputum is greatest.

To collect an expectorated sputum sample, the patient should gargle and rinse out the mouth with water to reduce the amount of oral bacteria that are normally present from contaminating the sputum. The patient must take a deep breath and cough into a sterile sputum container.

For a suspected common bacteria, one sputum sample may be required. If the suspected **infection** is more complex, a sputum sample may be required on three to five successive mornings.

Preparation

If there is any difficulty in expectorating, the physician may suggest the use of an inhalation, an expectorant, or physiotherapy to aid in producing sputum for collection. The sputum should be transferred to the laboratory within two hours for analysis.

Results

Sputum is mucoidal in appearance, resembling the thick liquid secreted by the mucous glands. It can be clear, white, or greenish in color, even **blood** stained. Blood in the sputum is called haemoptysis and may be a pink froth, mucus with a streak of blood, or an obvious clot, red in color representing fresh blood or brownish representing old blood. Haemoptysis may indicate that there has been some trauma to the respiratory tract, or that there is an infection present such as **tuberculosis** or even carcinoma. If it is determined that the blood is not from a simple cut to the mouth or a nosebleed, it is considered a serious condition and should be treated immediately. The sputum may also be frothy, indicating that the patient's pulmonary **blood pressure** is raised. Mucopurulent sputum contains mucus and pus and indicates an infection, such as an **abscess**, is present.

There may be an unpleasant odor associated with sputum.

Health care team roles

The procedure must be fully explained to the patient. The nurse should note if the patient has any difficulty with expectoration, and report it to the physician.

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Staphylococcal infections

Definition

Staphylococcal (staph) infections are communicable diseases caused by various species of staphylococcal **bacteria** and are generally characterized by the formation of abscesses. They are the leading cause of nosocomial infections (infections originating in hospitals) in the United States.

Description

Classified since the early twentieth century as among the deadliest of all disease-causing organisms, staph exists on the skin or inside the nostrils of 20% to 30% of healthy people. It is sometimes found in breast tissue and the mouth, as well as the genital, urinary, and upper respiratory tracts.

Although staph bacteria are usually harmless, when injury or a break in the skin enables the organisms to invade the body, consequences can range from minor discomfort to death. **Infection** is most likely to occur in:

- newborns
- women who are breastfeeding
- individuals whose immune systems have been compromised by radiation treatment, **chemotherapy**, or medication
- intravenous drug users
- patients with surgical incisions, skin disorders, and serious illness such as **cancer**, diabetes, and lung disease

Types of infections

Staph infections produce pus-filled abscesses located just beneath the surface of the skin or deep within the body. Risk of infection is greatest among the very young and the very old.

A localized staph infection is confined to a ring of dead and dying white **blood** cells and bacteria. The skin above it feels warm to the touch. Most of these abscesses eventually burst, and pus that leaks onto the skin can cause new infections.

A small fraction of localized staph infections enter the bloodstream and spread through the body. In children, these systemic (affecting the whole body) or disseminated infections frequently affect the ends of the long bones of the arms or legs, causing a bone infection called osteomyelitis. When adults develop disseminated staph

infections, bacteria are most apt to infect the **brain**, **heart**, **kidneys**, **liver**, **lungs**, or spleen.

There are three staphylococcal species that commonly cause infections: *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Staphylococcus saprophyticus*.

Staphylococcus aureus

Named for the golden color of the bacteria grown under laboratory conditions, *S. aureus* is a hardy organism that can survive in extreme temperatures or other inhospitable circumstances. About 70% to 90% of the population carry this strain of staph in the nostrils at some time. Staph aureus is present (colonizes) on the skin of 5% to 20% of healthy people. As many as 40% carry it elsewhere, such as in the throat, vagina, or rectum, for periods of time varying from hours to years without developing symptoms or becoming ill. These individuals may be called asymptomatic carriers.

S. aureus flourishes in hospitals, where it colonizes in health care personnel and postoperative patients along with those who have acute dermatitis, insulin-dependent diabetes, dialysis-dependent kidney disease; or patients who receive frequent allergy-desensitization injections. Staph bacteria can also contaminate bedclothes, catheters, and other objects.

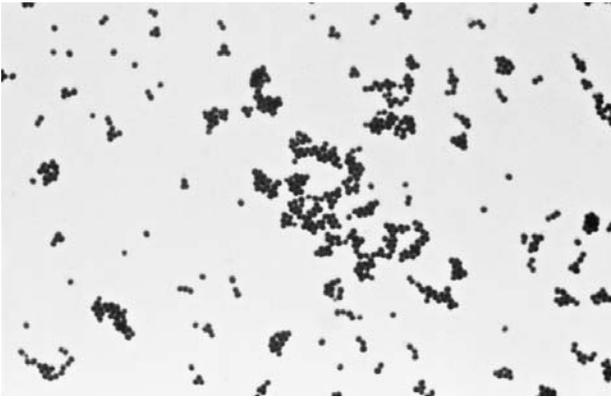
S. aureus causes a variety of infections. Folliculitis, a condition characterized by **boils** and inflammation of the skin surrounding a hair shaft, is the most common. Toxic shock and scalded skin syndromes are among the most serious.

TOXIC SHOCK. Toxic shock syndrome is a life-threatening infection characterized by sudden onset of symptoms: severe headache, **sore throat**, **fever** as high as 105°F, and a sunburn-like rash that spreads from the face to the rest of the body. Symptoms also may include **dehydration** and watery **diarrhea**.

Shock (inadequate blood flow to peripheral parts of the body) and loss of consciousness occur within the first 48 hours. Between the third and seventh day of illness, skin peels from the palms of the hands, soles of the feet, and other parts of the body. Kidney, liver, and muscle damage often occur.

SCALDED SKIN SYNDROME. Rare in adults and most common in newborns and children under the age of five, scalded skin syndrome originates with a localized skin infection. A mild fever and/or an increase in the number of infection-fighting white blood cells may occur.

A bright red rash spreads from the face to other parts of the body and eventually forms scales. Large, soft blisters develop at the site of infection and elsewhere. When



Gram stain of *Staphylococcus*. (Delmar Publishers, Inc. Reproduced by permission.)

they burst, they expose inflamed skin that looks as if it had been burned.

MISCELLANEOUS INFECTIONS. *S. aureus* can also cause:

- septic arthritis
- bacteremia (bacteria in the bloodstream)
- carbuncles (pockets of infection and pus under the skin)
- cellulitis (tissue inflammation that spreads below the skin, causing **pain** and swelling)
- **endocarditis** (inflammation of the valves and walls of the heart)
- meningitis (inflammation of tissue that encloses and protects the **spinal cord** and brain)
- osteomyelitis (inflammation of bone and bone marrow)
- pneumonia

Staphylococcus epidermidis

Capable of clinging to tubing such as that used for intravenous feeding, prosthetic devices, and other non-living surfaces, *S. epidermidis* is the organism that most often contaminates devices that provide direct access to the bloodstream.

The most common cause of bacteremia in hospital patients, this strain of staph is most likely to infect cancer patients, whose immune systems have been compromised, and high-risk newborns receiving intravenous supplements. *S. epidermidis* also accounts for two of every five cases of prosthetic valve endocarditis. Prosthetic valve endocarditis is endocarditis of an artificial heart valve. Although contamination usually occurs during surgery, symptoms of infection may not become evident until a year after the operation. More than half of the patients who develop prosthetic valve endocarditis die.

Staphylococcus saprophyticus

Existing within and around the urethra of about 5% of healthy males and females, *S. saprophyticus* is the second most common cause of unobstructed urinary tract infections in sexually active young women. This strain of staph is responsible for 10% to 20% of infections affecting healthy outpatients.

Causes and symptoms

Staph bacteria can spread through the air, but infection is almost always the result of direct contact with open sores or body fluids contaminated by these organisms. Staph bacteria often enter the body through inflamed hair follicles or oil glands. They also penetrate skin damaged by **burns**, cuts and scrapes, infection, insect bites, or **wounds**.

Multiplying beneath the skin, bacteria infect and destroy tissue in the area where they entered the body. Staphylococcal bacteremia (staph infection of the blood) develops when bacteria from a local infection infiltrate the lymph glands and bloodstream. These infections, which can usually be traced to contaminated catheters or intravenous devices, usually cause persistent high fever and may cause shock. They also can cause death within a short time.

Warning signs

Common symptoms of staph infection include:

- pain or swelling around a cut, or an area of skin that has been scraped
- boils or other skin abscesses
- blistering, peeling, or scaling of the skin; most common in infants and young children
- enlarged lymph nodes in the neck, armpits, or groin

Patients should be advised to contact a physician or seek medical attention whenever:

- Lymph nodes in the neck, armpits, or groin become swollen or tender.
- An area of skin that has been cut or scraped becomes painful or swollen, feels hot, or produces pus; may mean the infection has spread to the bloodstream.
- A boil or carbuncle appears on any part of the face or spine. Staph infections affecting these areas can spread to the brain or spinal cord.
- A boil becomes very sore. Usually a sign that infection has spread, this condition may be accompanied by fever, chills, and red streaks radiating from the site of the original infection.

- Boils develop repeatedly. This type of recurrent infection could be a symptom of diabetes.

Diagnosis

Blood tests that show unusually high concentrations of white blood cells may suggest staph infection, but diagnosis is based on laboratory analysis of material removed from pus-filled sores and on analysis of normally uninfected body fluids, such as blood and urine. Physicians may order x rays to locate internal abscesses and evaluate the severity of infection. Needle biopsy (removing tissue with a needle, then examining it under a **microscope**) may be used to assess bone involvement.

Treatment

Superficial staph infections can generally be cured by keeping the area clean, using antibacterial soaps that leave a germ-killing film on the skin, and applying warm, moist compresses to the affected area for 20 to 30 minutes three or four times a day.

Severe or recurrent infections may require a course of treatment with cephalexin or other oral anti-staphylococcal **antibiotics** lasting seven to 10 days. The location of the infection and the identity of the causal bacteria determines which of several effective medications should be prescribed.

In case of a more serious infection, antibiotics may be administered intravenously for as long as six weeks. Intravenous antibiotics are also used to treat staph infections around the eyes or on other parts of the face.

Surgery may be required to drain or remove abscesses that form on internal organs or on shunts or other devices implanted inside the body.

Alternative therapies for staph infection are intended to strengthen the **immune system** and prevent recurrences. Among the therapies believed to be helpful for the person with a staph infection are **yoga** (to stimulate the immune system and promote **relaxation**), acupuncture (to draw heat away from the infection), and selected herbal remedies. Patients should be counseled to use alternative therapies as complementary medicine in conjunction with conventional antibiotic treatment or other prescribed treatment.

Prognosis

Most healthy people who develop staph infections recover fully within a short time. Others develop repeated infections. Some patients become seriously ill, requiring long-term therapy or emergency medical care. A small percentage die from severe infection.



A close-up of woman's finger and nail cuticle infected with *Staphylococcus aureus*. (Custom Medical Stock Photo. Reproduced by permission.)

Health care team roles

Physicians supervise the treatment of staph infections in a hospital setting. Generally, laboratory technicians perform blood work and radiology technicians perform x rays when indicated. Nurses provide bedside management and patient-family education.

Prevention

Health care providers have a critical role in the prevention of nosocomial infections. Health care providers and patients should always wash their hands thoroughly with warm water and soap after treating a staph infection or touching an open wound or the pus it produces. Pus that oozes onto the skin from the site of an infection should be removed immediately. The affected area should then be cleansed with antiseptic or with antibacterial soap.

Because some strains of staph bacteria are known to contaminate artificial limbs, prosthetic devices implanted within the body, and tubes used to administer medication or drain fluids, catheters and other devices should be removed on a regular basis, if possible, and examined for microscopic signs of staph. Symptoms may not become evident until many months after contamination has occurred, so this practice should be followed even with patients who show no sign of infection. Nurses also teach importance of hand washing to staff, patients, and families.

To prevent infection from spreading from one part of the body to another, patients should be advised to shower rather than bathe during the healing process. Since staph infection is easily transmitted from one member of a household to others, towels, washcloths, and bed linens used by someone with a staph infection should not be used by anyone else. They should be changed daily until

KEY TERMS

Abscess—A cavity containing pus surrounded by inflamed tissue.

Endocarditis—Inflammation of the lining of the heart, and/or the heart valves, caused by infection.

Nosocomial infections—Infections acquired by a patient while in the hospital.

symptoms disappear and laundered separately in hot water with bleach. The judicious use of antibiotics in the treatment setting also helps prevent infections from becoming worse by lessening the likelihood that bacterial strains resistant to antibiotics will arise.

Children should frequently be reminded not to share:

- brushes, combs, or hair accessories
- caps
- clothing
- sleeping bags
- sports equipment
- other personal items

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Barbara Wexler

Static encephalopathy see **Cerebral palsy**

Stem cell research see **Bioethics**

Sterilization techniques

Definition

Sterilization techniques include all the means used to completely eliminate or destroy living microorganisms on any object, including tools used to test or treat patients.

Purpose

The term microorganism, or microbe, refers to any single-celled living organism, including **bacteria**, **viruses**, and **fungi**. (Though viruses are not true single-celled organisms, medical science still usually classifies them as microorganisms.) Microbes can be transferred by direct contact or indirectly through a vehicle (like a surgical tool) or via the air the patient breathes. If favorable conditions for growth exist in the new host, microbes reproduce and establish colonies. Many of these microscopic organisms are normal inhabitants of the human body (called microflora). For example, varieties of the bacterium *Staphylococcus* are normal inhabitants of the skin and nasal passages, and many different species of bacteria live in the small and **large intestine**, aiding in the process of digestion.

However, many types of microorganisms are pathogenic (considered foreign to the host body) and, upon entering the body, cause **infection** when they either damage cells directly or release toxins that will eventually cause damage. The prevention of disease-causing microbes in a patient-care environment is generally accomplished through aseptic or sterile techniques. The goal is to create as germ-free an environment as possible, primarily through sterilization and the maintenance of sterile/nonsterile barriers.

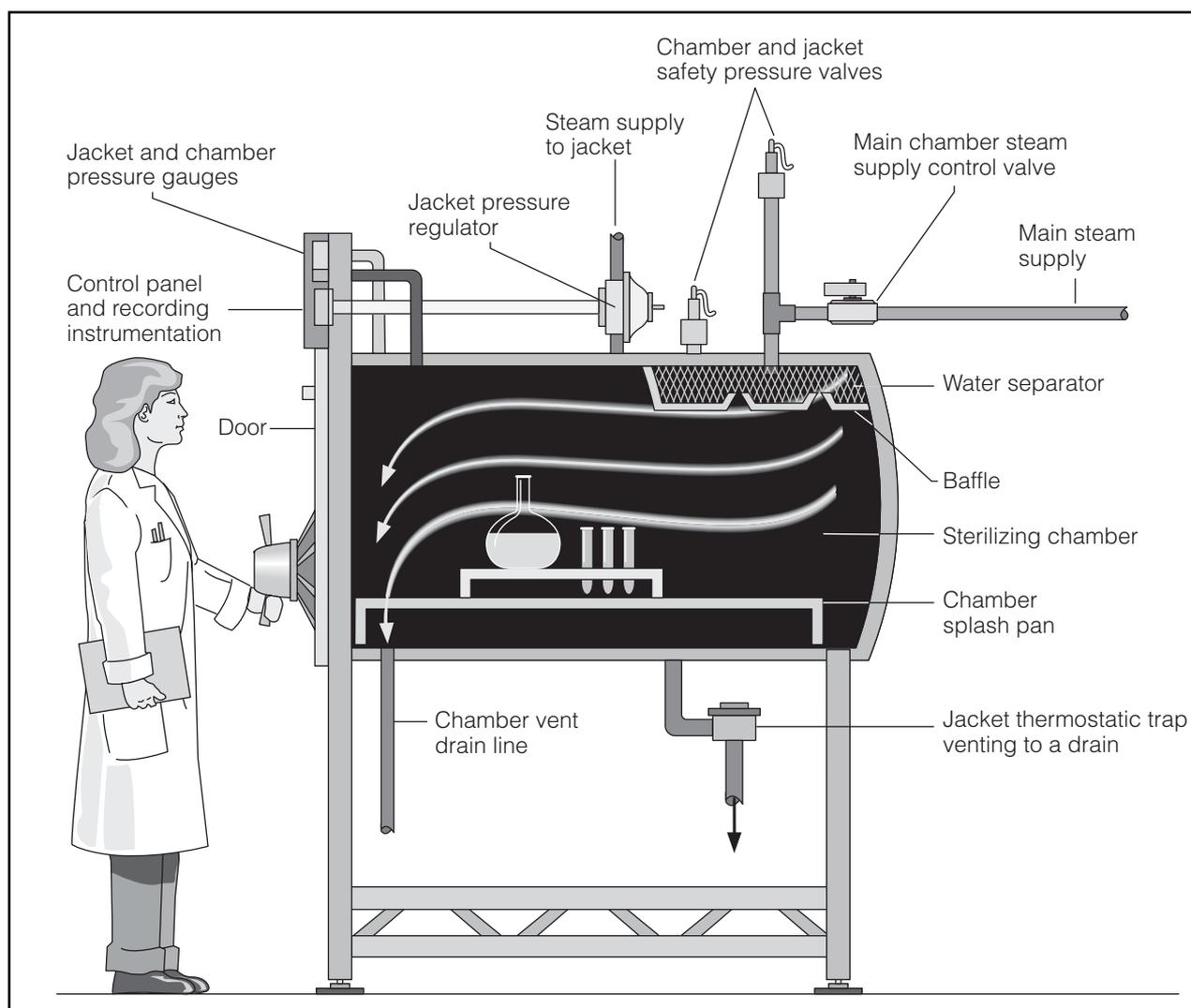
Precautions

Like foods sold in the grocery store, sterile medical and surgical solutions and some other equipment have expiration dates indicating when the product is no longer considered sterile. Although many hospitals consider sterile, prepackaged disposable materials to be sterile indefinitely if the packaging is undamaged, sterile goods must be examined carefully to ensure that there are no breaks in the integrity of the packaging or that the package has not gotten wet. Microbes are able to enter sterile goods through either breaks in the wrapping (the sterile barrier) or moisture. If the wrapper is no longer intact, or has been wet, sterile goods must be repackaged and resterilized.

Description

Patients having invasive medical or surgical procedures are at risk for infection primarily from four sources:

- Infection is transferred from other people, including patients and health care providers. Such infection is called direct transmission, which usually occurs as a result of direct contact with skin or bodily fluids, including saliva, coughing, and spitting.



A technician operates a steam pressure sterilizer. (Hans & Cassidy. Courtesy of Gale Group.)

- Infection results from equipment or other objects that come in contact with the patient. This is called vehicle-borne infection because the microbe is transported from another place on some object or vehicle and introduced through a break in the skin or mucosal membranes. Primary examples are **food poisoning** caused by contaminated food items or infection caused by the use of non-sterile equipment in an invasive procedure like **bronchoscopy** or phlebotomy.
- Infection arises from the patient's own body, such as the possible contamination of a surgical site during intestinal resection if the patient's own fecal material contaminates the abdominal cavity contents.
- The air transports microbes. An example of air-borne infection is **tuberculosis**, in which bacteria are trans-

mitted on air currents to others through coughing or spitting.

Managing as germ-free an environment as possible is necessary for surgical procedures and even minor medical treatments normally done in a doctor's office, such as suturing a laceration. Patients with conditions or under treatments that cause the **immune system** to be compromised are sometimes treated in an artificially created environment called reverse isolation. Leukemia patients, especially those on aggressive **chemotherapy** who receive bone marrow transplants and people with **immunodeficiency** disorders (which can lead to little or no natural defense against infection), are all potential candidates for reverse isolation procedures. Patients with **AIDS** (acquired immune deficiency syndrome) may be treated in an environment of isolation, both direct and reverse isolation for their protection, as well as the pro-

tection of caregivers. An extreme example of reverse isolation is the use of a sterilized plastic tent with filtered air circulation called an isolator. (**Premature infants** may be placed in special sterile plastic bassinets called an isolette.)

Aseptic technique

It has been known since the days of Florence Nightingale that clean surroundings are definitely less conducive to the growth of microorganisms than unclean ones. The creation of sterile environments always includes scrupulous cleanliness. The use of disinfectants in washing furniture, walls and floors, as well as in soaking medical equipment or other patient-care items is another important measure. Disinfectants are harsh chemical compounds described as bactericidal (capable of killing bacteria), or bacteriostatic (capable of stopping the growth or reproduction of bacteria). Some of these disinfectants may also be antiviral agents or antifungal. Disinfectants are usually too toxic to tissue to be used directly on the body. **Antiseptics** are chemical compounds that are also either bactericidal or bacteriostatic. But these are usually more diluted solutions and can safely be used in direct contact with human tissues. Common antiseptics include iodine, hydrogen peroxide, and thimerosal.

The importance of hand washing before and after the care of any patient cannot be over-stressed. It remains the simplest and most effective means of preventing infection. The Center for Disease Control (CDC) estimates that American hospitals produce two million hospital-borne infections (known as nosocomial infections) each year, and approximately one-quarter of these are postoperative surgical incision infections. Postoperative infections result from breaks in sterile technique during surgery or breaks in **aseptic technique** during **wound care**. Further, CDC studies have shown that the average compliance with hand washing by health care providers from 1981 to 1999 has never risen above 50%. Proper procedure is for health care personnel to scrub their hands prior to and immediately after performing any procedure on a patient, regardless of whether latex gloves were worn or not. Gloves, as a barrier, can be breached via holes the size of pinpoints.

For both surgery and reverse isolation, staff are usually required to wear presterilized gloves, hair nets, masks, and gowns, with clean shoe coverings. Insertion of a urinary catheter, changing a surgical drain, cleaning a **tracheotomy** tube or doing a sterile dressing are all instances when health care providers wear gloves. They also create what is termed a sterile field or area that has been prepared with antiseptics or covered with impene-

trable sterile drapes to reduce the likelihood of organism transfer.

Before surgical procedures, the operative site skin area is cleansed with an antiseptic solution, and sterile drapes are applied to the periphery. In the case of bowel surgery, **laxatives** and **enemas** are given prior to the surgery to remove as much fecal material as possible, thus limiting the amount of contamination from feces. When the bowel is clamped shut, all instruments, drapes, and sponges that may have come in contact with the patient are removed and replaced with sterile equipment before proceeding any further. In both surgical suites and in reverse isolation patients' rooms, air is passed through a special ventilation system that filters out microorganisms.

Five means are commonly used to sterilize objects in the patient's environment. These include:

- Moist heat is used via steaming or autoclaving (steaming under high pressure). Much like a pressure cooker used to can food at home and destroy bacteria, an autoclave circulates steam at temperatures of 260°F (120°C) at sustained pressure of 20 pounds per square inch for designated periods of time. All equipment used in carrying out medical or surgical procedures such as instruments, tubings (including catheters), bandages, and linens used for drapes are sterilized, usually in an autoclave.
- Ionizing and non-ionizing radiation is sometimes used. Ultraviolet light is a type of non-ionizing radiation used for items sensitive to heat.
- The passage of liquids through a filter sufficiently fine so as to trap microbes.
- Gas sterilization, usually using ethylene oxide, interferes with the **metabolism** and therefore the development of microorganisms and inhibits the growth of spores. It is effective in the sterilization of heat-sensitive items and penetrates deeply, but it has to be used with care since it is poisonous.
- Strong disinfectants are used primarily for instruments, such as thermometers and scopes that could not survive autoclaving. Medical equipment soaked in disinfectants to destroy microbes should be rinsed off prior to use due to the toxicity of many of the compounds used for disinfecting. Certain gasses such as ethylene oxide used for sterilization are extremely toxic to human beings and should be used with care.

Preparation

In general, preparations include standard sterilization techniques for the patient, health care staff, and environment. Surgery patients requiring reverse isolation pro-

cedures should be told about the actions of microorganisms, including the ways they gain entry into the human body, the diseases that can be caused, and how sterilization techniques work to prevent infection. Hair is no longer routinely removed from the site of the surgical incision prior to surgery as the skin is a natural barrier to infection and shaving it often produces small skin breaks.

Aftercare

Aftercare following use of sterilized or surgically clean equipment would include monitoring patients for the signs and symptoms of infection, which usually occur within 48 to 71 hours. Signs and symptoms of infection include:

- fever
- inflammation, or redness and swelling at the site of infection, often accompanied by **edema** and erythema
- purulent or pus-like drainage from wounds
- abnormally elevated white **blood** count
- pain at the site of infection

Complications

There should be no complications from using proper sterilization and aseptic techniques. An allergy to any of the various antiseptics used to sterilize skin prior to surgery may produce dermatitis or irritation. If disinfectant used to clean instruments are not properly rinsed before use, an inflammatory response similar to a first-degree burn may result on surfaces contacted by the solution.

Results

Proper sterilization techniques result in the prevention of infection. Sterilization techniques must be monitored and continually improved upon.

Health care team roles

All health care personnel are responsible for the primary means of preventing infection, which is hand washing. In the early days of nursing, sterilization of equipment and cleanliness of the patient's environment was the nurse's principal responsibility. The nurse still bears responsibility or accountability in these areas even though they may be implemented by others.

- Sterilization technicians work in either the operating room area of a hospital or in the hospital's central supply. They receive special orientation and training in sterile techniques at the health care facility where they are employed. They are responsible for carrying out

KEY TERMS

Bacteria—A group of single-celled organisms that can only be seen under a microscope and sometimes cause disease in other living things.

Fungi—Parasitic single-celled life forms that range from yeasts and mildews to mushrooms. Several minute or microscopic forms cause disease in other living things.

Ionizing radiation—Radiation that causes atoms or groups of atoms to carry a positive or negative electrical charge. Vital processes of life depend upon ions moving across cell membranes.

Non-ionizing—Radiation that does not cause atoms or groups of atoms to carry a positive or negative electrical charge. Vital processes of life depend upon ions moving across cell membranes.

Virus—A submicroscopic infective agent regarded as an extremely simple microorganism or extremely complex molecule capable of growth and multiplication only in living cells.

sterilization procedures and for monitoring sterile equipment conditions and expiration dates. Sometimes nurses or operating room technicians are responsible for providing sterile equipment.

- Some registered nurses (RNs) are certified in **infection control** and are required to keep statistical data on the incidence and types of infections in a health care facility. These RNs typically serve on infection control committees, along with physicians and clinical pharmacists.
- Clinical laboratory scientists have specialized training and must pass a state examination. They draw blood samples and culture wound drainage specimens, which are ordered by the physician to monitor patients for infection and for routine assessment of nosocomial infection sources throughout a facility.

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Sternum see **Thorax, bones of**

Stethoscope

Definition

The stethoscope is an instrument used to listen to sounds produced by the body. It is used to listen to the **lungs, heart**, and intestinal tract.

Purpose

A stethoscope is used to detect and study heart, lung, **stomach**, and other sounds in humans and animals. Using the stethoscope, the listener can hear abnormal respiratory, cardiac, pleural arterial, venous, uterine, fetal, and intestinal sounds.

Description

Stethoscopes vary in their design and material. Most are made of rubber tubing, shaped in a "Y," allowing sound to enter the device at one end, travel up the tubes and through to the ear pieces. Many stethoscopes have a two-sided sound-detecting device, which listeners flip, depending on whether they need to hear high or low frequencies. However, some of the newer models have one pressure-sensitive head. The various types of stethoscopes include: binaural stethoscopes, designed for use with both ears; single, designed for use with one ear; differential, with which listeners can compare sounds at two different body sites; and electronic, which electronically

amplifies tones. Some stethoscopes are designed specifically for hearing the fetal heartbeat or esophagus.

Operation

Some stethoscopes must be placed directly on the skin, while others can work effectively through clothing. For the stethoscopes with a two-part sound detecting device at the end, listeners press the rim against the skin, using the bowl-shaped side, to hear low-pitched sounds. The other flat side, called the diaphragm, detects high-pitched sounds.

Maintenance

In order to avoid the spread of **infection**, stethoscopes should be cleaned after each use—especially when placed directly on the patient's skin.

Health care team roles

Everyone on the health care team uses a stethoscope, as the provider may need to listen to sounds produced by the heart, lungs, stomach, or another body organ often.

Training

Stethoscope users must learn to assess what they hear. When listening to the heart, one must listen to the left side of the chest, where the heart is located. Specifically, it is between the fourth and sixth ribs, almost directly below the breast. The stethoscope must be moved around; the health care provider should listen for different sounds emanating from different locations. The bell of the instrument—generally used to listen to sounds of low pitch, and then its diaphragm—should be used to listen to different areas of the heart. The sounds will be different. "Lub-dub" is the sounds produced by the normal heart. Every time this sound is detected, it means that the heart is contracting one time. The noises represent the heart valves clicking to close. When one hears "lub," the atrioventricular valves are closing, and "dub" means the the pulmonic and aortic valves. Other heart sounds, such as the quiet "whoosh," heard after "lub-dub," reflect the existence of a "murmur." These are heard when the **blood** moves through the heart, and mean that there is "turbulence" in the blood flow. If a valve remains closed, rather than opening completely, one might hear a murmur. These are not at all uncommon; in fact, many people have them and are unaffected.

The lungs and airways require different listening skills than those used to detect heart sounds. The stethoscope must be placed over the chest, and the patient must

breathe in and out deeply, and slowly. Using the bell, the different sounds should be noted in various areas of the chest. Then, the diaphragm should be used in the same way. There will be no wheezes or crackles in normal lung sounds. When performing “percussion,” on the chest, the health care practitioner should be listening for sounds made by sounds the patient makes. One would lightly “thump” around the stethoscope, against the chest, with one finger. Lungs that sound hollow are normal; they have no air in them. Lungs that have a more solid sound appear dead. On percussion, this “dead” sound may be solidification of the lung. In this case, one might make an initial diagnosis of **pneumonia**.

When crackles or wheezes are detected, the practitioner is hearing lung sounds that are abnormal. When the chest wall is being rubbed by the lung, “friction rubs” are detected. When there is fluid in the lungs, crackles will be hard. This is often heard when the patient has pneumonia, or pulmonary **edema**. A high-pitched whistling sound (a wheeze) is often heard when there is pneumonia, or when an airway disease (like bronchitis) is present. Lastly, an infection between the lung and the chest might produce the friction rubs—squeaky noises that infections like pleuritis (an infection between the lung and chest wall) produce.

To listen to the abdomen, the stethoscope should be held over its upper left side. One can hear “gurgling” just under the ribs. The intestines, in the lower part of the abdomen, can also be heard. The noises they make are “borborygmus”—and they are normal. The abdomen is also a site where percussion can be heard. If one thumps all around the bell of the stethoscope, the individual will hear a solid sound, as if the organ is “dead.” When the sound is hollow, it means that the intestinal tract has gas in it.

Despite these somewhat basic instructions, it takes experience and skill to determine what tests might be needed once examination with the stethoscope has been completed. Examination with this instrument is particularly noninvasive, but useful. It can assist the physician and health care team in localizing the problem about which the patient is complaining.

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KEY TERMS

Murmur—A murmur may be heard as blood moves through the heart, when there is “turbulence” in the flow of blood; if a valve remains closed (does not open completely) a murmur might be heard.

Pleuritis—An infection between the lung and the chest wall.

Pulmonary edema—The buildup of fluid in the lungs or respiratory system. Usually results from an increase in pulmonary capillary pressure.

Stethoscope—An instrument used to listen to bodily sounds; used to listen to the lungs, heart, and intestinal tract.

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Lisette Hilton

Stings see **Bites and stings**

Stomach

Definition

The stomach is a muscular J-shaped organ of the digestive tract. It temporarily stores and mixes food; it also secretes gastric juice into the lumen (the hollow inside the stomach) and a hormone called gastrin into the **blood**.

Description

The stomach is located in the upper left quadrant of the abdomen, just beneath the diaphragm. It is positioned between the esophagus (the passage between the mouth and stomach) and the **small intestine**. There is a sphincter (circular muscle) between the esophagus and the stomach, which allows food to pass into the stomach and prevents chyme (the semi-fluid mass into which food is converted by gastric enzymes) from flowing backwards into the esophagus. The pyloric valve is situated between the stomach and the small intestine, which allows chyme to pass into the small intestine and back into the stomach.

The stomach is divided into three general areas. The upper portion of the stomach near the esophagus is called

the fundus; the middle section of the stomach is called the body; and the bottom portion of the stomach where the pyloric sphincter is located is called the antrum. When the stomach is completely distended (expanded), it measures about 10 in (26 cm) by about 4 in (10 cm). It can hold about one quart of semiliquid chyme.

The wall of the stomach is made up of four layers: the mucous, submucous, muscular, and peritoneal layers. The mucous and submucous layers are made up of ridges called rugae. Within the ridges are gastric glands made up of mucous cells, parietal cells, chief cells, and G-cells. Each of these cells secretes a chemical that aids in the process of digestion.

The muscular layer is actually composed of three different layers of smooth muscle, each with fibers running in a different direction: horizontal, vertical, and diagonal. The muscles are responsible for mixing the chyme and moving it through the stomach to the small intestine.

The peritoneal layer is the outer layer of stomach tissue. It is part of the peritoneum that lines the inside of the abdomen, covering most of the organs. It does not play a role in digestion.

The stomach has a large supply of **blood vessels** for the absorption of nutrients from digested food. Branches of the vagus nerve supply both sensory and nervous fibers to the stomach.

Function

Food storage

The stomach's primary role is to act as a temporary receptacle for food. While the food is in the stomach, it is mixed with gastric juices that are secreted by cells in the mucosal layer.

There are three general phases regulating gastric juice secretion. The first, or cephalic, phase occurs before food is actually eaten. The thought, **smell** and sight of food cause the **brain** to send signals to the stomach to increase its gastric secretions. The second phase is the gastric phase, which occurs when food enters the stomach. The food causes the stomach to stretch, which in turn sends nervous impulses to the brain. The brain sends return impulses back to the stomach to begin secreting gastrin. Gastrin then stimulates the release of other gastric juices. The third phase is called the intestinal phase, which occurs when food enters the small intestine. This phase results in a decrease in the movement of chyme into the small intestine, ensuring that the small intestine does not receive too much chyme at one time.

The stomach secretes 2–3 quarts (liters) of gastric juices every day. There are several types of specialized cells in the stomach that secrete gastric juices. Like the **pancreas**, the stomach has both exocrine and endocrine glandular functions. Exocrine secretory glands contain three types of secretory cells: chief cells, parietal cells and mucous cells. Endocrine cells called G-cells are scattered throughout the mucosa.

Exocrine secretions

Exocrine glands are located in the fundus and body of the stomach. The chief cells in these exocrine glands secrete pepsinogen, the inactive precursor of pepsin. Pepsin is an enzyme that is responsible for the initial breakdown of protein molecules into smaller polypeptides. If pepsin did not have an inactive form, it would destroy the chief cells as they produced it. Pepsin can be activated in the stomach, because the stomach lining is protected from its action.

The exocrine glands of the fundus and body of the stomach also contain parietal cells. These parietal cells secrete hydrochloric acid (HCl), which makes the stomach strongly acidic, with a pH of about 2 or 3. This is an optimal pH for the action of pepsin. Hydrochloric acid is responsible for transforming the inactive pepsinogen into active pepsin. The hydrochloric acid in the chyme also stimulates the production of pancreatic and biliary secretions that further stimulate digestion. The acidic environment kills most **bacteria** that enter the digestive tract through the mouth. Parietal cells also release a chemical called the intrinsic factor, which is necessary for the absorption of **vitamin B₁₂**.

Mucous cells release an alkaline mucous fluid into the gastric wall, protecting it against the damaging action of stomach acid. The fluid neutralizes the hydrochloric acid and also acts as a lubricant, protecting the inner lining of the stomach.

Endocrine secretions

The G-cells are the only endocrine cells located in the stomach and are located mainly in the antrum of the stomach where there are few acid producing cells. G-cells release the hormone gastrin into the bloodstream. Gastrin acts on the parietal cells, stimulating them to release hydrochloric acid.

Muscular activity

The stomach must undergo muscular contractions in order to mix food and gastric juices together. These waves of involuntary muscular contractions are called peristalsis. When food is present, peristaltic contractions

pass through the stomach muscles about two or three times every minute and continue at a constant rhythm. Pressure will begin to develop in the lower part of the stomach. When there is sufficient pressure, a small amount of the stomach's contents moves through the pyloric sphincter and into the duodenum (the first section of the small intestine). It takes about two to six hours for the entire contents of the stomach to empty, depending on the composition of the person's diet. Low-fat meals leave the stomach more quickly than high-fat meals. Psychological states also affect the rate of stomach emptying; depression and fear may cause the stomach to empty slowly, while anger and aggression may cause the stomach to empty quickly.

After the chyme has entered the duodenum and the pyloric sphincter has closed, some of the food returns to the stomach through retropulsion. Retropulsion is a process in which the stomach contents are squirted back into the stomach at a rate of about three times per minute. Retropulsion mixes the food with gastric juices and breaks larger clumps of food into smaller pieces.

Role in human health

The stomach prepares food for digestion in the small intestine. If the stomach is not functioning properly, there are many problems that can arise with regard to digestion. Further, the contents of the stomach are so acidic and caustic to other organs of the body that they can cause problems if they leak out of the stomach, as may happen with perforating ulcers of the duodenum or penetrating **wounds** of the abdomen.

Common diseases and disorders

Gastritis

Gastritis is a common health problem. It is an inflammation of the gastric mucosal layer caused by a range of factors, including bacterial infections, medications (particularly NSAIDs), acute **stress**, and spicy foods or alcohol. Gastritis can result in a lowered functioning of chief cells and parietal cells. Less pepsin is provided to the stomach, resulting in incomplete breakdown of **proteins**. There is also less stomach acid secretion, allowing overgrowth of microbial populations and a decrease in the absorption of vitamin B₁₂. Gastritis can occur at any age, but chronic gastritis is frequently seen in the elderly.

Gastroenteritis

Gastroenteritis is another common disorder of the digestive tract, characterized by inflammation of the stomach and the intestines. It is the most common cause

of mortality in underdeveloped nations, and in the United States it ranks second to the **common cold** as a cause of lost work time. Gastroenteritis is caused by specific bacteria (*Staphylococcus aureus*, *Escherichia coli*, etc.), amoebae or other parasites. The symptoms of gastroenteritis include **diarrhea**, nausea, vomiting, and abdominal cramping. Patients can become dehydrated and malnourished if this disorder continues over an extended period of time.

Peptic ulcer disease

Peptic ulcers can occur in the stomach, although they are more likely to develop in the small intestine. Small lesions develop in the mucosal membrane, causing bleeding. Other symptoms include heartburn and indigestion. Researchers think that a bacterium (*Helicobacter pylori*) or heavy consumption of aspirin can cause this type of ulcer. Although peptic ulcer disease can occur in children, it usually affects people 20–50 years of age.

Gastroesophageal reflux

Gastroesophageal reflux (GER) or gastroesophageal reflux disease (GERD) is caused by a malfunctioning sphincter between the esophagus and the stomach, resulting in a release of chyme back into the esophagus. The esophagus cannot tolerate the acidic nature of the chyme. Consequently, the acid causes a burning sensation called "heartburn." Generally, taking **antacids** after meals or medications to reduce acid secretion can relieve GERD. Severe cases may require surgery.

Cancer of the stomach

Cancer of the stomach affects about 24,000 people in the United States each year. It occurs most often in adults over 55; it is more common in men than in women, and more common in African Americans than in Caucasians. Stomach cancer may develop in any part of the stomach and metastasize (spread) to other parts of the digestive tract or to such distant organs as the ovaries or **lungs**. The early symptoms of stomach cancer are often vague and nonspecific, which means that they can be caused by a range of other health problems. A definite diagnosis of stomach cancer requires a series of laboratory tests and a biopsy of a tissue sample obtained by an instrument called a gastroscope.

The most common treatment for stomach cancer is surgical removal of part or all of the stomach. This procedure is called a gastrectomy. Patients with stomach cancer may also be treated with **chemotherapy**, radiation therapy, or immunotherapy.

KEY TERMS

Antrum—The lower portion of the stomach near the pyloric sphincter.

Chyme—The mass of semiliquid, partially digested food found in the stomach.

Fundus—The upper portion of the stomach near the esophagus.

Gastrin—A hormone that stimulates the secretion of gastric juice.

Gastritis—Inflammation of the stomach.

Gastroenteritis—Inflammation of the stomach and the intestines.

Lumen—The hollow inside a tubular organ such as the digestive tract.

Pepsin—An enzyme produced in the stomach that breaks down proteins in the presence of hydrochloric acid.

Peristalsis—Muscular contractions that move food through the digestive tract.

Retropulsion—A process in which muscular contractions push food that has entered the duodenum backward into the stomach. Retropulsion helps to mix the chyme with gastric juices, and to break large lumps of food into smaller pieces.

Rugae—Ridges or folds in the mucosal and submucosal layers of tissue in the wall of the stomach.

Sphincter—A circular band of muscle that encircles an orifice of the body or one of its hollow organs, such as the digestive tract.

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American College of Gastroenterology. 4900 B South 31st Street, Arlington, VA 22206-1656. (703) 820-7400. Fax: (703) 931-4520. <<http://www.acg.gi.org>>.

American Gastroenterological Association. 7910 Woodmont Avenue, 7th Floor, Bethesda, MD 20814. (301) 654-2055. Fax: (301) 652-3890. <<http://www.gastro.org>>.

National Cancer Institute, Office of Cancer Communications. 31 Center Drive, MSC 2580, Bethesda, MD 20892-2580. (800) 4-CANCER (1-800-422-6237). TTY: (800) 332-8615. <<http://www.nci.nih.gov>>.

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Stomach acid determination see **Gastric analysis**

Stomatitis

Definition

Stomatitis is an inflammation of the mucous membranes of the mouth. It may involve the cheeks, gums, tongue, lips, and roof or floor of the mouth. The inflammation may be caused by conditions within the mouth itself, such as poor **oral hygiene** and poorly fitted dentures, or from mouth **burns** caused by hot foods or drinks. It also may be caused by factors affecting the entire body, such as medications, allergic reactions, or infections.

Description

Stomatitis is an inflammation of the lining of any of the soft-tissue structures of the mouth. It is usually a painful condition, associated with redness, swelling, and occasionally bleeding from the affected area. Stomatitis affects all age groups, from infants to the elderly.

Causes and symptoms

A number of factors can cause stomatitis. Poorly fitted oral appliances, cheek biting, or jagged teeth can persistently irritate the oral structures. Chronic mouth

breathing may cause dryness of the mouth tissues, which in turn can lead to irritation. Drinking beverages that are too hot can burn the mouth, causing irritation and **pain**. Some diseases, such as infections (bacterial, viral, and fungal), gonorrhea, measles, leukemia, pellagra, oral erythema multiforme and **AIDS** may present with oral symptoms. **Chemotherapy** and radiation therapy can cause stomatitis by destroying the healthy cells of the oral cavity. Other causes include deficiencies in the **B vitamins** or **vitamin C**, and **iron deficiency anemia**. Stomatitis may also follow overuse of alcohol, tobacco, and spicy foods, as well as exposure to certain toothpastes and mouthwashes. Exposure to heavy metals, such as mercury, lead, or bismuth may also cause stomatitis.

Aphthous stomatitis, also known as “canker sores,” is a specific type of stomatitis that presents with shallow, painful ulcers that are usually located on the lips, cheeks, gums, or roof or floor of the mouth. These ulcers can range from pinpoint size up to 1 inch (2.5 cm) or more in diameter. Though the specific causes of canker sores are unknown, nutritional deficiencies are suspected.

The symptoms of stomatitis may include:

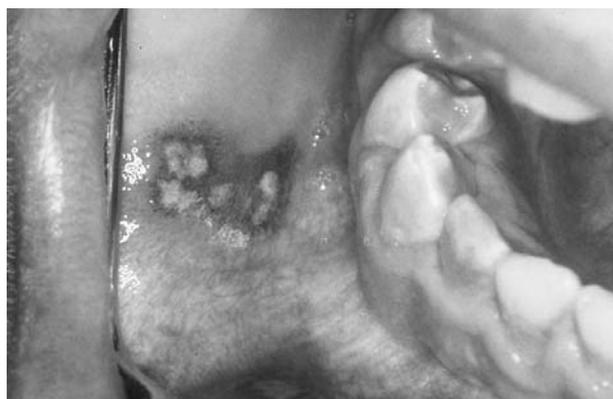
- reddened mucous membranes in the mouth
- painful areas in the mouth
- increased sensitivity to spicy foods
- presence of ulcers in the oral cavity
- dry or swollen tongue
- difficulty swallowing

Diagnosis

The patient will often present with complaints of painful lesions in the oral cavity. The physician or nurse performs a thorough assessment of the mouth, noting any signs of stomatitis. Regular oral examinations are especially important for the patient undergoing **cancer** treatment. A patient’s history may disclose a dietary deficiency, a systemic disease, or contact with materials causing an allergic reaction. **Blood** tests may be done to determine if any **infection** is present. Cultures of the mouth may be sent to the laboratory for microscopic evaluation, again to determine if an infectious agent is causing the stomatitis.

Treatment

The treatment of stomatitis is based on the problem causing it. Local cleansing and good oral hygiene is essential. Sharp-edged foods such as peanuts, tacos, and potato chips should be avoided. A soft-bristled toothbrush should be used, and the teeth and gums should be



This patient is afflicted with stomatitis, a common inflammatory disease of the mouth. (Photograph by Edward H. Gill. Custom Medical Stock Photo. Reproduced by permission.)

brushed very carefully. A dentist can correct local factors, including ill-fitting dental appliances. Infectious causes can usually be treated with **antibiotics** or other medications. Systemic causes, such as AIDS, leukemia, and anemia are treated by the appropriate medical specialist. Minor mouth burns from hot beverages or hot foods will usually resolve on their own in a week or so. Chronic problems with aphthous stomatitis are treated by first correcting any nutritional deficiencies. If those measures are ineffective, medication can be prescribed that is applied to each aphthous ulcer with a cotton-tipped applicator. This therapy is only successful with a limited number of patients. Mouth pain can be alleviated through the use of prescribed topical or oral **analgesics**.

Other treatments include measures to maintain oral hygiene and increase comfort as the stomatitis heals. These measures include:

- Avoiding spicy or acidic foods, or very hot foods.
- Avoiding tobacco products and alcohol.
- Rinsing the oral cavity after meals and before bedtime with a mild saltwater or baking soda and water solution to help keep the mouth clean and free of debris.

Some limited studies have suggested that a few alternative therapies may be effective in preventing and treating stomatitis. These include the use of glutamine, an amino acid; **vitamin E** supplementation; and chamomile mouthwashes. The patient with stomatitis should be instructed to consult their health care professional prior to using any alternative treatments.

Prognosis

The prognosis for the resolution of stomatitis is based on the cause of the problem. Many local factors

KEY TERMS

Aphthous stomatitis—A specific type of stomatitis presenting with shallow, painful ulcers. Also known as canker sores.

can be modified, treated, or avoided. Infectious causes of stomatitis can normally be managed with medications. Uncomplicated cases of stomatitis caused by cancer treatment will usually resolve within two to four weeks.

Health care team roles

The physician and nurse are responsible for thoroughly assessing the oral cavity for signs and symptoms of stomatitis. An awareness of the causes and associated conditions is important when treating the patient. The nurse should instruct the patient on the appropriate treatment and preventative measures, and about any medications used to treat the stomatitis.

Prevention

Stomatitis caused by local irritants can be prevented by good oral hygiene, regular dental checkups, and good dietary habits. Problems with stomatitis caused by systemic diseases can be minimized by practicing good oral hygiene measures, and by closely following the medical therapy prescribed. Cancer patients undergoing treatment can decrease the severity of stomatitis by maintaining good nutritional intake, good oral hygiene, and by having frequent assessments of the oral cavity by their health care professional.

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American Dental Association, 211 E. Chicago Ave., Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org>>.

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Stone analysis

Definition

Kidney stones are solid accumulations of material that form through precipitation in the tubal system of the kidney. Kidney stones cause problems when they block the flow of urine through or out of the kidney. When the stones move along the ureter, they cause severe **pain**.

Gallbladder stones are also solid accumulations of material that form through precipitation in the **liver** and then move into the gall bladder. They cause problems when they block the flow of bile out of the liver or out of the gall bladder. They can cause attacks of gall bladder disease (cholecystitis), hepatitis or **pancreatitis**. They can also cause severe pain.

Purpose

The purpose of analyzing kidney and gallbladder stones is to determine the source of the stones. Different materials can form stones. Once the source of the stones is known, steps can be taken to prevent subsequent formation.

Precautions

An adequately stocked laboratory is needed for accurate analysis of stones. The most difficult aspect of stone analysis is obtaining the stones.

Passing a kidney stone is exquisitely painful. Once passed, persons with stones must strain their urine to recover any stones. Retrieving a kidney stone is painful for the person experiencing the stone. It also requires skill on the part of an operator to retrieve the stone.

A gallbladder stone must also be obtained before chemical analysis can be performed. Gallbladder stones can become lodged at several locations and cause considerable pain and discomfort. Retrieving a stone usually requires surgery. Commonly, the gallbladder is removed in the process of collecting a stone.

Description

Kidney stones

Urine is formed by the **kidneys**. The kidney is made up of microscopic units called nephrons. Each nephron contains a capillary tuft (glomerulus) and a tubule. **Blood** flows into the kidneys, and engorges the capillary tufts. Water and small solutes pass through the vessel walls forming a filtrate of the plasma which enters the underlying space (Bowman’s capsule). The walls of the capsule

form a tubule that traverses the kidney. The cells of the tubule modify the filtrate along its length ultimately forming the urine which passes out of the body. Sometimes, a problem causes the dissolved solutes to become supersaturated resulting in the formation of crystals. When tiny crystals associate together they form a larger solid mass called a kidney stone or calculus. A kidney stone is also called a nephrolith or urolith (nephro-refers to the kidney, uro- refers to urine, and -lith means stone). Kidney stones have multifactorial causes, but some predisposing conditions are:

- **Diet:** Excessive **calcium** in water and foods rich in oxalate or purines can lead to excessive excretion of calcium, oxalate and uric acid in urine.
- **Dehydration:** Water deprivation or loss from other sources causes stasis in the tubules and concentrates the solutes there.
- **Deficiency of inhibitors:** Some dietary substances such as ascorbic acid and citric acid promote loss of organic calcium salts that are soluble. Absence of these can lead to excessive amounts of oxalate and phosphate.
- **Drugs:** Some drugs such as tetracycline are poorly soluble and may precipitate forming stones or become part of the stone matrix.
- **Metabolic disorders:** Hyperparathyroidism causes excessive calcium excretion by the kidneys. Cystine stones form because of a defect in the renal tubular reabsorption of dibasic amino acids, a condition known as cystinuria.
- **Genetics:** Some people produce and excrete greater quantities of certain metabolites such as uric acid.
- **pH:** Most solutes are only soluble within a finite pH range. For example, phosphates and carbonates are insoluble at an alkaline pH. Uric acid and calcium oxalate are insoluble at an acidic pH. People who produce chronic acid urine are more prone to develop uric acid and calcium oxalate crystals.

Many people never find out that they have stones in their kidneys. These stones are small enough to allow the kidney to continue functioning normally, never causing any pain. These are called “silent stones.” Kidney stones cause problems when they interfere with the normal flow of urine. They can block (obstruct) the flow down the tube (the ureter) that carries urine from the kidney to the bladder. The kidney does not normally experience any back pressure. When pressure builds from backed-up urine, the kidney may swell (hydronephrosis). If the kidney is subjected to this pressure for some time, it may cause damage to the delicate kidney structures. In the most severe case, this back pressure causes the pressure in Bowman’s space to equal the **blood pressure** in the

glomerular capillaries and filtration stops. The person stops producing urine, and waste products accumulate in the blood leading to renal failure. When the kidney stone is lodged further down the ureter, the backed-up urine may also cause the ureter to swell (hydronephrosis). Because the ureters are muscular tubes, the presence of a stone will make these muscular tubes spasm, causing severe pain.

About 10% of all people will have a kidney stone in their lifetimes. Kidney stones are most common among:

- Caucasians
- males
- people over the age of 30
- people who previously have had kidney stones
- relatives of persons with kidney stones

Gallbladder stones

Approximately 80% of gallbladder stones are primarily cholesterol (over 70% cholesterol by weight). They also contain bile pigments, bile acids, fatty acids, and calcium salts. The remainder of gall stones are primarily made of bilirubin. The primary constituents are calcium bilirubinate, calcium phosphate, and calcium carbonate. A gallbladder stone is also called a cholelith (chole-refers to the gallbladder and -lith means stone). Cholesterol-rich gallbladder stones typically develop when the following three conditions exist:

- supersaturation of gallbladder, due mainly to increased biliary cholesterol secretion
- abnormally rapid precipitation of micro-crystals of cholesterol due to an excess of promoters and/or a shortage of inhibitors of crystallization
- stasis within the gallbladder due to the combination of impaired motility, primarily reduced emptying in response to food and/or crystal trapping by an abnormally thick mucus glycoprotein on the gallbladder lining

Many people do not realize that they have stones in their gallbladders. These stones are small enough to allow the liver, gallbladder, and **pancreas** to continue functioning normally, never causing any pain. Gallbladder stones cause problems when they interfere with the normal flow of bile. They can obstruct the flow down the common bile duct that carries bile from the gallbladder to the **small intestine**. Gall stones may obstruct the pancreatic duct, the tube that connects the pancreas with the common bile duct. This can cause inflammation of the pancreas (pancreatitis). The pancreas and gall bladder do not normally experience any back pressure. When pressure builds from backed-up bile (gall bladder) or pancreatic secretions (pancreas), swelling

will occur. If the pancreas is subjected to this pressure for some time, it may cause damage to the internal structures of the organ. When the gallbladder is subjected to pressure, it simply enlarges and exerts pressure on the liver. When a gallbladder stone is lodged at the end of the common bile duct (in the Sphincter of Oddi where it opens into the small intestine), the backed-up bile may also cause all of the structures (liver, gallbladder, pancreas and ducts) to swell. Because the ducts have muscle tissue in their walls, the presence of a stone will make them spasm, causing pain.

About 12% of men and 25% of all women will develop gallstones in their lifetimes. Gallbladder stones are most common among:

- Caucasians
- females
- women who have had children
- people over the age of 40
- people who previously have had gallbladder stones
- people who are overweight

Composition of stones

Kidney stones can be composed of a variety of substances. About three-fourths of kidney stones contain calcium. The most prevalent kidney stone is made up of calcium oxalate usually in combination with other calcium salts. In addition to the chemical name, stones are often described by their mineralogical properties. For example, calcium oxalate exists in two forms, the monohydrate which is called whewellite and the dihydrate which is called weddellite. The most common types of kidney stones include:

- calcium oxalate (whewellite and weddellite)
- magnesium ammonium phosphate (struvite)
- tricalcium phosphate (whitlockite); calcium phosphate (apatite); and calcium hydrogen phosphate dihydrate (brushite)
- uric acid stones

Gallbladder stones are usually composed of cholesterol. They also contain some:

- bile pigments
- bile acid
- calcium salts

People who have kidney stones usually do not have symptoms until the stones pass into the ureter. Prior to this, some individuals may notice blood in their urine. Once the stone is in the ureter, however, most people will experience bouts of very severe pain. The pain is crampy

and spasmodic, and is referred to as “colic.” The pain usually begins in the flank region, the area between the lower ribs and the pelvis. As the stone moves closer to the bladder, a person will often feel the pain radiating along the inner thigh. In women, the pain may be felt in the vulva. In men, the pain may be felt in the testicles. Nausea, vomiting, extremely frequent and painful urination, and obvious blood in the urine are common. **Fever** and chills usually mean that the ureter has become obstructed, allowing **bacteria** to become trapped in the kidney causing a kidney **infection** (pyelonephritis).

People who have gallbladder stones usually do not have symptoms until the stones pass into the common bile duct. Once the stone is in the common bile duct, however, most people will experience bouts of pain, especially after eating fatty meals. The pain is also referred to as colicky. The pain usually begins in the upper right quadrant of the abdomen, the area just beneath the right ribs. As the stone moves closer to the Sphincter of Oddi, a person will often feel the pain radiating throughout the entire abdomen. If it obstructs the pancreatic duct, it may be felt in the posterior portion of the abdomen as flank pain. Nausea, vomiting, light (clay) colored stools and flatulence are common. Fever and chills usually mean that the Sphincter of Oddi has become obstructed, forcing pancreatic fluid and liver discharges to be trapped in their respective organs, often causing inflammation of the liver (hepatitis), gallbladder (cholecystitis) and pancreas (pancreatitis).

Preparation

Kidney stones that are less than 5 mm in diameter are usually passed. The physician or nurse must instruct the patient in the proper technique to recover the stone once it is passed. Special laboratory equipment is required for stone analysis. Most clinical laboratories do not perform this service. Consequently the stone must be packaged and mailed to a reference laboratory that performs stone analysis.

Laboratory analysis

For the most part, the analysis is qualitative in nature. Testing involves macroscopic evaluation of the stone. This includes determination of its weight, size, shape, hardness, and color. Kidney stones are usually analyzed by x ray diffraction. The stone is pulverized into a fine powder and the powder is spread over a glass fiber mat and exposed to x rays. The crystals scatter the x rays and the various patterns produced are analyzed to determine the chemical composition. The composition of non-crystalline stones cannot be determined by this method and are usually analyzed by infrared spectroscopy. These

crystals are usually composed of drugs or their metabolites that precipitated in the tubules. In special cases the stone may be analyzed by chemical analysis and by microscopic analysis. For example, cystine stones can be readily detected by grinding a small piece of the stone into a powder. The powder is boiled in a small amount of deionized water and a solution of sodium cyanide is added. The cyanide reduces the cystine to cystiene. After standing for five minutes, several drops of sodium nitroprusside are added. The solution will turn red if cystiene is present. Gall stones are composed of either cholesterol or bilirubin. These can be analyzed by infrared analysis, x ray diffraction or chemical analysis (detection of cholesterol and bilirubin after organic extracton).

Many stones can be seen using a basic x ray, but some cannot. A more sensitive imaging procedure is to use a series of x rays taken after injecting iodine dye into a vein. This procedure is called an intravenous pyelogram (IVP). The dye allows the **urinary system** to be visualized. In the case of an obstruction, the dye will be stopped by the stone or will only be able to get past the stone at a slow trickle.

A cholangiogram is used to visualize the location of a gallbladder stone that is causing an obstruction. A tube is passed though the mouth, throat and **stomach**. It enters the small intestine and is inserted into the Sphincter of Oddi. Dye is injected, allowing the interior of the common bile duct and connected structures to be visualized. As with a kidney stone, the dye is stopped by an obstruction, allowing a radiographer to pinpoint the position of a stone. A CT or MRI scan may also be used to locate a gallbladder stone.

Persons are prepared prior to obtaining a stone for analysis. Preparation for surgery (gallstones) involves anesthesia. Preparation for collecting passed kidney stones involves straining urine through a special sieve. Preparation for surgical collection of a kidney stone involves sedation and passing a catheter through a person's urethra and bladder before entering the ureter.

Aftercare

After stones have been analyzed, the goal becomes preventing subsequent formation by eliminating the cause of the stone.

Prevention

Prevention of kidney stones depends on the type of stone and the presence of an underlying disease. In almost all cases, increasing fluid intake so that a person consistently drinks several quarts of water a day is an important preventive measure. Persons with calcium

stones may benefit from taking a medication called a diuretic, which has the effect of decreasing the amount of calcium passed in the urine. Eating less meat, fish, and chicken may be helpful for individuals with calcium oxalate stones. Other items in the diet that may encourage calcium oxalate stone formation include beer, black pepper, berries, broccoli, chocolate, spinach, and tea. Uric acid stones may require treatment with a medication called allopurinol. Struvite stones will require removal and an affected person should receive an antibiotic. Adjustment of pH is an important preventative measure. For example, if the stone contains calcium phosphate or calcium carbonate or a mixture of these, an acidifier is used to keep the urine pH below seven because these stones form in alkaline urine. When a disease is identified as the cause of stone formation, treatment specific to that disease may lessen the likelihood of repeated stones.

Preventing gallbladder stones is usually accomplished by dietary modification. Fat intake must be diminished. This will also prevent intestinal colic as the gallbladder is usually removed. Drugs that inhibit the formation of cholesterol by the liver may be used. **Niacin**, cholestyramine, cholestipol, lovastatin, simvastatin, pravastatin, fluvastatin and gemfibrozil have all been approved for use in the United States as of 2001. Some experts recommend daily supplements of methionine. The drug ursodiol (Actigall) has also been approved for treatment of gallbladder stones.

Complications

Complications of actual stone analysis include laboratory error. These are very rare.

Complications for people with stones include recurrence. They also may include adverse drug reactions. These, too, are uncommon.

Results

A person with a kidney stone will say that the most important aspect of treatment is adequate pain relief. Because the pain of passing a kidney stone is so severe, narcotic pain medications (such as meperidine or morphine) are often required. It is believed that stones may pass more quickly if a person is encouraged to drink large amounts of water (2-3 quarts, or 2-3 L per day). If an individual is vomiting or unable to drink because of the pain, it may be necessary to provide fluids through a vein. If symptoms and urine tests indicate the presence of infection, **antibiotics** will be required.

A person with a gallbladder stone also finds that the most important aspect of treatment is adequate pain relief. Because the pain of gallbladder disease attacks are

so uncomfortable, pain medications (such as ibuprofen or acetaminophen with codeine) are often required. If symptoms and tests indicate the presence of infection, antibiotics will be required.

Treatment

Although most kidney stones will pass on their own, some will not. Surgical removal of a stone may become necessary when a stone appears too large to pass. Surgery may also be required if the stone is causing serious obstructions, pain that cannot be treated, heavy bleeding, or infection. Several alternatives exist for removing stones. One method involves passing a tube into the bladder and up into the ureter. A tiny basket is then passed through the tube, and an attempt is made to snare the stone and pull it out. Open surgery to remove an obstructing kidney stone was relatively common in the past, but current methods allow the stone to be crushed with shock waves (called **lithotripsy**). These shock waves may be aimed at the stone from outside of the body by passing the necessary equipment through the bladder and into the ureter. The shock waves may be aimed at the stone from inside the body by placing the instrument through a tiny incision located near the stone. The stone fragments may then pass on their own or may be removed through the incision. All of these methods reduce an individual's recovery time considerably when compared to the traditional open operation.

An individual with a gallbladder stone will usually have the gallbladder removed. The most common procedure for this task is a laparoscopic cholecystectomy. Three small incisions are made in the abdomen. Into one, a thin tube with a light and camera lens is passed. Into the second and third, thin tubes through which instruments are inserted, is passed. A surgeon visualizes the interior of the abdomen on a television screen using the camera in the first tube and removes the gall bladder using the instruments inserted through the second and third tubes. Using this approach, post-surgical complications have been reduced and the time required for recovery has been significantly reduced (when compared to traditional open surgical techniques).

Health care team roles

A physician makes an initial diagnosis of kidney or gall stones. A radiologist confirms the diagnosis using x rays or ultrasonography. A surgeon is needed to operatively remove a kidney or gall stone. Lithotripsy is performed by a technician under the supervision of a physician. Occasionally, open surgery is required and is performed by a surgeon. Nurses assist in lithotripsy and surgery. A laboratory specialist performs a chemical analysis of the stone to determine its composition and

origin. Pharmacists may dispense pain medications and antibiotics as required.

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American Academy of Family Physicians, 11400 Tomahawk Creek Parkway, Leawood, KS 66211-2672. (913) 906-6000. <<http://www.aafp.org/>>. fp@aafp.org.

American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. Fax: (847) 434-8000. <<http://www.aap.org/default.htm>>. kidsdoc@aap.org.

American Association for Clinical Chemistry, 2101 L Street, NW - Suite 202, Washington, DC 20037-1558. (800) 892-1400 or (202) 857-0717. Fax: (202) 887-5093. <<http://www.aacc.org>> info@aacc.org

American Foundation for Urologic Disease, 1128 North Charles Street, Baltimore, MD 21201. (800) 242-2383 or (410) 468-1800. <<http://www.afud.org>>. admin@afud.org.

National Kidney Foundation, 30 East 33 rd Street, Suite 1100, New York, NY 10016. (800) 622-9010 or (212) 889-2210. Fax: (212) 689-9261. <<http://www.kidney.org/>>. info@kidney.org.

OTHER

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KEY TERMS

Cholangiogram—X-ray technique used to visualize gallbladder stones.

Cholecystitis—Inflammation of the gallbladder.

Cholelith—Gallbladder stone.

Hepatitis—Inflammation of the liver.

Hydronephrosis—Swelling of a kidney due to elevated pressure from excess fluid accumulation.

Hydroureter—Swelling of a ureter due to elevated pressure from excess fluid accumulation.

Intravenous pyelogram (IVP)—X-ray technique used to visualize kidney stones.

Laparoscopic cholecystectomy—Surgical procedure for removing a gallbladder.

Lithotripsy—Technique that uses focused sound waves to pulverize kidney stones, thus avoiding surgery.

Nephrolith—Kidney stone.

Nephron—Tube within the kidney that processes filtrate from the blood, reclaiming some substances and creating urine.

Pancreatitis—Inflammation of the pancreas.

Pyelonephritis—Infection of the kidney.

Sphincter of Oddi—The opening of the common bile duct into the small intestine.

Ureter—Tube that connects the kidney and urinary bladder. Its function is to transport urine.

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Stool culture

Definition

A stool culture is a laboratory test used to isolate and identify pathogens in the feces of patients suspected of

having digestive tract infections. A sample of the patient's feces is placed on several different types of nutrient media and observed for growth. Any suspicious organisms that grow on the media are identified using microscopic and biochemical tests.

Purpose

Physicians normally order stool cultures on patients with symptoms of gastrointestinal **infection**, most commonly **diarrhea**. The purpose of this test is to isolate **bacteria** or other organisms that might be causing the symptoms so they can be identified. Identification of the causative organism is essential in determining how to treat the patient. For example, administering an antibiotic merely on the basis of the patient's symptoms could, in some cases, make the condition worse.

Precautions

A stool culture is performed only if an infection of the digestive tract is suspected. The test has no harmful effects.

Description

A routine stool culture (also called a fecal culture) is for the isolation of *Campylobacter*, enterotoxigenic *E. coli* (O57:H7), *Shigella*, and *Salmonella*. Less frequently isolated bacterial causes of diarrhea are *Vibrio spp.*, *Yersinia enterocolitica*, and *Aeromonas spp.* Requests for stool cultures for the isolation of other intestinal pathogens should include special instructions. The most common example is *Clostridium difficile*, which causes pseudomembranous colitis.

Stool cultures may be performed on rectal swabs containing feces or submitted stool samples. Swabs are placed in a tube containing Stuart or other transport medium and then delivered to the laboratory. Cultures for *C. difficile* are usually collected by swabbing the rectum (whereas watery stool is needed for immunoassay of *C. difficile toxin*). The swab must be placed immediately into prerduced (oxygen free) transport medium because this organism is a strict anaerobe. To submit a stool specimen for routine culture, the patient or caregiver collects a stool sample in a special container, taking care not to contaminate the specimen with water, urine, or other materials. Some containers include a transport solution to stabilize the specimen. Although some requests are for stool cultures on two or more consecutive days, a single specimen is considered to be sufficient. It is important to return the specimen to the doctor's office or the laboratory in the time specified by the physician or nurse. Laboratories normally do not accept stool specimens that

are contaminated or that arrive after the specified time period.

A routine bacterial stool culture involves placing a sample of the stool on several kinds of enriched and selective media containing nutrients that support the growth of certain types of organisms. Routine culture should include a sheep blood agar plate, MacConkey agar plate, MacConkey agar with sorbitol, Hektoen or XLD (xylose lysine desoxycholate) plate, Campy plate, and GN (gram-negative) broth. Blood agar supports the growth of most bacteria including *Staphylococcus aureus*, *Listeria monocytogenes*, and yeast, which are infrequently implicated in **food poisoning** or gastrointestinal infections, but do not grow on the other media. Most intestinal pathogens are gram-negative bacilli. MacConkey agar is selective for these organisms and differentiates those that can ferment lactose from those that cannot. MacConkey sorbitol substitutes sorbitol for lactose. This allows differentiation of nonpathogenic *E. coli* that ferment sorbitol well from the O57:H7 strain, which does not. Hektoen or XLD enhance the growth of *Salmonella* and *Shigella* by suppressing the growth of gram-positive organisms and gram-negative normal flora. They also differentiate lactose and sucrose fermenters such as *E. coli* from *Salmonella* and *Shigella*, which are not. Several drops of the GN broth can be transferred to Hektoen or XLD agar after a four-hour incubation at 36°C. This procedure can yield isolated colonies of a pathogen the next day that can be used to perform biochemical identification, serotyping, and antibiotic susceptibility tests. Campy agar contains 10% sheep blood, sodium bisulfite, and three **antibiotics**. The sodium bisulfite reduces some of the oxygen in the medium which enhances recovery of *Campylobacter*. The antibiotics prevent other gram-negative bacilli and yeast from growing. All inoculated media except the Campy plate are incubated in air or 5-10% carbon dioxide at 36°C and are examined for growth at 24 hours and again the next day. Campy plates must be incubated at 42°C. Plates are examined at 24 hours and each day for the next two days. Cultures for *Clostridium difficile* require CCFA agar and thioglycolate broth. These are incubated in an oxygen free environment at 36°C for two days. CCFA is cycloserine-cefoxitin fructose agar and it inhibits the growth of other enteric anaerobes found as normal flora in stool. *C. difficile* produces large yellow colonies on CCFA agar that will fluoresce yellow-green.

Gram stains are not performed routinely, but may be requested for the semiquantitation of white blood cells. If any suspicious bacterial colonies grow, they are presumptively identified on the basis of colonial growth, physical characteristics, microscopic features, and biochemical tests. The colonies are subcultured (transferred)

to an appropriate medium to obtain a pure culture. This is used to make a suspension of the organism that is inoculated onto biochemical media. Commercially prepared systems for rapid identification are used. These contain multiple pads or wells of media used to test for key defining biochemical characteristics. After overnight incubation, reactions are read by an automated computerized instrument that aids in species identification. Pure cultures are also used to perform antibiotic sensitivity testing. This is typically done by the microtube broth dilution method. This test determines the minimum inhibitory concentration (MIC) of each antibiotic required to prevent growth of the organism. Results are used to determine those antibiotics to which the organism is susceptible.

The length of time needed to perform a stool culture depends on the laboratory instrumentation and the culture methods used. A routine stool culture usually takes 72 hours or longer to complete.

Preparation

Before ordering a stool culture, the physician, or other health care professional, will ask the patient for a complete medical history and perform a **physical examination** to determine possible causes of the gastrointestinal problem. Information about the patient's diet, any medications taken, and recent travel may provide clues to the identity of possible infectious organisms.

A stool culture normally doesn't require any special preparation. Patients do not need to change their diets before collecting a specimen. Intake of some substances can contaminate the stool specimen and should not be taken the day before collection. These substances include castor oil, bismuth, and laxative preparations containing psyllium hydrophilic mucilloid.

Aftercare

No aftercare is necessary following a stool culture.

Complications

No complications are associated with this test.

Results

Some bacteria that are normal inhabitants of the digestive tract are known as the enteric bacteria. *Escherichia coli*, *Klebsiella*, *Enterobacter*, and *Pseudomonas* are members of this group. The enteric bacteria usually do not cause infection in the digestive tract, and are reported as normal flora in a stool culture. Because the presence of normal flora helps to protect

against pathogens, the absence of normal flora in a stool culture is also reported. When only normal flora are found the results are reported as "no enteric pathogens found." When normal flora are absent from the stool, a heavy growth of an organism not usually pathogenic may be recovered. Such organisms should be reported in this case.

The following bacteria are not normal inhabitants of the digestive tract, and are known to cause gastrointestinal infection:

- *Campylobacter*
- *Shigella*
- *Salmonella*
- *Yersinia*
- enterotoxigenic *E. coli*
- *Vibrio*
- *Aeromonas*

Although non-toxigenic strains of *E. coli* are normal flora of the intestines, *E. coli* O157:H7 is an intestinal pathogen. It produces a toxin (poison or harmful chemical) that causes severe inflammation and bleeding of the colon. Infection with this enterotoxigenic strain of *E. coli* is usually associated with eating contaminated meat, juice, or fruits.

Clostridium difficile, like enterotoxigenic *E. coli*, can produce a toxin that causes severe diarrhea. However, this bacterium does not become harmful unless the normal intestinal bacteria are suppressed. Patients taking certain antibiotics may be susceptible to infection with *Clostridium difficile*. In some cases, the stool culture is used to detect the toxin produced by this bacterium. Other bacteria that produce toxins are *Staphylococcus aureus* and *Bacillus cereus*.

If bacteria are not the cause of an intestinal infection, a fungal or viral culture might be necessary. Patients with **AIDS**, or other **immune system** diseases, sometimes have gastrointestinal infections caused by fungal organisms such as *Candida*, or by viral organisms including *Cytomegalovirus* (CMV). *Candida* can also become an opportunistic intestinal pathogen when antibiotics or radiation have destroyed the normal stool flora.

Several intestinal parasites, such as *Giardia lamblia*, also cause gastrointestinal infection and diarrhea. Parasites are not cultured, but are identified microscopically with a stool ova and parasites test.

Health care team roles

The physician orders the stool culture, evaluates the results, and determines the most appropriate treatment.

KEY TERMS

Bismuth—A substance used in medicines to treat diarrhea, nausea, and indigestion.

Enteric—Pertaining to the intestine.

Enterotoxigenic—Refers to an organism that produces toxins in the gastrointestinal tract that cause such things as vomiting, diarrhea, and other symptoms of food poisoning.

Feces—Material excreted by the intestines.

Gastrointestinal—Referring to the digestive tract; the stomach and the intestines.

Normal flora—Refers to normal bacteria found in a healthy person.

Pathogen—An organism that causes disease.

Psyllium hydrophilic mucilloid—A plant material contained in some laxatives.

Toxin—A poison; usually refers to protein poisons produced by bacteria, animals, and some plants.

Most laboratories provide instructions for the collection of a stool specimen. The physician, nurse, or other health care professional should instruct or assist the patient in collecting the specimen correctly and without contamination. Once the specimen is ready, the patient or health care professional should ensure that the specimen arrives at the laboratory within the time specified. The clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) performs the stool culture and sensitivity tests.

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ORGANIZATIONS

Ontario Association of Medical Laboratories.
<<http://www.oaml.com>>.

UTMB The University of Texas Medical Branch. 301 University Blvd., Galveston, TX 77555. (409) 772-1011.
<<http://www.utmb.edu/>>.

Yale University School of Medicine. 367 Cedar Street, New Haven, CT 06510. (203) 785-2643. <<http://www.info.med.yale.edu/ysm/ysminfo/index.html>>.

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Stool ova & parasites test

Definition

The stool ova & parasites (O & P) test involves examination of a stool (feces) sample for the presence of intestinal parasites. The distinct types of parasites differ with regard to their structures, life stages, and transmission forms. A parasite may be a worm that has a mature form, an immature form (larvae), and eggs (ova). A parasite may be a protozoa with an adult form that lives in the intestines (trophozoite) and a round, encapsulated transmissible form (cyst). Stool analyses examine all parasitic forms that may be present in the sample.

Purpose

The ova and parasites test is performed to identify intestinal parasites and their eggs or cysts in patients with symptoms of gastrointestinal **infection**. Patients may have no symptoms, or may experience **diarrhea**, **blood** in the stools, and other gastrointestinal distress. Stool O & P testing is usually ordered along with tests for the bacterium *Clostridium difficile* as well as a **stool culture** since overlapping symptoms may result from bacterial or parasitic infections. Identification of a particular parasite indicates the cause of the patient's disease and determines the medication needed to treat it.

Precautions

Health care providers should always use proper **infection control** procedures when handling stool samples since they are potentially infectious material.

Description

The stool O & P test is also called the stool ova and parasites test or the ova and parasites collection.

Examination of the stool for ova and parasites is done to diagnose parasitic infection of the intestines. Parasites can go through several different life stages depending on the unique characteristics of each type of parasite. For example, the parasite *Entamoeba histolytica* causes amoebiasis, a parasitic intestinal infection that can cause diarrhea and cramps. This disease is common in developing countries with poor sanitation or in the United States in institutions with poor hygiene practices. The stool of an infected person contains cysts of the parasite. These cysts have a protective covering and can survive outside the body in feces. If food or water is contaminated with such feces, another person can consume the cysts. Mature cysts that are ingested then turn into trophozoites that feed inside the **large intestine**. Some trophozoites then begin to encyst and create protective walls around their small, round center. These cysts are then expelled from the body in feces that can infect food or water, and the transmission process to another person is repeated. Stool O & P tests require the health care professional to identify parasites in a variety of structural forms.

The most common intestinal parasites in North America that cause infections are:

- roundworms: *Ascaris lumbricoides*
- hookworms: *Necator americanus*
- pinworms: *Enterobius vermicularis*
- whipworm: *Trichuris trichiura*
- tapeworms: *Diphyllobothrium latum*, *Taenia saginata*, and *Taenia solium*
- protozoa: *Entamoeba histolytica* (an amoeba), and *Giardia lamblia* (a flagellate)

Numerous other parasites are found in other parts of the world. These may be contracted by travelers to other countries. Patients with acquired immune deficiency syndrome (AIDS) or other **immune system** disorders are commonly infected with the parasites in the Microsporidia phylum, *Cryptosporidium*, and *Isospora belli*.

A stool O & P test may be performed in the physician's office or at an external laboratory. There are several commercial kits with instructions that patients can use at home to collect stool samples. These kits are comprised of sterile containers containing special chemical fixatives. The feces should be collected directly into the container and the patient should be careful not to contaminate the sample with urine, water, or other materials. Three specimens are collected, usually two or three days apart. However, as many as six specimens may be needed within 14 days to identify some organisms (like *E. histolytica*). A specimen held at room temperature should be examined within three hours. If testing is delayed, the

sample may be refrigerated for two to three days or preserved. If a preservative is used, it must preserve all forms of the parasite (including eggs, or cysts and trophozoites, etc.) without interfering with the testing required for the stool sample. A commonly used preservative is the combination merthiolate-iodine-formalin (MIF).

In the laboratory, the stool sample is examined for a variety of parasitic forms. Some parasites are large enough to be seen without a **microscope**. For others, microscope slides are prepared with either fresh unstained stool or stool dyed with special stains. These preparations are viewed with a microscope to detect the presence of parasites or their eggs.

The recovery of ova or parasite forms depends upon the consistency of the stool sample, which suggests the parasitic stage is likely to be present. For example, if the stool specimen is soft or loose, it may be more likely to contain trophozoites. If the stool specimen is formed, then it may be more likely to contain cysts.

A stool examination usually requires three procedures: a direct wet mount, a concentration test, and a permanent smear. A direct wet mount requires preparing a slide with an appropriate fecal sample and then viewing the slide under a microscope for evidence of parasites. In a concentration by sedimentation test, chemicals (most often ethyl acetate and formalin) are used to separate the parasites from other fecal material (oils, **fats**, etc.). When a test tube containing the sample and these chemicals is centrifuged, the sedimentation on the bottom of the tube contains the parasite forms while the fats and other substances are closer to the top of the tube. The sediment is then appropriately processed and examined for parasite forms. A permanent smear is made by preparing a slide with a fecal sample and adding Gomori trichrome stain. When viewed with a microscope, the background appears blue-green while parasite forms stain blue-green and red. This test is required to identify trophozoites and is the most sensitive of the three tests.

Sometimes another method of examination must be used, as is the case for *Cryptosporidium*. Modified acid-fast staining must be used for this organism. When this stain is used, forms of the organism (oocysts) turn red.

Obtaining a specimen to identify pinworm (*E. vermicularis*) infection requires a different technique. Adult parasites lay eggs outside of the intestines on the skin folds of the anus. Eggs are usually not present in stool. Clear adhesive tape or a sticky swab or paddle is applied to the anus. Eggs then stick to the tape, swab, or paddle and can be examined microscopically. When adhesive tape is used, this technique is often called the "scotch tape method" of collection.

KEY TERMS

Amoeba—A type of protozoa (one-celled animal) that can move or change its shape by extending projections of its cytoplasm.

Bismuth—A substance used in medicines to treat diarrhea, nausea, and indigestion.

Cryptosporidium—A type of parasitic protozoa.

Centrifuged—Spun via a centrifuge. A centrifuge is a specialized machine used to spin a test tube at a very fast rotation in order to separate the particles inside the tube into different layers according to their density.

Feces—Material excreted by the intestines.

Flagellate—A microorganism that uses flagella (hair-like projections) to move.

Gastrointestinal—The digestive tract; the stomach and intestines.

Isospora belli—A type of parasitic protozoa.

Microsporidia—A phylum of small parasitic protozoans.

Parasite—An organism that lives on or inside another living organism (host), causing damage to the host.

Protozoa—One-celled eukaryotic organisms belonging to the kingdom Protista.

Immunological testing of stool is a faster diagnostic tool and does not require knowledge of the structures and life stages of parasites. Fresh or fresh-frozen stool is diluted, filtered, and added to a commercial device containing antibodies that will react if several specific parasite antigens are present in the stool sample. If the antigen of the parasite is present, a purple color is produced. However, this type of testing can only be conducted with unpreserved stool and can only assist in identifying a few common parasites.

Insurance coverage for stool ova and parasites may vary among different insurance plans. This test usually is covered if ordered by a physician approved by the patient's insurance plan, and if it is done at an approved laboratory. However, since insurance plans vary greatly, patients should contact their insurance company with regard to specifics.

Preparation

The physician, or other healthcare provider, will ask the patient for a complete medical history, and perform a

physical examination to determine possible causes of the gastrointestinal symptoms. Information about the patient's diet, any medications taken, and recent travel may provide clues to the identity of possible infectious parasites.

Patients should avoid taking any medications or treatments containing mineral oil, castor oil, or bismuth, magnesium or other antidiarrheal medicines, or **antibiotics** for up to 10 days before collecting the specimen.

Aftercare

The patient should avoid taking preparations that interfere with specimens for the duration of time the specimen collection is required.

Complications

There are no complications associated with a patient providing a stool sample for stool O & P testing.

Results

Normally, parasites and eggs are not found in stools. Some parasites are not pathogenic (for example, *Endolimax nana* and *Iodamoeba butschlii*), which means they do not cause disease. If these are found, no treatment is necessary. The presence of any pathogenic parasite indicates an intestinal parasitic infection. Depending on the parasite identified, other tests may be required to determine if the parasite has invaded other parts of the body. Some parasites travel from the intestines to other parts of the body and may already have caused damage to other tissues by the time a diagnosis is made. For example, the roundworm *Ascaris* penetrates the intestinal wall and can cause inflammation in the abdomen. It can also migrate to the **lungs** and cause **pneumonia**. This kind of injury can occur weeks before the roundworm eggs appear in the stool.

Other types of damage caused by intestinal parasites include anemia due to hemorrhage caused by hookworms, and anemia caused by depletion of **vitamin B₁₂** due to infection with the tapeworm *Diphyllobothrium latum*.

When a parasite is identified, the patient can be treated with the appropriate medications to eliminate the parasite.

Health care team roles

Training

A physician orders a stool O & P test. Stool samples may be collected by a physician, nurse, physician assis-

tant, or other trained health care professionals. Laboratory professionals (usually called clinical laboratory scientists or medical technologists) who perform microscopic tests for stool ova and parasites have received specialized training in preparing, handling, and examining the samples. These professionals have been trained to look for specific characteristics of parasite forms that will lead to accurate diagnosis and treatment for the patient.

Patient education

Health care providers should teach the patient how to use the collection kit, how many samples will be required, and how to keep the samples free from contamination. Usually patients should be instructed to take the stool sample in the morning before bathing or taking a shower. Patients should be taught how to avoid re-infection based on how the parasite is contracted when a definite diagnosis is made. For example, patients with pinworms should practice sound personal hygiene in the future such as washing hands after using the restroom and before eating, and wearing clean undergarments daily. Patients with tapeworms should avoid eating specific raw or undercooked meat or fish in the future. Health care providers should also stress that patients follow the full duration of treatment as required to eliminate the parasite.

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- The American Society for Microbiology. 1752 N St. N.W., Washington, DC 20036. (202) 737-3600. <www.asmtusa.org>.
- Centers for Disease Control and Prevention. National Center for Infectious Disease. Division of Parasitic Diseases. 1600 Clifton Road NE, Atlanta, GA 30333. (800) 311-3435. <www.cdc.gov/ncidod/dpd>.

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Stool ova and parasites test see **Stool O & P test**

Stool specimen collection

Definition

Stool specimen collection is the process of obtaining a sample of a patient's feces for diagnostic purposes.

Purpose

This procedure is used to test for infectious organisms, mucus, fat, parasites, or **blood** in the stool.

Precautions

Depending on the proposed analysis of the feces, watery feces will not be suitable for conducting a test for any fat that may be present, but can be used for other analyses, such as testing for **bacteria**.

Description

A stool specimen or culture can also be called a fecal specimen or culture. A specimen of freshly passed feces of 1/2 to 1 ounce (15 g to 30 g) is collected, without contamination of urine or toilet tissue, into a small container that may have a small spoon or spatula attached inside the lid of the cup for easier collection of the sample.

Adult and older children patient can collect the specimen by passing feces into plastic wrap stretched loosely over the toilet bowl. A portion of the sample is then transferred into the supplied container.

With young children and infants wearing diapers, the diaper should be lined with plastic wrap. A urine bag can be attached to the child to ensure that the stool specimen is not contaminated with urine.

For a bedridden patient, the specimen should be collected in a bedpan lined with plastic wrap, and the nurse can transfer a portion of the feces into the appropriate container.

KEY TERMS

Barium sulfate—A water-insoluble salt used as an opaque medium for radiographic contrast.

Occult blood—Hidden blood.

Parasite—An organism that lives on or in another host.

Follow the manufacturer's guidelines if a commercial collection kit is used.

Preparation

If occult blood is suspected, the patient should be given a mild laxative and should avoid eating foods rich in meat extracts or leafy vegetables three days prior to the test. If the patient's gums bleed when brushing their teeth, the mouth should be cleansed with mouthwash and wiped with a cloth to avoid blood entering the digestive system and contaminating the stool specimen.

Certain drugs may interfere with the analysis of the specimen, and the patient should avoid ingesting products such as **antacids**, oily foods and drugs, and **antibiotics**. Barium sulfate should be excluded two weeks prior to the test, and medical procedure dyes three weeks prior to the test.

If fat in the stool is suspected, the patient will also be asked to collect the samples in pre-weighed airtight containers.

All feces passed in a 24-hour period are collected over two or three days and sent daily for analysis.

Aftercare

The patient should be made clean and comfortable.

All contents of kits, towels, plastic wrap, gloves, and bedpans should be disposed of in appropriate containers. The nurse should wash and dry his or her hands thoroughly.

Speed in testing the sample is essential, in order that an accurate result is obtained. Therefore the specimen should be sent for testing as quickly as possible.

Complications

If there is a delay in sending the specimen for testing, organisms present in the feces may die, while others may multiply, giving a false reading.

Patients should inform medical staff of any medications currently being taken as elements of the drugs may be present in the feces.

Results

The specimens are compared with normal values. Abnormal results indicate that **infection**, disease, or parasite infestation are present.

Health care team roles

The nurse should be aware of the qualities of normal feces, and note if the patient has any difficulties in passing feces. As many patients may feel uncomfortable performing this collection properly, the nurse should also educate the patient concerning the reasons for having it done.

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Margaret A Stockley, RGN

Strains *see* **Sprains and strains**

Strength testing *see* **Muscle testing**

Strep culture *see* **Throat culture**

Strep test *see* **Streptococcal antibody tests**

Strep throat

Definition

Strep throat is an **infection** of the mucous membranes lining the pharynx. Sometimes the tonsils are also infected (tonsillitis). The infection is caused by group A beta-hemolytic *Streptococcus* **bacteria**, commonly known as strep.

This bacterial infection typically causes a severe **sore throat**, **fever**, and difficulty swallowing. Strep throat may also produce a rash, known as scarlet fever, and swollen glands. Untreated, it can lead to rheumatic

fever, a serious kidney disorder called glomerulonephritis, and other infections.

Description

Strep throat accounts for 5-10% of all sore throats. Although anyone can get strep throat, it is most common in school-age children. It accounts for about one quarter of sore throats in children ages five to 15. Smokers, and people who are fatigued, immunosuppressed, or who live in damp, crowded conditions are more likely to become infected. Children under age two and adults who do not have contact with children are less likely to become infected.

Strep throat occurs most frequently from November to April. The disease passes directly from person to person by coughing, sneezing, and close contact. Rarely, it may be passed through food, when a food handler infected with strep throat accidentally contaminates food by coughing or sneezing. Statistically, when one member of a household is infected, one out of every four other household members will contract strep throat within two to seven days.

Causes and symptoms

Strep infection may produce a sudden, painful sore throat one to five days after exposure to the *Streptococcus* bacteria. The **pain** is indistinguishable from sore throats caused by viral infections.

The infected patient usually feels tired and has a fever, sometimes accompanied by chills, headache, muscle aches, swollen lymph glands, and nausea. Young children may complain of abdominal pain. The tonsils appear swollen and are bright red, and may have white or yellow patches of pus. Sometimes the roof of the mouth is red or has small red spots. Often a person with strep throat has bad breath.

Though most patients display some of these common symptoms, it is possible to have the disease without any of these symptoms. Many young children complain only of a headache and stomachache, rather than the characteristic sore throat.

Occasionally, within a few days of developing the sore throat, patients may develop a fine, rough, sunburn-like rash over the face and upper body, along with a fever of 101-104°F (38.3-40°C) and bright red tongue, with a flecked, strawberry-like appearance. When a rash develops, this form of strep throat is called scarlet fever. The rash is caused by toxins released by the streptococcus bacteria. Scarlet fever is no more dangerous than strep throat, and is treated the same way. The rash disappears in about five days. One to three weeks later, patches of

skin may desquamate (peel off), as might occur with a sunburn.

Untreated strep throat can cause rheumatic fever. This is a serious illness, although it occurs rarely. The most recent outbreak appeared in the United States in the mid-1980s. Rheumatic fever occurs most often in children between the ages of five and 15, and susceptibility to it may be genetic, since it seems to run in families. Although the strep throat that causes rheumatic fever is contagious, rheumatic fever itself is not.

Rheumatic fever begins one to six weeks after an untreated streptococcal infection. The joints, especially the wrists, elbows, knees, and ankles become red, sore, and swollen. The patient develops a high fever, and possibly a rapid heartbeat when lying down, paleness, shortness of breath, and fluid retention. A red rash over the trunk may come and go for weeks or months. An acute attack of rheumatic fever lasts about three months.

Rheumatic fever can cause permanent damage to the **heart** and heart valves. It can be prevented by promptly treating streptococcal infections with **antibiotics**. It does not occur if all the streptococcus bacteria are killed within the first 10-12 days after infection.

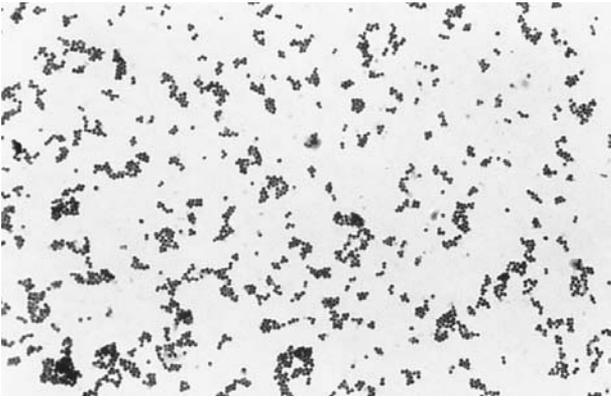
During the 1990s, outbreaks of a virulent strain of group A *Streptococcus* were reported to cause a toxic-shock-like illness and a severe invasive infection called necrotizing fasciitis, which destroys skin and muscle tissue. Although these diseases are caused by group A *Streptococci*, they rarely begin with strep throat. Usually the streptococcus bacteria enter the body through a skin wound. These infections are rare, however, since the death rate in necrotizing fasciitis is 30-50%, it is wise to promptly treat any streptococcal infection.

Diagnosis

Diagnosis of strep throat begins with a **physical examination** of the throat. The doctor will also look for signs of other illness, such as a sinus infection or bronchitis, and seek information about whether the patient has been exposed to anyone with strep throat. Patients likely to have strep throat will have a rapid strep test or **throat culture**, laboratory tests to detect the presence of bacteria.

There are two types of tests to confirm the diagnosis of strep throat. A rapid strep test determines the presence of streptococcal antigen, and results are available in about 20 minutes. The advantage of this test is the speed with which a diagnosis may be made.

The rapid strep test has a false negative rate of about 20%. For this reason, when a rapid strep test is negative, the physician may order a throat culture.



Gram stain of *Streptococci*. (Delmar Publishers, Inc. Reproduced by permission.)

For a rapid strep test or a throat culture, a physician, mid-level practitioner (i.e., nurse practitioner or physician assistant) or nurse will use a sterile swab to reach down into the throat to obtain a sample of material from the sore area. The procedure takes only a few seconds, but may cause some patients to gag.

For a throat culture, a sample of swabbed material is cultured, or grown, in the laboratory on a medium that allows laboratory technologists and technicians to accurately determine whether group A *streptococci* is present. Results are available in 24-48 hours. This test is very accurate and also detects the presence of bacteria other than *Streptococci*. Patients should be reminded by the nurse not to take antibiotics before a throat culture. Even small amounts of antibiotics can suppress the bacteria enough to mask their presence in the throat culture.

In the event that rheumatic fever is suspected, the physician will order a **blood** test. This test, called an anti-streptolysin-O test, determines whether the person has recently been infected with strep bacteria and helps to distinguish between rheumatic fever and rheumatoid arthritis.

Treatment

Strep throat is treated with antibiotics. Penicillin is the preferred medication. The typical dose for adults is Penicillin V, 250 mg by mouth, four times a day or 500 mg twice a day. Alternatively, 250 mg of erythromycin may be given four times a day. Oral antibiotics must be taken for 10 days. Patients must be advised to take the entire amount of antibiotic prescribed. They must be warned not to discontinue taking the medication when they feel better. Stopping the antibiotic early or failing to complete the prescribed course of medication can lead to a return of the strep infection. Occasionally, a single injection of benzathine penicillin G 1.2 million units IM

(intramuscularly) is given instead of 10 days of oral treatment.

About 10% of the time, penicillin is not effective against the strep bacteria. In such instances, other antibiotics such as amoxicillin (Amoxil, Pentamox, Sumox, Trimox), clindamycin (Cleocin), or a cephalosporin (Keflex, Durocef, Ceclor) may be prescribed. Erythromycin (Eryzole, Pediazole, Ilosone), another inexpensive antibiotic, is given to patients who are allergic to penicillin. Scarlet fever is treated with the same antibiotics as strep throat.

Without treatment, the symptoms of strep throat begin subsiding in four or five days. However, because of the possibility of contracting rheumatic fever, glomerulonephritis, or other infections, it is vital to treat strep throat promptly with antibiotics. If rheumatic fever does occur, it also is treated with antibiotics. Anti-inflammatory drugs are used to treat joint swelling and diuretics are used to reduce water retention. Once the rheumatic fever becomes inactive, children may continue on low doses of antibiotics to prevent a reoccurrence. Necrotizing fasciitis is treated with intravenous antibiotics.

Home care for strep throat

Patients may be taught home care measures to relieve the discomfort of their strep symptoms. They may be counseled by the nurse, mid-level practitioner, or physician to:

- Take acetaminophen or ibuprofen for pain. Aspirin should not be given to children because of its association with Reye's syndrome.
- Gargle with warm double strength tea or warm salt water, made by adding one teaspoon of salt to eight ounces of water, to relieve sore throat pain.
- Drink plenty of fluids, but avoid acidic juices like orange juice because they irritate the throat.
- Eat soft, nutritious foods like noodle soup. Avoid spicy foods.
- Avoid smoke and smoking.
- Rest until the fever is gone, then resume strenuous activities gradually.
- Use a room humidifier, as it may make sore throat sufferers more comfortable.
- Be aware that antiseptic lozenges and sprays may aggravate the sore throat rather than improve it.

Alternative treatment focuses on easing the symptoms of strep throat through herbs and botanical medicines. Honey, eucalyptus, and menthol-infused drops and syrups may all soothe the soreness of strep throat. These

treatments should never be used in place of antibiotic therapy. They should be used in addition to antibiotics, since they address symptoms rather than the underlying infection.

Prognosis

Patients with strep throat begin feeling better about 24 hours after starting antibiotics. Symptoms rarely last longer than five days.

Patients remain contagious until they have taken antibiotics for 24 hours. Children should not return to school or childcare until they are no longer contagious. Food handlers should not work for the first 24 hours after antibiotic treatment, because strep infections are occasionally passed through contaminated food. People who are not treated with antibiotics can continue to spread strep bacteria for several months.

About 10% of strep throat cases do not respond to penicillin. Patients with even a mild sore throat after a 10 days of antibiotic treatment should be advised to return to the doctor. One explanation for a persisting sore throat may be that the patient is simply a carrier of strep, and the sore throat is the result of another infectious (bacterial or viral) agent.

Timely administration of antibiotics within the first week of a strep infection acts to prevent rheumatic fever and other complications. If rheumatic fever does occur, the outcomes vary considerably. Some cases may be cured; others cause permanent damage to the heart and heart valves. In rare cases, rheumatic fever can be fatal.

Necrotizing fasciitis has mortality (death rate) of 30-50%. Patients who survive often suffer a great deal of tissue and muscle loss. Fortunately, this complication of a *Streptococcus* infection is very rare.

Health care team roles

Physicians, nurses, mid-level practitioners, and laboratory technologists are involved in the diagnosis and treatment of strep throat. In contacts with patients they can reinforce the value of adherence to prescribed treatment and can instruct patients in self-care and home care measures to relieve symptoms.

Patient education

Nurses, mid-level practitioners, and laboratory personnel have opportunities to teach patients how to minimize the risks of transmission by reinforcing the importance of personal hygiene, safe food handling, and avoiding exposures. They must also emphasize the

KEY TERMS

Desquamate—To peel off or exfoliate the skin.

Glomerulonephritis—A serious kidney disorder that sometimes results from an untreated strep infection.

Lactobacillus acidophilus—A bacteria found in yogurt that changes the balance of the bacteria in the intestine in a beneficial way.

importance of prompt and complete treatment of strep infection to prevent consequences and recurrence.

Prevention

There is no way to prevent getting a strep throat. Patients may be counseled about how to reduce the risk of transmission. Risk may be minimized by:

- Washing hands well and frequently, especially after nose blowing or sneezing and before food handling.
- Disposing of used tissues properly.
- Avoiding close contact with someone who has a strep throat.
- Not sharing food and eating utensils with anyone.
- Not smoking.

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Barbara Wexler

Streptococcal antibody tests

Definition

If left untreated, upper respiratory or skin infections caused by Group A streptococci (*Streptococcus pyro-*

genes) can develop complications, called sequelae. These include scarlet and rheumatic **fever** and a kidney disease called post streptococcal glomerulonephritis (a sequelae to respiratory but not skin infections). Streptococcal antibody tests detect antibodies to various antigens secreted by Group A streptococci. These include tests for antibodies to streptolysin O, DNase-B, and hyaluronidase that contribute to the virulence of Group A streptococcal infections. Four major streptococcal antibody tests are the antistreptolysin O titer (ASO), antideoxyribonuclease-B titer (anti-DNase-B, or ADB), anti-hyaluronidase (AH), and Streptozyme test. Other tests to determine past streptococcal infections have been developed including the anti-CHO test (possible use for rheumatic fever) and the anti-preabsorption antigen test (for glomerulonephritis).

Purpose

Tests for streptococcal antibodies are performed in order to document a recent **infection** with Group A streptococcus (*Streptococcus pyrogenes*). The antistreptolysin O titer, or ASO, is ordered primarily to determine whether a previous Group A streptococcus infection has caused a post streptococcal disease, such as scarlet fever, rheumatic fever, or glomerulonephritis. The ASO test also detects Groups C and G streptococci, which also produce streptolysin O. Antibodies to streptolysin O are produced in approximately 75-80% of Group A streptococcus infections, but are usually not seen in skin infections caused by this organism. The antibodies are usually detected within one to two weeks following acute pharyngitis.

The anti-DNase-B (ADB) test is also performed to determine a previous infection with Group A streptococci. Antibodies to DNase-B appear almost exclusively in Group A streptococcal infections, appear somewhat earlier than those to streptolysin O, and are produced by 85-90% of persons with group A streptococcal skin infections. When used with the ASO test, the ADB test adds clinical sensitivity.

The antihyaluronidase (AH) test is used as an adjunct to ASO testing (increases clinical sensitivity when used along with the ASO test). This test is not as sensitive as the ASO test, but antibodies to hyaluronidase are produced by some patients with either skin or respiratory infections with Group A streptococci.

Streptozyme is a screening test used to detect antibodies to several streptococcal antigens. An antigen is a substance that can trigger an **immune response**, resulting in production of an antibody as part of the body's defense against infection and disease. The test is not as sensitive or specific as the ASO test, but can be per-

formed within minutes, providing presumptive results that can be confirmed by use of the ASO or other more specific streptococcal antibody tests.

Precautions

Streptococcal antibody tests are performed on a **blood** (serum) sample collected by venipuncture. The nurse or phlebotomist performing the procedure should observe **universal precautions** for prevention of transmission of bloodborne pathogens. Hemolyzed blood samples are unsuitable for these tests. Increased levels of **fats** (beta lipoproteins) in the blood can cause false-positive test results. Antibiotic therapy can reduce the number of streptococci and decrease levels during these tests, giving a false negative. Steroids may also give false negative results. Group A streptococcal infections of the skin may not produce an ASO response. False negatives in the ASO test may arise from antibody deficiency syndromes, and false positives from hypercholesterolemia, hyperglobulinemia, and **liver** disorders. A false negative result in the ADB test may occur during hemorrhagic **pancreatitis**. The streptozyme test is more sensitive for adult patient samples than those obtained from children.

Description

Streptococcal infections are caused by **bacteria** known as *Streptococcus*. There are several disease-causing strains of streptococci (groups A, B, C, D, and G), which are identified by their clinical effects, biochemical characteristics, growth requirements, appearance on culture media, cell wall composition, and antigen production. Each group causes specific types of infections and symptoms. These antibody tests are useful for detecting a recent respiratory or skin infection caused primarily by group A streptococci.

Group A streptococci are the most virulent species for humans and are the cause of pharyngitis (**strep throat**), tonsillitis, wound and skin infections, blood infections (septicemia), scarlet fever, **pneumonia**, rheumatic fever, Sydenham's chorea (formerly called St. Vitus' dance), and post streptococcal glomerulonephritis.

Although symptoms may suggest a streptococcal infection, the diagnosis must be confirmed by tests. The best procedure, and one that is used for an acute infection, is to take a sample from the infected area for culture, a means of growing bacteria artificially in the laboratory. However, cultures will be negative for growth approximately two to three weeks after the initial infection. Consequently, the streptococcal antibody tests are used to determine if a streptococcal infection was present.

Antistreptolysin O titer (ASO)

The ASO titer is used to detect the body's reaction to an infection caused by group A beta-hemolytic streptococci. Group A streptococci (also Group C and G) produce the enzyme streptolysin O, that can destroy (lyse) red blood cells. Because streptolysin O is antigenic (contains a protein foreign to the body), the body reacts by producing anti-streptolysin O antibody (ASO), a neutralizing antibody. ASO appears in the blood one week to one month after the onset of a strep infection. A high titer (high levels of ASO antibody) is indicative that a streptococcal infection is present or may have happened in the recent past.

ASO testing can be done as a screening test by a rapid slide agglutination method. If positive, the antibody concentration is determined by the classical tube test. In this test, a standardized solution of streptolysin O is added to tubes containing serial dilutions of the patient's serum. After incubating, human group O red blood cells are added. If antibodies are present, they neutralize the streptolysin O and no hemolysis is seen. The antibody concentration (titre) is the highest dilution of the serum that shows no evidence of hemolysis.

Several, sequential tests for ASO are often performed over time (serial testing) to determine if the blood sample is acute or convalescent. The diagnosis of a previous strep infection is confirmed when serial titers of ASO rise over a period of weeks, then fall slowly. A four-fold or greater rise in titre from the acute to convalescent stage is considered diagnostic. ASO titers peak during the third week after the onset of acute symptoms of a streptococcal disease; at six months after onset, approximately 30% of patients still exhibit abnormal titers.

Anti-deoxyribonuclease B titer (anti-DNase B, or ADB)

Anti-DNase B, or ADB, also detects antigens produced by group A strep, and is elevated in most patients with rheumatic fever and post streptococcal glomerulonephritis. This test is often done concurrently with the ASO titer, and subsequent testing is usually performed to detect differences in the acute and convalescent blood samples. When ASO and ADB are performed concurrently, 95% of previous strep infections are detected. If both are repeatedly negative, the likelihood is great that the patient's symptoms are not caused by a post streptococcal disease. The ADB test is performed by measuring the ability of the serum to block the breakdown by streptococcal DNase B of calf thymus DNA bound to a dye. If the DNA is split by the enzyme, the color changes from blue to pink. If antibodies to DNase B are present in the

KEY TERMS

Antibody—A protein manufactured by a type of white blood cell, the lymphocyte, in response to the presence of an antigen, or foreign protein, in the body. Because bacteria, viruses, and other organisms commonly contain many antigens, antibodies are formed against these foreign proteins to neutralize or destroy the invaders.

Antigen—A substance that can trigger a defensive response in the body, resulting in production of an antibody as part of the body's defense against infection and disease. Many antigens are foreign proteins not found naturally in the body, and include bacteria, viruses, toxins, and tissues from another person used in organ transplantation.

Glomerulonephritis—An inflammation of the glomeruli, the filtering units of the kidney. Damage to these structures hampers removal of waste products, salt, and water from the bloodstream, which may cause serious complications. This disorder can be mild and cause no symptoms, or severe enough to cause kidney failure.

Rheumatic fever—A disease that causes inflammation in various body tissues. It is rare in most developed countries, but reported to be on the increase again in parts of the United States. Joint inflammation occurs, but more serious is the frequency with which the disease permanently damages the heart. The nervous system may also be affected, causing Sydenham's chorea.

Sydenham's chorea—A childhood disorder of the central nervous system. Once called St. Vitus' dance, the condition is characterized by involuntary, jerky movements that usually follow an attack of rheumatic fever. It is rare in the United States today, but a common disorder in developing countries. It usually resolves in two to three months with no long-term adverse effects.

serum, they neutralize the enzyme and the color remains blue.

When evaluating patients with acute rheumatic fever, the American Heart Association recommends the ASO titer rather than ADB. Even though the ADB is more sensitive than ASO, its results are more variable. It also should be noted that, while ASO is the recommended test, when ASO and ADB are done together, the combination is better than either ASO or ADB alone.

Antihyaluronidase (AH)

Group A streptococci produce an enzyme called hyaluronidase. If a patient with a recent infection with this organism produces antihyaluronidase, the level of antibodies in the blood against this enzyme will rise at about the second week of infection and decline for three to five weeks afterward. The patient's serum is diluted and streptococcal hyaluronidase added to each dilution. After incubation, potassium hyaluronate is added. If hyaluronidase is present, it will breakdown the hyaluronate by hydrolysis. Consequently, a clot will not form when acetic acid is added. If antihyaluronidase is present, it will neutralize the streptococcal hyaluronidase. The potassium hyaluronate added subsequently will not be hydrolyzed by the enzyme. The addition of acetic acid cross links the hyaluronate forming a mucin clot. The highest dilution of serum that forms a clot is the titer. This test is advantageous when used along with the ASO test because it increases clinical sensitivity. However, it should not be used as a singular test for streptococcal antibodies. False positive results may occur from hyperlipoproteinemia.

Streptozyme

The Streptozyme test is often used as a screening test for antibodies to the streptococcal antigens NADase, DNase, streptokinase, streptolysin O, and hyaluronidase. Streptozyme has two advantages over ASO and ADB. It can detect several antibodies in a single assay, and it is technically quick and easy to perform. However, the Streptozyme test is less sensitive and specific than the ASO test. While it detects different antibodies, it does not determine which one has been detected, and it is not as sensitive in children as in adults. In fact, borderline antibody elevations, which could be significant in children, may not be detected at all. A dilution of serum is mixed with sheep red cells that are coated with streptococcal antigens. A positive test is denoted by red blood cell clumping (agglutination).

Preparation

These tests are performed on blood specimens drawn from the patient's vein. The patient does not need to fast before these tests.

Aftercare

The patient may feel discomfort when blood is drawn from a vein. Bruising may occur at the puncture site, or the person may feel dizzy or faint. Pressure should be applied to the puncture site until the bleeding stops to reduce bruising. Warm packs can also be placed

over the puncture site to relieve discomfort. Patients should be informed if serial testing requires return visits.

Complications

The risks associated with these tests are minimal, but may include slight bleeding from the blood-drawing site, fainting or feeling lightheaded after the blood is drawn, or blood accumulating under the puncture site (hematoma).

Results

Normal results

Antistreptolysin O titer:

- Adult: up to 160 Todd units.
- Child: 6 months–2 years: up to 50 Todd units; 2–4 years: up to 160 Todd units; 5–12 years: 170–330 Todd units.
- Newborn: similar to the mother's value.

Antideoxyribonuclease-B titer:

- Adult: up to 85 units.
- Child (preschool): up to 60 units.
- Child (school age): up to 170 units.

Antihyaluronidase (AH):

- Titer less than 1:512.
- Streptozyme: less than 100 streptozyme units.

Abnormal results

Antistreptolysin O titer: Increased levels are seen after the second week of an untreated acute streptococcal infection, and are also increased with acute rheumatic fever, acute glomerulonephritis, scarlet fever, and other complications of streptococcal infection.

Antideoxyribonuclease-B titer: Increased levels are seen after the first week of an untreated acute streptococcal infection, and are also increased with acute rheumatic fever, acute glomerulonephritis, scarlet fever, and other complications of streptococcal infection.

Titer greater than 1:512. A rise in the titer between and acute patient sample of greater than fourfold is indicative of infection.

Streptozyme: As this is a screening test for antibodies to streptococcal antigens, increased levels require more definitive tests to confirm diagnosis.

Health care team roles

Streptococcal antibody tests are ordered by a physician. The nurse or phlebotomist collects the specimen and conveys it to the lab. The clinical laboratory scientist/medical technologist or clinical laboratory technician/medical technician performs the test. Results are interpreted by the physician.

Resources

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Jill I. Granger, M.S.

Streptococcal sore throat see **Strep throat**

Stress

Definition

Stress is defined as an organism's total response to environmental demands or pressures. When stress was first studied in the 1950s, the term was used to denote both the causes and the experienced effects of these pressures. Since the 1990s, however, the word stressor has been used for a stimulus that provokes a stress response. One recurrent disagreement among researchers concerns the definition of stress in humans. The issue is whether it is primarily an external response that can be measured by changes in glandular secretions, skin reactions, and other physical functions—or if it is an internal interpretation of, or reaction to, a stressor, or both.

Description

Stress in humans results from interactions between persons and their environment that are perceived as straining or exceeding their adaptive capacities and threatening their well-being. The element of perception indicates that human stress responses reflect differences in personality, as well as differences in physical strength or general health. Researchers have found that stressors can be:

- acute, such as a disaster or death of a loved one
- sequential, such as events leading up to a job promotion or a move
- intermittent, such as college exams
- chronic, such as living with a life-threatening illness, being in an unhappy marriage, or living in poverty

Risk factors for stress-related illnesses are a mix of personal, interpersonal, and social variables. These factors include lack or loss of control over one's physical environment, and lack or loss of social support networks. People who are dependent on others (e.g., children or the elderly) or who are socially disadvantaged (i.e., because of race, gender, education level, or similar factors) are at greater risk of developing stress-related illnesses. Other risk factors include feelings of helplessness, hopelessness, extreme fear or anger, and cynicism or distrust of others.

Causes and symptoms

The causes of stress can include any event or occurrence that a person considers a threat to his or her coping strategies or resources. Researchers generally agree that a certain degree of stress is a normal part of a living organism's response to the inevitable changes in its physical or social environment, and that positive, as well as negative, events can generate stress as well as negative occurrences. Stress-related disease, however, results from excessive and prolonged demands on an organism's coping resources.

The symptoms of stress can be either physical and psychological. Stress-related physical illnesses, such as irritable bowel syndrome, **heart** attack, and chronic headache, result from long-term overstimulation of a part of the nervous system that regulates the heart rate, **blood pressure**, and **digestive system**. Stress-related emotional illness results from inadequate or inappropriate responses to major changes in one's life situation, such as marriage, completing one's education, becoming a parent, losing a job, or retiring. Psychiatrists sometimes use the term adjustment disorder to describe this type of illness. In the workplace, stress-related illness often takes

KEY TERMS

Adjustment disorder—A psychiatric disorder marked by inappropriate or inadequate responses to a change in life circumstances. Depression following retirement from work is an example of adjustment disorder.

Burnout—An emotional condition, marked by tiredness, loss of interest, or frustration, that interferes with job performance. Burnout is usually regarded as the result of prolonged stress.

Stress hardiness—A personality characteristic that enables persons to stay healthy in stressful circumstances. It includes belief in one's ability to influence the situation; being committed to or fully engaged in one's activities; and having a positive view of change.

Stress management—A category of popularized programs and techniques intended to help people deal more effectively with stress.

Stressor—A stimulus, or event, that provokes a stress response in an organism. Stressors can be categorized as acute or chronic, and as external or internal to the organism.

the form of burnout—a loss of interest in, or ability to perform, one's job—due to long-term high stress levels.

According to the American Institute of Stress:

- Forty-three percent of all adults suffer adverse health effects due to stress.
- Seventy-five to 90% of all visits to primary care physicians (PCPs) are for stress-related complaints or disorders.
- An estimated 1 million workers are absent on an average workday due to stress-related complaints. Stress is believed to be responsible for more than half of the 550 million workdays lost annually because of absenteeism.
- Stress has been linked to all the leading causes of death, including heart disease, **cancer**, lung ailments, cirrhosis, and suicide.
- Nearly half of all American workers suffer from symptoms of burnout, a disabling reaction to stress on the job.
- Workplace violence is rampant. There are almost 2 million reported instances of homicide, aggravated assault, rape, or sexual assault. Homicide is the second leading

cause of fatal occupational injury and the leading cause of death for working women.

Diagnosis

When the doctor suspects that a patient's illness is connected to stress, he or she will take a careful history that includes stressors in the patient's life (i.e., family or employment problems; other illnesses). Many physicians will also evaluate the patient's personality, to assess his or her coping resources and emotional response patterns. There are a number of personality inventories and **psychological tests** that can be used to help evaluate the amount of stress the patient experiences and the coping mechanisms that he or she uses to deal with it. Stress-related illness can be diagnosed by PCPs or psychiatrists. The physician will need to distinguish between adjustment disorders and **anxiety** or mood disorders, and between psychiatric disorders and physical illnesses (e.g., thyroid deficiency or surplus) that have psychological side effects. A test that is used for measuring life stress is "Life Events Scale." It is used to determine whether the patient is at risk for stress-related illnesses, and can be administered while taking a social history at no extra cost. The test comprises stressors that are ranked in from most stressful (e.g., death of a spouse) to least stressful (e.g., minor violations of the law). Each item is assigned a value and is based on thousands of interviews and medical histories identifying the kinds of events that people found stressful.

Treatment

Recent advances in the understanding of the many complex connections between the human mind and body have produced a variety of treatments for stress-related illness. Present treatment regimens may include one or more of the following:

- Medications. These may include drugs to control **blood** pressure or other physical manifestations of stress, as well as drugs (e.g., tranquilizers and antidepressants) that affect a patient's mood.
- Homeopathy and herbal remedies. Some may relieve symptoms of stress.
- Stress management programs. These may be either individual or group treatments, and usually involve analysis of the stressors in the patient's life. They often focus on job- or workplace-related stress.
- Behavioral approaches. These strategies include **relaxation** techniques, breathing exercises, and physical **exercise** programs, such as walking.

- **Massage.** Therapeutic massage relieves stress by relaxing the large groups of muscles in the back, neck, arms, and legs.
- **Cognitive therapy.** This approach teaches patients to reframe or mentally re-interpret the stressors in their lives, so that they can modify the body's physical reactions.
- **Meditation and associated spiritual or religious practices.** Recent studies have found positive correlations between such activity and ability to manage stress.
- **Drawing, dance, music, sculpting, and other art forms.** These forms of therapy are used to help the patient get in touch with his or her sources of stress, and release them through creative expression.
- **Biofeedback.** Through this form of therapy, a patient learns to control his or her internal reactions to stressors, and discovers how to control them.
- **Yoga, t'ai chi, aikido.** A combination of physical and mental exercise are used to promote relaxation.
- **Aromatherapy.** Scented oils that are designed to generate relaxation.
- **Nutrition-based treatments (e.g., dietary control; nutritional supplements).** These help teach patients undergoing stress to focus on eating healthy foods.
- **Acupuncture.** This treatment corrects the imbalance of body energy that produces stress

Prognosis

The prognosis for recovery from a stress-related illness is related to a wide variety of factors in a person's life, many of which are genetically determined (i.e., race, sex, illnesses that run in families) or beyond the individual's control (e.g., economic trends, cultural stereotypes and prejudices). It is possible, however, for humans to learn new responses to stress. A person's ability to remain healthy in stressful situations is sometimes referred to as "stress hardiness." Stress-hardy people have a cluster of personality traits that strengthen their abilities to cope with stress. These traits include believing in the importance of what they are doing; believing that they have some power to influence their situation; and viewing life's changes as positive opportunities, rather than threats.

Prevention

Complete prevention of stress is neither possible nor desirable, because stress is an important stimulus of human growth and creativity, and an inevitable part of life. In addition, specific strategies for stress prevention

vary widely from person to person, depending on the nature and number of the stressors in an individual's life, and the amount of control he or she has over these factors. In general, however, a combination of attitude and behavioral changes works well for most patients.

Resources

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Barbara M. Chandler

Stress test

Definition

A stress test is primarily used to identify **coronary artery disease**. It requires patients to **exercise** on a treadmill or exercise bicycle while their **heart rate**, **blood pressure**, electrocardiogram (ECG), and symptoms are monitored.

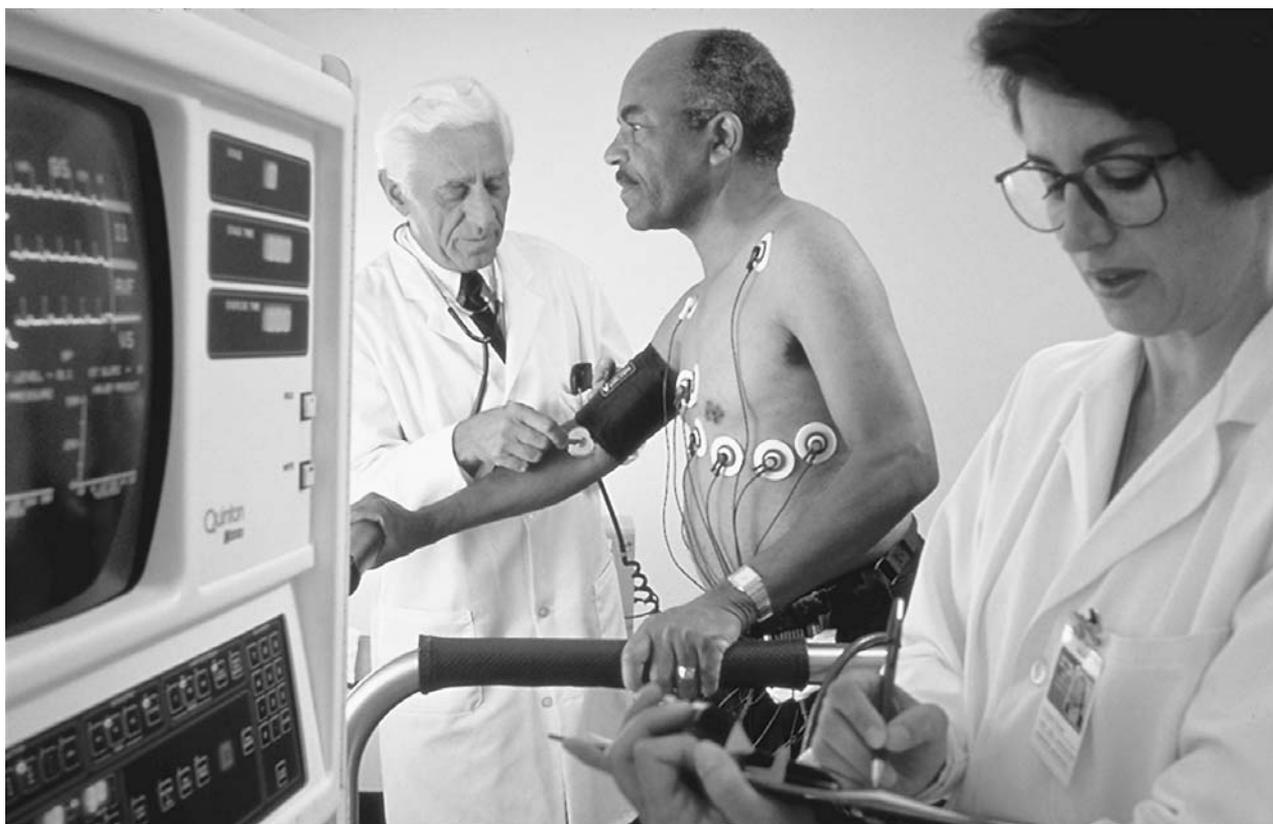
Purpose

The body requires more oxygen during exercise than rest. To deliver more oxygen during exercise, the heart has to pump more oxygen-rich **blood**. Because of the increased stress on the heart, exercise can reveal coronary problems that are not apparent when the body is at rest. This is why the stress test, though not perfect, remains the best initial, noninvasive, practical coronary test.

The stress test is particularly useful for detecting ischemia (inadequate supply of blood to the heart muscle) caused by blocked coronary arteries. Less commonly, it is used to determine safe levels of exercise in people with existing coronary artery disease.

Precautions

The exercise stress test carries a very slight risk (one in 100,000) of causing a heart attack. For this reason, exercise stress tests should be attended by health care



Doctors monitor a patient's vital signs during a stress test. (Photograph by Mug Shots. The Stock Market. Reproduced by permission.)

professionals with immediate access to defibrillators and other emergency equipment.

Patient are cautioned to stop the test should they develop any of the following symptoms:

- an unsteady gait
- confusion
- skin that is grayish or cold and clammy
- dizziness or fainting
- a drop in blood pressure
- angina (chest **pain**)
- cardiac arrhythmias (irregular heart beat)

Description

A technician affixes electrodes to the patient's chest, using adhesive patches with a special gel that conducts electrical impulses. Typically, electrodes are placed under each collarbone and each bottom rib, and six electrodes are placed across the chest in a rough outline of the heart. Wires from the electrodes are connected to an

ECG, which records the electrical activity picked up by the electrodes.

The technician runs resting ECG tests while the patient is lying down, then standing up, and then breathing heavily for half a minute. These baseline tests can later be compared with the ECG tests performed while the patient is exercising. The patient's blood pressure is taken and the blood pressure cuff is left in place, so that blood pressure can be measured periodically throughout the test.

The patient begins riding a stationary bicycle or walking on a treadmill. Gradually the intensity of the exercise is increased. For example, if the patient is walking on a treadmill, then the speed of the treadmill increases and the treadmill is tilted upward to simulate an incline. If the patient is on an exercise bicycle, then the resistance or "drag" is gradually increased. The patient continues exercising at increasing intensity until he or she reaches the target heart rate (generally set at a minimum of 85% of the maximal predicted heart rate based on the patient's age) or experiences severe fatigue, dizziness, or chest pain. During the test, the patient's heart rate, ECG, and blood pressure are monitored.

Sometimes other tests, such as **echocardiography** or thallium scanning, are used in conjunction with the exercise stress test. For instance, recent studies suggest that women have a high rate of false negatives (results showing no problem when one exists) and false positives (results showing a problem when one does not exist) with the stress test. They may benefit from another test, such as exercise echocardiography. People who are unable to exercise may be injected with drugs, such as adenosine, which mimic the effects of exercise on the heart, and then given a thallium scan. The thallium scan or echocardiogram are particularly useful when the patient's resting ECG is abnormal. In such cases, interpretation of exercise induced ECG abnormalities is difficult.

Preparation

Patients are usually instructed not to eat or smoke for several hours before the test. They should be advised to inform the physician about any medications they are taking, and to wear comfortable sneakers and exercise clothing.

Aftercare

After the test, the patient should rest until blood pressure and heart rate return to normal. If all goes well, and there are no signs of distress, the patient may return to his or her normal daily activities.

Complications

There is a very slight risk of **myocardial infarction** (a heart attack) from the exercise, as well as cardiac arrhythmia (irregular heart beats), angina, or cardiac arrest (about one in 100,000).

Results

A normal result of an exercise stress test shows normal electrocardiogram tracings and heart rate, blood pressure within the normal range, and no angina, unusual dizziness, or shortness of breath.

A number of abnormalities may appear on an exercise stress test. Examples of exercise-induced ECG abnormalities are ST segment depression or heart rhythm disturbances. These ECG abnormalities may indicate deprivation of blood to the heart muscle (ischemia) caused by blocked coronary arteries. Stress test abnormalities generally require further diagnostic evaluation and therapy.

KEY TERMS

Angina—Chest pain from a poor blood supply to the heart muscle due to stenosis (narrowing) of the coronary arteries.

Cardiac arrhythmia—An irregular heart rate or rhythm.

Defibrillator—A device that delivers an electric shock to the heart muscle through the chest wall in order to restore a normal heart rate.

False negative—Test results showing no problem when one exists.

False positive—Test results showing a problem when one does not exist.

Hypertrophy—The overgrowth of muscle.

Ischemia—Diminished supply of oxygen-rich blood to an organ or area of the body.

Health care team roles

A stress test is generally ordered by a primary care physician or cardiologist and is performed by a trained technician. All health care providers performing or monitoring stress tests should be prepared to provide emergency medical intervention, such as defibrillation.

Patient education

Patients must be well prepared for a stress test. They should not only know the purpose of the test, but also signs and symptoms that indicate the test should be stopped. Physicians, nurses, and ECG technicians can ensure patient safety by encouraging them to immediately communicate discomfort at any time during the stress test.

Resources

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The Faculty Members of the Yale University School of Medicine. *The Patient's Guide to Medical Tests*. Boston, New York: Houghton Mifflin Company, 1997.

ORGANIZATIONS

American Heart Association. 7272 Greenville Avenue, Dallas, TX 75231. (214) 373-6300. <<http://www.amhrt.org>>.

National Heart, Lung, and Blood Institute. Information Center.
PO Box 30105, Bethesda, MD 20824-0105. (301) 951-
3260. <<http://www.nhlbi.nih.gov>>.

Barbara Wexler

Stroke see **Cerebrovascular accident**

Stupor see **Coma**

Stuttering

Definition

Stuttering is a speech disorder in which there is a disruption in the normal flow of speech (disfluency). Disfluencies include repetitions of a sound, syllable, or word; silent blocks (drawing out a sound silently); and prolongations (drawing out a voiced sound). Certain behaviors such as eye blinks, facial twitches, or body movements may also accompany stuttering. Stuttering may become worse under stressful situations (such as speaking in front of a group) but may improve when speaking, reading aloud, or singing while alone.

Description

It is estimated that approximately three million Americans are affected by some form of stuttering. The disorder most often affects children between the ages of two and five, usually resolving before **puberty**. Boys are three times as likely to be stutters than girls. Less than 1% of adults in the United States suffer from stuttering.

Developmental stuttering (DS) most often occurs in children during the age at which they are developing their language and speech. The onset of DS is gradual, typically occurring before the age of 12. Persistent developmental stuttering (PDS) is defined as stuttering that does not resolve spontaneously or with treatment over time.

Acquired stuttering (AS) occurs in individuals who have been previously fluent. There is no gradual onset of disordered speech in persons with AS; disfluency occurs rather abruptly. AS may be neurogenic or psychogenic. Neurogenic stuttering is caused by problems in the signaling between the **brain** and the various muscles and nerves used in generating speech. This may occur after a stroke or damage to the brain. Psychogenic stuttering tends to occur after a trauma or period of extreme **stress**, or in individuals suffering from mental illness.

Causes and symptoms

Although the exact cause of stuttering is not known, there are three leading theories that propose how stuttering develops. The **learning theory** proposes that stuttering is a learned behavior and that most normal children are occasionally disfluent (i.e. speaking rapidly, searching for the right words, etc.) when at the age at which speech and language develop. If a child is criticized or punished for this, he or she may develop **anxiety** about the disfluencies, causing increased stuttering and increased anxiety.

The second theory suggests that stuttering is a psychological problem—that stuttering is an underlying problem that can be treated with **psychotherapy**. The third theory proposes that the cause of stuttering is organic, that neurological differences exist between the brains of those who stutter and those who don't.

There is also some indication that genetic factors are involved in the development of stuttering and subsequent recovery, as shown by various studies done on families and twins. It is not known to what degree stuttering is dependent on genetic factors, on environmental factors, or on both.

Symptoms

A certain measure of disfluency is expected in small children as they learn to speak a language. Some symptoms of normal disfluency are the following:

- less than 10 disfluencies per 100 spoken words
- whole-word repetitions (“She-she-she”)
- part-word repetitions (“M-milk”)
- phrase repetition (“I don’t want-I don’t want to go”)
- interjections (“Um,” “ah,” “uh”) (The child would also not normally appear visibly tense or anxious while communicating.)

There are some basic characteristics that differentiate stuttering from normal childhood disfluencies. The *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)* describes those characteristics as follows:

- sound and syllable repetitions
- sound prolongations
- interjections
- broken words (for example, pauses within a word)
- audible or silent blocking (filled or unfilled pauses in speech)
- circumlocutions (word substitutions to avoid problematic words)

- words produced with an excess of physical tension
- monosyllabic whole-word repetitions (“I-I-I-I see him”) (The DSM-IV also indicates that such disfluency “interferes with academic or occupational achievement or with social communication.”)

Diagnosis

A diagnosis of stuttering typically includes a complete medical history, a **physical examination**, a complete history of the speech disorder, and an evaluation of speech and language by a speech-language pathologist. An important function of the speech evaluation is to distinguish between normal disfluency and stuttering.

Treatment

Treatment for stuttering varies according to the patient’s age and type and severity of stuttering. Speech therapy is a popular method of treatment that involves learning new speech techniques (such as speaking syllable-by-syllable) and modifying current ways of speaking (such as reducing the rate of speech). It may also include psychological counseling as a way of boosting self-esteem and reducing the tendency of avoiding fearful situations such as speaking in front of a group.

Studies have looked into the potential of treating stuttering with medications. Haloperidol has been the most widely studied antistuttering medication and the only drug to show improvement in fluency. The side effects of haloperidol, however, are not well-tolerated and so the drug is often discontinued.

Prognosis

Nearly 80% of children with DS will recover by puberty, spontaneously or with treatment. One study looking at the recovery rate for stutterers ages nine to 14 who had undergone speech therapy noted that over 70% remained nonstutterers for one year after treatment. Five years after treatment, that rate remained approximately the same. The recovery rate among adult stutterers is not as high, in part because of extensive social phobias and depression.

Health care team roles

Common health care professionals involved in the care of an individual with a stuttering problem include:

- speech-language pathologists
- pediatricians and primary care physicians
- psychiatrists or psychologists

KEY TERMS

Disfluency—An interruption in the normal flow of speech.

- neurologists

Prevention

There is no cure for stuttering, but parents can do a number of things to help their child recover from DS, thereby preventing a life-long stutter. These include:

- Speaking slowly and fluently in front of the child, but avoiding criticizing or punishing his or her rate of speech or disfluencies.
- Questioning the child less and commenting on his or her activities more.
- Refraining from having the child speak in front of large groups.
- Listening carefully to what the child has to say.
- Resisting from completing the child’s words or sentences.

Resources

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Lawrence, Michael, and David M. Barclay. “Stuttering: A Brief Review.” *American Family Physician* 57 (1 May 1998): 2175–80.

ORGANIZATIONS

American Speech-Language-Hearing Association (ASHA). 10801 Rockville Pike, Rockville, MD 20852. (888) 321-ASHA. <<http://www.asha.org>>.

National Institute on Deafness and Other Communication Disorders (NIDCD) Information Clearinghouse. 1 Communication Ave., Bethesda, MD 20892-3456. (800) 241-1044. <<http://www.nidcd.nih.gov>>.

National Stuttering Association. 5100 E. La Palma, Suite 208, Anaheim Hills, CA 92807. (800) 364-1677. <<http://www.nsastutter.org>>.

Stuttering Foundation of America. 3100 Walnut Grove Rd., Suite 603, PO Box 11749, Memphis TN 38111-0749. (800) 992-9392. <<http://www.stuttersfa.org>>.

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Stéphanie Islane Dionne

Subacute spongiform encephalopathy *see*
Creutzfeldt-Jakob disease

Subcutaneous injection

Definition

A subcutaneous injection is a method of drug administration. Up to 2 ml of a drug solution can be injected directly beneath the skin. The drug becomes effective within 20 minutes.

Purpose

Subcutaneous injection is the method used to administer drugs when a small amount of fluid is to be injected, the patient is unable to take the drug orally, or the drug is destroyed by intestinal secretions.

Precautions

If the drug to be administered is harmful to superficial tissues, it should be administered intramuscularly or intravenously. It is useful to remember the following when administering any medication: the right patient, the right medicine, the right route, the right dose, the right site, and the right time.

Description

With the subcutaneous route, a small thin needle is inserted beneath the skin and the drug injected slowly. The drug moves from the small **blood vessels** into the bloodstream. Subcutaneous injections are usually given in the abdomen, upper arm, or the upper leg.

Preparation

The hands should be washed, and gloves may be worn during the procedure. A **syringe and needle** should be prepared. If a sterile, multiple-dose vial is used, the rubber-capped bottle should be rubbed with an antiseptic

KEY TERMS

Intramuscular—Within muscle tissue.

Intravenous—Within a vein.

Sterile—Free from living microorganisms.

Subcutaneous—Hypodermic, beneath the skin.

Superficial—On or near the surface.

Vial—A small glass bottle for medicines or chemicals.

swab. The needle is then inserted through the center of the cap and some air from the syringe inserted to equalize the pressure in the container. Slightly more of the required amount of drug is then removed. Holding the syringe vertically at eye level, the syringe piston is pushed carefully to the exact measurement line.

If a small individual vial containing the correct amount of drug is used, the outside should be wiped with an antiseptic swab and held in the swab while the top is removed. The needle is then inserted into the vial, taking care that the tip of the needle does not scratch against the sides of the vial, thereby becoming blunt.

A syringe and needle containing the drug should be placed on a tray with sterile cotton swabs, cleaning disinfectant, and adhesive tape. If the patient is unfamiliar with the procedure, the nurse should explain what he or she is about to do and that the patient is to receive medication prescribed for them. The dose on the patient's prescription sheet should be checked prior to administration.

A screen should be drawn around the patient to avoid any personal embarrassment. The injection site is then rubbed vigorously with a swab and disinfectant to cleanse the area and increase the **blood** supply. A small piece of skin and subcutaneous tissue is pinched between the thumb and forefinger, and the needle inserted quickly at a 45-degree angle. Certain drugs such as heparin are given at a 90-degree angle rather than at 45 degrees. It is important to ensure that the needle is not in a vein. Therefore the syringe should be aspirated a little by pulling back on the piston. If blood is present, the needle should be re-injected, and the piston withdrawn slightly once more. The skin is then released and the syringe piston pushed down steadily and slowly.

A sterile cotton swab should be pressed over the injection site as the needle is quickly withdrawn, and the swab is taped to the skin for a few minutes, if required.

Aftercare

Monitor the patient's reaction and provide reassurance if required. Dispose of all waste products carefully, and place the syringe and needle in a puncture-resistant receptacle. Wash the hands. For patients requiring frequent injections, the site is changed each time.

Complications

If the circulation is depleted, absorption of the drug administered may be slow. Certain drugs such as anticoagulants have specific side effects that the patient may experience. Injected drugs can also interact with other medications that the patient is taking. Check for any adverse reactions if the drug is being administered for the first time.

Results

The proper method of subcutaneous injection results in the safe administration of the drug with no complications for the health care provider or patient.

Health care team roles

The health care team should record any side effects or negative reactions to the injected drug and notify the medical staff as appropriate. If the medication is to be prescribed regularly for a specific disease, the patient can be directed to a self-help group where members have the same medical condition.

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World Health Organization. *Guide to Good Prescribing* Annex 4: The Use of Injections.

ORGANIZATIONS

American Academy of Nurse Practitioners. AANP, PO Box 12846, Austin, TX 78711. (512)442-4262. admin@aanp.org.

American Nurses Association. 600 Maryland Avenue, SW, Suite 100 West, Washington, DC 20024 (202)651-7000.

National Association of Clinical Nurse Specialists. 3969 Green Street, Harrisburg, PA 17110. (717)234-6799. info@nacns.org.

National League for Nursing. 61 Broadway, 33rd Floor, New York, NY 10006. (212)363-5555 or (800)669-1656.

Margaret A Stockley, RGN

Sublingual and buccal medication administration

Definition

Sublingual and buccal medications are administered by placing them in the mouth, either under the tongue (sublingual) or between the gum and the cheek (buccal). The medications dissolve rapidly and are absorbed through the mucous membranes of the mouth, where they enter into the bloodstream. The medications are compounded in the form of small, quick-dissolving tablets, sprays, lozenges, or liquid suspensions.

Purpose

Sublingual and buccal medications are given for a variety of conditions. The most common sublingual medication is the nitroglycerin tablet. Its rapid action to relax the **blood vessels** reduces the workload on the **heart** and relieves the **pain** of angina pectoris. Other buccal and sublingual medications, however, serve a variety of purposes—such as narcotic pain relief, migraine pain relief, **blood pressure** control, and mental decline due to **dementia** (i.e., ergoloid mesylates). This form of medication is extremely effective, because it bypasses the **digestive system** and is absorbed into the bloodstream in minutes. Not all medications can be prepared for sublingual or buccal administration; some of the compounding difficulties are **taste**, solubility, and dosage limitations of the medicine.

Precautions

Sublingual medications should not be administered if the gums or mucous membranes have open sores or areas of irritation. Rather, the physician should be notified, and medication held. The patient should be placed in a sitting position to prevent accidental aspiration of the medication. Buccal or sublingual medication should not be used when a patient is uncooperative or unconscious. The patient should not eat, drink, chew, or swallow until the medication has been absorbed; swallowing the medication must be prevented, as it will decrease the drug's effectiveness. The patient should not smoke while taking sublingual or buccal medication, because smoking causes vasoconstriction of the **blood** vessels. This will decrease the absorption of the medication.

Description

To administer sublingual tablets, the clinician should have the patient open his or her mouth and raise the tongue. The tablet should then be placed under the

KEY TERMS

Angina pectoris—Severe pain in the chest caused by vasoconstriction of the blood vessels and a decreased level of oxygen to the cardiac muscle.

Aspiration—The accidental sucking of fluid or solids along with air into the bronchial tubes or lungs.

Buccal—The inner aspect of the cheek or mouth cavity.

Sublingual—The area in the mouth under the tongue.

Vasoconstriction—The narrowing or constriction of blood vessels.

tongue. Administration of buccal tablets is similar to that of sublingual tablets. First, the patient should open his or her mouth. The tablet should be placed between the gum and the wall of the cheek. With the mouth closed, the tablet should be held in this position for five to 10 minutes, or until it has dissolved. Lozenges are also placed in the mouth and held until they dissolve. Administration of sublingual or buccal sprays also requires having the patient open the mouth. The patient should be reminded not to breathe while the nurse is spraying the medicine. If the spray is ordered sublingual, the spray should be held about one inch (2.5 cm) away from the site, and directed toward the tongue. If the patient cannot hold up his or her tongue voluntarily, the nurse tongue should be held by the nurse with his or her non-dominant hand, using a 2x2 gauze pad to provide grip. If the spray is ordered buccal, the tongue should be held out of the way, the cheek held outward, and the spray directed into the gum area between the cheek and the teeth. Liquid suspensions may be given in a medicine cup or squirted into the patient's mouth using a medicine syringe with no needle. The patient should be directed to hold and swish the liquid in the mouth for the amount of time designated by the physician's order. Some liquid suspensions are then swallowed and some expectorated into a sink or basin. In all cases, the physician's orders should be followed.

Preparation

The clinician should wash his or her hands and put on gloves. The medication label must be checked each time medication is administered, to avoid medication errors. It must be confirmed that it is the right medicine, the right dose (strength), the right time, the right patient, and the right method. The expiration date on the label

should be checked. If the medicine is outdated, it should not be used. The patient should be placed in a sitting or upright position. Oral medications need to be given before sublingual or buccal medications. The clinician should examine the mucous membranes of the patient's mouth for irritation or sores. If there are sores in the mouth, the physician should be contacted any sublingual or buccal drugs are administered. Alternating sites should be used when giving regular doses of sublingual or buccal medications. The procedure should be explained to the patient, who should also be reminded that nothing should be eaten, drank, swallowed, chewed, or smoked until the tablet has dissolved. When administering a liquid suspension, the bottle should be shaken the bottle before the appropriate dose is poured. When administering sprays, the container also needs to be shaken, and the top taken off before the medication is given.

Aftercare

The patient should be reminded not to eat, drink, swallow, chew, or smoke until the tablet has dissolved. The nurse can assist the patient by noting the time the medicine is given, as well as the time when it will be okay to drink or eat. If a liquid suspension must be spit out after a specific amount of time, the nurse must be sure that the patient knows when that is, and has a basin nearby or access to a sink. If the patient experiences a tingling or burning sensation from a sublingual tablet, he or she should be encouraged to move the tablet to another part of the mouth. Sublingual medicines deteriorate rapidly with heat or humidity. The nurse should be sure to close the cover of the tablet bottle securely. Gloves should be removed and placed, with the gauze pads, in a plastic bag that can be sealed and discarded. The clinician must wash his or her hands when the procedure is complete.

Complications

Complications of sublingual and buccal medications are rare, but could include inflammation of the mucous membranes. If symptoms such as soreness, redness, swelling, bleeding, or sores in the mouth are evident, the physician should be contacted before the medication is administered. If the patient demonstrates any symptoms of an allergic reaction (i.e., itching, **hives**, or swelling of the lips or tongue), the remaining tablet should be removed. The patient should rinse his or her mouth, and the clinician should contact the physician immediately.

Results

Sublingual and buccal medications are fast acting and when given correctly act within one to five minutes

of administration. The length of time to reach the desired therapeutic response, however, depends upon the dose and type of medication administered. For example it may take three doses of sublingual nitroglycerin given five minutes apart to relieve the pain of angina.

Health care team roles

Sublingual and buccal medications are administered by a **registered nurse** (R.N.) or a license practical nurse (L.P.N). in the health care setting. Sublingual or buccal medicine may be administered in some settings by unlicensed staff, but only under the direction of a registered nurse. A licensed nurse, however, must evaluate the mucous membranes of the mouth regularly and assess the outcome of medication administration. The patient, or members of the patient's family, can be taught to administer sublingual or buccal medications in the home setting.

Resources

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Subluxations see **Dislocations and subluxations**

Substance abuse and dependence

Definition

Substance abuse is a pattern of drug, alcohol or other substance use that creates many adverse results from its continual use. The characteristics of abuse are a failure to carry out obligations at home or work, continual use under circumstances that present a hazard (such as driving a car), and legal problems such as arrests. Use of the drug is persistent despite personal problems caused by the effects of the substance on self or others.

Substance dependence has been defined medically as a group of behavioral and physiological symptoms that indicate the continual, compulsive use of a substance in self-administered doses despite the problems related to the use of this substance. Sometimes increased amounts are needed to achieve the desired effect or level of intoxication. Consequently the patient's tolerance for the drug increases. Withdrawal is a physiological and psychological change that occurs when the body's concentration of the substance declines in a person who has been a heavy user.

Description

Substance abuse and dependence crosses all lines of race, culture, education, and socioeconomic status, leaving no group untouched by its devastating effects. A recent survey estimated that about 16 million citizens of the United States had used an illegal substance in the month preceding the study. Substance abuse is an enormous **public health** problem, with far-ranging effects throughout society. In addition to the toll substance abuse can take on one's physical health, it is considered an important factor in a wide variety of social problems, affecting rates of crime, domestic violence, sexually transmitted diseases (including HIV/AIDS), unemployment, homelessness, teen **pregnancy**, and failure in school. One study estimated that 20% of the total yearly cost of health care in the United States is spent on the effects of drug and alcohol abuse.

A wide range of substances can be abused. The most common classes include:

- opioids, including such prescription **pain** killers as morphine and Demerol, as well as illegal substances such as heroin
- benzodiazapines, including prescription drugs used for treating **anxiety**, such as Valium
- sedatives or "downers," including prescription barbiturate drugs commonly referred to as tranquilizers

- stimulants or “speed,” including prescription amphetamine drugs used as weight-loss drugs and in the treatment of attention deficit disorder
- cannabinoid drugs obtained from the hemp plant, including **marijuana** (“pot”) and hashish
- cocaine-based drugs
- hallucinogenic or “psychedelic” drugs, including LSD, PCP or angel dust, and other PCP-type drugs
- inhalants, including gaseous drugs used in the medical practice of anesthesia, as well as such common substances as paint thinner, gasoline, glue
- alcoholic drinks, including beer, liquor, and wine

Those substances of abuse that are actually prescription medications may have been obtained on the street by fraudulent means or may have been a legal, medically indicated prescription that a person begins to use without regard to the directions of his/her physician.

A number of important terms must be defined in order to have a complete discussion of substance abuse. Drug tolerance refers to a person’s body becoming accustomed to the symptoms produced by a specific quantity of a substance. When a person first begins taking a substance, he/she will note various mental or physical reactions brought on by the drug, some of which are the very changes in consciousness that the individual is seeking through substance use. Over time, the same dosage of the substance may produce fewer of the desired feelings. In order to continue to feel the desired effect of the substance, progressively higher drug doses must be taken.

Substance dependence is the phenomenon whereby a person becomes physically addicted to a substance. A substance-dependent person must have a particular dose or concentration of the substance in their bloodstream at any given moment in order to avoid the unpleasant symptoms associated with withdrawal from that substance. The common substances of abuse tend to exert either a depressive (slowing) or a stimulating (speeding up) effect on such basic bodily functions as respiratory rate, **heart rate**, and **blood pressure**. When a drug is stopped abruptly, the person’s body will respond by overreacting to the substance’s absence. Functions slowed by the abused substance will be suddenly speeded up, while previously stimulated functions will be suddenly slowed. This results in very unpleasant symptoms, known as withdrawal symptoms.

Addiction refers to the mind-state of a person who reaches a point where he/she must have a specific substance, even though the social consequences of substance use are clearly negative (loss of relationships, employment, housing). Craving refers to an intense hunger for a specific substance, to the point where this need essential-

ly directs the individual’s behavior. Craving is usually seen in both dependence and addiction. Such craving can be so strong that it overwhelms a person’s ability to make any decisions which will possibly deprive him/her of the substance. Drug possession and use becomes the most important goal, and other forces (including the law) have little effect on changing the individual’s substance-seeking behavior.

Causes and symptoms

There is not thought to be a single cause of substance abuse, though scientists are increasingly convinced that certain people possess a genetic predisposition that can affect the development of addictive behaviors. One theory holds that a particular nerve pathway in the **brain**, dubbed the “mesolimbic reward pathway,” holds certain chemical characteristics that can increase the likelihood that substance use will ultimately lead to substance addiction. Certainly, however, other social factors are involved, including family problems and peer pressure. Primary mood disorders, such as **bipolar disorder**, **personality disorders**, and the role of learned behavior can influence the likelihood that a person will become substance dependent.

The symptoms of substance abuse may be related to its social effects as well as its physical effects. The social effects of substance abuse may include dropping out of school or losing a series of jobs, engaging in fighting and violence in relationships, and legal problems, ranging from driving under the influence to the commission of crimes committed to obtain the money needed to support an expensive drug habit.

Physical effects of substance abuse are related to the specific drug being abused:

- Opioid drug users may appear slowed in their physical movements and speech, may lose weight, exhibit mood swings, and have constricted (small) pupils.
- Benzodiazapine and barbiturate users may appear sleepy and slowed, with slurred speech, small pupils, and occasional confusion.
- Amphetamine users may have excessively high energy, inability to sleep, weight loss, rapid pulse, elevated **blood pressure**, occasional psychotic behavior and dilated (enlarged) pupils.
- Marijuana users may be sluggish and slow to react, exhibiting mood swings and red eyes with dilated pupils.
- Cocaine users may have wide variations in their energy level, severe mood disturbances, psychosis, paranoia,

and a constantly runny nose. Crack cocaine may cause aggressive or violent behavior.

- Hallucinogenic drug users may display dilated pupils and bizarre behavior due to hallucinations. (Hallucinations are imagined sights, voices, sounds, or smells which seem completely real to the individual experiencing them.) LSD can cause flashbacks.

Other symptoms of substance abuse may be related to the form in which the substance is used. For example, heroin, certain other opioid drugs, and certain forms of cocaine may be injected using a needle and a hypodermic syringe. A person abusing an injectable substance may have “track marks”—outwardly visible signs of the site of an injection, with possible redness and swelling of the vein in which the substance was injected. Furthermore, poor judgment brought on by substance use can result in the injections being made under horrifyingly dirty conditions. These unsanitary conditions and the use of shared needles can cause infections of the injection sites, major infections of the heart, as well as **infection** with human **immunodeficiency** virus (HIV) (the virus that causes acquired immunodeficiency syndrome, or **AIDS**), certain forms of hepatitis (a **liver** infection), and **tuberculosis**.

Cocaine is often taken as a powdery substance which is inhaled or “snorted” through the nose. This can result in frequent nose bleeds, sores in the nose, and even erosion of the nasal septum, the structure that separates the two nostrils. Cocaine can also be smoked.

Overdosing on a substance is a frequent complication of substance abuse. Drug **overdose** can be purposeful (with suicide as a goal), or caused by carelessness, the unpredictable strength of substances purchased from street dealers, mixing of more than one type of substance, or as a result of the ever-increasing doses which a person must take of those substances to which he or she has become tolerant. Substance overdose can be a life-threatening emergency, with the specific symptoms dependent on the type of substance used. Substances with depressive effects may dangerously slow the breathing and heart rate, drop the body temperature, and result in a general unresponsiveness. Substances with stimulatory effects may dangerously increase the heart rate and blood pressure, increase body temperature, and cause bizarre behavior. With cocaine, there is a risk of stroke.

Still other symptoms may be caused by unknown substances mixed with street drugs in order to “stretch” a batch. A health care worker faced with a patient suffering extreme symptoms may have no idea what other substance that person may have unwittingly put into his or her body. Thorough drug screening can help with this problem.

Diagnosis

The most difficult aspect of diagnosis involves addressing and overcoming the patient’s denial. Denial is a psychological trait whereby a person is unable to allow him- or herself to acknowledge the reality of a situation. This may lead a person to completely deny his or her substance use, or may cause the person to greatly underestimate the degree of the problem and its effects on his or her life.

One of the simplest and most commonly used screening tools used by nursing staff or allied health professionals to begin the process of diagnosing substance abuse is called the CAGE questionnaire. CAGE refers to the first letters of each word that forms the basis of each of the four questions of the screening exam:

- Have you ever tried to Cut down on your substance use?
- Have you ever been Annoyed by people trying to talk to you about your substance use?
- Do you ever feel Guilty about your substance use?
- Do you ever need an Eye opener (use of the substance first thing in the morning) in order to start your day?

Other, longer lists of questions exist in order to try to determine the severity and effects of a person’s substance abuse. Certainly, it is also relevant to determine whether anybody else in a person’s family has ever suffered from substance or alcohol addiction.

A **physical examination** may reveal signs of substance abuse in the form of needle marks, tracks, trauma to the inside of the nostrils from snorting drugs, unusually large or small pupils. With the person’s permission, substance use can also be detected by examining an individual’s blood, urine, or hair in a laboratory. This **drug testing** is limited by sensitivity, specificity and the time elapsed since the person last used the drug.

Treatment

Treatment has several goals, which include helping a person deal with the uncomfortable and possibly life-threatening symptoms associated with withdrawal from an addictive substance (called detoxification), helping a person deal with the social effects which substance abuse has had on his or her life, and efforts to prevent relapse (resumed use of the substance). Individual or group **psychotherapy** is sometimes helpful.

Detoxification may take from several days to many weeks. Detoxification can be accomplished “cold turkey,” by complete and immediate cessation of all substance use, or by slowly decreasing (tapering) the dose

KEY TERMS

Addiction—The state of being both physically and psychologically dependent on a substance.

Dependence—A state in which a person requires a steady concentration of a particular substance in order to avoid experiencing withdrawal symptoms.

Detoxification—A process whereby an addict is withdrawn from a substance.

Disease model of alcoholism—Also known as the Minnesota model, the disease model contends that alcoholism is a disease that is chronic, progressive, and frequently fatal.

High—The altered state of consciousness that a person seeks when abusing a substance.

Street drug—A substance purchased from a drug dealer; it may be a legal substance, sold illicitly (without a prescription, and not for medical use), or it may be a substance which is illegal to possess.

Tolerance—A phenomenon whereby a drug user becomes physically accustomed to a particular dose of a substance, and requires ever-increasing dosages in order to obtain the same effects.

Withdrawal—Those side effects experienced by a person who has become physically dependent on a substance, upon decreasing the substance's dosage, or discontinuing its use.

that a person is taking, to minimize the side effects of withdrawal. Some substances absolutely must be tapered, because “cold turkey” methods of detoxification are potentially life threatening. Alternatively, a variety of medications may be utilized to combat the unpleasant and threatening physical symptoms of withdrawal. A substance (such as methadone in the case of heroin addiction) may be substituted for the original substance of abuse, with gradual tapering of this substituted drug. In practice, many patients may be maintained on methadone and lead a reasonably normal life. Because of the rebound effects of fluctuating blood pressure, body temperature, heart and breathing rates, as well as the potential for bizarre behavior and hallucinations, a person undergoing withdrawal must be carefully monitored and treated appropriately.

A recent discovery for the treatment of opiate addiction is a medication called naltrexone. This medication

blocks the receptors involved with the “high” produced by heroin. The drug is useful for many patients since it does not produce physical dependence and has virtually zero potential for abuse. Scientists have found that unfortunately, many heroin addicts do not like to take naltrexone quite possibly because they enjoy the effects of opiates. Since the medication eliminates the craving for opiates, in one recent study only 15% of heroin addicts were still taking the drug after one month.

Alternative treatments for substance abuse include those specifically designed to aid a person who is suffering from the effects of withdrawal and the toxicities of the abused substance, as well as treatments which are intended to decrease a person's **stress** level, thus hopefully decreasing the likelihood that he or she will relapse.

Additional treatments thought to improve a person's ability to stop substance use include acupuncture and hypnotherapy. Ridding the body of toxins is believed to be aided by **hydrotherapy** (bathing regularly in water containing baking soda, sea salt, or Epsom salts). Hydrotherapy can include a constitutional effect where the body's vital force is stimulated and all organ systems are revitalized. Elimination of toxins is aided by hydrotherapy as well as by such herbs as milk thistle (*Silybum marianum*), burdock (*Arctium lappa*), a blood cleanser, and licorice (*Glycyrrhiza glabra*). Anxiety brought on by substance withdrawal is thought to be lessened by using other herbs, which include valerian (*Valeriana officinalis*), vervain (*Verbena officinalis*), skullcap (*Scutellaria baicalensis*) and kava (*Piper methysticum*).

Other treatments aimed at reducing the stress a person suffers while attempting substance withdrawal and throughout an individual's recovery process include biofeedback, guided imagery, and various meditative arts, including **yoga** and tai chi. Alternative medicine also places a great emphasis on proper **nutrition**, for detoxification, healing, and sustained recovery.

Prognosis

After a person has successfully withdrawn from substance use, the even more difficult task of recovery begins. Recovery refers to the lifelong efforts of a person to avoid returning to substance use. The craving can be so strong, even years and years after initial withdrawal has been accomplished, that a previously addicted person is virtually forever in danger of slipping back into substance use. Triggers for such a relapse include any number of life stressors: problems on the job or in the marriage, loss of a relationship, death of a loved one, and financial stresses, in addition to seemingly mundane exposure to a place or an acquaintance associated with previous substance use. While some people remain in

counseling indefinitely as a way of maintaining contact with a professional who can help monitor behavior, others find that various support groups or 12-Step programs such as Narcotics Anonymous are the most successful and useful way of monitoring the recovery process and avoiding relapse. Research indicates that a good prognosis is more likely for individuals who have a strong support than for those who have little or no support.

Another important aspect of treatment for substance abuse is the inclusion of close family members in treatment. Because substance abuse has severe effects on the functioning of the family, and because research shows that family members can accidentally develop behaviors that inadvertently serve to support a person's substance habit, most good treatment programs will involve all family members.

Health care team roles

Nursing staff and allied health professionals can assist in the treatment of substance abuse and dependence by understanding the disease model of **alcoholism** and addiction.

During the treatment phase, nursing staff and allied health professionals can help patients by providing them with appropriate educational materials and referrals for supportive services such as Alcoholics Anonymous or Narcotics Anonymous.

Prevention

Prevention is best aimed at teenagers, who are at very high risk for substance experimentation. Data compiled in 1999 revealed that 14% of high school seniors had used an illegal substance other than marijuana in the preceding year. Education regarding the risks and consequences of substance use, as well as teaching methods of resisting peer pressure, are both important components of a prevention program. Furthermore, it is important to identify children at higher risk for substance abuse, including victims of physical or sexual abuse, children of parents who have a history of substance abuse, especially alcohol, and children with school failure and/or attention deficit disorder. These children will require a more intensive prevention program.

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ORGANIZATIONS

Al-Anon, Alanon Family Group, Inc. PO Box 862, Midtown Station, New York, NY 10018-0862. (800) 356-9996. <<http://www.recovery.org/aa>>.

National Alliance On Alcoholism and Drug Dependence, Inc. 12 West 21st St., New York, NY 10010. (212) 206-6770.

National Clearinghouse for Alcohol and Drug Information. <<http://www.health.org>>.

Parent Resources and Information for Drug Education (PRIDE). 10 Park Place South, Suite 340, Atlanta, GA 30303. (800) 853-7867.

Bethanne Black

Substance abuse counseling

Definition

Substance abuse is a maladaptive pattern of alcohol or other drug use that causes social, physical, legal, vocational, or educational distress or impairment. In addition to those trained specifically as substance abuse counselors, mental health and rehabilitation counselors work with individuals who abuse alcohol and other drugs.

Description

Counselors who work with substance abusers should have the same qualities as other counselors. For example, they should be able to pose direct questions and confront clients, self-disclose appropriately, identify countertransference issues, and recognize the effect of their own beliefs on the counseling relationship. Essential qualities include empathy, sincerity, warmth, genuineness, and nonjudgmental acceptance.

In order to assess, diagnose, and treat substance abusers, counselors must have general counseling skills and abilities in addition to specialized skills and abilities relative to this population. Counselors working with substance abusers must have knowledge of assessment instruments and techniques in order to communicate with other professionals and make treatment recommendations.

Substance abuse counselors develop a treatment plan based on the individual client's needs. The information necessary for the individual's treatment plan is gathered through interviews in conjunction with assessment instruments.

Major substance abuse counseling theories include reality therapy, psychodynamics, grief therapy, client-centered therapy, rational emotive therapy, and cognitive-behavioral. Additional approaches such as life-skills training and behavior modification are often included.

Mental health counselors work with individuals and groups to promote optimum mental health. They deal with addictions and substance abuse, suicide, **stress** management, problems with self-esteem, issues associated with mental and emotional health, and family and marital problems. Mental health counselors work closely with other mental health specialists, including psychiatrists, psychologists, clinical social workers, psychiatric nurses, and school counselors.

Substance abuse among people with disabilities exceeds that of the general public. According to the **Americans with Disabilities Act** of 1990, recovery from alcohol or drug addiction is considered a disability. Rehabilitation counselors work with people with disabilities resulting from birth defects, illness or disease, accidents, or the stress of daily life. They help people with disabilities deal with the personal, social, and vocational effects of their disabilities. Rehabilitation counselors evaluate the individual's strengths and limitations, provide personal and vocational counseling, and arrange for medical care, vocational training, and job placement. They interview individuals with disabilities and their families, evaluate school and medical reports, and confer and plan with physicians, psychologists, occupational therapists, and employers to determine the capabilities and skills of the individual. By conferring with the client they develop a rehabilitation program, which often includes training to help the person develop job skills. Increasing the client's capacity to live independently is also a priority. To enhance the likelihood that the substance abuse client will continue to recover, many counselors encourage or support the client's attendance at meetings of Alcoholics Anonymous or Narcotics Anonymous.

Work settings

Substance abuse counselors work in a variety of settings including residential and outpatient treatment programs, hospitals and clinics, government agencies, private practice, schools, and correctional facilities. Substance abuse counseling takes place individually and

in groups. To enhance continued recovery, counselors also work with family members.

Rehabilitation counselors usually work a traditional 40-hour week. Counselors in private practice and those working in mental health and community agencies often work evenings to counsel clients who work during the day.

Education and training

Some employers provide training for newly hired counselors. Many have work-study programs so that employed counselors are able to pursue graduate degrees. However, most employers require, or prefer, that counselors have a master's degree. At least 45 states and the District of Columbia have some form of counselor credentialing, licensure, certification, or registry legislation governing practice. Although requirements vary from state to state, many require a master's degree.

Accredited master's degree counseling programs include a minimum two years of full-time study, including 600 hours of supervised clinical internship experience. Counselors with a master's degree who work with substance abusers come from a variety of disciplines, including substance-abuse counseling, rehabilitation counseling, agency or community counseling, clinical mental health counseling, counseling psychology, and related fields.

Graduate-level counselor education programs in colleges and universities are most often located in education or psychology departments. Course work is grouped into a number of core areas including **human growth and development**; social and cultural foundations; helping relationships; group work; career and lifestyle development; appraisal; research and program evaluation; and professional orientation. Most accredited graduate programs require the student to complete 48–60 semester hours of course work, including a period of supervised clinical experience in counseling. More than 100 institutions offer programs accredited by the Council for Accreditation of Counseling and Related Educational Programs (CACREP). These include programs in substance abuse, mental health, rehabilitation, and community counseling. Graduate programs in rehabilitation counseling are accredited by the Council on Rehabilitation Education (CORE).

Many counselors pursue national certification by the National Board for Certified Counselors (NBCC). To be certified a counselor must hold a graduate degree in counseling from a regionally accredited institution, have at least two years of supervised field experience in a counseling setting, and pass the NBCC's National

Counselor Examination for Licensure and Certification. This national certification is distinct from state certification, however, in some states those who pass the national exam are exempt from taking a state certification exam. NBCC offers specialty certification in clinical mental health and addictions counseling. To maintain certification, counselors must complete 100 hours of acceptable continuing education credit every five years.

The Commission on Rehabilitation Counselor Certification offers national certification for rehabilitation counselors, which is required by many employers. To become certified, rehabilitation counselors must graduate from an accredited educational program, complete an internship, and pass a written examination. To maintain certification, counselors must complete 100 hours of acceptable continuing education credit every five years.

Most clinical mental health counselors have a master's degree in mental health counseling, another area of counseling, psychology, or social work. Certification is available through the NBCC. To be certified as a clinical mental health counselor, a counselor must have a master's degree in counseling, two years of post-master's experience, a period of supervised clinical experience, a taped sample of clinical work, and pass a written examination.

Prospects for advancement vary by counseling field. Rehabilitation, mental health, and substance-abuse counselors can become supervisors or administrators in their agencies. Some counselors move into research, consulting, college teaching, or go into private or group practice.

Future outlook

A study conducted by the Substance Abuse and Mental Health Services Administration (SAMHSA) estimated that in 1996 the cost for alcohol and drug abuse treatment surpassed \$13 billion. The combined costs of substance abuse and mental health treatment services ranked third after spending for **heart** disease, injury, and trauma. As a result, employment for counselors is expected to increase from 21–35% through 2008. Demand is expected to be strong for rehabilitation and mental health counselors.

Due to the toll substance abuse takes on worker productivity, an increasing number of employers offer employee assistance programs that provide alcohol and drug abuse counseling services. A growing number of people are expected to use these services, creating a demand for counselors as many seek ways to maintain their recovery from substance abuse while dealing with the stresses associated with job and family.

For general information about counseling, as well as information on specialties such as substance abuse, mental health, or rehabilitation counseling, contact the American Counseling Association, 5999 Stevenson Ave., Alexandria, VA 22304-3300. <<http://www.counseling.org>>.

For information on accredited counseling and related training programs, contact the Council for Accreditation of Counseling and Related Educational Programs, American Counseling Association, 5999 Stevenson Ave., 4th floor, Alexandria, VA 22304. <<http://www.counseling.org/cacrep>>.

For information on national certification requirements for counselors, contact: National Board for Certified Counselors, Inc., 3 Terrace Way, Suite D, Greensboro, NC 27403-3660. <<http://www.nbcc.org>>.

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National Center on Addiction and Substance Abuse at Columbia University. 633 Third Avenue, 19th floor, New York, NY 10017-6706. (212) 841-5200. <<http://www.casacolumbia.org/>>.

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Bill Asenjo, MS, CRC

Substance use disorder *see* **Substance abuse and dependence**

Sugar diabetes *see* **Diabetes mellitus**

Sunstroke *see* **Heat disorders**

Supportive cancer therapy *see* **Cancer therapy, supportive**

Surgical instruments

Definition

Surgical instruments are tools or devices that perform such functions as cutting, dissecting, grasping, holding, retracting, or suturing. Most surgical instruments are made from stainless steel. Other metals and alloys, including titanium and vitallium, are also used.

Purpose

Surgical instruments facilitate a variety of procedures and operations. Specialized surgical packs contain the most common instruments needed for particular surgeries.

Description

Basic categories of instruments include:

- cutting and dissecting
- clamping
- grasping and holding
- probing
- dilating
- retracting
- suctioning

Scissors are an example of cutting instruments. Dissecting instruments are used to cut or separate tissue. Dissectors may be sharp or blunt. Scalpels are one example of sharp dissectors. Examples of blunt dissectors include the back of a knife handle; curettes and elevators can also be blunt. Grasping and holding instruments include clamps, tenacula, and forceps. Probing instru-

ments are used to enter natural openings, for example the common bile duct, or such openings as a fistula. Dilating instruments serve to expand the size of an opening, such as the urethra or the cervical os. Retractors assist in the visualization of the operative field while preventing trauma to other tissues. Suction devices remove **blood** and other fluids from the surgical or dental field.

Operation

Counting

Sharps and related items should be counted prior to the beginning of the procedure; before the closure of a cavity within a cavity; before wound closure begins; and at skin closure or the end of the procedure. In addition, a count should be taken at any time when either scrub or circulating personnel are replaced. Instruments, sharps, and sponges should be counted during all procedures in which the possibility exists of leaving an item in the patient.

Cleaning and sterilizing

Surgical instruments must be kept clean during a procedure. Cleaning is done by carefully wiping instruments with a moist sponge and frequently rinsing them in sterile water. Periodic cleaning during the procedure prevents blood and other tissue from hardening and becoming trapped on the surface of an instrument. After the procedure, instruments are promptly rinsed and thoroughly cleaned and sterilized. Ultrasonic cleaning and automatic washing often follow the manual cleaning of instruments. Instruments may also be placed in an autoclave after manual cleaning. The manufacturer’s instructions should be followed for each type of machine. Staff members responsible for cleaning instruments should wear protective gloves, waterproof aprons, and face shields.

Patient status

Observation of patients after surgical procedures provides the best indication that correct instrument handling and **aseptic technique** was followed during surgery. Postoperative patients should show no evidence of:

- retained instruments or sponges
- infection at the site of the incision or operation
- excessive swelling or discoloration at the operative site

Maintenance

Inspection

The misuse of surgical instruments frequently causes alignment problems. Instruments should always be inspected before, during, and after surgical procedures. Clamps, scissors and forceps should be examined to make sure that the tips are even and in proper alignment. The instrument tips should not overlap. To test the alignment of clamps, first close the clamp. Then, hold the instrument up to a light. No light will be visible if the clamp is correctly aligned. Instruments that have teeth or serrated tips should also be checked for proper alignment. Be sure that the instrument opens and closes freely. Hinged instruments must hold firmly and close properly. To test ratchet teeth, close the instrument on the first tooth. Then, tap the ratchet part against a solid surface. The ratchet is faulty if the instrument springs open. Clamps that open when placed on **blood vessels** have the potential to injure patients. Scissors must be sharp and smooth, and cut easily. Inspect the edges of sharp instruments for chips, nicks, or dents. Needle holders must hold needles without slippage or twisting of the needle. To test needle holders, place a needle in the jaws of the instrument, then lock the holder in the second tooth. If the needle can be easily removed, replace the instrument. Inspection is an ongoing process that must be carried out by all members of the surgical team.

After the procedure, staff members responsible for cleaning and disinfecting the instruments should also inspect them. The instruments should be inspected again after cleaning and during packaging. Any instrument found not in good working order should be sent for repair. Depending on use, surgical instruments can last for up to ten years, given proper care.

High-risk diseases

Evidence from animal models and case reports in humans has shown that such prion diseases as **Creutzfeldt-Jakob disease (CJD)** can be transmitted via stainless steel instruments. As of 2001, British surgeons are moving toward using only disposable, single-use instruments—particularly in adenotonsillectomy procedures—to minimize the risk of transmission of CJD. Research in the United States has concluded that surgical instruments and devices contaminated with particles of **brain, spinal cord**, and eye tissue from high-risk patients require special treatment.

Health care team roles

Team members involved with the care and use of surgical instruments include surgeons, the first assistant,



Surgical instruments on a tray. (Archive Photos, Inc. Reproduced by permission.)

the circulator, and the scrub person. Such other personnel as medical students, orderlies, or aides may also be included in the surgical team.

The surgeon works under the policies of the facility in which the procedure is performed. The surgeon is responsible for guiding the operation. During the procedure, the surgeon may also identify instrument malfunctions not evident until the device is actually in use.

The first assistant generally acts to provide retraction, grasp tissue, perform suturing, and other duties as required by the surgeon and the procedure performed.

The person performing the scrub function is responsible for maintaining a sterile operative field. The scrub person hands instruments to the surgeon or assistant. Instruments and other materials are passed in such a way that the surgeon does not have to look away from the wound in order to receive the item. The scrub person is responsible for conducting counts of instruments, sponges, and sharps with the circulator. The scrub person should also inspect the surgical instruments prior to the procedure.

The person performing the circulating function does not undergo a surgical scrub prior to the procedure, and therefore does not enter the sterile operating field. The circulator is responsible for conducting counts of instruments, sponges and sharps with the scrub person. The circulator positions the patient for the procedure, adjusts lighting, and assists the surgical team in carrying out functions that do not require sterile, only aseptic, techniques.

Training

Training in the use and care of surgical instruments may range from the medical training required by physicians to on-the-job training for orderlies and aides.

KEY TERMS

Autoclave—A heavy vessel that uses pressurized steam for disinfecting surgical instruments.

Creutzfeldt-Jakob disease (CJD)—A degenerative disorder of the nervous system that is usually fatal within a year. CJD is transmitted by a prion.

Curette—A scoop-shaped surgical instrument for removing tissue from body cavities.

Instruments—Tools or devices that perform such functions as cutting, dissecting, grasping, holding retracting, or suturing.

Prion—A infectious agent composed of protein and lacking a genetic component.

Sharps—Surgical implements with thin cutting edges or a fine point. Sharps include such devices as suture needles, scalpel blades, hypodermic needles, and safety pins.

Sponges—Pieces of absorbent material, usually cotton gauze, used to absorb fluids, protect tissue, or apply pressure and traction.

Tenaculum (plural, tenacula)—A small, sharp-pointed hook set in a handle, used to seize or pick up pieces of tissue during surgical operations.

- Surgeons are graduates of medical or osteopathic institutions, with additional training and education in surgical procedures.
- First assistants. Depending on institutional policy, the first assistant may be another physician, a surgical resident, or a **registered nurse**.
- Circulator. Depending on facility policy, the circulator may be a registered nurse, a **licensed practical nurse**, or a surgical technologist.
- Scrub person. The scrub person may be a registered nurse, a licensed practical nurse, or a surgical technologist.
- Other personnel. Depending on the facility, there may be surgical orderlies and aides that assist in a variety of tasks, such as patient positioning and transfers, instrument cleaning and disinfecting, and cleaning the surgical suites. No special license is required for these positions, and training may be acquired on the job.

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Association of Surgical Technologists (AST). 7108-C South Alton Way, Suite 100, Englewood, CO 80112-2106. (800) 637-7433.

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Sklar Instruments. 889 South Matlack St., West Chester, PA 19382. (800) 221-2166. <<http://www.sklarcorp.com/>>.

Surgical Instruments Corporation. 4575 Hudson Drive, Stow, OH 44224. (800) 444-5644. <<http://www.spectrumsurgical.com/>>.

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Surgical technology

Definition

Surgical technology is an allied health profession. Surgical technologists are responsible for **surgical instruments** and other equipment in the surgical unit. They assist a variety of personnel in the surgical area, including surgeons and registered nurses.

Description

Surgical technologists are also sometimes referred to as operating or surgical room technicians. The primary goal of the surgical technologist is to adequately prepare the operating room for a surgical procedure and to assist surgical professionals in performing their duties during the surgery. This preparation generally involves setting up the surgical instruments and equipment; it also includes the organization and placement of sterile linens and solutions. In addition, the surgical technologist gathers, adjusts, and assesses nonsterile equipment to verify that it is operational. The surgical technologist also helps patients with preparation for the surgical procedure by cleaning, shaving, and disinfecting the areas of the body where the surgery will take place. Surgical technologists move the patients into the operating room, where they help with the proper positioning of the patient on the operating table, having dressed the patient with sterile surgical clothing.

In the preoperative phase, surgical technologists often help with the important task of monitoring the **vital signs** of patients and checking patient charts. They also help other surgical personnel scrub and dress for the surgical procedure. During surgical procedures, technologists supply instruments and supplies to the surgeons and surgical assistants. This will involve counting needles, sponges, instruments, and supplies. It may also include holding retractors and cutting sutures. One of the most important duties of the technologist is to help with the collection, preparation, and disposal of specimens taken from the patient. Such specimens are usually taken to the laboratory for analysis. Other duties include applying dressings to the surgical site and maintaining equipment in the operating room, such as suction devices, lights, and sterilizers. They may also be involved in the management of **blood** and plasma. After surgery, the surgical technologist often takes the patient to a recovery room. Another role of the technologist is to clean the operating room after the surgery is complete, and the replenishment of surgical room supplies.

Work settings

Most surgical technologists work in surgical units in hospitals, which are comfortable environments that are clean and well-lit. However, it is often necessary for the surgical technologist to stand for hours during lengthy surgical procedures. Surgical technologists, as well as other surgical personnel, are sometimes exposed to contagious disease, in addition to challenging situations involving bad odors and sights associated with serious disease. They wear traditional surgical gowns along with head coverings, masks, gloves, shoe covers, and protec-

tive eyewear. The majority of surgical technologists work a 40-hour week. This work week may involve some weekend, evening, and holiday shifts.

Education and training

Almost all surgical technologists receive their training in one of the following places: the military, hospitals, vocational schools, universities, or junior and community colleges. A formal body called the Commission on Accreditation of Allied Health Education Programs (CAAHEP) officially recognized and accredited 165 such programs as of 1998. Generally, a person must be a high-school graduate before being admitted to these programs. These programs vary in length from nine to 24 months. Those who graduate from these programs receive either a certificate, diploma, or associated degree. Those who have prior medical training, such as certain military personnel or licensed practical nurses, often train in the programs for a shorter duration.

The typical surgical technology program includes courses in anatomy, physiology, **pharmacology**, **medical terminology**, microbiology, surgery, and ethics. These programs also have a significant period of supervised hands-on clinical training. During the program, the student learns the proper techniques to ensure the care and safety of patients during surgical preparation and procedures. In addition, surgical technology students learn to handle a variety of equipment, supplies, solutions, and drugs. The surgical technologist must learn in detail the types and functions of a wide variety of surgical instruments. In addition to these more traditional surgical implements, a fully-trained modern surgical technologist must know about modern surgical technology and how it is used. This technology may include endoscopes, lasers, and power tools. For obvious reasons, surgical technology students receive extensive training in the use of the appropriate tools in various surgical situations.

There is a strong emphasis on proper **sterilization techniques** and the prevention of **disease transmission** before, during, and after surgical procedures. Significant discussion of disinfectant agents and their application to instrumentation, equipment, and supplies are also part of the curriculum. Surgical technologists also receive training in the principles of wound healing from the suturing process to the various stages of healing. Surgical technologists are also often trained to perform basic **cardiopulmonary resuscitation (CPR)** or basic life support (BLS). In addition to patients who are scheduled for surgery in advance, surgical technologists also help prepare patients who enter the hospital in emergency situations.

KEY TERMS

Computed axial tomography—Noninvasive imaging in which planes of tissue are assessed by radiography combined with computer analysis.

Endoscope—A device that consists of a tube and an optical system that allows the observation of the inside of a hollow organ or cavity.

Magnetic resonance imaging—Noninvasive technique that allows the viewing of soft tissues in the body using a strong magnetic field.

Positron emission tomography—a noninvasive technique that allows the observing of blood and oxygen flow in tissues, particularly the brain, using positron-emitting radionuclides.

Surgical technologists also receive training in the various ways that diseases are diagnosed, such as radiography, computed axial tomography (CT), **positron emission tomography**, **magnetic resonance imaging**, and ultrasonography. These imaging techniques are generally used preoperatively, though some of these methods may be used in an operative setting.

Surgical technologists need to be able to handle a fairly high level of **stress** due to the typical conditions in an operating environment. They also need to be organized and conscientious. A high level of manual dexterity is also required in the manipulation of operating room supplies and instruments. They need to know the equipment, supplies, and procedures of the operating room to efficiently help the surgical team. There is no time to waste in this environment, and the surgical technologist should not have to be told how and what to do at every step. As with other health professionals, the surgical technologist needs to keep up with the latest developments within the field.

The Liaison Council on Certification for the Surgical Technologist certifies technologists as professionals. This body grants such certification after the person graduates from one of the accredited programs and passes a national certification examination. At this point, the individual can use the title Certified Surgical Technologist (CST). This certification has to be renewed every six years. The certification requires either passing an examination or taking continuing education courses. Generally, those who have obtained the CST designation have an advantage in the recruitment process.

Advanced education and training

There are a variety of ways for the surgical technologist to keep up with developments within the field. There are many continuing education courses available. One of the best ways for the technologist to advance within the field is to specialize in a particular type of surgical technology, for example, cardiothoracic surgery, neurosurgery, orthopedic surgery, or as circulating technologists. The circulating technologist is the only member of the surgical team that is not completely sterile. In this role the technologist helps with the patients or assists in the anesthesia. This person also retrieves and opens supplies for sterile members of the team. They may also interview the patient before surgery, keeping detailed notes about the surgery itself, and act as a resource of information about the patient during surgery. There are four levels of CST certification. Level 1 is one that has been certified in basic patient care concepts and has the training to perform as first scrub during basic surgeries. Level 2 has all of the abilities and training of those at level 1 and has circulating skills. Level 3 has the skills and knowledge of the first two levels and has some defined management position. Level 4 surgical technologists are called surgical first assistants. These technologists actually help with the surgery itself. First assistants typically have additional training. Another means for surgical technologists to advance is by getting into management positions, such as operating supply departments in hospitals. Practice standards have been developed to help surgical technologists in these roles.

Future outlook

The United States Department of Labor has forecast that the employment of surgical technologists will grow at a rate that is much faster than average through the year 2008. This reflects growth in the number of surgical procedures being performed currently. This number is growing because those born in the baby boom after World War II are reaching retirement age and many require surgical interventions. New surgical technologies will also be increasingly utilized, and this will require highly trained personnel. The majority of surgical technologists will continue to be employed by hospitals, but many will work in clinics and in the offices of physicians.

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Association of Surgical Technologists, 7108-C South Alton Way, Englewood, CO 80112. <<http://www.ast.org>>.

Liaison Council on Certification for the Surgical Technologist, 7790 East Arapahoe Rd, Suite 240, Englewood, CO 80112-1274.

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Swallowing disorders see **Dysphagia**

Swan-Ganz catheterization

Definition

Swan-Ganz catheterization, also known as pulmonary artery catheterization, is a diagnostic procedure in which a small catheter is threaded through a vein in the arm, thigh, chest, or neck until it passes through the right side of the **heart** into the pulmonary artery. The catheter is then able to measure the pressures in the right heart and pulmonary artery.

Purpose

Swan-Ganz catheterization is performed in order to:

- Evaluate heart failure.
- Determine whether pulmonary **edema** is caused by a weak heart (cardiogenic pulmonary edema) or leaky pulmonary capillaries (non-cardiogenic pulmonary edema or adult respiratory distress syndrome).
- Monitor therapy after a **myocardial infarction** (heart attack).
- Check the **fluid balance** of patients in **shock** as well as those recovering from heart surgery, serious **burns**, or kidney disease.
- Monitor the effect of medications on the heart.

Precautions

Pulmonary artery catheterization is an invasive and potentially complicated procedure. The physician must decide if the value of the information obtained outweighs the risks of catheterization.

Description

Swan-Ganz catheterization is usually performed in the hospital intensive care unit. A catheter is threaded through a vein in the arm, thigh, chest, or neck until it

passes through the right side of the heart into the pulmonary artery. The procedure takes about 30 minutes. **Local anesthesia** is administered at the catheter insertion site to reduce discomfort.

Once the catheter is in place, the physician briefly inflates a tiny balloon at its tip. This temporarily blocks the **blood** flow and allows the physician to make a pressure measurement in the pulmonary artery system. This pressure reading is called the pulmonary capillary wedge pressure. Pressure measurements are usually recorded for the next 48-72 hours in different parts of the heart. During this time, the patient must remain in bed so the catheter remains in position. Once the pressure measurements are no longer needed, the catheter is removed.

Preparation

Before and during the test, the patient will be connected to an electrocardiograph, which records the electrical stimuli that cause the heart to contract. The insertion site is sterilized and prepared prior to the test. The catheter is often sutured to the skin to prevent dislodgment.

Aftercare

The patient is observed for any sign of infections or complications from the procedure.

Complications

Swan-Ganz catheterization is not without risk. Possible complications from the procedure include:

- lung collapse (pneumothorax)
- infection at the site of catheter insertion
- pulmonary artery perforation
- blood clots in the lungs
- irregular heartbeat

Results

Normal pressures reflect a normally functioning heart with no fluid accumulation. These normal pressure readings are:

- Right atrium: 1-6 mm of mercury (mm Hg).
- Right ventricle during contraction (systolic): 20-30 mm Hg.
- Right ventricle at the end of relaxation (end diastolic): less than 5 mm Hg.
- Pulmonary artery during contraction (systolic): 20-30 mm Hg.

KEY TERMS

Cardiac shunt—A defect in the wall of the heart that allows blood from different chambers to mix.

- Pulmonary artery during relaxation (diastolic): about 10 mm Hg.
- Mean pulmonary artery: less than 20 mm Hg.
- Pulmonary capillary wedge pressure: 6-12 mm Hg.
- Cardiac output: 3-7 L/min.

Abnormally high right atrium pressure can indicate:

- pulmonary disease
- right-sided heart failure
- fluid accumulation
- cardiac tamponade (compression of the heart by a pericardial effusion)
- right heart valve abnormalities
- pulmonary **hypertension** (high blood pressure)

Abnormally high right ventricle pressure may indicate:

- pulmonary hypertension (high blood pressure)
- pulmonary valve abnormalities
- right ventricle failure
- defects in the heart wall between the right and left ventricle
- congestive heart failure
- serious heart inflammation

Abnormally high pulmonary artery pressure may indicate:

- left-to-right cardiac shunt
- pulmonary artery hypertension
- chronic obstructive pulmonary disease or emphysema
- blood clots in the lungs
- fluid accumulation in the lungs
- left ventricular failure

Abnormally high pulmonary capillary wedge pressure may indicate:

- left ventricular failure
- mitral valve abnormalities
- compression of the heart after hemorrhage

Health care team roles

Swan-Ganz catheterization is generally performed in the hospital intensive care or critical care unit by trained physicians. Physicians from a variety of specialties are trained to perform the procedure, including cardiologists, surgeons, anesthesiologists, and critical care specialists. Patients in the intensive care unit are monitored and cared for by critical care nurses, laboratory and radiology technicians as well as other physician specialists such as internists, pulmonologists, and cardiothoracic surgeons.

Patient education

Specially trained nurses assist during catheterization procedures and provide pre- and postoperative education, monitoring, and supportive care.

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Sweat test *see* **Electrolyte tests**

Syncope

Definition

Syncope, or fainting, is a temporary loss of consciousness, usually caused by decreased **blood** flow to the **brain**. Syncope is a symptom, rather than a disease itself, and has many causes. The vasovagal faint, which usually occurs in young, otherwise healthy people, is one particular form of syncope. Syncope accounts for about 300,000 emergency department visits per year, and about 6% of hospital admissions.

Description

Syncope usually begins while a person is either sitting or standing upright. Sometimes, the onset may be almost instantaneous. In other cases, up to a few minutes before the attack there may be warning symptoms such as:

- profuse sweating (diaphoresis)

- nausea or vomiting
- light-headedness or weakness
- confusion or **anxiety**
- blurry or dim vision
- ringing in the ears

The patient usually becomes very pale and collapses. Loss of consciousness can last from seconds to several minutes. During this time, the patient may have a slight awareness of the situation, or may lose consciousness completely. During this time there may be some twitching or jerking of the body, but not usually incontinence or biting of the tongue; this helps distinguish the episode from a seizure. The patient's **blood pressure** is usually low with a weak pulse, but the **heart** rate may be fast or slow. Breathing is often very slow or shallow.

As the person lies flat, blood flow returns to the brain. The patient's **vital signs**, color, and alertness improve. Depending on the cause, the patient may have no sequelae (continuing symptoms), or may remain weak, confused, nauseated, or sweaty. A patient who tries to get up too soon may faint again.

Causes and symptoms

Dozens of different underlying problems can cause syncope; some are life-threatening, others are of little importance. Here is one way to classify them.

Orthostatic

Orthostatic, or postural, syncope occurs when the body cannot supply enough blood to the brain in the upright position because of low blood pressure. The patient may have minimal symptoms of illness while lying flat, but becomes very faint when standing. Causes include:

- blood loss (trauma, gastrointestinal hemorrhage, ruptured aortic aneurysm, ruptured ectopic **pregnancy**)
- dehydration (vomiting, **diarrhea**, heat exposure)
- certain medications (beta blockers, **calcium** channel blockers, diuretics)

Cardiac

The heart itself is the source of many episodes of syncope. There are numerous possible mechanisms. For example, certain cardiac arrhythmias (irregular heart-beat) reduce the output of the heart. In severe bradycardia (slow heartbeat), the ventricles beat too slowly to supply enough blood to the brain. In rapid tachycardias (rapid heartbeat), the heart beats quickly but very ineffi-

ciently, so relatively little blood and oxygen reach the brain.

Reflex-mediated

Reflex-mediated syncope occurs when a certain stimulus triggers a bodily response that lowers the cardiac output. The most common example of this is the vasovagal faint (also known by many other names, including simple faint or neurocardiogenic syncope). This condition typically affects young, otherwise healthy people who experience something very unpleasant, such as **pain**, fear, or horror. Nervous system **reflexes** cause the blood pressure, and often the pulse, to drop. The patient experiences warning symptoms such as sweating, nausea, and light-headedness, and then faints if not able to lie down quickly. Other reflex-mediated faints often involve the Valsalva maneuver (taking a deep breath and bearing down), as when straining to urinate, defecate, cough, or lift a heavy object.

Medication-related

Medications may lead to fainting by their direct effects of lowering the blood pressure (anti-hypertensives, nitroglycerine) or slowing the heart rate (digoxin). Some drugs may promote arrhythmias (tricyclic antidepressants). Other drugs that may cause syncope include antiparkinsonians, phenothiazines and other antipsychotics, insulin and other hypoglycemics, alcohol, and cocaine.

Neurologic

Neurologic causes of syncope include stroke and transient ischemic attack, subarachnoid hemorrhage, and migraine. In these cases a part of the brain does not receive its normal blood supply, and the patient loses consciousness. Seizure is the condition most often mistaken for syncope, because patients with true seizures often lose consciousness as well.

Psychiatric

Psychiatric disorders may cause syncope on the basis of anxiety and hyperventilation, hysterical seizures, or major depression.

Diagnosis

The challenge for health professionals is to determine the cause of an episode of syncope, and especially whether the cause requires further medical intervention.

KEY TERMS

Antiparkinsonian—A drug which treats Parkinson's disease.

Aortic aneurysm—A dangerous widening and weakening of the wall of the aorta.

Aortic stenosis—A narrowing and stiffening of the aortic valve of the heart.

Arrhythmia—An abnormal beating pattern of the heart.

Beta blockers—A class of medicines including propranolol (Inderal), atenolol (Tenormin), and many others, used to slow the heart rate and reduce the blood pressure.

Bradycardia—Heart rate less than 60 beats per minute.

Calcium channel blockers—A class of medicines including verapamil (Calan), diltiazem (Cardizem), and many others, used to slow the heart rate and reduce the blood pressure.

Cardiomyopathy—A disease which weakens the heart muscle.

Diaphoresis—Profuse sweating.

Diuretic—Causing urination.

Ectopic pregnancy—A dangerous condition in which a woman becomes pregnant but the pregnancy grows outside the uterus.

Incontinence—Loss of control over the release of urine or the bowels.

Insulin and hypoglycemics—Various drugs which

reduce the level of sugar in the blood, used to treat diabetes mellitus.

Myocardial infarction—Heart attack, or death of some part of the heart muscle.

Neurocardiogenic—Arising from the nervous and cardiac systems of the body.

Orthostatic—Related to being upright.

Pericardial tamponade—A condition in which fluid accumulates in the pericardium, the sac that surrounds the heart. This restricts the amount of blood that can enter the heart's chambers.

Phenothiazines—A class of drugs including prochlorperazine (Compazine), chlorpromazine (Thorazine), and many others, used to treat nausea or psychosis.

Sequelae—Conditions which result from an event.

Subarachnoid hemorrhage—A dangerous condition of bleeding within the subarachnoid space of the brain.

Tachycardia—Heart rate greater than 100 beats per minute.

Transient ischemic attack (TIA)—A temporary interruption of the blood supply to part of the brain that causes a reversible impairment of some brain function.

Valsalva maneuver—The act of taking a deep breath and bearing down forcefully. This may be done intentionally, or as part of straining to move the bowels, urinate, or lift a heavy object, for example.

History

Nurses and aides are invaluable when they obtain details of the patient's episode not only from the patient, but also from family or friends, witnesses, and rescue personnel. The staff must not allow such people to leave without providing information, as well as phone numbers for further contact. Nurses and aides should focus on:

- the precise sequence of events leading up to, and following, the faint
- associated features (tongue biting, incontinence)
- the patient's **memory** of the event and any associated symptoms (pain, focal numbness or weakness, recent illness)
- past similar events and other medical history

- prescribed medications and how the patient takes them
- use of illicit drugs or alcohol
- possible emotional stress
- menstrual history

Physical examination

The examination must always start with the ABCs of resuscitation: airway, breathing, and circulation. Nurses and aides then:

- record vital signs frequently including oxygen saturation
- attach a cardiac monitor
- undress the patient completely

- observe for physical signs such as sweating, pallor, restlessness, confusion, or pain
- immediately communicate all abnormal findings to the physician

Laboratory

The patient likely will require blood work (**complete blood count**, blood chemistries, cardiac enzymes, and perhaps blood typing and coagulation studies) and urine tests (pregnancy, **urinalysis**, and drug screen), usually performed by a clinical laboratory technician. An EKG technician or the nurse will record an electrocardiogram, and the nurse may check bedside blood sugar determination and stool guaiac. The nurse will either initiate these directly or check first with the physician, depending on local policies. In all cases the nurse must not allow the patient to void or defecate without collecting a specimen.

Treatment

If the patient has no discernable pulse or respiration, the nurse and all available personnel immediately start **cardiopulmonary resuscitation** and summon help. The nurse and respiratory technician must ensure adequate oxygenation. The nurse starts an intravenous line (IV) in all but the least serious cases, and begins normal saline infusion if the blood pressure is low or the pulse is fast. The patient may need two large-bore IVs to replace fluids in a case of severe reduction in blood volume, or to receive drips of cardiac medications.

The nurse must give the patient nothing by mouth if there is any likely surgical cause of the problem (such as ruptured ectopic pregnancy), or if nausea persists. If the patient is about to vomit, the staff must quickly put the head down and roll the patient to the side. The nurse or aide should loosen tight clothing. The staff should keep the patient supine until clearly improved; thereafter, the patient may rise slowly while the nurse or aide checks for orthostatic pulse and blood pressure changes. More specific treatment depends on the underlying cause of the event.

Prognosis

The prognosis depends on such factors as the underlying cause of the problem, length of unconsciousness, injuries that may have occurred when fainting, and the patient's ability to modify circumstances that may have

contributed to the event (learning to rise slowly, stopping alcohol abuse, switching to different medications).

Health care team roles

The nurse, typically in the emergency department, initially receives the patient, makes the initial assessment of the patient's condition, often begins early diagnosis and treatment measures, continues to monitor the patient, and communicates all relevant information to the physician. The nurse's aide helps prepare the patient for examination and assists the rest of the care team. The laboratory technician helps collect specimens and process them in the lab. The EKG technician records one or more cardiograms and may help with other heart monitoring tests. A respiratory technician assists when there is difficulty breathing, and may perform an arterial blood gas. Radiology technicians carry out required x-ray tests. A social worker may discuss the patient's living situation with the patient, family, and caregivers, and help arrange future assistance.

Prevention

The nurse must provide clear instructions to the patient and caregivers. The patient may need to alter behavior (eat regularly, avoid stressful situations), stop or start various medications, have further tests or appointments, and understand warning signs requiring an immediate return to the hospital.

Resources

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Synovial fluid analysis see **Joint fluid analysis**

Syphilis

Definition

Syphilis is an infectious systemic disease that may be either congenital or acquired through sexual contact or by exposure to contaminated needles.

Description

Syphilis has both acute and chronic forms that produce a wide variety of symptoms affecting most of the body's organ systems. Acquired syphilis has four stages, including primary, secondary, latent, and tertiary, and can be spread by sexual contact during the first three of these four stages.

Syphilis has been a major **public health** problem since the sixteenth century. The disease was treated with mercury or other unsuccessful remedies until World War I, when effective treatments based on arsenic or bismuth were introduced. **Antibiotics** were introduced after World War II. At that time, the number of syphilis cases in the general population decreased, partly due to public health measures. But since 1980, the number of cases of syphilis in the United States has risen steadily. This increase includes men and women, all races, all parts of the nation, and all age groups, including adults over age 60. The number of women of childbearing age with syphilis is the highest that has been recorded since the 1940s. About 25,000 cases of infectious syphilis in adults are reported annually in the United States. It is estimated, however, that 400,000 people in the United States need treatment for syphilis every year, and that the annual worldwide total of persons infected with syphilis is 50 million.

The increased incidence of syphilis in recent years is associated with drug abuse as well as changes in sexual behavior. The connections between drug abuse and syphilis include needle sharing and exchanging sex for drugs. In addition, people using drugs are more likely to engage in risky sexual practices. With respect to changing patterns of conduct, a sharp increase in the number of people having sex with multiple partners makes it more difficult for public health professionals to trace the contacts of infected individuals. High-risk groups for syphilis include:

- sexually active teenagers
- people infected with another sexually transmitted disease (STD), including **AIDS**
- sexually abused children
- women of childbearing age

- prostitutes of either gender and their customers
- prisoners
- people who abuse drugs or alcohol

The chances of contracting syphilis from an infected person in the early stages of the disease during unprotected sex are 30–50%.

Causes and symptoms

Syphilis is caused by *Treponema pallidum*, a spirochete, which is a thin spiral- or coil-shaped bacterium that enters the body through the mucous membranes or breaks in the skin. In 90% of cases, the spirochete is transmitted by sexual contact.

Primary syphilis

Primary syphilis refers to the initial stage of the organism's entry into the body. The first signs of **infection** are not always noticed. After an incubation period ranging between 10 and 90 days, an individual develops a chancre, which is a small blister-like sore about 0.5 inches (13 mm) in size. Most chancres are on the genitals, but they may also develop in or on the mouth or on the breasts. Rectal chancres are common among male homosexuals. Chancres in women are sometimes overlooked if they develop in the vagina or on the cervix. The chancres are not painful and disappear in three to six weeks, with or without treatment. They resemble the ulcers of lymphogranuloma venereum, herpes simplex virus, or skin tumors.

About 70% of people with primary syphilis also develop swollen lymph nodes near the chancre. The nodes may have a firm or rubbery feel, but they are not usually painful.

Secondary syphilis

Syphilis enters its secondary stage between six to eight weeks and six months after the initial infection begins. Chancres may still be present but are usually healing. Secondary syphilis is a systemic infection marked by the eruption of skin rashes and ulcers in the mucous membranes. The skin rash may mimic a number of other skin disorders such as drug reactions, rubella (German measles), ringworm, mononucleosis, and pityriasis rosea. Characteristics of the rash that point to syphilis include:

- a coppery color
- absence of **pain** or itching
- occurrence on the palms of hands and soles of feet

The skin eruption may resolve in a few weeks or last as long as a year. A person may also develop condylomata lata, which are watery pink or gray areas of flattened skin in the moist areas of the body. The skin rashes, mouth and genital ulcers, and condylomata lata are all highly infectious.

About 50% of people with secondary syphilis develop swollen lymph nodes in the armpits, groin, and neck areas; about 10% develop inflammations of the eyes, kidney, **liver**, spleen, bones, joints, or the meninges (membranes covering the **brain** and **spinal cord**). They may also have a flu-like general illness with a low **fever**, chills, loss of appetite, headaches, runny nose, **sore throat**, and aching joints.

Latent syphilis

Latent syphilis is a phase of the disease characterized by relative absence of external symptoms. The latent phase is sometimes divided into early latency (less than two years after infection) and late latency. During early latency, people are at risk for spontaneous relapses marked by recurrence of the ulcers and skin rashes of secondary syphilis. In late latency, these recurrences are much less likely. Late latency may either resolve spontaneously or continue for the rest of the person's life.

Tertiary syphilis

Untreated syphilis progresses to a third, or tertiary, stage in about 35–40% of people. Individuals with tertiary syphilis cannot infect others with the disease. It is thought that the symptoms of this stage are a delayed hypersensitivity reaction to spirochetes. Some people develop so-called benign late syphilis, which begins between three and 10 years after initial infection and is characterized by the development of gummas. Gummas are rubbery tumor-like growths that are most likely to involve the skin or long bones but may also develop in the eyes, mucous membranes, throat, liver, or **stomach** lining. Gummas are increasingly uncommon since the introduction of antibiotics for treating syphilis. Benign late syphilis is usually rapid in onset and responds well to treatment.

CARDIOVASCULAR SYPHILIS. Cardiovascular syphilis occurs in 10–15% of people who have progressed to tertiary syphilis. It develops between 10 and 25 years after initial infection and often occurs together with neurosyphilis. Cardiovascular syphilis usually begins as an inflammation of the arteries leading from the **heart** and causes heart attacks, scarring of the aortic valves, congestive **heart failure**, or the formation of an aortic aneurysm.

NEUROSYPHILIS. About 8% of persons with untreated syphilis will develop problems in the **central nervous system** that include both physical and psychiatric symptoms. Neurosyphilis can appear at any time, from five to 35 years after the onset of primary syphilis. It affects men more frequently than women and Caucasians more frequently than African Americans.

Neurosyphilis is classified into four types:

- **Asymptomatic:** In this form, the person's spinal fluid gives abnormal test results, but there are no symptoms affecting the central nervous system.
- **Meningovascular:** This type is marked by changes in the **blood vessels** of the brain or inflammation of the meninges. A person develops headaches, irritability, and visual problems. If the spinal cord is involved, an individual may experience weakness of the shoulder and upper arm muscles.
- **Tabes dorsalis:** This type causes a progressive degeneration of the spinal cord and nerve roots. People lose their sense of perception of their body position and orientation in space (proprioception), resulting in difficulties with walking and the loss of muscle **reflexes**. They may also have shooting pains in the legs and periodic episodes of pain in the abdomen, throat, bladder, or rectum. Tabes dorsalis is sometimes called locomotor ataxia.
- **General paresis:** This type refers to the effects of neurosyphilis on the cortex of the brain. A person experiences slow but progressive losses of **memory**, ability to concentrate, and interest in self-care. Personality changes may include irresponsible behavior, depression, delusions of grandeur, or complete psychosis. General paresis is sometimes called **dementia** paralytica, and is most common among people over age 40.

Special populations

CONGENITAL SYPHILIS. Congenital syphilis has increased at a rate of 400–500% over the past decade, on the basis of criteria introduced by the Centers for Disease Control (CDC) in 1990. In 1994, more than 2,200 cases of congenital syphilis were reported in the United States. The prognosis for early congenital syphilis is poor: about 54% of infected fetuses die before or shortly after birth. Those which survive may look normal at birth but show signs of infection between three and eight weeks later.

Infants with early congenital syphilis have systemic symptoms that resemble those of adults with secondary syphilis. There is a 40–60% chance that a child's central nervous system will be infected. These infants may have symptoms ranging from **jaundice**, enlargement of the spleen and liver, and anemia to skin rashes, condylomata



This patient has secondary syphilis, which is characterized by the appearance of lesions on the skin.
(Custom Medical Stock Photo. Reproduced by permission.)

lata, inflammation of the **lungs**, a persistent runny nose, and swollen lymph nodes.

CHILDREN. Children who develop symptoms after the age of two years are said to have late congenital syphilis. The characteristic symptoms include facial deformities (saddle nose), Hutchinson's teeth (abnormal upper incisors), saber shins, dislocated joints, deafness, mental retardation, **paralysis**, and seizure disorders.

PREGNANT WOMEN. Syphilis can be transmitted from a mother to her fetus through the placenta at any time during **pregnancy**, or through the child's contact with syphilitic ulcers during the birth process. The chances of infection are related to the stage of the mother's disease. Almost all infants of mothers with untreated primary or secondary syphilis will be infected, whereas the infection rate drops to 40% if the mother is in the early latent stage, and 6–14% if she has late latent syphilis.

Pregnancy does not affect the progression of syphilis in the mother. However, pregnant women should not be treated with tetracyclines as this drug will discolor the teeth of her infant.

PEOPLE WITH HIV. Syphilis has been closely associated with HIV infection since the late 1980s. Syphilis sometimes mimics the symptoms of AIDS. Conversely, AIDS appears to increase the severity of syphilis in people suffering from both diseases, and to speed up the development or appearance of neurosyphilis. People with

HIV are also more likely to develop lues maligna, a skin disease that sometimes occurs in secondary syphilis. In addition, people with HIV have a higher rate of treatment failure with penicillin than those without HIV.

Diagnosis

Personal history and physical diagnosis

Because of the long-term risks of untreated syphilis, certain groups of people are now routinely screened for the disease, including:

- pregnant women
- sexual contacts or partners of people diagnosed with syphilis
- children born to mothers with syphilis
- individuals with HIV infection
- persons applying for marriage licenses

When a physician takes a person's history, there will be questions about recent sexual contacts to determine whether the person falls into a high-risk group. Symptoms such as skin rashes or swollen lymph nodes will be noted with respect to the dates of the person's sexual contacts. Definite diagnosis, however, depends on the results of laboratory **blood** tests.

Blood tests

There are several types of blood tests for syphilis presently used in the United States. Some are used in follow-up monitoring of infected people as well as diagnosis.

NON-TREPONEMAL ANTIGEN TESTS. Non-treponemal antigen tests are used with initial screening. They measure the presence of reagin, which is an antibody formed in reaction to syphilis. In the venereal disease research laboratory (VDRL) test, a sample of a person's blood is mixed with cardiolipin and cholesterol. If the mixture forms clumps or masses of matter, the test is considered reactive, or positive.

The rapid plasma reagin (RPR) test, which is available as a kit, works on the same principle as the VDRL. A person's serum is mixed with cardiolipin on a plastic-coated card that can be examined with the naked eye.

Non-treponemal antigen tests require a physician's interpretation and sometimes further testing. They can yield both false-negative and false-positive results. False-positive results can be caused by other infectious diseases, including mononucleosis, **malaria**, leprosy, rheumatoid arthritis, and lupus. People with HIV have a particularly high rate (4%, compared to 0.8% of people who are HIV-negative) of false-positive results on reagin tests. False-negatives can occur when individuals are

tested too soon after exposure to syphilis; it takes about 14–21 days after infection for the blood to become reactive.

TREPONEMAL ANTIBODY TESTS. Treponemal antibody tests are used to rule out false-positive results on reagin tests. They measure the presence of antibodies that are specific for *T. pallidum*. The most commonly used tests are the microhemagglutination-*T. pallidum* (MHA-TP) and the fluorescent treponemal antibody absorption (FTA-ABS) tests. In the FTA-ABS test, a person's blood serum is mixed with a preparation that prevents interference from antibodies to other treponemal infections. In a positive reaction, syphilitic antibodies in the blood coat the spirochetes on the slide. In the MHA-TP test, red blood cells from sheep are coated with *T. pallidum* antigen. The cells will clump if the person's blood contains antibodies for syphilis.

Treponemal antibody tests are more expensive and more difficult to perform than non-treponemal tests. They are therefore used to confirm the diagnosis of syphilis rather than to screen large groups of people. These tests are, however, very specific and very sensitive; false-positive results are relatively unusual.

Other laboratory tests

MICROSCOPE STUDIES. The diagnosis of syphilis can also be confirmed by identifying spirochetes in samples of tissue or lymphatic fluid.

SPINAL FLUID TESTS. Testing of cerebrospinal fluid (CSF) is an important part of monitoring programs as well as being a diagnostic test. The VDRL and FTA-ABS tests can be performed on CSF as well as on blood. An abnormally high white cell count and elevated protein levels in the CSF, together with positive VDRL results, suggest a possible diagnosis of neurosyphilis. CSF testing is not used for routine screening. It is most frequently used for infants with congenital syphilis, people who are HIV-positive, and individuals of any age who are not responding to penicillin treatment.

Treatment

Medications

Syphilis is treated with antibiotics given either intramuscularly (benzathine penicillin G or ceftriaxone) or orally (doxycycline, minocycline, tetracycline, or azithromycin). Neurosyphilis is treated with a combination of aqueous crystalline penicillin G, benzathine penicillin G, or doxycycline. It is important to keep the levels of penicillin in the person's tissues at sufficiently high levels over a period of days or weeks because the spirochetes have a relatively long reproduction time.

Penicillin is more effective in treating the early stages of syphilis than the later stages.

Physicians do not usually prescribe separate medications for the skin rashes or ulcers of secondary syphilis. A person is advised to keep the rashes clean and dry, and to avoid exposing others to fluid or discharges from condylomata lata.

Pregnant women should be treated as early in pregnancy as possible. Infected fetuses can be cured if the mother is treated during the second and third trimesters of pregnancy. Infants with proven or suspected congenital syphilis are treated with either aqueous crystalline penicillin G or aqueous procaine penicillin G. Children who acquire syphilis after birth are treated with benzathine penicillin G.

Jarisch-Herxheimer reaction

The Jarisch-Herxheimer reaction, first described in 1895, is a reaction to penicillin treatment that may occur during the late primary, secondary, or early latent stages. A person develops chills, fever, headache, and muscle pains within two to six hours after the penicillin is injected. The chancre or rash temporarily gets worse. The Jarisch-Herxheimer reaction, which lasts about a day, is thought to be an allergic reaction to toxins released when the penicillin kills massive numbers of spirochetes.

Alternative treatment

Antibiotics are essential for the treatment of syphilis. Recovery from the disease can be assisted by dietary changes, changes in sexual practices, sleep, **exercise**, and **stress** reduction.

HOMEOPATHY. Homeopathic practitioners are forbidden by law in the United States to claim that homeopathic treatment can cure syphilis. The remedies most frequently recommended by alternative practitioners who treat people with syphilis are *Medorrhinum*, *Syphilinum*, *Mercurius vivus*, and *Aurum*.

Prognosis

The prognosis is good for the early stages of syphilis if a person is treated promptly and given sufficiently large doses of antibiotics. There are no definite criteria for cure for individuals with primary and secondary syphilis, although people who are symptom-free and have had negative blood tests for two years after treatment are usually considered to be free of syphilis. Treated people should follow up with blood tests at one, three, six, and 12 months after treatment, or until the results are negative. CSF should be examined after one

KEY TERMS

Chancre—The initial skin ulcer of primary syphilis, consisting of an open sore with a firm or hard base.

Condylomata lata—Highly infectious patches of watery pink or gray skin that appear in the moist areas of the body during secondary syphilis.

General paresis—A form of neurosyphilis in which a person's personality, as well as the control of movement, is affected.

Gumma—A symptom that is sometimes seen in tertiary syphilis, characterized by a rubbery swelling or tumor that heals slowly and leaves a scar.

Jarisch-Herxheimer reaction—A temporary reaction to penicillin treatment for syphilis that includes fever, chills, and worsening of the skin rash or chancre.

Lues maligna—A skin disorder of secondary syphilis in which areas of ulcerated and dying tissue are formed.

Spirochete—A type of bacterium with a long, slender, coiled shape.

Tabes dorsalis—A progressive deterioration of the spinal cord and spinal nerves associated with tertiary syphilis.

year. People with recurrences during the latency period should be tested for re-infection.

The prognosis for people with untreated syphilis is spontaneous remission for about 30%, lifelong latency for another 30%, and potentially fatal tertiary forms of the disease in 40%.

Health care team roles

Trained lay people often take medical and personal histories. Phlebotomists draw blood for testing. A pathologist often interprets the results of specialized tests. A physician may also administer and check test results and provide treatment. Psychiatrists or other counselors may treat psychiatric symptoms.

Prevention

Immunity

People with syphilis do not acquire lasting immunity against the disease. As of 2001, no effective vaccine

for syphilis has been developed. Prevention depends on a combination of personal and public health measures.

Lifestyle choices

The only reliable methods for preventing transmission of syphilis are sexual abstinence or monogamous relationships between uninfected partners. Latex condoms offer some protection but protect only the covered parts of the body.

Public health measures

CONTACT TRACING. The law requires reporting of syphilis cases to public health agencies. Sexual contacts of people diagnosed with syphilis are traced and tested for the disease. This includes all contacts for the past three months in cases of primary syphilis, and for the past year in cases of secondary disease. Neither the affected people nor their contacts should have sex with anyone until they have been tested and treated.

All people who test positive for syphilis should be tested for HIV infection at the time of initial diagnosis.

PRENATAL TESTING OF PREGNANT WOMEN. Pregnant women should be tested for syphilis at the time of their first visit for **prenatal care**, and again shortly before delivery. Proper treatment of secondary syphilis in the mother reduces the risk of congenital syphilis in the infant from 90% to less than 2%.

EDUCATION AND INFORMATION. People diagnosed with syphilis should be given information about the disease and counseling regarding sexual behavior and the importance of completing antibiotic treatment. It is also important to inform the general public about the transmission and early symptoms of syphilis, and provide adequate health facilities for testing and treatment.

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ORGANIZATIONS

American Society of Clinical Pathologists. 2100 West Harrison Street, Chicago, IL 60612. (312) 738-1336. <<http://www.ascp.org/index.asp>>. info@ascp.org.

OTHER

- Centers for Disease Control and Prevention. <http://www.cdc.gov/nchstp/dstd/Fact_Sheets/Syphilis_Facts.htm>.
- Columbia Presbyterian Medical Center. <<http://cpmcnet.columbia.edu/texts/gcps/gcps0036.html>>.
- National Institute of Allergy and Infectious Disease. <<http://www.niaid.nih.gov/factsheets/stdsyph.htm>>.
- University of Virginia Health System. <<http://hsc.virginia.edu/hs-library/historical/apology/>>.
- Vanderbilt University Medical Center. <<http://www.mc.vanderbilt.edu/peds/pidl/infect/congsyph.htm>>.

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Syphilis tests

Definition

Syphilis is a sexually transmitted disease (STD) caused by the bacterium *Treponema pallidum*. Tests for syphilis can be either treponemal (identifying an antibody that occurs specifically in *T. pallidum* **infection**) or nontreponemal (identifying a nonspecific antibody that is present in a variety of infectious diseases, including syphilis). Treponemal tests include the fluorescent treponemal antibody-absorbed double stain test (FTA-ABS DS) and the microhemagglutination-*T. pallidum* test (MHA-TP). The most common diagnostic tests used to diagnose syphilis are the nontreponemal tests called the rapid plasma reagin test (RPR) and the Venereal Disease Research Laboratory test (VDRL). These two tests are both reagin flocculation tests used to verify that an antigen-antibody reaction has occurred.

Purpose

Syphilis tests can be used to screen for the disease in sexually active young adults and other high risk groups, pregnant women, patients requiring premarital examinations, and **blood** donors. Syphilis tests also are used to diagnose the disease when the patient has symptoms indicative of the disease. These symptoms can include a single genital ulcer (chancre), a reddish brown rash, and swollen lymph glands. RPR and VDRL tests are initial screening tests for syphilis and positive results are confirmed with more sophisticated tests. Of the two tests, RPR testing is more common.

Precautions

The RPR and VDRL tests are nontreponemal tests, meaning that they do not identify the bacterium or the antibodies unique to syphilis. These tests indicate the presence of reagin antibodies. Reagin is a nonspecific type of antibody that can occur during many types of infection other than syphilis. Since these tests are only initial screening tests, the more sophisticated treponemal tests must be used to confirm the diagnosis.

As with all venous blood samples taken from the inner crease of the arm, special precautions should be taken for compromised patients. Health care providers should avoid drawing a blood sample from the arm that also has an intravenous line, is edematous, or has scar tissue, an existing hematoma, or damaged veins. As with all blood samples or body fluid collections, health care providers should use standard precautions to protect themselves and others from exposure to the potentially infectious samples or equipment used to obtain the samples.

Biological false-positive results

There are many conditions that can cause a false-positive test result when a patient is tested for syphilis with RPR or VDRL tests. Conditions that can produce a reactive test result include:

- chicken pox
- endocarditis
- hepatitis
- infectious mononucleosis
- leprosy
- lupus erythematosus
- malaria
- measles
- pneumococcal pneumonia

- rheumatic fever
- rheumatoid arthritis

Description

In 1999, the Centers for Disease Control documented over 35,000 cases of syphilis reported in the United States. Although on the decline in recent years, syphilis remains a serious sexually transmitted disease that can lead to organ damage and eventual death if left untreated. Treatment cures the infection, but cannot reverse damage already done. While transmission is primarily through sexual contact, a mother can transmit the disease to her fetus. After the bacterium enters the body, the organism incubates for several weeks. After that time, the disease can progress through additional distinct stages over several years if not treated. The four stages of syphilis are:

- Primary stage (about 21 days after contact): chancre on an area that has contacted an infected person, like the penis, vagina, anus, or mouth; swollen lymph glands in the groin area.
- Secondary stage (about 4–8 weeks after the chancre appears and heals): **sore throat**, low fever, tiredness, weight loss, skin lesions, reddish brown rash especially on bottoms of feet and palms of hands.
- Latent stage (after the passing of the first secondary attack): no clinical signs evident and cerebrospinal fluid is normal; this stage may last for several months or years or for the remainder of the patient's life.
- Late (or Tertiary) stage (1–10 years after initial infection): destructive stage; **cardiovascular system** and **central nervous system** attacked; skin or organ tumors, **paralysis**, madness, blindness, sometimes death.

Because syphilis is a serious yet curable disease that can be transmitted to others, it is important that potentially infected patients be tested. The two most common tests are the RPR and the VDRL test, both of which test blood for antibodies the **immune system** produces in response to a variety of infections, including syphilis. The blood sample is obtained through simple venipuncture. The RPR and VDRL tests mix a sample of the patient's blood with a lipid antigen. If reagin antibodies are present in patient's blood, a clumping reaction (flocculation) occurs between the antibody and the antigen. However, the body creates reagin antibodies in a variety of conditions other than syphilis infection, and the test can appear reactive (or positive) when the patient does not have syphilis.

The RPR test uses a charcoal emulsion of cardiolipin to detect reagin antibodies. With a blunt needle, the anti-

gen is placed into the center of a small circle on a plastic-coated card. Then, a small sample of the patient's serum is added to the circle and mixed with the antigen. The card is mechanically rotated at room temperature for eight minutes and the suspension is examined for visible clumping, which indicates a positive test. Generally, a positive result requires that the test be repeated. If a positive result occurs from the repeat testing, the serum is titered and a confirmatory test is performed.

The VDRL test requires that the patient's serum sample be heat inactivated before the test. Charcoal is not a component of this test; cardiolipin-lecithin-cholesterol antigen is used and the serum/antigen mixture is then examined with a **microscope** for evidence of clumping. The VDRL test can also be used with a cerebrospinal fluid sample rather than a blood sample.

If a chancre is present during the examination, a sample of fluid can be taken from the ulcer and examined with a specialized darkfield microscope to detect corkscrew-shaped *T. pallidum*. While this method of early diagnosis is extremely accurate, many patients do not have a chancre when they seek treatment or are in a later stage of infection. Treponemals are the first antibodies to appear in a syphilis patient and remain elevated for life. Nontreponemal antibodies appear in 1–4 weeks after infection and remain elevated until treatment begins or the patient moves into a later stage of infection.

Because these antibodies are present at different stages of the disease, the validity of the specific test depends on when it is used relative to the patient's stage of disease. The approximate percentages of how sensitive the tests are in detecting syphilis relative to the patient's stage of disease are as follows:

- VDRL: 70% primary stage; 100% secondary stage; 95% latent stage; 71% late stage.
- RPR: 86% primary stage; 100% secondary stage; 98% latent stage; 73% late stage.
- FTA-ABS: 84% primary stage; 100% secondary stage; 100% latent stage; 96% late stage.
- MHA-TP: 76% primary stage; 100% secondary stage; 97% latent stage; 94% late stage.

Insurance coverage varies greatly between plans, and these tests may or may not be covered by the insurance provider. Patients should check with their insurance provider for specifics as to cost and coverage of these tests.

Preparation

The patient should receive basic information about syphilis, STDs, and the possible results of the test.

Patients should not drink alcohol 24 hours before a VDRL test. The health care provider should obtain a complete medical history of the patient since other conditions can create false-positive test results.

Aftercare

The patient should be comforted and direct pressure should be applied to the venipuncture site for several minutes or until the bleeding has stopped. An adhesive bandage may be applied, if appropriate. If swelling or bruising occurs, ice can be applied to the site. Since many patients find needles unpleasant and are often fearful of the blood collection process, the health care provider should always reassure and monitor the patient for nervousness or fainting.

Complications

Careful vein and equipment selection are paramount to successful venipuncture. Veins that are too small can collapse and yield an insufficient sample. Probing with the needle can cause extensive bruising. Shaking the tube vigorously, collecting an insufficient sample, or using the wrong tube required for the sample are unacceptable and will require a second venipuncture. In normal circumstances, a blood draw for RPR or VDRL testing only takes a few minutes, while the patient experiences minor discomfort and a minute puncture wound at the site of the venipuncture.

Results

The test results are reported as follows:

- RPR: negative or reactive.
- VDRL: Negative, weakly reactive, reactive.
- Titer: Reported as the highest dilution of serum that is reactive.
- FTA-ABS: Negative, borderline, or reactive.

Health care team roles

The non-physician health care provider is an important partner in laboratory testing. In accordance with the physician's orders, the nurse, blood collection specialist (phlebotomist), or laboratory professional usually prepares the patient, performs the blood draw, and readies the specimen for transport to either an internal or external laboratory for testing.

Training

The health care provider that performs the venipuncture procedure should be trained in correct technique, vein selection, appropriate equipment selection, and **infection control** procedures. Health care providers must follow strict guidelines on processing and disposing of items containing blood or body fluids to control for contamination and infection.

Patient education

The non-physician health care provider can be an important resource for patients with a STD. Often, these providers counsel patients, provide literature and pamphlets on STDs, provide information on using condoms during sexual intercourse, and can reassure the patient about treatment regimens. Patients with syphilis may be embarrassed about their condition or hesitant to seek medical attention. The effective health care provider supplies information in a supportive and non-judgmental environment that reassures the patient that he or she has made a positive step in obtaining medical care. The medical professional also informs the patient that he or she will require periodic retesting to evaluate the infection and monitor the effectiveness of treatment. Since syphilis is transmitted sexually, health care providers should work with the patient to obtain the names of sexual partners so that they may also be tested.

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KEY TERMS

Antibody—A specific protein created by the immune system in response to an invading infectious organism.

Antigen—A protein covering a foreign invader in the body (like a bacterium); the immune system produces antibodies to combat antigens and fight disease.

Darkfield microscope—A specialized microscope with a unique condenser that manipulates the light. Objects seen through this microscope appear white against a dark background.

Direct florescence—A laboratory process using the application of dyes that can glow in specific conditions when applied to a specimen and can be seen with an ultraviolet microscope.

Edematous—The state of having swelling (edema) caused by the collection of excess fluid within tissues.

Hematoma—Swelling and subsequent bruising when blood leaks from a vein into local tissues; can be caused by improper venipuncture when the needle has gone through a vein or when the needle has been inserted incorrectly.

Titer—A central concept in serologic testing; determines the concentration of an antibody (if present) in a blood sample. A high titer indicates that a considerable amount of an antibody is present in a blood sample.

Venipuncture—Puncture of a vein with a needle for the purpose of withdrawing a blood sample for analysis.

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Linda D. Jones, B.A., PBT (ASCP)

Syringe and needle

Definition

Syringes and needles are sterile devices used to inject solutions into or withdraw secretions from the body. The syringe is a calibrated glass or plastic cylinder with a plunger at one and an opening to which the needle attaches.

Purpose

This method is used to administer drugs when a small amount of fluid is to be injected, the patient is unable to take the drug orally, or intestinal secretions destroy the drug. It is also to withdraw various types of bodily fluids, most commonly **blood**.

Description

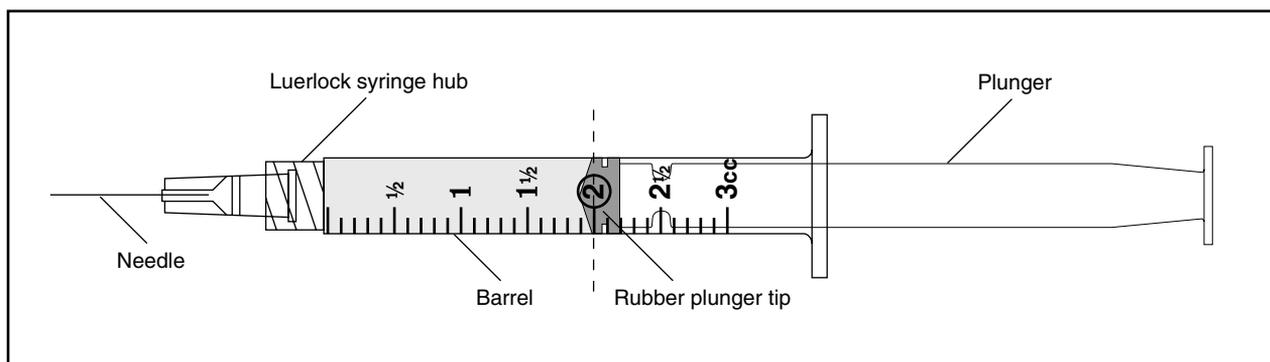
There are different types and sizes of syringes used for a variety of purposes. Syringe sizes may vary from 0.25 ml to 450 ml, and can be made from glass or assorted plastics. Latex-free syringes eliminate the exposure of the health care professional and the patient to an allergen to which he or she may be sensitive. The most common type of syringe is the piston syringe. The pen, cartridge, and dispensing syringes are also extensively used.

A syringe consists of a hollow barrel with a piston at one end and a nozzle at the other end that connects to a needle. Other syringes have a needle already attached. These devices are often used for subcutaneous injections of insulin and are single-use (i.e., disposable). Syringes have markings etched or printed on their sides, showing the graduations (i.e., in milliliters) for accurate dispensing of drugs or removal of body fluids. Cartridge syringes are for multiple use, and are often sold in kits where a prefilled drug cartridge with a needle is inserted into the piston syringe. Syringes may also have anti-needlestick features, as well as positive stops that prevent accidental pullouts.

There are three types of nozzles:

- Luer-lock, which locks the needle onto the nozzle of the syringe.
- Slip tip, which secures the needle by compressing the hub onto the syringe nozzle.
- Eccentric, which secures with a connection that is almost flush with the side of the syringe.

The hypodermic needle is a hollow, metal tube, usually made of stainless steel and sharpened at one end. It has a female connector end that fits into the male connector of a syringe or intravascular administration set.



Parts of a syringe. (Delmar Publishers, Inc. Reproduced by permission.)

The size of the diameter of the needle ranges from the largest gauge (13) to the smallest (27). The needle's length extends to 3.5 inches (8 cm) for the 13 gauge, and from 0.25–1 inch (0.6–2.5 cm) for the 27 gauge. The needle consists of a hub with a female connector at one end—that connects to a syringe—to the other end, where the bevel is located. The bevel is a flat aperture on one side of a needle's tip.

Needles are almost always disposable, but reusable ones are available for home use by a single patient.

Operation

Syringes and needles are used for injecting or withdrawing fluids from a patient. The most common procedure for removing fluids from a patient is the venipuncture, or blood drawing. In this procedure, the syringe and appropriate needle are used with a vacutainer, which is used to collect the blood as it is drawn. The syringe and needle can be left in place while the vacutainer is changed, allowing for multiple samples to be drawn.

Fluids can be injected into a patient by **intra**dermal injection, **subcutaneous injection**, **intramuscular injection**, or **Z-track injection**. In all types of injections, the size of syringe should be chosen based on the amount of fluid being delivered, and the gauge and length of needle should be chosen based on the size of the patient and the type of medication. A needle with a larger gauge may be chosen for drawing up the medication into the syringe, and a smaller gauge needle will replace the previous one for injection into the patient. In all injections, proper procedures for **infection control** should be strictly followed.

Maintenance

Syringes and needles are normally sterile products and should be stored in appropriate containers. Care

should be taken prior to using them. One should ensure that the needles are not blunt and that the packets are not torn; this would expose the contents to air and allow contamination by microorganisms.

Health care team roles

All personnel must be offered vaccines against blood-borne infections, such as hepatitis B. This is the responsibility of medical staff.

Used syringes and needles should be disposed of quickly in appropriate containers.

If a needlestick injury occurs, it is important that it is reported immediately and that proper treatment is administered to the injured person.

Training

Those responsible for training should ensure staff is skilled at up-to-date methods of **aseptic technique** and correct handling/use of syringes and needles.

Teaching the correct use of and syringes and needles, as well as their disposal, is important to protect medical staff and patients from needlestick injuries and contamination from blood-borne infections. Presently, some of the more serious infections are human **immunodeficiency virus** (HIV), hepatitis B (HBV), and hepatitis C (HCV).

The staff should be aware of current methods of **infection prevention**.

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Margaret A Stockley, R.N.

KEY TERMS

Bevel—The flat aperture on one side of a needle at the tip.

Piston—The plunger that slides up and down the inside barrel of a syringe.

Sterile—Free from living microorganisms.

Subcutaneous—Beneath the skin.

T

T-cell count see **Flow cytometry analysis**

T-uptake test see **Thyroid function tests**

T'ai chi

Definition

T'ai chi is an ancient Chinese **exercise** with movements that originate from the martial arts. While used as a type of self-defense in its most advanced form, t'ai chi is practiced widely for its health and **relaxation** benefits. Those in search of well being and a way to combat **stress** have made what has also been called “Chinese shadow boxing” one of the most popular low-intensity workouts around the world.

Origins

Also known as t'ai chi ch'uan (pronounced *tie-jee chu-wan*), the name comes from Chinese characters that translated mean “supreme ultimate force.” The concept of t'ai chi, or the “supreme ultimate,” is based on the Taoist philosophy of yin and yang, or the nature of when opposites attract. Yin and yang combine opposing, but complementary, forces to create harmony in nature. By using t'ai chi, it is believed that the principal of yin and yang can be achieved. A disturbance in the flow of ch'i (qi), or the life force, is what traditional Chinese medicine bases all causes of disease in the body. By enhancing the flow of ch'i, practitioners of t'ai chi believe that the exercise can promote physical health. Students of t'ai chi also learn how to use the exercise in the form of **meditation** and mental exercise by understanding how to center and focus their cerebral powers.

The origination of t'ai chi is rooted deep in the martial arts and Chinese folklore, causing its exact beginnings to be based on speculation. The much disputed

founder of t'ai chi is Zhang San-feng (Chang San-feng), a Daoist (Taoist) monk of the Wu Tang Monastery, who, according to records from the Ming-shih (the official records of the Ming dynasty), lived sometime during the period from 1391–1459. Legend states that Zhang happened upon a fight between a snake and a crane, and, impressed with how the snake became victorious over the bird through relaxed, evasive movements and quick counterstrikes, he created a fighting-form that shadowed the snake's strongest attributes. With his experience in the martial arts, Zhang combined strength, balance, flexibility, and speed to bring about the earliest form of t'ai chi.

Historians also link Zhang to joining yin-yang from Taoism and “internal” aspects together into his exercises. This feeling of inner happiness, or as a renowned engineering physicist and t'ai chi master, Dr. Martin Lee, states in his book *The Healing Art of Tai Chi*, “1; of becoming one with nature,” remains a primary goal for those who practice t'ai chi. Although its ancient beginnings started as a martial art, t'ai chi was modified in the 1930s to the relaxing, low-intensity exercise that continues to have the potential to be transformed into a form of self-defense, similar to karate or kung-fu.

Benefits

The art of t'ai chi is many things to the many who practice it. To some, it is a stretching exercise that incorporates a deep-breathing program. To others, it is a martial art—and beyond this, it is often used as a dance or to accompany prayer. While the ways in which it is used may vary, one of the main benefits for those who practice it remains universal—t'ai chi promotes good health. This sense of well being complements t'ai chi's additional benefits of improved coordination, balance, and body awareness, while it also calms the mind and reduces stress. Those in search of harmony between the mind and the body practice “dynamic relaxation.”



Group of people practicing t'ai chi in the streets of Shanghai, China. (Kelly-Mooney Photography. Corbis Images. Reproduced by permission.)

Dr. Martin Lee believes that the ancient art also holds healing powers. In his book, *The Healing Art of T'ai Chi*, he states: "By practicing t'ai chi and understanding chi and its breathing techniques, I was able to heal my **allergies** and other ailments." Lee contends that stress is the culprit of much of the **pain** and suffering that are a part of everyday life. The growing evidence that stress contributes to devastating physical and mental ailments has led Lee to teach a systematic, effective, and manageable way to restore both body and mind to a natural, stress-free state. As of 1996, Lee has been teaching t'ai chi for 20 years to help his students with physical ailments that have been caused by stress. He believes that illness can be overcome through understanding the body as a mental and physical system, which is accomplished through t'ai chi.

While the martial arts are very vigorous and often result in injuries, the practice of t'ai chi is a good alternative to these sports without over-exerting the body. Those with bad backs have also found t'ai chi to ease their discomfort.

Description

Zhang, the notable originator of t'ai chi, created a combination of movements and beliefs that led to the formation of the fundamental "Thirteen Postures" of his art. Over time, these primary actions have transformed into soft, slow, relaxed movements, leading to a series of movements known as the form. Several techniques linked together create a form. Proper posture is a key element when practicing t'ai chi to maintain balance. All of the movements used throughout the exercise are relaxed with the back straight and the head up.

Just as the movements of t'ai chi have evolved, so have the various styles or schools of the art. As the form has grown and developed, the difference in style along with the different emphasis from a variety of teachers has as well. A majority of the different schools or styles of t'ai chi have been given their founder's surnames.

The principal schools of t'ai chi include:

- Chen style
- Hao (or Wu Shi) style
- Hu Lei style

- Sun style
- Wu style
- Yang style
- Zhao Bao style

Many of the most commonly used groupings of forms are based on the Yang style of t'ai chi, developed by Yang Pan-Hou (1837–1892). Each of the forms has a name, such as “Carry the Tiger to the Mountain,” and as the progression is made throughout the many forms, the participant ends the exercise almost standing on one leg. While most forms, like “Wind Blows Lotus Leaves,” has just one movement or part, others, like “Work the Shuttle in the Clouds,” have as many as four. While the form is typically practiced individually, the movement called “Pushing Hands” is a sequence practiced by two people together.

Preparations

Masters of t'ai chi recommend that those who practice the art begin each session by doing a warm-up of gentle rotation exercises for the joints and gentle stretching exercises for the muscles and tendons. Some other suggestions to follow before beginning the exercise include: gaining a sense of body orientation; relaxation of every part of the body; maintaining smooth and regular breaths; gaining attention or feeling; being mindful of each movement; maintaining proper posture; and moving at the same pace throughout each movement. The main requirement for a successful form of t'ai chi is to feel completely comfortable while performing all of the movements.

Precautions

Although t'ai chi is not physically demanding, it can be demanding on the posture. Those who want to practice the exercise should notify their physician before beginning. The physician will know whether the person is taking medications that might interfere with balance, or has a condition that could make a series of t'ai chi movements unwise to attempt.

Research and general acceptance

While the reasons why t'ai chi is practiced vary, research has uncovered several reasons why it may help many medical conditions. For example, people with rheumatoid arthritis (RA) are encouraged to practice t'ai chi for its graceful, slow sweeping movements. Its ability to combine stretching and range-of-motion exercises with relaxation techniques work well to relieve the stiffness and weakness in the joints of RA patients.

In 1999, investigators from Johns Hopkins University in Baltimore, Maryland, studied the effects of t'ai chi on those with elevated **blood pressure**. Sixty-two sedentary adults with high-normal **blood pressure** or stage I **hypertension** who were aged 60 or older began a 12-week aerobic program or a light-intensity t'ai chi program. The exercise sessions both consisted of 30-minute sessions, four days a week. The study revealed that while the aerobics did lower the systolic blood pressure of participants, the t'ai chi group systolic level was also lowered by an average of seven points—only a point less than the aerobics group. Interestingly, t'ai chi hardly raises the **heart** rate while still having the same effects as an intense aerobics class.

In addition to lowering blood pressure, research suggests that t'ai chi improves heart and lung function. The exercise is linked to reducing the body's level of a stress hormone called cortisol, and to the overall effect of higher confidence for those who practice it. As a complementary therapy, t'ai chi is also found to enhance the mainstream medical care of **cancer** patients who use the exercise to help control their symptoms and improve their quality of life.

Physical therapists investigated the effects of t'ai chi among 20 patients during their recovery from coronary artery bypass surgery. The patients were placed into either the t'ai chi group or an unsupervised control group. The t'ai chi group performed classical Yang exercises each morning for one year, while the control group walked three times a week for 50 minutes each session. In 1999, the study reported that after one year of training, the t'ai chi group showed significant improvement in their cardiorespiratory function and their work rate, but the unsupervised control group displayed only a slight decrease in both areas.

T'ai chi has also shown to keep people from falling—something that happens to one in three people over age 65 each year. Researchers from Emory University in Atlanta, Georgia, had dozens of men and women in their 70s and older learn the graceful movements of t'ai chi. The study discovered that those who learned to perform t'ai chi were almost 50% less likely to suffer **falls** within a given time frame than subjects who simply received feedback from a computer screen on how much they swayed as they stood. Those who suffer falls experience greater declines in everyday activities than those who do not fall, and are also at a greater risk of needing to be placed in a nursing home or another type of assisted living home. Researchers recommend the use of t'ai chi for its ability to help people raise their consciousness of how their bodies are moving in the environment around them. By raising awareness of how the body moves, people can focus on their relationship to

KEY TERMS

Coronary artery bypass surgery—A shunt, a surgical passage created between two blood vessels to divert blood from one part to another, is inserted to allow blood to travel from the aorta to a branch of the coronary artery at point past the obstruction.

Rheumatoid arthritis—A form of arthritis with inflammation of the joints, resulting in stiffness, swelling, and pain.

Taoism—A Chinese religion and philosophy based on the doctrines of Lao-tse which advocates simplicity and selflessness.

their physical environment and situations they encounter everyday.

While the additional benefits of t'ai chi remain to be studied in the United States, it continues to be widely practiced in this and other Western countries. The ancient art maintains its prominence in China, where many people incorporate it into their daily routines at sunrise.

Training and certification

Masters of t'ai chi are trained extensively in the various forms of the art by grandmasters who are extremely skillful of the exercise and its origins. For those who wish to learn t'ai chi from a master, classes are taught throughout the world in health clubs, community centers, senior citizen centers, and official t'ai chi schools. Before entering a class, the instructor's credentials should be reviewed, and they should be questioned about the form of t'ai chi they teach. Some of the more rigorous forms of the art may be too intense for older people, or for those who are not confident of their balance. Participants are encouraged to get a physician's approval before beginning any t'ai chi program.

There is no age limitation for those who learn t'ai chi, and there is no special equipment needed for the exercise. Participants are encouraged to wear loose clothing and soft shoes.

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Beth Kapes

Taste

Definition

Taste is one of the five senses (the others being **smell**, touch, **vision**, and **hearing**) through which all animals interpret the world around them. Specifically, taste is the sense for determining the flavor of food and other substances.

Description

One of the two chemical senses (the other being smell), taste is stimulated through the contact of certain chemicals in substances with clusters of taste bud cells found primarily on the tongue. However, taste is a complex sensing mechanism that is also influenced by the smell and texture of substances. An individual's unique sense of taste is partially inherited, but factors such as culture and familiarity can help determine why one person's favorite food made be hot and spicy while another cannot get enough chocolate.

The primary organ for tasting is the mouth. Clusters of cells called taste buds (because under the **microscope** they look similar to plant buds) cover the tongue and are also found to a lesser extent on the cheek, throat, and the roof of the mouth. First discovered in the 19th century by German scientists Georg Meissner and Rudolf Wagner, taste buds lie on the bumps and grooves of the tongue (called the papillae) and have hairlike extensions (microvilli) to increase the receptor surface of the cells. Four different

pairs of nerves are involved in the tongue, which helps explain in part why the sense of taste is a robust one, and not easily knocked out by disease or trauma.

Genetic and other factors affecting taste

Scientists have also discovered that genetic makeup partially accounts for individual tasting abilities and preferences for specific foods. According to Yale University researchers, some people are genetically programmed to have more taste buds and, as a result, taste more flavors in a particular food. (The number of taste buds varies in different animal species. For example cows have 25,000 taste buds, rabbits 17,000, and adult people approximately 10,000.) In general, a person's ability to taste can lie anywhere in a spectrum from poor to exceptional, with the ability to sense tastes increasing in proportion to the number of taste buds present. The difference in the number of taste buds can be extreme. Researchers have found anywhere from 11 to 1,100 taste buds per square inch in various young people tested. They have also found that women tend to have more taste buds than men and, as a result, are often better tasters. How well people taste greatly affects what they like. Studies at Yale, for example, revealed that children with fewer taste buds who are classified as poor tasters liked cheese more often than exceptional tasters, who experienced a more bitter sensation, probably because of increased sensitivity to the combination of **calcium** and the milk protein casein found in cheese.

Despite the important role that taste buds play in recognizing flavors, they do not work alone in providing the experience of taste. For example, the amount of naturally occurring salt in saliva varies; with the result that those with less saliva can better taste the saltiness of certain foods than others, who may end up adding salt to get a similar flavor. The smell and texture of foods are also important contributing factors to how people perceive a food to taste and whether or not they like it. Food in the mouth produces an odor that reaches the nose through the nasopharynx (the opening that links the mouth and the nose). Since smell is much more sensitive to odors than taste is to flavors, people often first experience the flavor of a food by its odor. The texture and temperature of food also influences how it tastes. For example, many people would not think of drinking cold coffee, while others will not eat pears because of a dislike for the fruit's gritty texture.

The predilection for certain foods and tastes is not determined merely by biology. Culture and familiarity with foods greatly influence taste preferences. The Japanese have long considered raw fish, or sushi, to be a savory delicacy. Until the 1990s, few Americans would

have enjoyed such a repast. As the number of Japanese restaurants grew along with the sushi bars they often contained, so did Americans' familiarity with this delicacy, resulting in a new taste for it.

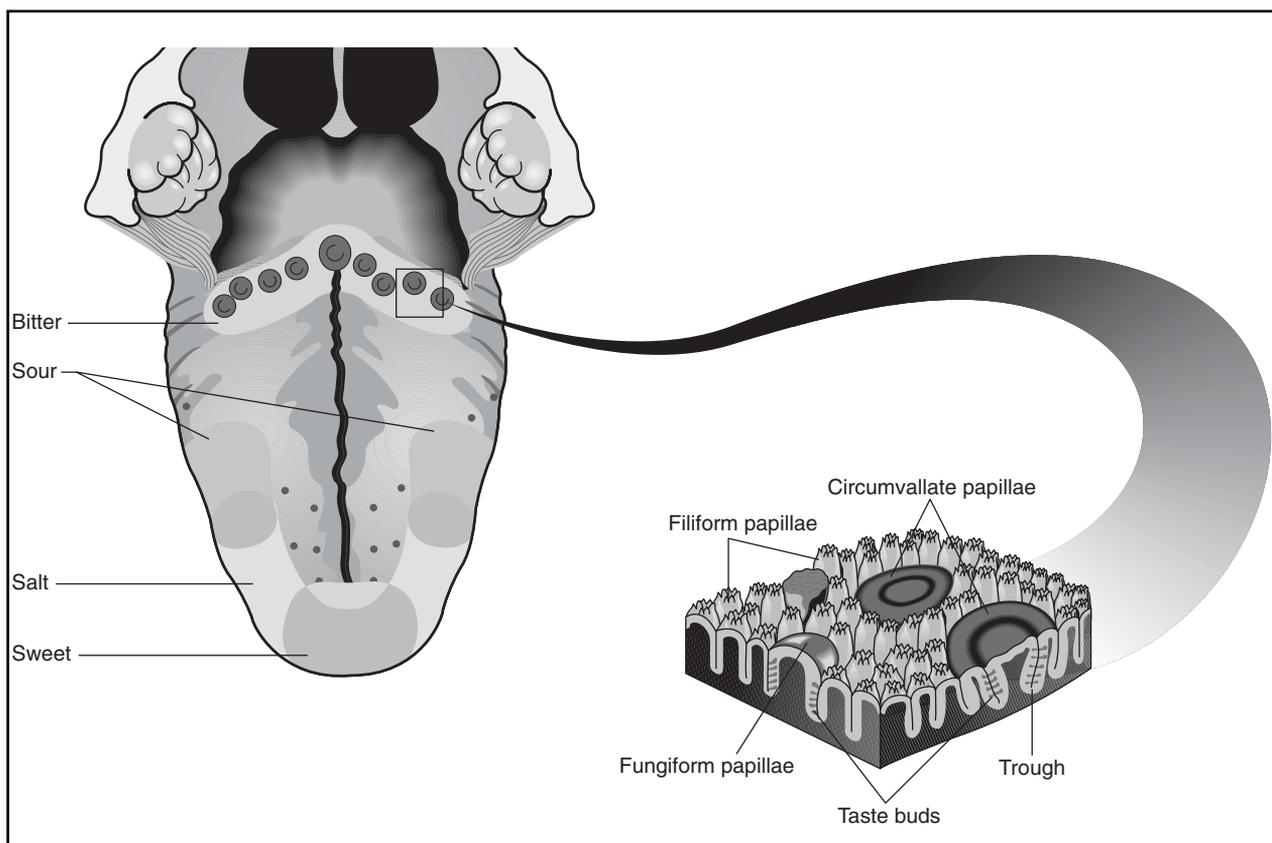
Function

Taste's primary function is to react to items placed in the mouth. For most foods and substances, saliva breaks down the chemical components which travel through the pores in the papillae to reach the taste buds. These taste buds specialize primarily in processing one of the four major taste groups: sweet, sour, salty, and bitter. Because the four taste groups may not describe all taste sensations, other proposed tastes include metallic, astringent and umami. Umami is the oral sensation stimulated by monosodium glutamate.

Taste occurs when specific **proteins** in the food bind to receptors on the taste buds. These receptors, in turn, send messages to the brain's cerebral cortex, which interprets the flavor. The actual chemical processes involved for each major taste group vary and involve various mechanisms. For example, salty and sour flavors occur when saliva breaks down sodium or acids, respectively. The chemical constituents of foods that give bitter and sweet tastes are much more difficult to specify due to the large number of chemical components involved.

Although certain taste buds seemed to have an affinity for one of the four major flavors, continued research into this intricate biological process has revealed a complex neural and chemical network that precludes simple black and white explanations. For example, each taste bud actually has receptors for sweet, sour, salty, and bitter sensations, indicating that taste buds are sensitive to a complex flavor spectrum similar to the way vision is sensitive to a broad color spectrum grouped into the four major colors of red, orange, yellow, and green. Particular proteins of taste are also under study, like gustducin, which may set off the plethora of chemical reactions that causes something to taste bitter and sweet.

Taste buds for all four taste groups can be found throughout the mouth. A common but mistaken tongue diagram shows areas labeled with basic tastes, such as sweet at the tip of the tongue while bitter is at the back. While specific kinds of buds tend to cluster together, the four tastes can be perceived on any part of the tongue and to a lesser extent on the roof of the mouth. Bitterness does appear to be perceived primarily on the back of the tongue because of several mechanisms.



A diagram of taste buds. (Hans & Cassidy. Courtesy of Gale Group.)

Role in human health

Taste helps people determine whether potential foods are palatable. It also plays a major role in appetite. People constantly regenerate new taste buds every three to 10 days to replace the ones worn out by scalding soup, frozen yogurt and the like. As people grow older, their taste buds lose their fine tuning because they are replaced at a slower rate. As a result, middle-aged and older people require more of a substance to produce the same sensations of sweetness or spiciness, for example, than would be needed by a child eating the same food.

Common diseases and disorders

The inability to taste is so intricately linked with smell that it is often difficult to tell whether the problem lies in tasting or smelling. An estimated two to four million people in the United States suffer from some sort of taste or smell disorder. The inability to taste or smell not only robs an individual of certain sensory pleasures, it can also be dangerous. Without smell or taste, for example, people cannot determine whether food is spoiled, making them vulnerable to **food poisoning**. Also, some psychiatrists believe that the lack of taste and smell can

have a profoundly negative affect on a person's quality of life, leading to depression or other psychological problems.

The reasons for taste and smell disorders range from biological breakdown to the effects of environmental toxins; but a clear precipitating event or underlying pathology is often lacking in taste disorders. Here are some of the more common ones:

- Cold and flu are the most common physical ailments that can assault the sense of taste and smell. **Allergies**, viral or bacterial infections can all produce swollen mucous membranes, which diminish the ability to taste. Most of these problems are temporary and treatable.
- Medications, including those used in **chemotherapy** for **cancer** treatments, can also inhibit certain enzymes, affect the body's **metabolism**, and interfere with the neural network and receptors needed to taste and smell.
- Neurological disorders due to **brain** injury or diseases like Parkinson's or Alzheimer's can cause more permanent damage to the intricate neural network that processes the sense of taste and smell.

KEY TERMS

Cerebral cortex—The external gray matter surrounding the brain and made up of layers of nerve cells and fibers. Thought to process sensory information and impulses.

Microvilli—Hair or fingerlike projections found on cell membranes that increase surface area to better receive outside stimuli.

Papillae—Nipplelike projections found on tissue which constitute the ridge-like surfaces on the tongue.

Protein—Macromolecules that constitute three-fourths of cell matter's dry weight and which play an important role in a number of life functions, such as sensory interpretation, muscle contraction, and immunological response.

Taste buds—Cells found primarily on the tongue that are the primary biological components for interpreting the flavor of foods and other substances.

- Twenty to 30% of head trauma patients suffer some degree of smell disorder, which can in turn affect taste.
- Exposure to environmental toxins like lead, mercury, insecticides, and solvents can also severely hinder the ability to smell and taste by causing damage to taste buds and sensory cells in the nose or brain.
- Aging itself is associated with diminished taste and smell sensitivity.

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Linda Richards, R.D.

TB *see* Tuberculosis

Technetium heart scan

Definition

The technetium **heart** scan is a non-invasive nuclear scan that uses a radioactive isotope called technetium to evaluate **blood** flow after a heart attack.

Purpose

The technetium heart scan is used to evaluate the heart after a heart attack. It can confirm that a patient had a heart attack when the symptoms and **pain** usually associated with a heart attack were not present, identify the size and location of the heart attack, and provide information useful in determining the patient's post-heart attack prognosis. The scan is most useful when the electrocardiogram and cardiac enzyme studies do not provide definitive results; after heart surgery, for example, or when chest pain occurred more than 48 hours before the patient was examined. It is also used to evaluate the heart before and after heart surgery.

Precautions

Pregnant women and those who are breastfeeding should not be exposed to technetium.

Description

The technetium heart scan is a nuclear heart scan, which means that it involves the use of a radioactive isotope that targets the heart and a radionuclide detector that traces the absorption of the radioactive isotope. The isotope is injected into a vein and absorbed by healthy tissue at a known rate during a certain time period. The radionuclide detector, in this case a gamma scintillation camera, picks up the gamma rays emitted by the isotope.

KEY TERMS

Electrocardiogram—A test in which electronic sensors called electrodes are placed on the body to record the heart's electrical activities.

Non-invasive—A procedure that does not penetrate the body.

Radioactive isotope—One of two or more atoms with the same number of protons but a different number of neutrons with a nuclear composition. In nuclear scanning, radioactive isotopes are used as a diagnostic agent.

Technetium—A radioactive isotope frequently used in radionuclide scanning of the heart and other organs. It is produced during nuclear fission reactions.

The technetium heart scan uses technetium Tc-99m stannous pyrophosphate (usually called technetium), a mildly radioactive isotope which binds to **calcium**. After a heart attack, tiny calcium deposits appear on diseased heart valves and damaged heart tissue. These deposits appear within 12 hours of the heart attack. They are generally seen two to three days after the heart attack and are usually gone within one to two weeks. In some patients, they can be seen for several months.

After the technetium is injected into a blood vessel in the arm, it accumulates in heart tissue that has been damaged, leaving “hot spots” that can be detected by the scintillation camera. The technetium heart scan provides better image quality than commonly used radioactive agents such as thallium because it has a shorter half life and can thus be given in larger doses.

During the test, the patient lies motionless on the test table. Electrocardiogram electrodes are placed on the patient's body for continuous monitoring during the test. The test table is rotated so that different views of the heart can be scanned. The camera, which looks like an x-ray machine and is suspended above the table, moves back and forth over the patient. It displays a series of images of technetium's movement through the heart and records them on a computer for later analysis.

The test is usually performed at least 12 hours after a suspected heart attack, but it can also be done during triage of a patient who goes to a hospital emergency room with chest pain but does not appear to have had a heart attack. Recent clinical studies demonstrate that technetium heart scans are very accurate in detecting heart

attacks while the patient is experiencing chest pain. They are far more accurate than electrocardiogram findings.

The technetium heart scan is usually performed in a hospital's nuclear medicine department but it can be done at the patient's bedside during a heart attack if the equipment is available. The scan is done two to three hours after the technetium is injected. Scans are usually done with the patient in several positions, with each scan taking 10 minutes. The entire test takes about 30 minutes to an hour. The scan is usually repeated over several weeks to determine if any further damage has been done to the heart. The test is also called technetium 99m pyrophosphate scintigraphy, hot-spot myocardial imaging, infarct avid imaging, or **myocardial infarction** scan.

The technetium heart scan is not dangerous. The technetium is completely gone from the body within a few days of the test. The scan itself exposes the patient to about the same amount of radiation as a **chest x ray**. The patient can resume normal activities immediately after the test.

Preparation

Two to three hours before the scan, technetium is injected into a vein in the patient's forearm.

Results

If the technetium heart scan is normal, no technetium will show up in the heart.

In an abnormal technetium heart scan, hot spots reveal damage to the heart. The larger the hot spots, the poorer the patient's prognosis.

Health care team roles

The health care team will need to take a careful history of patient **allergies** and medications, and make sure that necessary **pregnancy** tests are done before the patient is scheduled for the technetium heart scan. The nurse or nurse practitioner will need to educate the patient about the pre-scan regime (not using Viagra 48 hours before the scan and avoiding alcohol, tobacco, **caffeine**, and nonprescription medications). Additional education about the procedure (how the scan is done, what happens during it, what kinds of information the scan can produce for the doctor, etc.) often is necessary to keep the patient informed and to insure cooperation during the procedure.

The technologist will need to verify that the pre-scan protocols have been done and that the patient is not pregnant or allergic to medications used in the scans.

The nuclear heart medicine technologist will also need to reassure the patient before and during the scans in order to keep the patient relaxed and still during the scans.

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Lori De Milto

Teeth see **Dental anatomy**

Teeth classification see **Classification of teeth**

Temperature regulation see **Thermoregulation**

Temporomandibular joint disorders

Definition

Temporomandibular joint (TMJ) disorder, also known as TMD, is the name given to a group of symptoms that cause **pain** in the facial muscles and dysfunction in the head, face, and jaw. TMD often has psychological as well as physical causes.

Description

TMD results from pressure on the facial nerves due to muscle tension, injury, or bone abnormalities. Some 70% of adults exhibit at least one sign of TMD, but only 5% seek treatment. Most sufferers are women between ages 20 and 50.

The TMJ connects the temporal bone with the condyle of the mandible anterior to the ear on each side of the **skull**. The jaw pivots on ligaments, tendons, and muscles to allow motion downward and laterally as well as forward. Anything that causes a change in shape or functioning of the TMJ can cause pain and other symptoms.

Causes and symptoms

Causes

TMD has varied causes:

- **Bruxism**, or unconscious clenching or grinding of the teeth, is the most common cause of TMD. Bruxism occurs during periods of **stress** or during sleep. It results in muscle tension and soreness around the jaw joint and in the facial muscles.
- Misalignment of the teeth or displacement of the TMJ disc may contribute to TMD.
- Injury to the jaw or side of the head, either from a direct blow or from repeated and prolonged opening and closing (as in gum chewing), can result in a dislocation of the TMJ and subsequent TMD problems.
- Arthritis in different forms can lead to TMD. Traumatic arthritis from an injury, **osteoarthritis**, and rheumatoid arthritis are all possible causes.
- Hypermobility, a condition in which the ligaments of the TMJ are too loose, may allow the mandible to slip out of position and create TMD.
- Poor posture is another potential cause of TMD. When an individual carries his or her head too far forward and strains the neck muscles, TMD can result. In one research study in Texas, patients who were given posture training along with traditional treatment had greater improvement than those without posture training.
- Birth abnormalities are the least frequent cause of TMD, but can occur. In some cases, the condyle of the mandible is too large or too small.

KEY TERMS

Arthrography—A testing technique in which a special dye is injected into the joint, which is then x rayed.

Bruxism—Habitual clenching and grinding of the teeth, especially during sleep.

Condyle—An articular prominence of a bone.

Electromyographic biofeedback—A method for relieving jaw tightness by monitoring the patient's attempts to relax the muscle while the patient watches a gauge. The patient gradually learns to control the degree of muscle relaxation.

Fibromyalgia—A complex, chronic condition which causes widespread pain and fatigue, as well as a variety of other symptoms.

Malocclusion—The misalignment of opposing teeth in the upper and lower jaws.

Mandible—The lower jaw.

Orofacial—Pertaining to the mouth and face.

Osteoarthritis—A type of arthritis marked by chronic degeneration of the cartilage of the joints, leading to pain and sometimes loss of function.

Rheumatoid arthritis—A chronic autoimmune disorder marked by inflammation and deformity of the affected joints.

Temporal bones—The compound bones that form the right and left sides of the skull above the ears.

Tinnitus—A sensation of ringing or roaring in the ears that can only be heard by the individual affected.

Transcutaneous electrical nerve stimulation—A method for relieving the muscle pain of TMD by stimulating nerve endings that do not transmit pain. It is thought that this stimulation blocks impulses from nerve endings that do transmit pain.

Symptoms

The symptoms of TMD depend in part on its cause. They include orofacial pain, restricted jaw function, and clicking or stiffness in the joints. Patients may also suffer from headaches, ear, neck, and shoulder pain, or tinnitus. Classic symptoms are pain in front of the ear that spreads to the ear, mandible, cheek, and temple. Pain may be worse in the morning, and may be cyclical. Patients may also report noise in the joint during chewing, and limited mouth opening.

Diagnosis

Physical examination and patient history

TMD is most frequently diagnosed in the dental office based on **physical examination**. As the patient opens, closes, and moves the jaw laterally, palpation (physical examination by feeling with the hands) can detect joint popping and clicking, or a **stethoscope** may be placed in front of the ear to listen to the jaw movements. Jaw and facial muscles are checked for tenderness, and the patient's bite is checked for misalignment.

A careful patient history looks for such clues as recent injury or recent dental work. The patient should be asked about the duration and severity of jaw and face pain. Any history of insomnia, stress, **anxiety**, depression, chronic pain, or **fibromyalgia** should be documented.

Imaging studies

Imaging studies are not usually necessary to diagnose TMD. In most cases, x rays and **magnetic resonance imaging** (MRI) scans of the temporomandibular joint are normal. If the dentist suspects the patient has malpositioning of the TMJ disc, he or she can use **arthrography** to make the diagnosis. Arthrography can be used to evaluate the movement of the jaw and disc as well as their size and shape, and to evaluate the effectiveness of treatment.

Treatment

In 80% of TMD sufferers, symptoms improve in six months without treatment. When treatment is necessary, various modalities are used.

Phase I treatment

Phase I treatment is conservative and non-invasive, with no irreversible changes. Its purpose is to eliminate muscle spasms, swelling, and pain. Initially, a dentist may prescribe moist heat, aspirin, or a nonsteroidal anti-inflammatory drug, with a soft diet to alleviate symptoms.

Patients who have difficulty with bruxism are usually treated with splints. A plastic splint called a nightguard or mouthguard is constructed and worn at night. The splint can break the cycle of bruxing and allow sore muscles to relax. Splints can also be used to treat malpositioning by holding the mandible forward and keeping the disc in place until the ligaments tighten. The splint is adjusted over a period of two to four months.

Muscle relaxants can be prescribed if symptoms are related to muscle tension or fibromyalgia. If the TMD is related to rheumatoid arthritis, it may be treated with

corticosteroids, methotrexate (MTX, Rheumatrex), or gold sodium (Myochrysin).

TMD can also be treated with ultrasound, electromyographic biofeedback, stretching exercises, transcutaneous electrical nerve stimulation, stress management techniques, friction massage, or posture training.

A patient who is suffering emotional or psychological problems that contribute to his or her TMD must address those problems before expecting relief of TMD symptoms.

Phase II treatment

By definition of the American Dental Association, Phase II treatment is non-reversible, invasive therapy. Its purpose is to definitively correct any discrepancies in the TMJ. Modalities include adjustment of the occlusion, orthodontics, reconstruction of the teeth, surgery, or a combination of these treatments.

In the 1980s, synthetic implants were used to replace the TMJ disc, but the implants proved to be too fragile to withstand jaw pressure. By 1999, all implants were taken off the market by the FDA. A new implant design was approved by the FDA in 2000.

Any patient considering Phase II treatment should be advised to get a second and possibly third opinion, and to proceed cautiously.

Prognosis

The prognosis for recovery from TMD is excellent for almost all patients. Most do not need any form of long-term treatment. In the case of patients with TMD associated with arthritis or fibromyalgia, the progression of the condition determines whether TMD can be eliminated.

Health care team roles

Every member of the dental team should be alert for TMD symptoms in patients, though only the dentist can prescribe treatment. A dental hygienist or assistant can use a skull or charts to help the patient understand the function and action of the TMJ. Additionally, dental auxiliaries can educate the patient about correct posture and modifying behavior such as gum chewing and fingernail biting.

If the dentist determines a splint is necessary, the hygienist or assistant can take impressions of the teeth and prepare plaster casts from the impressions. A **dental laboratory technician** then constructs the splint, and the dentist places it, checking to ensure an exact fit.

Prevention

To prevent TMD from developing, suggestions to patients can include:

- Avoid overuse of the jaw. Gum chewing is the major culprit, along with fingernail biting.
- Try not to grind the teeth. Follow the “lips together, teeth apart” rule. Upper and lower teeth should meet only for chewing. Make a conscious effort to keep the masseter (cheek) muscles relaxed.
- Sleep on the back. Sleeping on either side can put pressure on the TMJ.
- Manage stress. **Relaxation** exercises and biofeedback can help.
- Use correct posture. Carrying the head in a forward position has been shown to affect TMD. Also, correct bad ergonomic habits such as holding a telephone receiver between the ear and shoulder.

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TENS (Transcutaneous electrical nerve stimulation) *see* **Electrotherapy**

TENS unit *see* **Transcutaneous electrical nerve stimulation unit**

Tension headache

Definition

This most common type of headache is caused by severe muscle contractions triggered by **stress** or exertion. It affects as many as 90% of adult Americans.

Description

While most American adults get a tension headache from time to time, women and people with more education are slightly more likely to suffer from them. People who are so anxious that they grind their teeth or hunch their shoulders may find that the physical strain in their body can be experienced as **pain** and tension in the muscles of the neck and scalp, producing almost constant pain.

Causes and symptoms

Tension headaches are caused by tightening in the muscles of the face, neck, and scalp because of stress or poor posture. They can last for days or weeks and can cause pain of varying intensity. The tightening muscles cause more expansion and constriction of **blood vessels**, which can make head pain worse. Eyestrain caused by dealing with a large amount of paperwork or reading can cause a tension headache as well.

Many people report the pain of a tension headache as a kind of steady ache (as opposed to a throb) that forms a tight band around the forehead, affecting both sides of the head. Tension headaches usually occur in the front of the head, although they also may appear at the top or the back of the **skull**.

Tension headaches often begin in late afternoon and can last for several hours; they can occur every day and last throughout most of the day. When this happens, the headache is called a chronic tension headache. Unlike migraines, tension headaches do not cause nausea and vomiting, and sufferers do not exhibit sensitivity to light or signs of any kind of aura before the headache begins.

Diagnosis

Diagnosis of tension headaches is made from a medical history, discussion of symptoms, and elimination of other types of headaches or underlying disorders.

Very few headaches are the sign of a serious underlying medical problem. However, sufferers should call a physician at once if they:

- Have more than three headaches a week.
- Take medication for pain almost every day.
- Need more than the recommended dose of pain medication.
- Have a stiff neck and/or **fever** in addition to a headache.
- Are dizzy, unsteady, or have slurred speech, weakness, or numbness.
- Have confusion or drowsiness with the headache.
- Have headaches that began with a head injury.
- Have headaches triggered by bending, coughing, or exertion.
- Have headaches that keep getting worse.
- Have severe vomiting with a headache.
- Have the first headache after age 50.
- Awaken with headache that gets better as the day goes on.

Treatment

There are many different treatments for tension headaches, which respond well to both medication and massage. If these headaches become chronic, however, they are best treated by identifying the source of tension and stress and reducing or eliminating it.

Medication

Tension headaches usually respond very well to over-the-counter medicines such as aspirin, ibuprofen, or acetaminophen. However, some of these drugs (especially those that contain **caffeine**) may trigger rebound headaches if their use is discontinued after they are taken for more than a few days.

More severe tension headaches may require combination medications, including a mild sedative such as butalbital. These should be used sparingly, though. Chronic tension headaches may respond to low-dose amitriptyline taken at night.

Massage

Massaging the tense muscle groups may help ease pain. Instead of directly massaging the temple, persons will get more relief from rubbing the neck and shoulders, because tension headaches often arise from tension in this area. In fact, relaxing the muscles of the neck can cut the intensity and duration of tension headaches at least in half.

To relax these muscles, the neck should be rotated from side to side as the shoulders shrug. Some people find that imagining a sense of warmth or heaviness in the neck muscles can help. Taking three very deep breaths at the first hint of tension can help prevent a headache.

Other therapy

If tension headaches are a symptom of either depression or **anxiety**, the underlying problem should be treated with counseling, medication, or a combination of both.

Alternative treatment

Eliminating the sources of the tension as much as possible will help prevent tension headaches. Acupuncture or **acupressure** may be helpful in treating some chronic tension headaches. Homeopathic remedies and botanical medicine can also help relieve tension headaches. Valerian (*Valeriana officinalis*), skullcap (*Scutellaria lateriflora*), and passionflower (*Passiflora incarnata*) are three herbal remedies that may be helpful. A tension headache can also be relieved by soaking the feet in hot water while an ice cold towel is wrapped around the neck.

Prognosis

Reducing stress and relying less on caffeine-containing medications can reduce the number of tension headaches for most people. Also, reducing the intake of products such as coffee, tea, and soft drinks that contain caffeine often reduces headaches.

Health care team roles

Many headaches are identified and treated at home using over-the-counter products. Physicians become involved in diagnosing and treating the underlying causes of tension headaches. Therapists and psychiatrists are involved in processing underlying stress.

Prevention

Tension headaches can often be prevented by managing everyday stress and making some important lifestyle changes. Those who are prone to tension headaches should:

- Take frequent “stress breaks.”
- Get regular **exercise**. Even a brisk 15-minute walk can help prevent tension headaches.
- Get enough sleep.
- Release angry feelings.

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Testicular scan see **Scrotal nuclear medicine scan**

Testicular ultrasound see **Scrotal ultrasound**

Testosterone test see **Sex hormones tests**

Thallium heart scan

Definition

A thallium **heart** scan is a diagnostic test that uses a special perfusion-scanning camera and a small amount of thallium-201, a radioactive substance, injected into the bloodstream to produce an image of the **blood** flow to the heart.

Purpose

A thallium heart scan is used to evaluate the blood supply to the heart muscle. It can identify areas of the heart that may have a reduced blood supply as a result of damage from a previous **myocardial infarction** (heart attack) or blocked coronary arteries. While **exercise** testing has long been a standard examination in the diagnosis of **coronary artery disease**, in some instances, the thallium scan may provide more sensitive and more specific information. In other words, the test may be better able to detect a problem and to differentiate one condition from another. For example, a thallium heart scan may more accurately detect ischemic heart disease. A thallium scan is most likely to aid diagnosis in cases where the exercise test is inconclusive, the patient cannot exercise adequately, or a quantitative evaluation of blood flow is required. In addition to evaluating coronary artery disease, thallium scanning can help to evaluate coronary blood flow following coronary artery bypass graft surgery or **angioplasty**.

Precautions

Radioisotopes such as thallium 201 should not be administered during **pregnancy** because they may be harmful to the fetus.

Description

The thallium scan is performed in conjunction with an exercise **stress test**. At the end of the **stress test** (once the patient has reached the highest level of exercise he or she can comfortably achieve), a small amount of the radioisotope thallium 201 is injected into the patient's bloodstream through an IV (intravenous) line. The patient then lies down under a gamma scintillation camera, which generates photographs from the gamma rays emitted by the thallium.

Thallium attaches to the red blood cells and is carried throughout the body in the bloodstream. It enters the heart muscle by way of the coronary arteries and accumulates in the cells of the heart muscle. Since the thallium can only reach those areas of the heart with an adequate blood supply, it can help to detect perfusion defects. In patients with perfusion defects, no thallium will show up in poorly perfused areas of the heart. Instead, these areas show up as “cold spots” on the thallium scan. The patient is then given a second injection of thallium. Several hours later, the gamma scintillation camera takes more pictures in order to obtain an image of the heart when the patient is at rest.

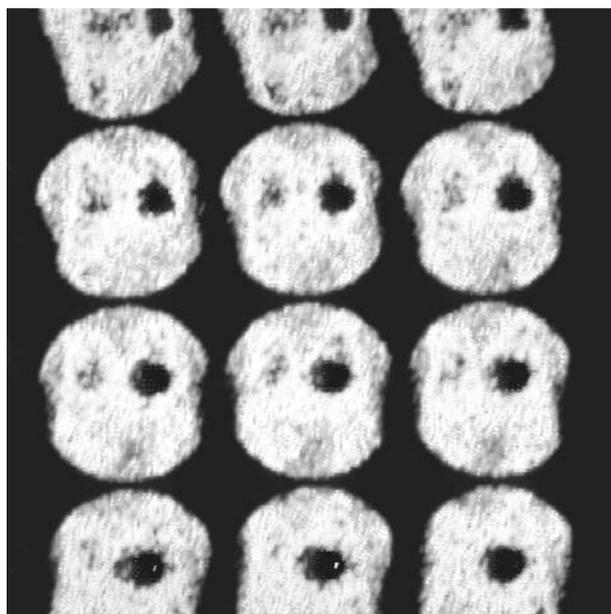
Cold spots that appear at rest as well as during exercise often indicate an area of previously damaged heart tissue or scars that have resulted from a prior myocardial infarction. Sometimes perfusion is adequate during rest but cold spots appear during exercise, when the heart has to work harder and has a greater demand for blood. This cold spot indicates ischemia resulting from a blockage in the coronary arteries. In ischemia, the heart temporarily does not get enough blood flow. Patients with perfusion defects, especially perfusion defects that appear only during exercise, have the greatest risk of future cardiac events such as myocardial infarctions.

In recent years, there have been improvements in heart scanning. Many centers now use a single photon emission computed tomographic (SPECT) camera, which provides a clearer image. Some centers also use, in place of thallium, a chemical called sestamibi. Sestamibi is used along with a radioactive compound called technetium. While thallium may still be better for some uses, such as providing a better image of the heart muscle itself, sestamibi may produce clearer images in overweight patients and is more useful in assessing how well the heart pumps blood.

When patients are unable to exercise because of another medical condition, such as arthritis or lung disease, they may be given a pharmacological thallium test instead of an exercise thallium stress test. In the pharmacological test, a drug is administered to mimic the effects of exercise on the heart such as dipyridamole (Persantine), which dilates the coronary arteries, or dobutamine, which increases blood flow through the heart muscle.

Preparation

Patients should be instructed not to drink alcoholic or caffeinated beverages, smoke tobacco, or ingest other nicotine products for 24 hours before the test. These substances can affect test results. Patients should also be advised not to eat anything for at least three hours before the test. They may also be instructed to stop taking cer-



A thallium scan of the human heart. This set of pictures was taken over time. The dark areas receive an inadequate supply of blood. (Custom Medical Stock Photo. Reproduced by permission.)

tain medications during the test that may interfere with test results. **Patient education** preceding a thallium scan may be performed by a nurse or cardiovascular laboratory technician.

Aftercare

In most cases, another set of scans may be needed (one in conjunction with exercise, one at rest), and the patient may be given special instructions regarding eating and test preparation. In most cases, patients are free to return to their normal daily activities.

Complications

Radioisotopes such as thallium 201 should not be administered during pregnancy because they may be harmful to the fetus.

Results

A normal thallium scan shows healthy blood flow through the coronary arteries and normal perfusion of the heart muscle, without cold spots, both at rest and during exercise.

Cold spots on the scan, where no thallium shows up, indicate areas of the heart that are not getting an adequate supply of blood. Cold spots appearing both at rest and during exercise may indicate areas where the heart tissue

KEY TERMS

Angioplasty—The reconstruction of damaged blood vessels.

Coronary bypass surgery—Surgery in which a section of blood vessel is used to bypass a blocked coronary artery and restore an adequate blood supply to the heart muscle.

Perfusion—The passage of fluid (such as blood) through a specific organ or area of the body (such as the heart).

Radioisotope—A radioactive form of a chemical element, which is used in medicine for therapeutic or diagnostic purposes.

has been damaged. However, “reversible” cold spots, appearing only during exercise, usually indicate some blockage of the coronary arteries.

Health care team roles

A thallium scan is generally ordered by a primary care physician or cardiologist and is performed by a trained technician. All healthcare providers performing or monitoring cardiac tests should be prepared to provide emergency medical intervention, such as defibrillation. The exam is interpreted by a radiologist, cardiologist, or nuclear medicine physician.

Patient education

Patients must be well-prepared for a thallium scan. They should not only know the purpose of the test, but also signs and symptoms that indicate the test should be stopped. Physicians, nurses, and ECG technicians can ensure patient safety by encouraging them to immediately communicate discomfort at any time during the scan.

Resources

BOOKS

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Thelan, Lynne A. et al. *Critical Care Nursing Diagnosis and Management*. St. Louis, MO: Mosby, 1998, pp. 438.

ORGANIZATIONS

American Heart Association. 7272 Greenville Ave., Dallas, TX 75231. (214) 373-6300. <<http://www.amhrt.org>>.

National Heart, Lung, and Blood Institute Information Center. PO Box 30105, Bethesda, MD 20824-0105. (301) 951-3260. <<http://www.nhlbi.nih.gov>>.

Barbara Wexler

Therapeutic drug monitoring

Definition

Therapeutic drug monitoring (TDM), or simply drug monitoring, is the measurement of drug levels in the **blood**.

Purpose

TDM is employed to measure blood drug levels so that the most effective dosage can be determined and toxicity can be prevented. Drug monitoring is not needed for most drugs. Many drugs have a wide therapeutic window, meaning that the difference between the therapeutic and toxic level is large. Often, the physician can measure an expected outcome to see if a drug is working. For example, body temperature can be measured to evaluate an antipyretic drug. Monitoring is mainly used for drugs that can be toxic or cause severe side effects. Examples are antiepileptic drugs, antiarrhythmic agents, oral anticoagulants, theophylline, tricyclic antidepressants, lithium, antineoplastics, aminoglycoside **antibiotics**, cardiac glycosides, and drugs to prevent transplant rejection. TDM is also utilized to identify noncompliant patients (i.e., those patients who, for whatever reason, either cannot or will not comply with **drug dosages** as prescribed by the physician).

Precautions

Many different factors influence blood drug levels, and the following points should be taken into consideration during TDM: the age, sex, and weight of the patient; the route of administration of the drug; the drug’s absorption rate, excretion rate, delivery rate, and dosage; other medications the patient is taking; other diseases the patient has; the patient’s compliance regarding the drug treatment regimen; and the laboratory methods used to measure the drug.

Drugs taken orally should not be measured until the processes of absorption and elimination have nearly reached a steady state. The steady state is reached when the drug in the next dose is sufficient to replace the drug that is eliminated. This requires approximately five drug

elimination half-lives. Some drugs such as tricyclic antidepressants may be decreased by the gel in serum separator tubes. Since drug levels rise and then fall in between oral, bolus intravenous, and intramuscular doses, the interpretation of blood drug levels requires strict adherence to the appropriate time of collection. Blood collected at an improper time will provide misleading information. Blood should not be taken from an intravenous line immediately following infusion of medication. Before collecting a sample from an intravenous line, at least 3 mL of blood should be collected from the line and discarded to clear the line of heparin, IV contents, and medication.

Description

TDM is a practical tool that can help the physician provide effective and safe drug therapy in patients who need medication. Monitoring can be used to confirm that a blood drug concentration is within the therapeutic range. If the desired therapeutic effect of the drug is not as expected, two blood levels can be used to determine the drug's half-life in the body. This data along with dose information can be used to calculate the change in dose or dosing interval needed to bring the concentration into the therapeutic range.

Blood drug levels are influenced by five processes: liberation, absorption, distribution, **metabolism**, and excretion. Liberation is the release of the drug in the body (usually the gastrointestinal tract) and absorption is the transport of the drug to the blood. These variables determine the fraction of the dose that is bioavailable. Many drugs are absorbed by the portal circulation and transported directly to the **liver**, where they are partly metabolized to inactive forms. This process reduces the amount of drug available to the target tissues. Distribution refers to the volume of body fluids in which the drug becomes diluted. Metabolism refers to the chemical transformation of the drug performed by the liver. Most drug metabolites are water soluble and removed by the **kidneys**. Individual differences in any of these processes alters the relationship between dose and drug blood levels, called drug pharmacokinetics. For example, persons with decreased renal function will have a longer drug half-life (decreased clearance) causing the blood level (and tissue level) of drug to be higher than expected. Drugs in the blood are mainly protein-bound, and therefore, inactive. Decreased albumin, abnormal blood pH, or displacement of one drug by another may alter protein binding increasing the blood level of free (active) drug. Persons may metabolize a drug more slowly than expected due to genetic factors or liver disease. Smoking, **stress**, and drug formulation (generic versus

trade name) can alter pharmacokinetic properties, making some drugs ineffective or toxic at usual doses. In such cases TDM can explain the discordance between dose and outcome and provide data needed to safely make changes in drug administration.

Blood specimens for drug monitoring can be taken at two different times, called peak and trough levels. Blood for peak level is collected at the drug's highest therapeutic concentration within the dosing period. For drugs given intravenously, the peak level is drawn 30 minutes after completion of the dose. For drugs given orally, this time varies with the drug because it is dependent upon the rates of absorption, distribution and elimination. For intravenous drugs, peak levels can be measured immediately following complete infusion. Trough levels (occasionally called residual levels) are measured just prior to administration of the next dose, and are the lowest concentration in the dosing interval. Too low a dose or too great a dose interval will produce a trough level that is below the therapeutic range, and too great a dose or too close a dose interval will show a peak level greater than the therapeutic range. Most therapeutic drugs have a narrow trough to peak difference, and therefore, only trough levels are needed to detect blood levels that are too low or too high. Peak levels are needed for some drugs, especially aminoglycoside antibiotics. A concentration below the therapeutic range will not resolve the bacterial **infection**. However, too high a level can cause damage to the kidneys, bone marrow, and acoustic nerves.

Many methods are available to measure the concentration of specific drugs. The most widely used methods are immunoassay and chromatography.

Preparation

In preparing for this test, the following guidelines should be observed:

- For patients suspected of symptoms of drug toxicity, the best time to draw the blood specimen is when the symptoms are occurring.
- If there is a question as to whether an adequate dose of the drug is being achieved, it is best to obtain trough levels.
- Peak (highest concentration) levels are usually obtained 30 minutes after an intravenous dose, one hour after intramuscular (IM) administration, and approximately one to two hours after oral dosing. However, slow-release formulas for many drugs will not produce peak levels for several hours after ingestion.

THERAPEUTIC DRUG MONITORING: THERAPEUTIC AND TOXIC RANGE			
Drug Level*	Use	Therapeutic Level*	Toxic
Acetaminophen mg/ml	Analgesic, antipyretic	Depends on use	>250
Amikacin mg/ml	Antibiotic	12-25 mg/ml**	>25
Aminophylline ng/ml	Bronchodilator	10-20 mg/ml	>20
Amitriptyline ng/ml	Antidepressant	120-150 ng/ml	>500
Carbamazepine mg/ml	Anticonvulsant	5-12 mg/ml	>12
Chloramphenicol mg/ml	Antibiotic	10-20 mg/ml	>25
Digoxin ng/ml	Cardiotonic	0.8-2.0 ng/ml	>2.4
Gentamicin	Antibiotic	4-12 mg/L	>12 mg/L
Lidocaine	Antiarrhythmic	1.5-5.0 mg/ml	>5 mg/ml
Lithium mEq/L	Antimanic	0.7-2.0 mEq/L	>2.0
Nortriptyline ng/ml	Antidepressant	50-150 ng/ml	>500
Phenobarbital mg/ml	Anticonvulsant	10-30 mg/ml	>40
Phenytoin mg/ml	Anticonvulsant	7-20 mg/ml	>30
Procainamide mg/ml	Antiarrhythmic	4-8 mg/ml	>16
Propranolol ng/ml	Antiarrhythmic	50-100 ng/ml	>150
Quinidine mg/ml	Antiarrhythmic	1-4 mg/ml	>10
Theophylline mg/ml	Bronchodilator	10-20 mg/ml	>20
Tobramycin mg/ml	Antibiotic	4-12 mg/ml**	>12
Valproic acid mg/ml	Anticonvulsant	50-100 mg/ml	>100
* Values are laboratory-specific. **Concentration obtained 30 minutes after the end of a 30-minute infusion.			

Drug therapy monitoring. (Illustration by Standley Publishing. Courtesy of Gale Group.)

KEY TERMS

Absorption—Uptake of drug into the circulation.

Bioavailability—The amount of drug in a dosage that can be absorbed by the patient.

Distribution—The division of the drug into different parts of the body such as the liver, blood, spinal fluid, and urine.

Elimination—The final excretion of a drug and its metabolites.

Half-life—The amount of time that is needed to reduce a drug level to one half of what was absorbed in the blood.

Maintenance dose—The amount of drug that is needed to keep the patient's blood levels at a steady state.

Metabolism—The breakdown of a drug into its metabolites.

Metabolites—Compounds that the drug is broken down into, usually done by the liver.

Peak concentration—The highest level of drug reached in the blood.

Slow release—A preparation of the drug that allows for slow absorption, over hours or days.

Therapeutic range—Levels of a drug that will yield the desired effect without toxicity.

Toxic—Poisonous, a drug is toxic when levels in the body are too high.

Trough concentration—The lowest level of a drug in the plasma, usually seen right before the next dose is given.

Health care team roles

Physicians will determine the initial dose of drug. A nurse or phlebotomist collects the specimen by venipuncture documenting the time of draw. Pharmacists may assist by providing information about drug half-life, recommended peak collection time, therapeutic ranges, side-effects, and **drug interactions**. Clinical laboratory scientists, CLS (NCA)/medical technologists, MT (ASCP) or clinical laboratory technicians, CLT (NCA) or medical laboratory technicians, MLT (ASCP) perform drug assays. They are responsible for notifying the physician when critical values are exceeded.

Patient education

Patients should be educated on the importance of complying with their physician's orders for medications, and should be told to report any complications or side effects they may experience. Patients should also be told about the frequency of their drug monitoring tests, and why keeping their appointment is important.

Resources

BOOKS

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- Kaplan, Lawrence A. and Amadeo J. Pesce. *Clinical Chemistry, Theory, Analysis and Correlation, Third Edition*. St. Louis: Mosby Publishing, 1996.
- Lane, Keryn A.G. *The Merck Manual of Medical Information*. Merck Research Laboratories, 1997.
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Jane E. Phillips

Complications

Risks for this test are minimal, but may include slight bleeding from the blood-drawing site, fainting or feeling lightheaded after blood is drawn, or accumulation of blood under the puncture site (hematoma).

Aftercare

Bruising may occur at the puncture site or the person may feel dizzy or faint. Pressure should be applied to the puncture site until the bleeding stops to reduce bruising. Warm packs can also be placed over the puncture site to relieve discomfort. Drug dose, dosing schedule, or medication changes may be required, if the blood drug level is outside the therapeutic range.

Therapeutic exercise

Definition

Therapeutic **exercise** is a **physical therapy** intervention encompassing a broad range of activities designed to restore or improve musculoskeletal, cardiopulmonary and/or neurologic function.

Purpose

Some form of therapeutic exercise is indicated in almost every physical therapy case. Physical therapists may assist clients in designing therapeutic exercise pro-

grams to prevent injury or secondary impairments. In addition, physical therapists use therapeutic exercise as one component of patient care to improve functional ability and general well-being in those who are experiencing limitations or disability due to a disease, disorder, trauma, or surgery.

Precautions

Therapeutic exercise includes a broad spectrum of activities, from passive range of motion and breathing exercises to high-speed agility drills. Precautions, therefore, are specific to each individual depending upon his or her condition. The physical therapist must use his or her specialized knowledge to determine exercises that are appropriate for a patient or client's level of ability, age, endurance, severity of injury and/or stage of recovery. Outlined below, however, are a few examples of situations in which general precautions should be observed.

Post-operative

A progression of therapeutic exercise is usually more gradual in a patient recovering from surgery than in one who did not require surgery, especially in order to allow inflamed tissues to heal. In general, specific joint motions and weightbearing are often restricted. High-intensity stretching and resistance exercise is usually limited for at least six weeks to allow adequate healing time for muscles or tendons that have been repaired.

Osteoporosis

In **osteoporosis**, bone resorption has taken place at a much higher rate than bone formation, resulting in weakened osseous structures. The risk for pathologic fracture resulting from very minor **stress** is high. In patients with osteoporosis, low-impact weight-bearing and endurance exercise should be introduced. Caution should be taken when adding resistive exercises, and explosive or twisting movements should be avoided altogether.

Pregnancy

There are several high-risk conditions that are contraindications to exercise. These include: incompetent cervix, vaginal bleeding, **placenta previa**, preterm rupture of membranes, premature labor, and maternal **heart** disease, diabetes, or **hypertension**. Precautions need to be taken when women present with the following: multiple gestation, anemia, systemic **infection**, extreme fatigue, musculoskeletal **pain**, overheating, phlebitis, diastasis recti, or uterine contractions which last several hours after exercise. In these cases, women who partici-

pate in exercise should be monitored closely by both physician and therapist.

Resistance exercise

Resistance exercise is often a key part of a therapeutic exercise program; however, considerations must be made regarding risk factors. Resistive exercise should not be performed when there is muscle or joint inflammation, or when severe pain is present during or after exercise. Precautions should be taken with high-risk cardiovascular patients. All patients should be taught to avoid the Valsalva maneuver, excessive fatigue and overwork.

Joint mobilization

Joint mobilization techniques are often used to increase range of motion by passively distracting or gliding the joint surfaces. Gentle, small grade oscillatory movements may be used to inhibit pain and relax the patient; however, larger movements are contraindicated in the cases of hypermobility, joint effusion and inflammation. In addition, precautions should be taken when any of the following exist: malignancy, unhealed fracture, connective tissue or bone disease, total joint replacements, or weakened connective tissue (due to recent trauma, surgery, disuse, or medication).

Description

Therapeutic exercise can be an intervention used in a physical therapy plan of care or as part of a recommendation in client consultation. The physical therapist uses a thorough examination including subjective and objective data to assess each patient's specific needs. It is clear that an 80-year-old woman with osteoporosis with a history of **fractures** is going to require a much different program from a 20-year-old athlete who wants to return to sports following a knee injury.

The main goal of therapeutic exercise is to improve or maintain functional ability, including daily living skills, through the application of careful and gradual forces to the body. Often, this overall goal is achieved through the objectives of developing, improving, restoring or maintaining one or more of the following: strength, endurance, flexibility, stability, coordination and/or balance.

Strength

Strength in muscular tissue is improved through graded and deliberate overloading of the targeted muscle(s). When the main focus is strength, exercise is usually performed against heavy loads with relatively few

repetitions. Physiologically, this training leads first to an increase in the number of motor units being fired, which increases force output. Gradually, the cross-sectional size of individual skeletal muscle fibers increases as well, which produces bulk and improves strength capacity.

Endurance

Endurance affords individuals the ability to perform activities over a relatively prolonged period. When muscular endurance is developed, a muscle can generate and sustain a larger number of contractions over a period of time. With total body endurance, an individual develops the ability to participate in a period of low-intensity conditioning such as walking, jogging and other aerobic activity. Cardiovascular and pulmonary fitness are increased through this means. In a program directed at improving endurance, large muscle groups are recruited for prolonged periods of time (at least 15 minutes).

Flexibility

Contractile and noncontractile tissues both are susceptible to tightening when injured or exposed to a neurological disease process that causes weakening and/or spasticity. Prevention, through careful and regular movement and stretching, is key to maintaining flexibility. Consideration, however, must be taken regarding restrictions to mobility in post-operative or post-traumatic healing. Muscular flexibility may be increased or maintained through active or passive stretching, while connective tissue mobility requires passive procedures.

Stability

Stability is required in order to provide a stable base for functioning. Usually, stability concerns are focused on proximal musculature in the trunk, shoulders, and hips to allow for movement of the extremities.

Coordination and balance

The ability to execute complex patterns of movement with the right timing and sequencing is essential to motor function, as is the ability to maintain one's center of gravity over the available base of support. Coordination and balance are usually trained using motor learning principles, and are important components of a therapeutic exercise program designed to increase function.

Along with training in the above areas, therapeutic exercise may include education about body mechanics, gait and locomotion training, neuromuscular re-education, developmental activities and **relaxation** strategies. It is important to note also that, although trunk and extremity musculature may be the first to come to mind

when discussing strength and endurance, physical therapists may also address ventilatory and pelvic-floor issues with therapeutic exercise.

Because the ultimate goal is function, any discussion about therapeutic exercise has to include the topic of closed-chain exercise, which is the movement of the body over a fixed distal segment such as the hand or foot. Open-chain exercise, in which the distal segment moves freely in space, is the traditional form seen in weight rooms; however, it does not train the patient to perform functional weight-bearing activities such as walking, stair climbing or jumping. If there is a restriction on weight bearing, closed-chain exercises should be delayed or modified to comply with restrictions. Modifications may include performing the exercise in a pool or while sitting instead of standing.

Results

Depending on the individual, the anticipated outcomes may include:

- increase in physical function following a trauma or surgery
- maintenance of, or minimizing loss of, function with respect to a disease process
- prevention of complications post-operatively or after an injury
- prevention of future or further limitations or disability

These outcomes may be reached through increases in strength, endurance, flexibility, mobility, stability, coordination and/or balance. Numerous tests and measures are available to assist in assessing desired outcomes. Strength may be measured using **electromyography**, dynamometry, and/or manual **muscle testing**. Muscular endurance may be assessed with physical capacity tests, timed activity tests, and/or functional muscle tests. Aerobic endurance is often measured using cardiovascular and pulmonary signs and symptoms, ergometry, step tests, and timed walk/run, treadmill, or wheelchair tests. Flexibility can be measured by observation of functional range of motion, goniometry, inclinometry, and joint play movements. In addition, many motor control and function tests assess stability, coordination and balance.

Health care team roles

The physical therapist is responsible for evaluating the patient or client and developing a plan of care that includes appropriate therapeutic exercise intervention. The physical therapist also must teach, assist and monitor the patient with the exercise program. Modifications must be made as the patient shows signs of distress, inap-

KEY TERMS

Motor learning—A set of processes related to practice or experience that results in relatively permanent changes in the ability to produce a skilled action.

Neuromuscular re-education—The training of an individual to recover or develop effective sensory and motor strategies for task demands.

appropriate fatigue, or progress. The physical therapist assistant, under the supervision of a physical therapist, may participate in all aspects of care except for initial evaluation, modifications outside of the plan of care, or interventions requiring the specific expertise of the physical therapist.

Resources

BOOKS

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ORGANIZATIONS

American Physical Therapy Association, 1111 North Fairfax St., Alexandria, VA 22314-1488. (703) 684-2782. <<http://www.apta.org>>.

Peggy Campbell Torpey, MPT

Therapeutic nutrition see **Medical nutrition therapy**

Therapeutic touch

Definition

Therapeutic touch, or TT is a noninvasive method of healing that was derived from an ancient laying on of hands technique. In TT, the practitioner alters the patient's energy field through an energy transfer that transpires from the hands of the practitioner to the patient.

Origins

Therapeutic touch was developed in 1972 by Dora Kunz, a psychic healer, and Dolores Krieger, Ph.D., R.N, a nurse and professor of nursing at New York University. The year before in 1971, when Krieger was working as a **registered nurse** in a hospital, she became very frustrated when one of her patients, a 30-year-old female, lay dying from a **gallbladder** condition. In desperation, she tried what she was learning from Kunz. Within one treatment, the patient's condition began to shift, and she lived, surprising the other hospital staff. Krieger and Kunz met during the study of Oskar Estebany, a world-renowned healer. They had invited Estebany to form a study for three years, observing his work with patients. In this study, Estebany practiced laying on of hands healing on various patients. Using her psychic and intuitive abilities, Kunz would observe and assist in the healing, while Krieger recorded the activities of the healing session and created profiles of the patients.

As the study progressed, Kunz began teaching Krieger how to heal, based on her perceptions of Estebany's healing techniques. During her research of ancient healing methods, Krieger concluded that the energy transfer between the healer and the healee that takes place in a TT session is prana, an Eastern Indian concept representing energy, vitality, and vigor. Krieger then combined her research with Kunz's techniques to create TT.

TT was initially developed for persons in the health professions, but is currently taught worldwide to anyone who is interested in learning the technique. As of 1998, an estimated 100,000 people around the world have been trained in TT; 43,000 of those persons are health care professionals, many of whom use TT in conjunction with traditional medicine, as well as osteopathic, chiropractic, naturopathic, and homeopathic therapies. TT is taught in over 100 colleges, universities, and medical schools.

Benefits

The major effects of TT are **relaxation, pain** reduction, accelerated healing, and alleviation of psychosomatic symptoms. Studies have shown that TT has a beneficial effect on the **blood** as it has the ability to raise hemoglobin values. It also affects **brain** waves to induce a relaxed state. TT can induce the relaxation response often within five minutes.

Krieger has said that it is not individual illnesses that validate the effectiveness of TT, but rather, it is questioned which systems are most sensitive to TT. She and others have found that the most sensitive is the **autonomic nervous system** (ANS), which, for example, controls urination, and is followed by dysfunctions of lymphatic and circulatory systems, and then finally musculoskeletal systems. In addition, the female **endocrine system** is more sensitive to TT than the corresponding male system. Thus, TT helps with dysmenorrhea, amenorrhea, problems with **contraception**, and the course of **pregnancy**.

TT is reported to have a positive effect on the **immune system** and thus accelerates the healing of **wounds**. Nurses use therapeutic touch in operating rooms to relax patients before surgery and in recovery rooms on postoperative patients to help speed the healing process. TT is used in the treatment of terminally ill patients, such as those with **cancer** and autoimmune deficiency syndrome (**AIDS**), to relieve **anxiety** and **stress**, create peace of mind, and reduce pain.

Many nurses use TT in the nursery. The conditions of many premature babies who received TT reportedly improved rapidly. TT has been used to calm colicky infants, assist women in **childbirth**, and increase milk let-down in breast-feeding mothers.

Other claims of TT include relief of acute pain, nausea, **diarrhea**, tension and migraine headaches, **fever**, and joint and tissue swelling. TT has been used to treat thyroid imbalances, ulcers, psychosomatic illnesses, premenstrual syndrome, **Alzheimer's disease**, stroke and **coma** patients, **multiple sclerosis**, measles, infections, **asthma**, and bone and muscle injuries.

Therapeutic touch is performed in many different locations, including healing centers, delivery rooms, hospitals, hospice settings, accident scenes, homes, and schools.

Description

Therapeutic touch treats the whole person: relaxes the mind, heals the body, and soothes the spirit. The principle behind it is that it does not stop at the skin: the

human body extends an energy field, or aura, several inches to several feet from the body. When illness occurs, it creates a disturbance or blockage in the vital energy field. The TT practitioner uses her/his hands to sense the blockage or disturbance. In a series of gentle strokes, the healer removes the disturbance and rebalances the energy to restore health.

The TT session generally lasts about 20–30 minutes. Although the name is therapeutic touch, there is generally no touching of the physical body, only the energetic body or field. It is usually performed on fully clothed patients who are either lying down on a flat surface or sitting up in a chair.

Each session consists of five steps. Before the session begins, the practitioner enters a state of quiet **meditation** where he/she becomes centered and grounded in order to establish intent for the healing session and to garner the compassion necessary to heal.

The second step involves the assessment of the person's vital energy field. During this step, the practitioner places the palms of his/her hands 2–3 in (5–8 cm) from the patient's body and sweeps them over the energy field in slow, gentle strokes beginning at the head and moving toward the feet. The practitioner might feel heat, coolness, heaviness, pressure, or a prickly or tingling sensation. These cues, as they are called, each signal a blockage or disturbance in the field.

To remove these blockages and restore balance to the body, the practitioner then performs a series of downward, sweeping movements to clear away any energy congestion and smooth the energy field. This is known as the unruffling process and is generally performed from head to feet. To prevent any energy from clinging to him/her, the practitioner shakes his/her hands after each stroke.

During the next phase, the practitioner acts as a conduit to transfer energy to the patient. The energy used is not solely the energy of the practitioner. The practitioner relies on a universal source of energy so as not to deplete his/her own supply. In short, the healer acts as an energy support system until the patient's immune system is able to take over.

The practitioner then smoothes the field to balance the energy and create a symmetrical flow. When the session is over, it is recommended that the patient relax for 10–15 minutes in order for the energies to stabilize.

Side effects

The side effects reported occur when an excess of energy enters the body for an extended period of time creating restlessness, irritability, and hostility, or increas-

ing anxiety and pain. **Burns** are sensitive to therapeutic touch, and it is recommended that TT be performed on burned tissue for short periods, generally two to three minutes at a time.

Research and general acceptance

Therapeutic touch is not generally accepted by Western medical professionals. Basic and anecdotal research has been performed on TT since its development in 1972, although little quantitative research has been carried out. It is based on a theory derived from formal research. It began as the basis of Dolores Krieger's post-doctoral research.

Dolores Krieger has performed extensive research on TT, including with pregnant women, and has noted that the following changes occur in a patient after short, consistent treatment: relaxation within the first five minutes of a session, a reduction of pain, and the acceleration of the healing process.

One study was created to determine the effect TT would have on wounds that resulted from a biopsy of the upper arm. Forty-four patients placed their injured arms through a hole in a door. Twenty-two of them received TT on their arms. The other half received no treatment. The wounds treated with TT healed more quickly than the wounds that received no treatment.

In 1998, a study was performed on 27 patients with **osteoarthritis** in at least one knee. For six weeks, the patients were treated with therapeutic touch, mock therapeutic touch, or standard care. According to *The Journal of Family Practice*, the journal who published the study, the results showed that the group who had received TT had "significantly decreased pain and improved function as compared with both the placebo and control groups."

Therapeutic touch can be combined with a number of different therapies, including **acupressure**, massage, mental imagery, **physical therapy**, and **yoga**. When combined with massage and physiotherapy, TT may reduce tension headaches, back pain, stress-related problems, circulatory problems, and constipation. **Shiatsu** and TT may help sinusitis, digestive disorders, muscle cramps, menstrual difficulties, and insomnia. Yoga and TT may be beneficial in the treatment of bronchitis, asthma, **blood pressure**, fatigue, and anxiety.

TT is practiced in over 70 countries worldwide: by Egyptians and Israelis during fighting in the Gaza Strip; in South Africa to reduce racial strife; and in Poland, Thailand, and the former Soviet Union.

Training and certification

Therapeutic touch is taught at over 100 universities and nursing and medical schools around the United States and Canada. Although it was developed primarily for nurses, anyone can learn TT.

State laws vary regarding the practice of TT. In general, laypersons are allowed to practice TT within their families. Therapeutic touch is considered an extension of health care skills, so most health care professionals are covered under the state medical practice act.

Many hospitals have established policies allowing nurses and staff to perform TT on patients at no extra charge. The American Nurse's Association often holds workshops on TT at national conventions. Therapeutic touch classes are often held for the general public through community education, healing clinics, and holistic schools.

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Jennifer Wurges

Thermometer

Definition

A thermometer is a device used to monitor temperature.

Purpose

A thermometer is used to establish a baseline on the admission of a patient to a health care facility, to detect any abnormalities from the normal state, and to establish if current medication is having the desired effect.

Temperature is recorded to check for pyrexia or monitor the degree of hypothermia present in the body. The body's normal temperature is 98.6°F (37°C). A **fever** is a temperature of 101°F or higher in an infant younger than three months or above 102°F for older children and adults. Hypothermia is recognized as a temperature below 96°F (35.5°C).

Description

A thermometer can be mercury, liquid-in-glass, electronic with digital display, infrared or tympanic, or disposable dot-matrix. It can be used in a clinical or emergency setting or at home.

A mercury thermometer consists of a narrow glass stem approximately 5 in (12.7 cm) in length with markings along one or both sides indicating the temperature scale in Fahrenheit, Centigrade or both. Mercury is held in a reservoir bulb at one end that rises when the glass chamber is placed in contact with the body. Mercury thermometers are not used in modern clinical settings.

Electronic thermometers can record a wide range of temperatures between 94°F to 105°F, (35°C to 42°C) and can be used orally, axillary (under the arm), or rectally. They have temperature sensors inside round-tipped probes and can be covered with disposable guards to prevent **infection** passing from one patient to another. The sensor is connected to the container housing the central processing unit, and the information gathered by the sensor is then shown on the display screen. Some models have other features such as **memory** recall of the last recording and a large display screen for easy reading. The thermometer probe is placed under the arm, tongue, or placed in the rectum and held in place for a few seconds, depending on the model used. The device will beep when the peak temperature is reached. The time required for obtaining the reading is between a few seconds to thirty seconds.

A tympanic thermometer has a round-tipped probe containing the sensor that can be covered with disposable guards to prevent infection from one patient to another. It is placed in the ear canal for one second while an infrared sensor records the body heat radiated by the eardrum. The reading then appears on the unit's screen.

Digital and tympanic thermometers should be used in accordance with the manufacturer's guidelines.



Thermometer. (Archive Photos, Inc. Reproduced by permission.)

Disposable thermometers are plastic strips that have chemicals impregnated in dots on the surface. They are sticky on one side to adhere to the skin and prevent slippage and are worn under the armpit. The dots change color at different times as the chemicals respond to the body heat. The temperature is readable after two to three minutes, depending on the manufacturer's guidelines. Some products are disposable, reusable, or can be used continuously for up to 48 hours. These devices are useful for children, and the temperature can be recorded even while the child is asleep.

Operation

The patient should be sitting or lying comfortably to ensure that the readings are taken in similar positions each time and that there is little excitement to affect the results.

The manufacturer's guidelines should be followed when taking a temperature with a digital, tympanic, or disposable thermometer. Dot-matrix thermometers are placed next to the skin and usually held in place by a sticky strip. With the tympanic thermometer, caregivers should ensure that the probe is properly inserted into the ear in order to allow an optimal reading. The reading will be less accurate if the sensor cannot accurately see the tympanic membrane or if the view is obscured by wax and debris in the ear canal.

A mercury thermometer can be used to monitor a temperature by three methods:

- Axillary.
- Orally or sub-lingually. This method is never used with infants.
- Rectally. This method is used with infants. The tip of the thermometer is usually blue-tipped to distinguish it from the silver tip of an oral/axillary thermometer.

KEY TERMS

Axillary—Under the armpit.

Hypothermia—A body temperature below 96°F (35.5°C).

Orally—By mouth.

Pyrexia—A temperature of 101°F (38.3°C) or higher in an infant younger than three months or above 102°F (38.9°C) for older children and adults.

Rectally—By the rectum.

Sub-lingually—Under the tongue.

Before recording a temperature using a mercury thermometer, the mercury is shaken down by holding the thermometer firmly at the clear end and flicking it quickly a few times in a downward motion toward the silver end. The mercury level should be below 96°F (35.5°C) before taking a temperature.

The silver tip is placed under the patient's right armpit, with the arm clamping it in place against the chest. The thermometer should stay in place for six to seven minutes. During this waiting period, the remaining **vital signs** may be recorded.

When the time has elapsed, the thermometer is removed and held at eye level. The mercury will have risen to a mark that indicates the temperature of the patient.

To record oral temperature, the procedure is the same as the axillary method, except that the silver tip of the thermometer is placed beneath the tongue for four to five minutes before reading.

In both cases, the thermometer is wiped clean and stored in an appropriate container to prevent breakage.

To record rectal temperature, a rectal thermometer is used and shaken down as described above. A small portion of a water-based lubricant is placed on the colored tip of the thermometer. With the infant lying on his back, the nurse holds him securely in place. The tip of the thermometer is inserted into the child's rectum no more than 0.5 in (1.3 cm) and held there for two to three minutes. The thermometer is removed, read as before, and wiped with an antibacterial wipe. It is then stored in an appropriate container to prevent breakage, as ingestion of mercury can be fatal.

Liquid-in-glass thermometers contain alternatives to mercury (such as alcohol) and are used in the same manner.

Maintenance

Many digital and infrared thermometers are self-calibrating. To ensure accuracy, mercury thermometers should be shaken down prior to every use and left in place for at least three minutes. They require careful storage to prevent breakage and require cleaning after each use to prevent cross-infection.

Currently, there is a nationwide initiative to ban the sale of mercury thermometers and **blood pressure** monitors. Health activists are concerned about mercury contaminating the environment after it has been disposed of. A mercury thermometer contains 0.7g (0.025 oz) of mercury; one gram of the substance can contaminate a 20-acre lake. Several states have banned the use of products containing mercury, and stores such as Wal-Mart, CVS, and Kmart have already stopped selling mercury thermometers. According to a study by the Mayo Clinic in March 2001, mercury-free devices can monitor information without compromising accuracy. In October 1999, the Environmental Protection Agency (EPA) advised using alternative mercury products to avoid the need for increased regulations in years to come and to protect human health and wildlife by reducing unnecessary exposure to mercury.

Health care team roles

Patients may ask questions about specific concerns they have regarding aspects of vital signs or a particular disease. The nurse can provide counseling on the prevention of illness or direct the person to their doctor.

The nurse should make the patient comfortable and reassure them that recording temperature is part of normal health checks and that it is necessary that their health be correctly monitored. Any abnormalities in the temperature must be reported to the medical staff.

Training

Staff should be given appropriate training in the device used in the clinical setting.

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Margaret A. Stockley

Thermoregulation

Definition

Thermoregulation refers to the mechanisms and control systems used by the body to balance thermal inputs and thermal losses so as to maintain its core temperature nearly constant.

Description

In a healthy individual, the temperature of the core of the body is regulated by feedback control mechanisms that maintain it nearly constant around 98.6°F (37°C) throughout the day, week, month or year. This thermoregulation is efficiently coordinated by the **central nervous system** (CNS) as long as the temperature of the surroundings ranges between 68°F (20°C) and 130°F (54°C).

The body increases and lowers its core temperature using a temperature control system that works like a thermostat. Increased body temperature activates mechanisms promoting heat loss, and lowered body temperature activates mechanisms enabling the accumulation or production of heat. Such a system is called a feedback control system, because it uses as input the total or partial output of the system, meaning that the consequences of the process dictate how it will go on further. A feedback system has three components: sensors that register the change, a control center that receives the signals of the sensors, and an effector mechanism, meaning a pathway for the commands of the control center when it responds to the information received from the sensors. In thermoregulation, the control center is located in the hypothalamus, a tiny cluster of **brain** cells located in the brain just above the **pituitary gland**. It also contains the key temperature sensors. Other sensors, located all over the body, record whether the body temperature is too high or too low. There are three main effector mecha-

nisms involved in thermoregulation. The first is the vasomotor system, which consists of the nerves that act on vascular smooth muscle to control **blood** vessel diameter; the second is provided by metabolic effectors, which are substances produced by the body to increase its activity. The third main effector mechanism is provided by the sweat glands. The vasomotor system is responsible for two physiological responses called vasodilation and vasoconstriction. The first increases blood flow in the tissues and the second decreases it.

Heat production, also called thermogenesis, is the result of several different body functions. One of them is the action of the thyroid gland, located in the neck. Hormones released by this gland increase the body's metabolism, meaning the activity of the body. Increased production of heat is thus achieved by increasing the metabolic processes in which energy is released in the form of heat. Other producers of heat are the **skeletal muscles**, the **liver**, the internal organs, and the brain. Muscles play a major role in thermogenesis. Because of their weight, they are able to produce very large amounts of heat very rapidly during increased physical activity. Digestion also results in an increased production of heat.

Heat is lost from the body in four different ways: by conduction, convection, evaporation, and radiation. Heat loss by conduction occurs because there is a gradient between the body temperature and the temperature of the surrounding environment. When the external temperature is lower, heat flows from the body to the colder external environment. The body also loses heat by evaporation, mainly through sweating. This mechanism occurs especially during phases of increased heat production, for example during physical **exercise**. The sweat glands are controlled by cholinergic impulses through the sympathetic nerve fibers. During intensive sweating, up to one liter of sweat may be formed. When the humidity of the environment is higher, heat loss through sweating is easier. When the body needs to accumulate heat, adrenergic impulses restrict the blood flow through the skin, with the result that the skin becomes an insulator, thus decreasing heat loss to a minimum. The body can also lose heat by convection, through the circulatory system. With this mechanism, heat flows from each cell to the surrounding extracellular fluid (ECF) and afterwards to the circulating blood. Heat loss is modulated by the amount of blood that circulates through the body surface. The high flow occurring through the subcutaneous area and the skin transfers the heat carried by the blood to the environment through the body surface. Finally, the body can lose heat by simply radiating it away.

Several conditions can influence body temperature, such as exercise, the time of day, the environmental temperature, digestion and the level of water consumption. For example, body temperature varies in the narrow range between 36.5°C and 37.5°C. It slightly increases during the day, reaching a peak between 6:00 to 10:00 p.m. and a low between 2:00 and 4:00 a.m. This diurnal variation depends on the body activity throughout the day. Diurnal variations do not change in persons that work at night and sleep during the day and they also occur when **fever** is present. Fever reaches a peak in the evening, and decreases during the night so that, in the morning, even a very sick person may have an almost normal temperature. Body temperature changes are also more intensive in young people than in older people. Physical activity also increases body temperature, in some cases very significantly. For example, the average body temperature of marathon runners may increase to 39–41°C. The feedback control system responsible for thermoregulation is very complex, but overall, it can be summarized as follows:

When the surroundings are hot or when the body is vigorously exercising:

- The body core temperature starts to rise.
- This increase in temperature is detected by heat sensors in the body.
- These sensors send signals to the CNS.
- The CNS stimulates the sweat glands.
- This increases the production of sweat.
- And this activates the evaporation of sweat.
- Which promotes heat loss by evaporation.
- The CNS also signals the vasomotor system to dilate the capillaries underlying the skin.
- Vasodilation occurs and the capillaries become larger.
- More blood flows underneath the skin surface.
- Which promotes heat loss by conduction, radiation, and convection.
- The body core temperature returns to normal.

When the surroundings are cold or when the body is resting:

- The body core temperature starts to drop.
- This is detected by cold sensors in the body.
- These sensors send signals to the CNS.
- The CNS slows down the activity of the sweat glands.
- This lowers the production of sweat.
- And it decreases the evaporation of sweat.

- Which reduces heat loss by evaporation.
- The CNS also signals the vasomotor system to constrict the capillaries underlying the skin.
- Vasoconstriction occurs and the capillaries become narrower.
- Less blood flows underneath the skin surface.
- This reduces heat loss by conduction, radiation, and convection.
- The body core temperature returns to normal.

Function

The major function of thermoregulation is to help maintain homeostasis, meaning the stability of the body's internal environment. A wide variety of body systems and organs interact to maintain the body's internal environment (the immediate surroundings of cells) constant in response to changes that occur either in the conditions of the external environment or in the conditions of the internal body environment. Thermoregulation is one of these essential homeostatic mechanisms.

Role in human health

Thermoregulation is of the utmost importance in maintaining health, because human life is only compatible with a narrow range of temperatures. Core temperature changes of the order of 3°C will not interfere with physiological functions, but any variation outside that range has very serious effects. For example, at 28°C, the muscles can no longer respond, at 30°C, confusion occurs and the body can no longer control its temperature, at 33°C, loss of consciousness occurs, at 42°C, the CNS breaks down with irreversible brain damage, and at 44°C, death occurs, the result of the body **proteins** starting to denature.

Common diseases and disorders

- **Fever**—Increase in body core temperature. Fever is not an illness but a natural reaction to a number of illnesses.
- **Hyperthermia**—Overheating of the body caused only by an external factor, as for example a hot environment, or a hot bath.
- **Hypothermia**—A low body temperature, as caused by exposure to cold weather or a state of low temperature of the body induced by decreased **metabolism**.
- **Hypothyroidism**—Hypothyroidism refers to a condition in which the amount of thyroid hormones in the body is below normal. Since the thyroid hormones are

KEY TERMS

Acetylcholine—Neurotransmitter produced by an enzyme in the body that stimulates muscle tissue.

Adrenaline—A hormone produced by the adrenal medulla that causes vasodilation of the small arteries in muscle and increases cardiac output.

Adrenergic—Substance that has an effect similar to that of adrenaline.

Antagonist—A substance that cancels or counteracts the action of another.

Capillaries—The smallest vessels of the body.

Central nervous system (CNS)—One of two major divisions of the nervous system. The CNS consists of the brain, the cranial nerves and the spinal cord.

Cholinergic—Substance that has an effect similar to that of acetylcholine.

Conduction—Heat transfer by means of molecular agitation within a material without any motion of the material as a whole. If one end of a metal piece is at a higher temperature, then heat will be transferred down the piece toward the colder end.

Convection—Heat transfer by motion of a fluid when the heated fluid is caused to move away from the source of heat, carrying energy with it.

Dermis—Layer of connective tissue underlying the skin. Contains smooth muscle tissue, nervous tissue and blood vessels.

Endocrine glands—Glands that secrete substances which are released directly into the bloodstream and that regulate metabolism and other body functions.

Endocrine system—The system of glands in the body that secrete their hormones directly into the circulatory system.

Enzyme—A type of protein produced by the body that speeds up chemical reactions. Some enzymes regulate certain functions due to their ability to change their activity by modifying their structure.

Extracellular fluid (ECF)—The fluid found outside of the cells and between the cells in body tissues.

Feedback system—A feedback system uses as input the total or partial output of the system. Feedback systems are used to control and regulate processes. They use the consequences of the process (for

example, too much or too little produced) to regulate the rate at which the process occurs (decrease or increase the rate of the process).

Homeostasis—Stability of the body's internal environment, achieved by a system of integrated control systems activated by feedback systems. Homeostasis is thus the maintenance of a constant internal environment (the immediate surroundings of cells) in response to changes occurring in the conditions of the external environment and the conditions of the internal body environment.

Hormone—A naturally occurring substance secreted by specialized cells that affects the metabolism or behavior of other cells possessing receptors for the hormone.

Hypothalamus—The hypothalamus is a tiny cluster of brain cells just above the pituitary gland, that is involved in the regulation of body temperature.

Metabolic effectors—Substances, such as hormones, that can increase the metabolism of the body or of a target organ.

Metabolism—The sum of all the physical and biochemical processes occurring in the body to produce what is required to maintain life. This includes the transformation of nutrients into energy and the use of energy by the body.

Nervous system—The entire system of nerve tissue in the body. It includes the brain, the brainstem, the spinal cord, the nerves and the ganglia and is divided into the peripheral nervous system (PNS) and the central nervous system (CNS).

Peripheral nervous system (PNS)—One of the two major divisions of the nervous system. The PNS consists of the somatic nervous system (SNS), that controls voluntary activities and of the autonomic nervous system (ANS), that controls regulatory activities. The ANS is further divided into sympathetic and parasympathetic systems.

Radiation—Heat transfer that occurs by the emission of electromagnetic waves which carry energy away from the emitting object.

Thermogenesis—Production of heat.

Thermoregulation—Regulation of body temperature so as to maintain it nearly constant at 98.6°F (37°C).

KEY TERMS [CONTINUED]

Thyroid gland—A butterfly-shaped endocrine gland located in the neck on both sides of the windpipe. It controls the rate at which the body produces energy from nutrients. It secretes the hormones triiodothyronine (T3) and thyroxine (T4) which increase the rate of metabolism and cardiac output.

Vasoconstriction—The decrease in the internal diameter of a blood vessel resulting from tightening the smooth muscle located in the walls of the vessel. Vasoconstriction decreases the blood flow.

Vasodilation—The increase in the internal diameter of a blood vessel resulting from relaxation of the smooth muscle located in the walls of the vessel. Vasodilation increases the blood flow.

Vasomotor system—The neural systems which act on vascular smooth muscle to control blood vessel diameter.

important in thermoregulation, hypothyroidism affects the body's capacity to control temperature.

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Monique Laberge, Ph.D.

Thiamine

Description

Thiamine, also known as vitamin B₁, was the first of the water-soluble B-vitamin family to be discovered. It is an essential component of an enzyme, thiamine pyrophosphate, that is involved in metabolizing **carbohydrates**. Thiamine works closely with other B **vitamins** to assist in the utilization of **proteins** and **fats** as well, and helps mucous membranes and the **heart** to stay healthy. The **brain** relies on thiamine's role in the conversion of **blood** sugar (glucose) into biological energy to function properly. Thiamine is also involved in certain key metabolic reactions occurring in nervous tissue, the heart, in the formation of red blood cells, and in the maintenance of smooth and skeletal muscle.

General use

The recommended daily allowance (RDA) of thiamine is 0.3 mg for infants less than six months old, 0.4 mg for those from six months to one year old, 0.7 mg for children ages one to three years, 0.9 mg for those four to six years, and 1.0 mg for those seven to 10 years. Requirements vary slightly by gender after age ten. Males need 1.3 mg from 11-14 years, 1.5 mg from 15-50 years, and 1.2 mg when over age 50 years. Females require 1.1 mg from 11-50 years of age, and 1.0 mg if older than 50 years. The RDA is slightly higher for women who are pregnant (1.5 mg) or lactating (1.6 mg). Adults need a minimum of 1.0 mg of thiamine a day, but the requirement is increased by approximately 0.5 mg for each 1,000 calories of daily dietary intake over a 2,000-calorie base.

Thiamine has limited therapeutic use apart from supplements for people who are deficient or have significant risk factors for deficiency, such as **alcoholism**. High doses are used to treat some metabolic disorders, including certain enzyme deficiencies, Leigh's disease, and maple syrup urine disease. People suffering from diabetic neuropathy may sometimes benefit from additional thiamine. This should be undertaken with the advice of a healthcare provider. Claims have been made that it can

also help people with **Alzheimer's disease**, epilepsy, canker sores, depression, fatigue, **fibromyalgia**, and motion sickness. Improvement of these conditions based on supplementation with thiamine is unsubstantiated. Although a deficiency of thiamine may cause canker sores, taking extra of the vitamin after they appear does not appear to help them resolve.

Preparations

Natural sources

While all plant and animal foods have thiamine, higher levels of thiamine are found in many nuts, seeds, brown rice, seafood, and whole-grain products. Sunflower seeds are a particularly good source. Grains are stripped of the B vitamin content during processing, but it is often added back to breads, cereals, and baked goods. Legumes, milk, beef liver, and pork are other foods with high vitamin B₁ content. Thiamine is destroyed by prolonged high temperatures, but not by freezing. Food should be cooked in small amounts of water so that thiamine and other water-soluble vitamins don't leach out. Do not add baking soda to vegetables, and do eat fresh foods to avoid sulfite preservatives. Both of these chemicals will break down the thiamine content found in foods. Drinking tea or alcohol with a meal will also drastically decrease the amount of thiamine that is absorbed by the body.

Supplemental sources

Thiamine is available in oral, **intramuscular injection**, and intravenous formulations. Injectable types are usually preserved for the severely deficient. Supplements should always be stored in a cool dry place, away from direct light, and out of the reach of children.

Deficiency

A deficiency of thiamine leads to a condition known as beriberi. Once common in sailors, it has become rare in the industrialized parts of the world except in the cases of alcoholism and certain disease conditions. The syndrome typically causes poor appetite, abdominal **pain**, heart enlargement, constipation, weakness, swelling of limbs, muscle spasms, insomnia, and **memory** loss. Under treatment, the condition can resolve very quickly. Untreated beriberi will lead to Wernicke-Korsakoff syndrome. These patients experience confusion, disorientation, inability to speak, gait difficulties, numbness or tingling of extremities, **edema**, nausea, vomiting, visual difficulties, and may progress to psychosis, **coma**, and death. Even in advanced states, this condition can be

KEY TERMS

Hypermetabolic—Conditions that increase the rate of metabolism, such as fever and hyperthyroidism.

Neuropathy—Abnormality of the nerves that may be manifested as numbness, tingling, or weakness of the affected area.

reversible if thiamine is given, nutritional status is improved, and use of alcohol is stopped.

Risk factors for deficiency

The leading risk factor for developing a deficiency of thiamine is alcoholism. Generally, alcoholics eat poorly, and therefore have low dietary intake of thiamine and other vitamins to begin with. Alcohol also acts directly to destroy thiamine, and increases the excretion of it. People with cirrhosis of the liver, malabsorption syndromes, diabetes, kidney disease, chronic infections, or hypermetabolic conditions also have increased susceptibility to deficiency. The elderly are more prone to poor nutritional status, as well as difficulties with absorption, and may need a supplement. Others with nutritionally inadequate diets, or increased need as a result of **stress**, illness, or surgery may benefit from additional vitamin B₁ intake since utilization is higher under these conditions. Those who diet or fast frequently may also be at risk for low levels of thiamine. Use of tobacco products or carbonate and citrate food additives can impair thiamine absorption. A shortage of vitamin B₁ is likely to be accompanied by a shortage of other B vitamins, and possibly other nutrients as well. A supplement containing a balance of B complex and other vitamins is usually the best approach unless there is a specific indication for a higher dose of thiamine, or other individual vitamins.

Precautions

Thiamine should not be taken by anyone with a known allergy to B vitamins, which occurs rarely.

Side effects

In very unusual circumstances, large doses of thiamine may cause rash, itching, or swelling. This is more likely from intravenous injection than oral supplements. Most people do not experience any side effects from oral thiamine.

Interactions

Oral contraceptives, **antibiotics**, sulfa drugs, and certain types of diuretics may deplete thiamine. Consult a health care professional about the advisability of supplementation. Taking this vitamin may also intensify the effects of neuromuscular blocking agents that are used during some surgical procedures. B vitamins are best absorbed as a complex, and magnesium also promotes the absorption of thiamine.

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Judith Turner

Thoracentesis

Definition

Thoracentesis is a procedure in which pleural fluid is removed from the space between the lung and the chest wall. The space in which this fluid collects is called the pleural space. It is formed in between the serous membrane covering each lung, called the visceral pleura, and the serous membrane covering the chest wall, called the parietal pleura. Normally very little fluid is present in the pleural space, and it serves to lubricate the two pleural surfaces, so they can easily slip across each other during respiration.

Purpose

Abnormal quantities of pleural fluid may accumulate in various conditions. Removal of pleural fluid for analysis is commonly performed in order to determine the cause of fluid accumulation. Sometimes the effusion is so large that it interferes with normal lung function. In such

cases, thoracentesis may be performed to relieve the respiratory distress caused by lung compression.

An excess of pleural fluid is called an effusion. Laboratory analysis is directed at distinguishing between two types of effusion, transudates and exudates. Transudates are caused by hemodynamic changes outside the **lungs** that increase the movement of fluid from the capillaries in the parietal pleura into the pleural space. These include increased hydrostatic pressure (i.e., high **blood pressure**); decreased oncotic pressure (i.e., low plasma protein due to **liver** or renal disease); increased pleural capillary permeability; and lymphatic obstruction. Exudates are caused by injury, **infection**, inflammation, or malignancy. Exudates usually involve the lungs, but in some cases such as esophageal rupture or **pancreatitis**, they do not.

Precautions

Practitioners should be aware that many pleural fluids display some characteristics of both transudates and exudates. These conditions have many causes which may be present concurrently, making the distinction complicated. The physician performing thoracentesis must take great care to avoid puncturing the lung, which can cause air to enter the pleural space (pneumothorax) and result in lung collapse. A **blood** sample should be collected at the time of thoracentesis to provide a basis for comparison to certain pleural fluid results. When collecting pleural fluid or blood, the physician and other members of the health care team should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. If pH is to be measured, the syringe containing the fluid must be capped, placed in an ice bath, and sent immediately to the laboratory.

Preparation

Written consent should be obtained before the procedure is begun. X ray of the chest is performed prior to the procedure. A special view of a pleural effusion, called a lateral decubitus film, may be ordered. In this view, the patient lies down on the side on which the effusion is known to exist. If the effusion is "free-flowing," gravity will cause it to spread up the lateral chest wall. If an effusion is not free-flowing, it may be more difficult to access for thoracentesis, and ultrasound or CT guidance may be helpful. A thorough history is performed to determine if any conditions such as a bleeding disorder are present that may complicate the procedure. The history should also document the medications that the patient is currently taking, and **allergies** to drugs or anesthetics. Prior to the procedure, a blood sample should be collected and a platelet count and prothrombin time should be per-

formed. These tests determine whether there is an abnormally high risk of uncontrolled bleeding from the site that may contraindicate the procedure.

Description

Generally the effusion has been identified already on **chest x ray**, and may be noticeable by percussion of the chest wall. If there is any question about the location of the excess fluid, ultrasound or computed tomography (CT) may be used as a guide for the procedure. The patient should be seated upright, generally on the edge of a bed or chair, with arms propped up on a stable surface. The lateral chest wall is scrubbed with an antiseptic preparation, **local anesthesia** is administered, and a needle inserted between two ribs known to overlie the effusion. Generally the needle enters the chest below the armpit. Using a syringe, the appropriate amount of fluid is removed. The fluid should be collected in a heparinized syringe or transferred to a tube containing heparin or EDTA, and delivered to the lab for analysis. If the effusion is large, recurrent, or particularly concerning (e.g. very low pH and signs of infection), a chest tube may be placed and attached to a one-way system to promote continued drainage and prevent air from entering the pleural space. A **pulse oximeter** can be used to monitor the patient's oxygenation, and oxygen can be administered via a nasal cannula if needed. Generally **oxygen therapy** is not required, but if a pneumothorax occurs as a complication, or a large volume of pleural fluid is removed in a short period of time, lung function can be compromised.

Transudates form from diseases that occur outside the lungs. They are most frequently caused by congestive **heart failure** which accounts for up to 90% of all pleural effusions, pulmonary embolism (which sometimes causes exudates), cirrhosis of the liver, myxedema (hypothyroidism) or kidney disease. Exudates are generally due to infection, malignancy, trauma, pulmonary infarction, ruptured esophagus, pancreatitis systemic lupus erythematosis, and rheumatoid arthritis.

Sometimes bloody fluid is found in the pleural space. This may be due to major trauma that has severed **blood vessels** in the chest. This is termed a hemothorax, and will produce a **hematocrit** that approximates that of blood. Malignancies involving the pleural fluid cause an increased red blood cell count but usually do not cause massive bleeding into the pleural space. Occasionally a thoracentesis sample may appear milky (chylothorax). This can be caused by a perforated or torn thoracic duct which carries lymph from the intestines to the **heart**. Chylothorax can also be caused by an aggressive **cancer** which blocks the flow of lymph. A similar appearance to

the fluid can result from necrosis which causes formation of a pseudochylous effusion. Such fluids are characterized by foul odor, cholesterol, and high cellularity. Chylous effusions are odorless and have high triglycerides.

Malignancy is a common cause of pleural effusions and exudative fluids should always be examined for malignant cells. Approximately 35% of lung cancers, 25% of breast cancers, and 10% of lymphatic cancers shed cells into the pleural fluid.

Laboratory evaluation

Pleural fluid is generally evaluated for gross appearance and volume, protein, specific gravity, glucose, lactate dehydrogenase, blood cell counts, pH, cytology, culture and **Gram stain**. Other tests may be requested such as lactate, amylase, flow cytometry, triglycerides, complement, other enzymes, bilirubin, and tumor markers.

Normal pleural fluid has a volume of 3-5 mL, but effusions of several hundred milliliters are not uncommon. The fluid should be clear and light yellow (straw-colored). Turbidity can be caused by a traumatic tap or by an abnormal condition. Bloody taps are associated with streaking of the fluid as it is collected, and a clear supernatant after centrifugation. Turbidity can result from infection, mucin, or fat in the fluid. It takes very little blood to turn the pleural fluid red. In addition to a traumatic tap, red tinged fluids are caused by trauma, malignancy, and pulmonary infarction. Turbid, yellow fluids are associated with infection. Turbid, green fluids are associated with rheumatoid arthritis, and milky-white fluids with lymph containing chyle. The specific gravity of the fluid should be equal to or less than plasma. Exudates are associated with a specific gravity of 1.015 or higher, but transudates sometimes overlap this cutoff.

Chemistry tests are performed on pleural fluid by the same methods used for plasma. The pleural fluid glucose should be the same as the plasma glucose. Low levels are significant. Pleural fluid glucose below 40 mg/dL are associated with infection, malignancy, and rheumatic disease (i.e., rheumatoid arthritis and systemic lupus erythematosis). LD is the single best test to differentiate transudates from exudates. Pleural fluid LD in excess of 200 U/L or a fluid to serum LD ratio of 0.6 or higher indicates an exudate. Lactate levels are increased in exudative fluids as well but cannot differentiate between the causes. Total protein in pleural fluid is increased when the fluid is exudative, but the interpretation is difficult whenever there is bleeding or a traumatic tap. A total protein of less than 3.0 g/dL is consistent with a transudate. Pleural fluid amylase is increased in both chronic and acute pancreatitis, in amylase producing

KEY TERMS

Pulse oximeter—A non-invasive device which uses a beam of light that passes through a digit or earlobe to assess oxygenation.

cancers that infiltrate the pleura, and in rupture of the esophagus. pH is below 7.45 in exudative fluids and is extremely low (7.0-7.3) in malignancy, bacterial infection, rupture of the esophagus, **tuberculosis**, and rheumatoid arthritis. A pH below 7.0 is seen only in empyema (bacterial infection with a white count greater than 10,000 per microliter), esophageal rupture, and rheumatoid arthritis. Triglycerides are increased (greater than 110 mg/dL) in chylous effusions.

The white blood cell (WBC) count of pleural fluid is performed manually. Transudates have a WBC count of less than 1,000 per microliter. Exudates have a WBC count of 10,000 per microliter or higher. WBC counts in excess of 50,000 per microliter signal infection of the pleura. A WBC differential is always performed on pleural fluid using a method to concentrate the cells. No single cell type should predominate. A predominance of lymphocytes (greater than 50%) occurs in lymphoid cancers (lymphoma), lymphocytic leukemias, and tuberculosis. Greater than 50% neutrophils occurs in acute infections, acute injuries (such as pulmonary infarction and rupture of the esophagus), malignancies, and granulocytic leukemia. Increased eosinophils are seen in pneumothorax, pulmonary infarction, congestive heart failure, parasitic infestation, and some infections. Red blood cell counts are also performed manually. Red counts in excess of 100,000 per microliter are associated with trauma, malignancy, and pulmonary infarctions.

A Gram stain and culture should be performed on the sediment of all pleural fluids. The Gram stain of sediment is positive in about 50% of persons with pleural infections. Cultures for tuberculosis are frequently requested because this disease is associated with approximately 8% of pleural fluid effusions. Cultures should be performed using blood agar plates, chocolate (heated blood) agar plates, and thioglycolate broth. Transudative fluids are usually negative for growth. The most common bacterial isolates are *Staphylococcus aureus* and gram negative bacilli.

Cytological analysis of pleural fluid is usually requested and should be performed on a concentrate of any fluid that is exudative. As with microbiological culture, the sensitivity of cytology is proportional to the volume of fluid concentrated. Metastatic carcinoma,

sarcomas, mesothelioma, Hodgkin's and nonHodgkin's lymphoma, and leukemias can cause cellular infiltration of the pleura and produce exudative effusions. Activated and phagocytic mesothelial cells are often seen in inflammatory pleural fluids, and are difficult to distinguish from malignant mesothelial cells. Cytology is performed on both Wright and Papanicolaou stains. Special cytochemical stains and flow cytometry are often used to differentiate reactive from malignant mesothelial cells and identify the type of other malignant cells present.

Aftercare

Vital signs are assessed every fifteen minutes until stable. A chest x ray is ordered to document changes in the appearance of the lung fields, and to look for possible pneumothorax. Examination of the chest with a **stethoscope** is also useful for documenting bilateral breath sounds that make pneumothorax very unlikely. The site of the needle puncture is covered with a simple dressing and monitored for bleeding or drainage.

Complications

With any procedure which breaks the skin, bleeding and infection are possibilities, although very unlikely if careful and sterile technique are followed. Pneumothorax is a very real complication, and may need to be treated with a chest tube. If very large effusions are drained quickly, pulmonary **edema** and low oxygen levels can occur, requiring oxygen and possibly other support measures for the patient. A chest x ray should be ordered right after the procedure. If the pH and glucose are very low (e.g. pH below 7.2), white blood cells are found to be greater than 25,000 per microliter, or there are other signs of frank infection, a chest tube may need to be placed.

Results

Representative normal values for pleural fluid are shown below:

- Volume: less than 10 mL.
- Appearance: clear, light yellow.
- Specific gravity: less than 1.015.
- Protein: less 3.0 g/dL.
- Lactate dehydrogenase: less than or equal to 200 U/L.
- Pleural fluid: serum LD ratio: less than 0.6.
- pH: 7.65 (transudates 7.4-7.5).

- Glucose: greater than 60 mg/dL (pleural fluid: serum ratio greater than 0.5).
- Triglycerides: 13-107 mg/dL.
- WBC count: less than 1000 per microliter.
- Neutrophils: less than 50%.
- Lymphocytes: less than 50%.
- Eosinophils: less than 10%.

Health care team roles

A physician performs the thoracentesis, and orders and interprets the results of the laboratory tests. Nursing staff will be very involved in documenting a patient's response to the procedure, and providing support and instruction for the patient during thoracentesis. Careful observation of respiratory status and pulse oximetry is important to aid in speedy intervention if necessary. Clinical laboratory scientists/medical technologists perform all of the laboratory tests done on the pleural fluid with the exception of cytological evaluation which is performed by a pathologist. Radiology technicians will perform x rays and other imaging studies before and after thoracentesis.

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Erika J. Norris

Thorax, bones of

Definition

The skeleton of the thorax or chest is a cage that encloses and protects the main organs of respiration and circulation. It has a conical shape, being narrower at the top and broader at the bottom, and longer behind than in front. It consists of the sternum and the ribs.

Description

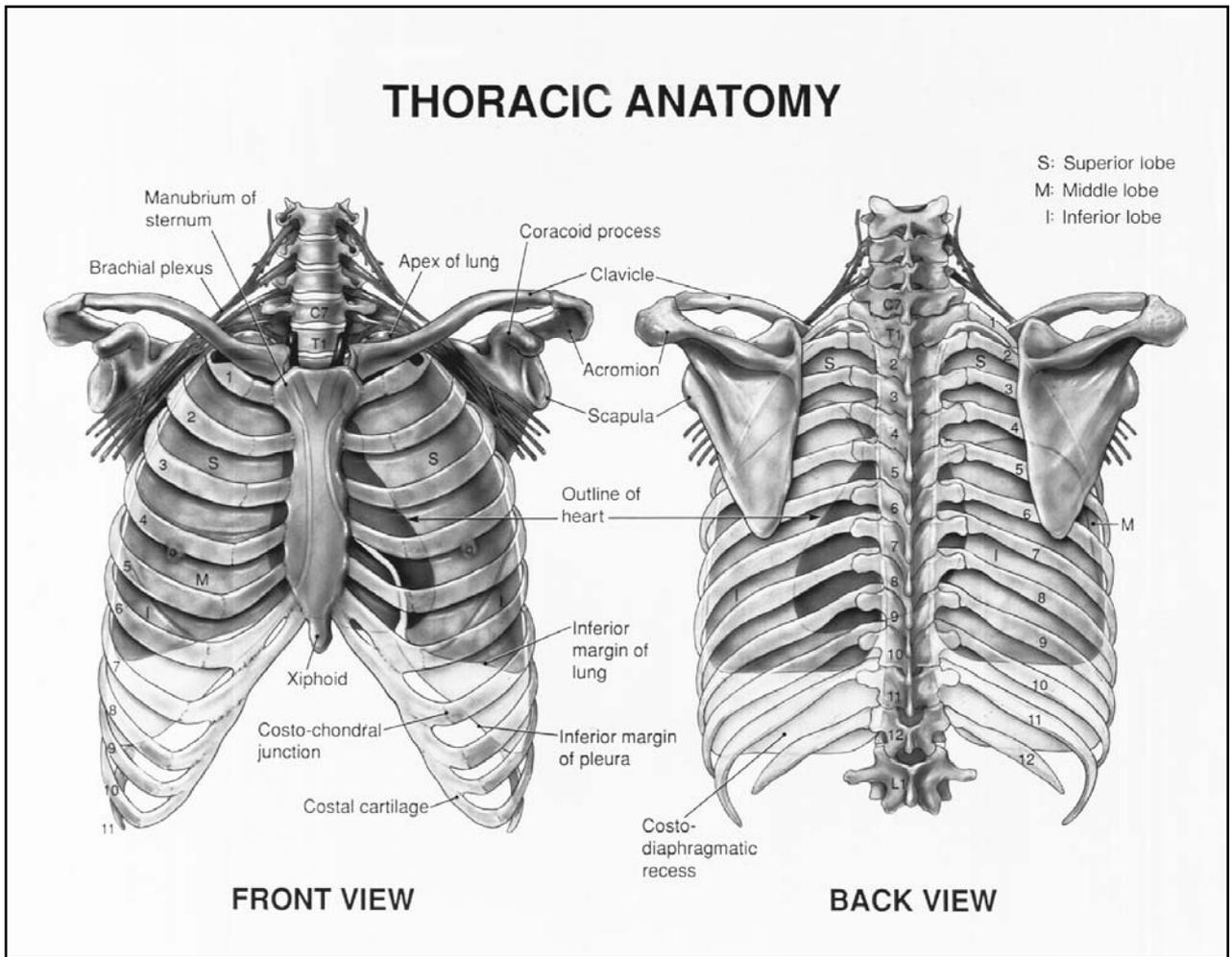
The bones of the thorax include the sternum, commonly called the breastbone, and the ribs.

The sternum is a narrow, elongated, flattened bone that forms the center of the front of the chest. It consists of three parts: an upper section called the manubrium, a middle section called the body, and a lower section called the xiphoid process that projects down. The junction of the manubrium and body is called the sternal angle. In early life, the xiphoid process is not a bone, but a piece of cartilage. Cartilage is a type of connective tissue containing collagen, a protein substance that forms tough and elastic fibers. It is a softer and more flexible material than bone. As the child grows, the xiphoid process slowly hardens into bone and by adulthood, it has become fused to the body of the sternum. The sides of both manubrium and body are notched so as to attach to seven costal cartilages. These are strips of strong cartilage that prolong into ribs and provide elasticity to the thorax. The upper section of the sternum supports the clavicles (shoulder blades). It contains a notch called the clavicular notch that allows it to articulate with the clavicle. The average length of the adult sternum is about 6.7 in (17 cm), and it is usually somewhat longer in the male than in the female.

The ribs are flexible, long bones that look like arches, and they form a large part of the thoracic skeleton. There are 12 ribs on each side and they are located one below the other in such a way that spaces called intercostal spaces occur between them. The first seven (1-7) are called the true ribs or the vertebro-sternal ribs. They connect in the back to the **vertebral column**, and in front to the sternum, through the costal cartilages. The following three ribs (8-10) are called the false ribs or the vertebro-chondral ribs. These ribs have their costal cartilages attached to the cartilage of the true rib above. The last two ribs (11-12) are only attached to the vertebral column and are thus called the floating or vertebral ribs.

All ribs have many structural features in common:

- **Head.** The head of the rib is the flat surface that connects with the vertebrae in the vertebral column.
- **Neck.** The neck of the rib is a flattened section that has a length of about 1 in (2.5 cm). It is located between the head and the tubercle. Its inferior surface is flat and smooth and its superior surface is rough for the attachment of ligaments.
- **Tubercle.** The tubercle is a bony eminence, or growth, that comes right after the neck of the rib. It has two sections, one that serves as a point of attachment to the vertebrae and another that attaches to ligaments.



Anterior and posterior view of thoracic anatomy. (MVI/Science Source/Photo Researchers, Inc. Reproduced by permission.)

- **Body.** The body—or shaft—is the longest part of a typical rib.
- **Angle.** The angle is the point at which the body of the rib starts to curve, just after the tubercle.
- **Costal groove.** The costal groove is located on the inner surface of the body of a rib. It provides a seat and protection for the intercostal nerve bundle.

Ribs present some degree of variability. For example, they vary in their angle, the upper ribs being less oblique than the lower. Characteristic features of some special ribs include:

- **Rib 1.** The first rib is the most curved of all ribs; it is also the broadest, shortest and widest rib. The head is small, rounded, and only has a single bony projection for articulation with the first thoracic vertebra.
- **Rib 2.** The second rib is much longer than the first, and its body is not flat like that of the other ribs. It has a rough section near its angle for attachment of a large

back muscle and also attaches to the sternal angle of the sternum.

- **Rib 10.** This rib only has one point of attachment to the vertebrae.

The upper opening of the thorax is broader from side to side than from front to back. It is formed by the first thoracic vertebra in the back, the upper section of the sternum in front, and the first rib on either side. It slopes downward and forward, so that the front part of the opening is on a lower level than the back part. The lower opening of the thorax is formed by the twelfth thoracic vertebra in the back, by the eleventh and twelfth ribs on the sides, and by the costal cartilages of the tenth, ninth, eighth, and seventh ribs in the front. The lower opening is closed by the diaphragm, the thin muscle located below the **lungs** and **heart**, that forms the floor of the thorax.

Function

The major function of the thorax bones is to form the thoracic cavity that encloses and protects the most important organs of the circulatory and respiratory systems, the heart and lungs. The rib cage has a very special function—it allows breathing to take place, which occurs as a result of the rib cage moving up and down as air is inhaled and exhaled.

Role in human health

Besides its role in protecting major organs and in breathing, the thorax also provides a structural frame for the attachment of the trunk muscles, which are needed for movement. Thus, it also plays a role in body locomotion.

Common diseases and disorders

Injuries to the bony structures of the thorax are very serious because of the relationship of the thorax to the spine as a whole and because of the importance of the major respiratory and circulatory organs that the thoracic cavity contains. For example, broken ribs can cause disease by mechanical interference with internal organs, irritation of surrounding soft tissues, straining ligaments, impinging nerves, or blocking **blood vessels**. Likewise, the sternum is a very strong bone and requires great force to fracture. But the main danger in this type of injury is not so much the fracture itself, but the risk that the broken bone may be driven into the heart, which lies just behind it. Some thoracic diseases and disorders include:

- Asphyxiating thoracic dystrophy. Also known as Jeune's syndrome, this is a form of dwarfism characterized by an abnormally long and narrow thorax with a reduced thoracic cage capacity that results in the lungs not having enough room for respiration to occur.
- Chondrosarcoma. Chondrosarcoma is a **cancer** that can arise in the costal cartilage of the ribs.
- Costochondritis. Also called Tietze's syndrome, it is an inflammation of the costochondral or costosternal joints that causes localized **pain** and tenderness. Any of the seven rib junctions may be affected, and more than one site is affected in 90% of cases.
- Luxation of ribs. A luxation is a sprain of a rib. It is the result of twisting a rib about its head in such a way that the rib departs from its normal conformation.
- Pleurisy. Pleurisy is an inflammation of the membrane that covers the inside of the thorax.

KEY TERMS

Cartilage—Connective tissue containing collagen, the protein substance that forms tough and flexible fibers. Cartilage is more flexible and compressible than bone and often serves as a bone precursor, becoming mineralized as the body ages.

Costal cartilages—Cartilage which prolongs the ribs forward and connects each rib to the sternum.

Diaphragm—The thin muscle located below the lungs and heart that separates the chest from the abdomen.

False ribs—The three ribs, 8-10, that attach to the costal cartilage of the seventh true rib.

Floating ribs—The two last ribs, 11-12, that are not attached to the sternum. Also called the vertebral ribs.

Manubrium—The upper section of the sternum, it articulates with the shoulder blades and connects to the first seven ribs.

Ribs—The long, elastic bones resembling arches that are part of the thoracic skeleton. There are 12 ribs on either side of the thorax.

Sternum—One of the bones of the thorax, located in front of the chest. It has three sections: the manubrium, the body, and the xiphoid process.

Thorax—The bones that surround and form the chest cavity. The thorax includes the sternum and the ribs.

True ribs—The first seven ribs, 1-7, directly attached to the sternum.

Vertebra—Flat bones that make up the vertebral column. The spine has 33 vertebrae.

- Thorax hematoma. This is bruising due to the breaking of **blood** vessels that results in a localized accumulation of blood.

Resources

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Monique Laberge, PhD

Throat culture

Definition

A throat culture is a technique for identifying disease-causing microorganisms in material taken from the throat. Most throat cultures are performed to identify infections caused by Group A beta-hemolytic streptococci, which cause **strep throat**.

Purpose

The primary purpose of a throat culture is to isolate and identify organisms from the throat that cause **infection** of the posterior pharynx and tonsillar areas. Since most sore throats are caused by viral infections rather than by **bacteria**, a correct diagnosis is important to prevent unnecessary use of **antibiotics**. The bacterium that most often causes a **sore throat** is *Streptococcus pyogenes* or Group A beta-hemolytic streptococcus. In many circumstances, the throat culture is performed for the purpose of identifying this organism only. Throat cultures are also performed to identify people who are carriers of the organisms that may cause **meningitis** (*Neisseria meningitidis*, *Streptococcus pneumoniae*) and whooping cough (*Bordetella pertussis*).

Precautions

Throat cultures should be taken before the patient is given any antibiotic medications. In addition, the patient’s immunization history should be checked to evaluate the possibility that diseases other than strep are causing the sore throat. The health care provider should use a mask and gloves for **infection control**, as the patient may cough or gag when the throat is swabbed. Swabs for rapid strep tests should be made of dacron or rayon.

Description

Throat cultures are performed for isolation of bacteria that cause throat infections. Throat washings or swabs are also required for culture of **viruses** that cause throat infections, but these viral cultures are not commonly per-

formed. Most bacterial throat infections are caused by Group A streptococci. Strep throat is more common in children (ages five to 15) than in adults, and is spread by droplets of mucus and other respiratory secretions. The tonsils and the back of the throat often appear red, swollen, and streaked with pus. The symptoms usually appear within three days after being exposed to group A strep and include an abrupt sore throat, headache, **fever**, loss of appetite and malaise. Group A strep infections may be associated with complications called sequelae, if not treated promptly with antibiotic therapy. In addition to causing sore throat (pharyngitis), this group of strep can also cause scarlet fever, rheumatic fever, glomerulonephritis, or abscesses around the tonsils

Other bacteria may cause pharyngitis, but do so less frequently. These include Groups B, C and G streptococci, *Neisseria gonorrhoeae*, *Corynebacterium diphtheriae*, *Haemophilis influenzae*, *Mycoplasma pneumoniae*, and *Chlamydia trachomatis*. In addition, anaerobic bacteria are often implicated as the cause of Vincent’s angina, a form of tonsillitis. Many other pathogenic bacteria can be isolated from sites in the upper respiratory tract other than the pharynx such as the sinuses, nasopharynx, and epiglottis.

The specimen for culture is obtained by swabbing the throat with a sterile swab. The patient is asked to tilt the head back and open the mouth wide. A tongue depressor is used to hold down the tongue and the swab tip is rubbed against the area behind the uvula (posterior pharynx) and tonsillar areas on both sides of the throat. Any red or whitish patches on the throat should also be swabbed. The swab is removed gently without touching the teeth, gums, or tongue. It is then placed in a sterile tube for immediate delivery to a laboratory. For optimal recovery, especially if the laboratory is located off-site, the tube should contain Stuart’s or Cary-Blair transport medium in order to maintain the viability of the organisms. The swab tip is used to break the ampoule and is immersed in the fluid. If a rapid strep test (streptococcal antigen test) is being performed, two swabs should be taken of the throat. One is used for the rapid test, and the other is used for culture should the rapid test result be negative. Obtaining the specimen takes less than 30 seconds. The swabbing procedure may cause gagging but is not painful. The physician or nurse should indicate if any disease organisms other than strep are suspected, because some bacteria require special culture media and growth conditions.

S. pyogenes, group A beta hemolytic streptococcus, is cultured on a growth medium called blood agar. Agar is a gel that is made from the cell walls of red algae. Blood plates are made from agar that contains a low carbohydrate nutrient such as trypticase soy and 5% sheep

red blood cells. When the throat swab reaches the laboratory, it is wiped across a blood agar plate. An inoculating loop is used to streak the plate and stab the agar. This process separates the bacteria so that individual colonies can be isolated. An antibiotic disk containing bacitracin (A disk) is placed on the agar in an area containing the initial inoculum. Blood agar allows differentiation of streptococci based upon the characteristic hemolysis that they produce. Beta hemolytic strep releases products into the medium called beta hemolysins, which lyse the red blood cells and cause a clear zone to form around the colonies. Alpha strep releases alpha hemolysins, which causes a green discoloration to the blood around the colonies. Gamma hemolysis (no hemolysins produced) refers to no zone of discoloration around the colonies. Blood agar is nonselective and permits the growth of normal throat flora as well as other potential pathogens. For identification of Group A strep, a selective medium such as strep selective agar (SSA) is used. This medium contains colistin, crystal violet, and trimethoprim-sulfamethoxazole (SXT). These antibiotics inhibit the growth of most normal flora and all streptococci except groups A and B. Plates are allowed to incubate for 18 hours at 35°C in 10% carbon dioxide or under anaerobic conditions.

Plates should be examined after 18 hours of incubation, and if negative, again after an additional 24 hours incubation. Group A streptococci produce small oval-shaped transparent colonies that produce beta hemolysis and will not grow around the bacitracin disk. The colonies are catalase and coagulase negative and pyroglutamyl aminopeptidase (PYR) positive which differentiates them from the genera *Staphylococcus* and *Micrococcus*, which may appear similar on blood agar. Colonies of beta hemolytic strep isolated from the medium should be tested with group specific antibodies to confirm that they are group A. Antibiotic susceptibility testing is not usually necessary because Group A strep are susceptible to penicillin and related antibiotics such as ampicillin. Persons who are allergic to penicillin may be given erythromycin.

Rapid strep tests are enzyme immunoassays that detect Group A streptococcal antigens. The specificity of these tests is very high (approximately 98%), but the sensitivities have been reported to be from 60-96%. Consequently, negative tests can occur in the presence of Group A streptococcal infections, and culture should be performed on samples that test negative. These tests can be performed in a medical office or clinic and results can be available within 10 minutes, allowing for quicker diagnosis and treatment. Usually, the physician will order a throat culture if the rapid strep test is negative, but the patient has clinical symptoms that are suggestive of strep



This nurse is taking a throat culture from a patient for laboratory analysis. (Photograph by David Weinstein & Associates, Custom Medical Stock Photo. Reproduced by permission.)

infection. If the rapid strep test is positive, then treatment is ordered immediately.

Rapid strep tests are based upon the principle of double antibody sandwich immunoassay. The first step of a rapid strep test is the extraction of specific Group A streptococcal antigen from the swab. The swab is placed in a test tube containing the extracting reagents (usually dilute acid). The swab is rotated vigorously in the solution while pressing the tip against the sides of the test tube. After all fluid is pressed from the swab, it is discarded and the extract is applied to a nitrocellulose membrane containing both immobilized antibodies and non-immobilized antibodies to different regions of the Group A strep antigen. The non-immobilized antibodies are conjugated to colored particles or colloidal gold. If Group A streptococcal carbohydrate antigen is present in the extract, the conjugated antibodies bind to it, forming antigen-antibody complexes. These migrate along the pad until they reach the reaction zone containing immobilized antibodies to the same Group A strep antigen. These antibodies capture the antigen-antibody complexes, forming a colored bar or line in the reaction zone area.

Preparation

Recent gargling or treatment with antibiotics will adversely affect the culture results. The laboratory should be notified if the patient has recently taken antibiotic medications.

KEY TERMS

Antibiotic—A drug given to stop the growth of bacteria. Antibiotics are ineffective against viruses.

Antigen—A substance that interacts with an antibody and causes an immune reaction.

Carrier—A person harboring an infectious disease who may be immune to it but who can transmit the disease to others.

Diphtheria—A serious disease of the throat, nose, and lungs caused by a bacterium, *Corynebacterium diphtheriae*.

Streptococcus—A category (genus) of sphere-shaped bacteria that occur in pairs or chains.

Thrush—A disease occurring in the mouth or throat that is caused by a yeast, *Candida albicans*, and is characterized by a whitish growth and ulcers.

Whooping cough—An infectious disease of the respiratory tract caused by a bacterium, *Bordetella pertussis*.

Aftercare

No specific aftercare is needed.

Complications

There is a minor risk to the health care provider collecting the specimen of contracting a viral or bacterial infection from the patient.

Results

The results from throat cultures identify the presence of any pathogenic bacteria growing on the media. Non-disease-producing organisms that grow in healthy throat tissues include non-hemolytic and alpha-hemolytic streptococci, some *Neisseria* species, *Moraxella catarrhalis*, coagulase negative staphylococci, and diphtheroids. These organisms are described on the culture report as normal flora. Group A streptococci are identified as described previously. Unless the culture is done solely for the identification of Group A strep, any other potential pathogen (e.g., *Haemophilus influenzae*, *Neisseria gonorrhoeae*) is isolated on appropriate growth media, and the colonies that grow are identified by a selection of biochemical tests. Antimicrobial susceptibility testing is performed on a standardized growth of the isolated

organism to determine which antibiotics will be effective in treating the infection.

Health care team roles

A physician, nurse, or physician assistant collects the throat swab. A health care provider such as a nurse will usually perform the rapid strep test in the outpatient setting. Cultures are performed by a clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP). Culture results are reported directly to the ordering physician who will select the appropriate antibiotic therapy if required.

Patient education

Because strep is highly contagious, the health care provider should stress that other family members and close contacts of patients diagnosed with strep throat also seek medical attention if they have similar symptoms. The health care provider should stress that the patient should wash hands frequently (especially after coughing or sneezing), stay home, and follow the treatment regimen prescribed by the physician.

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The American Society for Clinical Laboratory Science. 7910 Woodmont Ave., Suite 523, Bethesda, MD 20814. (301) 657-2768. <<http://www.ascls.org>>.

Division of Bacterial and Mycotic Diseases, National Center for Infectious Disease, Centers for Disease Control and Prevention. 1600 Clifton Road NE, Atlanta, GA 30333. (800) 311-3435. <<http://www.cdc.gov>>.

National Institute of Allergy and Infectious Diseases, National Institutes of Health. Building 31, Room 7A-50, 31 Center Drive MSC 2520, Bethesda, MD, 20892. <<http://www.niaid.nih.gov>>.

Linda D. Jones, B.A., PBT (ASCP)

Throat swab see **Throat culture**

Thrombocyte count see **Complete blood count**

Thrombosis risk tests

Definition

Thrombosis risk tests check for defects in the anticoagulant system (hypercoagulability) that can cause a predisposition to thrombosis. The D-dimer test is used to screen for the presence of fibrin associated with deep vein and other forms of thrombosis.

Purpose

The purpose of thrombosis risk tests is to establish whether someone has a predisposition for developing thrombosis or has suffered a thrombotic episode, so that appropriate interventions can be instituted. The most common thrombosis risk tests are the D-dimer test, protein C test, protein S test, factor V Leiden test, prothrombin 1+2 (prothrombin 1.2) test, and the antithrombin test. These tests can be ordered individually but are usually ordered as a part of a panel.

Common indications for testing include:

- venous thrombosis
- pulmonary embolism
- cerebral **brain** thrombosis
- transient ischemic attack or premature stroke
- peripheral vascular disease
- prior to **pregnancy**, oral contraceptive prescription, estrogen therapy or major surgery if there is a family history of thrombosis
- relative with known genetic predisposition to thrombosis
- history of thrombosis and presence of a known genetic predisposition to thrombosis
- previous laboratory finding of activated protein C resistance (indication for factor V Leiden DNA test)
- premature **myocardial infarction** in a female patient (indication for prothrombin DNA test)
- history of multiple unexplained miscarriages

Precautions

Treatment with Coumadin, an anticoagulant, can interfere with the protein C and protein S tests. Ideally, the patient should discontinue treatment with Coumadin two weeks prior to undergoing these tests. If this is not possible then, an alternate panel of risk tests should be used. Alternatively heparin therapy can replace Coumadin therapy for two weeks prior to the tests, although heparin anticoagulant therapy can sometimes result in false positive antithrombin III test results. Protein S assays are not reliable during pregnancy. Heterophilic antibodies and rheumatoid factor are known to cause false positive reactions for D-dimer.

Description

The D-dimer test is the only laboratory test that is used to screen for the presence of deep vein thrombosis. The test is positive only when fibrin has formed. The D fragment of fibrinogen is produced by the action of plasmin on fibrinogen. Thrombin activates factor XIII, which stabilizes the fibrin clot by dimerizing the D fragments. In disseminated intravascular coagulation, pulmonary embolism, deep vein thrombosis, sickle cells disease and other conditions such as post surgical thrombus formation, the D-dimer level will be elevated in serum or plasma. D-dimer is measured by immunoassay, either latex agglutination or enzyme immunoassay (EIA). Latex agglutination is a qualitative assay that is not sufficiently sensitive to screen for deep vein thrombosis. Levels measured by EIA below 200 ng/ml indicate that thrombosis is unlikely in patients with no apparent signs of deep vein thrombosis.

Prothrombin fragment 1.2 (1+2), like D-dimer, is a marker for thrombotic disease. Prothrombin fragment 1+2 (1.2) can be measured by enzyme immunoassay. This fragment is produced when factor Xa activates prothrombin. The prothrombin fragment is increased in persons at risk for thrombotic episodes.

Other thrombosis risk tests check for mutations in the genes or **proteins** that are involved in the anticoagulant system. The anticoagulant system is designed to regulate coagulation and prevent excess **blood** clotting. Each anticoagulant protein is produced by a different gene. Each person possesses two copies of each anticoagulant gene. Mutation in an anticoagulant gene can cause it to produce abnormal protein, an increased or decreased amount of normal protein or can cause it to stop producing protein altogether. The common anticoagulant abnormalities (protein S, protein C, antithrombin III, prothrombin and factor V Leiden) are autosomal dominant, since only one gene of a pair needs to be

altered to cause an increased risk of thrombosis. Someone with one normal copy of an anticoagulant gene and one changed copy of an anticoagulant gene (heterozygote) will have a moderately increased risk of thrombosis. Someone with both copies of an anticoagulant gene changed (homozygous) will have a significantly increased risk of thrombosis. People who have changes in multiple anticoagulant genes also have a significantly increased risk of thrombosis. There are other genetic and environmental factors that affect the risk of thrombosis, making it difficult to predict the exact risk in an individual with an anticoagulant gene mutation.

In some cases a thrombosis risk test checks for a change in the anticoagulant gene. In other cases, it is not feasible to check for a gene change and the activity of the protein is assayed.

Proteins C and S

Mutation in the genes that produce protein C and protein S can cause an increased risk of thrombosis. The frequency of protein C deficiency in the general population is 0.5% or less and the frequency of protein S deficiency is approximately 0.7%. Activated protein C (APC) is involved in inactivating **blood coagulation** factors V and VIII. Inactivation of these factors decreases blood coagulation. Activated protein S is a cofactor that enhances the activity of protein C. A deficiency in activated factors C or S can result in increased levels of factor Va and VIIIa, which increases the risk of thrombosis.

As of 2001, DNA testing for proteins C and S deficiencies is not available on a clinical basis. Proteins C and S can be measured by immunoassay which determines the mass of protein present, or by one of two functional tests. Protein C is a serine protease that inactivates factors Va and VIIIa. In the chromogenic substrate assay, plasma is mixed with *Agkistrodon* snake venom, an activator of protein C. The activated protein C splits a synthetic anilide substrate producing a yellow product. The amount of color is proportional to the concentration of functional protein C. However, this test does not detect all abnormal forms of protein C and will be normal in those cases where the defect occurs in the binding of protein C to protein S. All forms of protein C deficiency can be detected using a coagulation test in which protein C deficient plasma is mixed with *Agkistrodon* snake venom and the patient's plasma. **Calcium** chloride and activated thromboplastin are added and the time required for clot

formation is measured. The clotting time is proportional to the concentration of functional protein C in the sample.

Protein S is a cofactor required for enzymatic activity of protein C. Protein S can be measured by immunoassay or by a coagulation test using protein S deficient plasma, activated protein C, activated factor V, and calcium. The time required for a clot to form is proportional to protein S activity.

Factor V Leiden

A mutation in the gene that produces factor V protein, called a factor V Leiden mutation, causes this factor to become resistant to inactivation by protein C (APC resistance). APC resistance increases the risk of thrombosis. If another type of factor V mutation, called an R2 mutation, is found in one copy of the factor V gene, and a Leiden mutation is found in the other copy, the risk of thrombosis is further increased. An R2 mutation alone does not cause an increased risk of thrombosis. R2 mutation testing is, therefore, only performed if a Leiden mutation is found in one copy of the factor V gene. Factor V Leiden has normal coagulation activity when activated, and therefore, does not affect clotting tests such as the prothrombin time. It is detected by the polymerase chain reaction (PCR) using a probe that recognizes the point mutation in the factor V gene. Factor V Leiden is the most common inherited risk factor for hypercoagulability. Its prevalence is 2–7% in the general population.

Prothrombin (factor II)

A mutation in the gene that produces prothrombin can also result in an increased risk of thrombosis. Prothrombin is the precursor to thrombin. Thrombin when activated converts fibrinogen to fibrin which forms the clot. A mutation, called G20210A, in the gene that produces prothrombin results in increased prothrombin plasma levels and an increased risk of thrombosis. Prothrombin mutation is the second most common inherited risk factor for hypercoagulability; the point mutation occurs in approximately 2% of the general population. The changed gene is detected by PCR analysis of DNA.

Antithrombin III

Mutation in the gene that produces Antithrombin III can result in increased thrombosis. Antithrombin III (AT), when activated by heparin, neutralizes thrombin and other activated coagulation factors. A deficiency in this protein results in increased levels of coagulation fac-

tors which is associated with an increased risk of thrombosis. The frequency of antithrombin deficiency in the general population is approximately 17%. As of 2001, DNA testing for antithrombin III deficiency is not available on a clinical basis. Testing typically involves measuring antithrombin activity. Antithrombin is measured by a chromogenic substrate assay. Antithrombin is a serine protease inhibitor that blocks the enzymatic activity of factor Xa and thrombin. The plasma is mixed with heparin causing formation of the antithrombin-heparin complex. Factor Xa is added and incubated with the antithrombin-heparin complex. After incubation, an anilide-conjugated substrate is added. This reacts with factor Xa that has not been inhibited by the antithrombin-heparin complex producing a yellow product. Therefore, the amount of color is inversely proportional to the antithrombin activity of the sample.

Specimen requirements.

DNA tests require 5 mL of whole blood in an EDTA (lavender top) tube and protein activity tests require 3 mL of fresh or frozen citrated plasma. Thrombosis risk panels require 5 mL of whole blood in an EDTA (lavender top) tube and 3 mL of fresh or frozen citrated plasma in 1 mL aliquots. The turn around time for thrombosis risk tests range from one to five days.

Thrombosis risk panels

Two thrombosis risk panels are used, one for patients not receiving Coumadin therapy and one for those who are.

Panel for patients not on Coumadin therapy:

- factor V Leiden DNA test
- prothrombin (Factor II) DNA test
- antithrombin activity
- protein C activity
- protein S activity

(This panel is less accurate and should only be used if discontinuation of therapy is not possible.) Panel for patients on Coumadin therapy:

- factor V Leiden DNA test
- prothrombin (Factor II) DNA test
- antithrombin activity
- protein C/factor IX antigen ratio
- protein S/factor IX antigen ratio

Preparation

If possible, Coumadin anticoagulant therapy should be discontinued at least two weeks prior to undergoing the thrombosis risk tests.

Aftercare

There are no post-test procedures required.

Complications

Excessive bleeding, bruising, and soreness around the puncture site, as well as fainting and feeling light-headed are possible complications of the blood draw.

Infection is also an occasional complication.

Results

The type of results, interpretation, and management recommendations vary by type of thrombosis risk. Factor V and prothrombin DNA testing is fairly definitive. Test results for protein S, C, and antithrombin deficiencies are more difficult to interpret since environmental factors can influence the results. The clinical history and family history should be used to aid in the interpretation. It is important to rule out acquired protein S, C, and antithrombin deficiency prior to establishing a diagnosis. Acquired protein S deficiency is quite common and can be caused by factors such as: the lupus anticoagulant, pregnancy, **liver** disease, inflammatory conditions, nephritic syndrome, and thromboembolism. Liver disease can decrease protein C levels and oral contraceptives can increase protein C levels. Acquired antithrombin deficiency can result from mild liver disease, acute thrombosis, and heparin anticoagulant therapy. When the results are borderline, repeat testing and comparative studies of other family members may be appropriate. Protein activity testing cannot definitively differentiate those with one abnormal copy from those with two abnormal copies of an anticoagulant gene.

Normal values

These may be defined in mass units for immunoassay methods or as the percentage of normal for functional assays. Values presented below are representative of immunoassay and functional assays but will vary depending upon the method employed.

- antithrombin III: 20-30 mg/dL or 80-120% of normal
- D-dimer: less than 200 ng/mL
- protein C: 3-4 µg/mL or greater than 65% of normal
- protein S: 0.7-1.4 µg/mL or greater than 65% of normal

KEY TERMS

Anticoagulant—A medication that prevents blood clotting.

Blood clot—The solid clump of accumulated blood factors that results when blood coagulates.

Cerebral brain thrombosis—Thrombus that forms within a blood vessel in the brain.

DNA testing—Testing for a change or changes in a gene or genes.

Embolism—A blood clot that has traveled from a different location.

Gene—A building block of inheritance, made up of a compound called DNA (deoxyribonucleic acid) and containing the instructions for the production of a particular protein.

Heterozygous—Changes in one copy of a gene.

Homozygous—Changes in both copies of a gene.

Mutation—Change in a gene.

Peripheral vascular disease—Narrowing of the blood vessels that carry blood to the extremities such as the arms and legs.

Neonatal purpura fulminans—A life-threatening condition in the neonate that results in small hemorrhages in the skin.

Placental infarction—An area of dead tissue in the placenta that is due to an obstruction of circulation in the area.

Preeclampsia—Pregnancy-induced high blood pressure which is associated with edema, and protein in the urine.

Protein—A substance produced by a gene that is involved in creating the traits of the human body or is involved in controlling the basic functions of the human body such as blood coagulation.

Thrombosis—The development of a thrombus.

Thrombus—An accumulation of blood factors that often causes a vascular obstruction. Often used synonymously with the term blood clot.

Transient ischemic attack—A temporary blockage of an artery which supplies blood to the brain and lasts less than 24 hours. Often called a “mini-stroke.”

Health care team roles

The main role for the nurse is **patient education**. Patients with positive results need to be informed of the increased risk of thrombosis. Patients need to be reassured, however, that many people with a genetic predisposition to thrombosis remain free of symptoms for their entire life. Women should be informed that they have an increased risk of second- or third-term pregnancy loss and obstetrical complications such as preeclampsia, fetal growth retardation, and placental infarction. Patients also need to be counseled about the common environmental risk factors for thrombosis. Thrombosis risk tests are performed by a clinical laboratory scientist, CLS(NCA)/medical technologist, MT(ASCP) or clinical laboratory technician, CLT(NCA) or medical laboratory technician, MLT(ASCP). Results of a thrombosis risk panel or test is interpreted by a physician. The physician also determines if further tests (e.g. Doppler ultrasound) are needed and directs any anticoagulant therapy.

Common environmental risk factors for thrombosis include:

- pregnancy
- oral contraceptive use
- estrogen therapy
- medications that are estrogen receptor modulators such as Tamoxifan and Raloxifene
- obesity
- diabetes mellitus
- presence of lupus anticoagulant
- smoking
- cancer
- surgery
- prolonged bed rest

Smoking should be discouraged in all patients with positive test results. Oral contraceptive use should be strongly discouraged in patients who are homozygous for the prothrombin or factor V Leiden mutations or who have a severe C, S, or antithrombin deficiency. Patients who are heterozygous for factor V Leiden or prothrombin G20210A or who have a mild deficiency in protein C, S, or antithrombin should be informed of the risks associated with oral contraceptive use.

It is important that the patient be informed of the hereditary nature of the disorder. Heterozygotes have a 50% chance of passing on the changed gene to their offspring and homozygotes have a 100% chance of passing on a changed gene. Homozygotes have inherited a changed gene from each parent. Heterozygotes have usually inherited the changed gene from either their father or mother. In some cases the gene change will occur spon-

taneously in the embryo at the time of conception. In these cases siblings and parents are not at increased risk.

Patients with positive test results should be encouraged to inform first degree relatives of their risks. It can sometimes be helpful to provide the patient with an informational letter about their test results that they can give to other family members.

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Thyroid-stimulating hormone test see
Thyroid function tests

Thyroid function tests

Definition

Thyroid function tests are **blood** tests used to evaluate how effectively the **thyroid gland** is working.

These tests include the thyroid-stimulating hormone test (TSH), free and total thyroxine tests (FT₄, T₄), the free and total triiodothyronine tests (FT₃, T₃), the thyroxine-binding globulin test (TBG), and the T-uptake test.

Purpose

Thyroid function tests are used to:

- Help diagnose an underactive thyroid (hypothyroidism) and an overactive thyroid (hyperthyroidism).
- Evaluate thyroid gland activity.
- Monitor response to thyroid therapy.

Thyroid hormones regulate the rate of cellular activity and affect body temperature, appetite, sleep, and mental health. A low level of thyroid hormone results in myxedema. Although the severity of disease may range from very mild to severe, symptoms associated with hypothyroidism are anemia, malaise, intolerance to cold, hyperlipidemia, fluid retention, and depression. A high level of thyroid hormone causes hyperthyroidism. Classical symptoms include insomnia, intolerance to heat, weight loss, and rapid **heart** rate.

Both hypo- and hyperthyroidism can be caused by several mechanisms. Primary hypo- and hyperthyroidism are caused by conditions intrinsic to the thyroid, while secondary hypo- and hyperthyroidism are caused by pituitary-hypothalamic failure. T₄ is present in much higher concentrations than T₃, but T₃ is physiologically more potent. Thyroid hormones are active only when not protein bound (i.e. as free hormone). Circulating free hormone levels are regulated by pituitary release of thyroid stimulating hormone (TSH). The release of TSH controlled by negative feedback. Increased blood levels of free hormone inhibit pituitary release of TSH.

Precautions

Many drugs affect the results of thyroid function tests without causing thyroid disease. Some common drugs known to depress thyroid hormone levels are dopamine, **corticosteroids**, lithium, salicylates, anticonvulsants, and androgens. Thyroid hormone levels may be increased by estrogens, clofibrate, and opiates. TSH, TBG, and T-uptake levels are also affected by many of the drugs cited above. In addition, acute and chronic illnesses and **pregnancy** also affect thyroid function tests. Such conditions may be confused with clinical hypo- or hyperthyroidism. When possible, patients may be requested to discontinue medications that are known to

interfere with the tests several days or more prior to testing.

While most drugs that interfere with thyroid function tests do so by altering thyroxine-binding protein concentrations, peripheral conversion of T_4 to T_3 , and other *in vivo* mechanisms, a few substances (mainly heterophile and autoantibodies) may interfere directly with the analysis. Such interference should be suspected by a physician who sees a test result that is inconsistent with the patient's symptoms or other thyroid function test results.

Description

Currently, thyroid testing is performed on plasma or serum specimens using immunoassay methods including enzyme multiplied immunoassay technique (EMIT), cloned enzyme donor immunoassay (CEDIA), radioimmunoassay (RIA), fluorescence polarization immunoassay (FPIA), and chemiluminescence.

The high-sensitivity thyroid-stimulating hormone (TSH) test is the most sensitive and specific screening test for thyroid disease. TSH levels change exponentially with changes in T_4 and T_3 and are less likely to be elevated or depressed by nonthyroid illnesses or drugs.

This strategy is more cost-effective than a panel approach (e.g. TSH + FT_4 or FT_4 + FT_3) but necessitates the use of a TSH assay with a functional sensitivity below 0.02 mU/L. This level of sensitivity is required to differentiate primary hyperthyroidism, which causes levels to be near undetectable from the low end of the reference range, which is only 0.4 mU/L. A normal TSH level rules out clinical thyroid disease. Low TSH levels may result from primary hyperthyroidism or secondary hypothyroidism caused by pituitary TSH deficiency. High TSH levels are caused by primary hypothyroidism or secondary hyperthyroidism resulting from pituitary adenoma. Abnormal TSH levels are followed by measurements of T_3 and T_4 (preferably free T_4) to confirm the diagnosis. For example, a person with a low TSH who has primary hyperthyroidism will have an elevated T_3 and usually an elevated free T_4 ; a person with a low TSH caused by pituitary disease will have low levels of these hormones. Measurement of T_4 (and FT_4) is considered a more specific indicator of hypothyroidism than T_3 , while T_3 (and FT_3) are more sensitive in detecting cases of hyperthyroidism than is T_4 .

TSH levels are sometimes abnormal in persons with subclinical thyroid disease and in patients with severe acute or chronic illness (called euthyroid sick syndrome). These cases may require the thyrotropin releasing hormone stimulation test (TRH stimulation test) and reverse T_3 test to determine if underlying thyroid disease is pres-

ent. TRH stimulation is performed by measurement of the TSH level followed by IV administration of thyrotropin releasing factor. The TSH is measured 30 and 60 minutes after the injection. Persons with primary hypothyroidism show an excessive TSH response. The TRH stimulation test is usually normal in persons with euthyroid sick syndrome. Reverse T_3 forms from peripheral conversion of T_4 to T_3 . Levels of rT_3 are low in persons with hypothyroidism and usually increased in persons with euthyroid sick syndrome.

Pregnancy and certain diseases (e.g. viral hepatitis) and several drugs (e.g. steroids) affect the level of thyroxine binding **proteins**. In such cases, the level of total hormone will be abnormal, but the level of free hormone will be unaffected. FT_4 and FT_3 improve diagnostic accuracy for detecting hypo- and hyperthyroidism in patients with thyroid hormone binding abnormalities that compromise the diagnostic utility of total hormone tests.

In cases where abnormal levels of thyroxine binding proteins is suspected, two tests are helpful, the T-uptake test and measurement of thyroxine binding globulin (TBG). The T-uptake test [historically called the triiodothyronine resin uptake (T₃RU) test] measures the available binding sites on TBG. The test is reported as the thyroid hormone binding ratio (THBR). The THBR is determined by dividing the percent T-uptake of the patient by that for a normal sample. The ratio is high in hyperthyroidism and low in hypothyroidism. When thyroxine-binding proteins are reduced the THBR is high and when binding proteins are elevated the THBR is low.

The thyroxine-binding globulin (TBG) test measures blood levels of this substance, which is manufactured in the **liver**. TBG binds to T_3 and T_4 , and prevents the **kidneys** from filtering the hormones from the blood. Bound hormone is not physiologically active. The hormone-protein complex is reversible, and in equilibrium with free hormone levels. Therefore, when binding proteins such as TBG are increased, there will be an increase in the amount of total hormone.

Additional tests:

- Ultrasound exams of the thyroid gland are used to detect signs of growth and other irregularities.
- Thyroid scans using radioactive iodine or technetium (a radioactive metallic element) reveal the size and activity of the gland. Growths or nodules are seen and can be classified as inactive (cold) or active (hot) depending upon the amount of radioactivity present.
- Thyroid-specific autoantibodies. Autoimmune disease is the most frequent cause of both hypo- and hyperthyroidism. Commonly performed tests for thyroid autoantibodies are thyroid peroxidase antibody (TPOAb), thy-

KEY TERMS

Cirrhosis—Progressive disease of the liver, associated with failure in liver cell functioning and blood flow in the liver. Tissue and cells are damaged, the liver becomes fibrous, and jaundice can result.

Clofibrate (Altromed-S)—Medication used to lower levels of blood cholesterol and triglycerides.

Graves' disease—The most common form of hyperthyroidism, characterized by bulging eyes, rapid heart rate, and other symptoms.

Hepatitis—Inflammation of the liver.

Hyperthyroidism—Overactive thyroid gland; symptoms include irritability/nervousness, muscle weakness, tremors, irregular menstrual periods, weight loss, sleep problems, thyroid enlargement, heat sensitivity, and vision/eye problems. The most common type of this disorder is called Graves' disease.

Hypothyroidism—Underactive thyroid gland; symptoms include fatigue, difficulty swallowing, mood swings, hoarse voice, sensitivity to cold, forgetfulness, and dry/coarse skin and hair.

Myxedema—Hypothyroidism, characterized by thick, puffy features, an enlarged tongue, and lack of emotion.

Nephrosis—Any degenerative disease of the kidney (not to be confused with nephritis, an inflammation of the kidney due to bacteria).

Reverse T₃ (rT₃)—An isomer of T₃ that is formed from deiodination of T₄ in the blood. It is not physiologically active.

Salicylates—Aspirin and certain other nonsteroidal anti-inflammatory drugs (NSAIDs).

T₃—The more active of the two thyroid hormones triiodothyronine).

T₄—The principal thyroid hormone (tetraiodothyronine).

T-uptake test—Also known as the T₃ resin uptake test this test measures the number of available binding sites on TBG.

Thyroid gland—A butterfly-shaped gland in front and to the sides of the upper part of the windpipe; influences body processes like growth, development, reproduction, and metabolism.

Thyroid stimulating hormone (TSH)—A pituitary polypeptide that regulates the activity of the thyroid gland.

Thyrotropin releasing hormone (TRH)—A neuropeptide produced by the hypothalamus that stimulates pituitary synthesis of TSH.

Thyroxine binding globulin—The primary thyroxine binding protein in blood.

roglobulin antibody (TgAb) and TSH receptor antibodies (TRAb). Although low levels of these antibodies may be found in healthy persons, elevated levels point to the presence of autoimmune disease that involves the thyroid.

- Thyroglobulin (Tg) methods are critical for the post-operative management of patients with differentiated thyroid carcinoma (DTC).

Preparation

There is no need to make changes in diet or activities. The patient may be asked to stop taking certain medications until after the test is performed. Venipuncture is performed in the usual manner following standard precautions for prevention of exposure to bloodborne pathogens.

Aftercare

Aftercare consists of routine care of the area around the puncture mark. Pressure is applied for a few seconds, and the wound is covered with a bandage.

Complications

Generally, thyroid function tests are easily interpreted by a physician. However, under certain circumstances interpretation of results is less straightforward. According to an article published in the February 2001 issue of *Lancet*, one or more of the following features should prompt further investigation:

- abnormal thyroid function in childhood
- familial disease
- thyroid function results inconsistent with the clinical picture

- an unusual pattern of thyroid function tests results
- transient changes in thyroid function

Results

Not all laboratories measure all of the thyroid function tests that are available. Different methods may result in different normal ranges. Each laboratory will provide a range of values that are considered normal for each test. Some acceptable ranges are listed below.

TSH

Normal TSH levels for adults are 0.4-5.0 mU/L.

T₄

Normal T₄ levels are:

- 10.1-2.0 microg/dl at birth
- 7.5-16.5 microg/dl at 1-4 months
- 5.5-14.5 microg/dl at 4-12 months
- 5.6-12.6 microg/dl at 1-6 years
- 4.9-11.7 microg/dl at 6-10 years
- 4-11 ug/dl at 10 years and older

Levels of free T₄ (thyroxine not attached to TBG) are higher in teenagers than in adults.

Normal T₄ levels do not necessarily indicate normal thyroid function. T₄ levels can register within normal ranges in a patient who:

- is pregnant
- has recently had contrast x rays
- has nephrosis or cirrhosis

T₃

Normal T₃ levels are:

- 90-170 ng/dl at birth
- 115-190 ng/dl at 6-12 years
- 110-230 ng/dl in adulthood

TBG

Normal TBG levels are:

- 1.5-3.4 mg/dl or 15-34 mg/L in adults
- 2.9-5.4 mg/dl or 29-54 mg/L in children

T-Uptake (THBR)

Normal THBR levels are:

- 0.75 - 1.05 at birth

- 0.83 - 1.15 at 1-15 years
- 0.85 - 1.11 for adult males
- 0.80 - 1.04 for adult females
- 0.68 - 0.87 for second half of pregnancy

LATS

Long-acting thyroid stimulator is found in the blood of only 5% of healthy people.

Health care team roles

Thyroid function tests are ordered and interpreted by a physician. In difficult cases, an endocrine specialist may be needed. A phlebotomist, or sometimes a nurse, collects the blood, and a clinical laboratory scientist, CLS (NCA)/medical technologist, MT (ASCP) or clinical laboratory technician CLT (NCA)/medical laboratory technician MLT (ASCP) performs the testing.

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Thyroid gland

Definition

The thyroid gland is a bilobed organ of the **endocrine system** located in the front of the neck. It secretes hormones that are involved in human development, growth, and **metabolism**.

Description

The thyroid gland is a small, butterfly-shaped gland made up of two lobes separated by tissue called the isthmus, which lies across the trachea. The lobes of the thyroid are each approximately 2 inches (5 cm) in length, and the isthmus is approximately 2 inches (5 cm) in width and length and the thyroid gland weighs approximately 1 ounce (28 g). Each lobe of the thyroid gland wraps around and is affixed by fibrous tissue to one side of the trachea. A narrow projection of thyroid tissue, called the pyramidal lobe, is often present and originates at the isthmus and extends up to and lays on the surface of the thyroid cartilage (Adam's apple). The upper projections of the right and left lobes are called the upper poles of the gland while the lower projections of the lobes are called the lower poles. The lobes of the thyroid lie between the larynx and trachea medially and the sternomastoid muscles and carotid sheath laterally. The thyroid gland can be felt through palpitation of the neck, unless the neck is very thick and short or the sternomastoid muscles are very well developed.

A thin capsule of connective tissue surrounds the thyroid and divides it into a cluster of globular sacks called follicles. The gland does not, however, have any true subdivisions, and the follicles are packed together like a bag of berries. The follicles are lined with follicular cells that secrete hormones called thyroxine (T4) and triiodothyronine (T3) and enclose a glutinous material called colloid. Colloid is primarily made of a protein called thyroglobulin that is involved in the formation of T4 and T3. Cells called parafollicular cells or C-cells, which secrete the hormone calcitonin, are found between the follicles.

Function

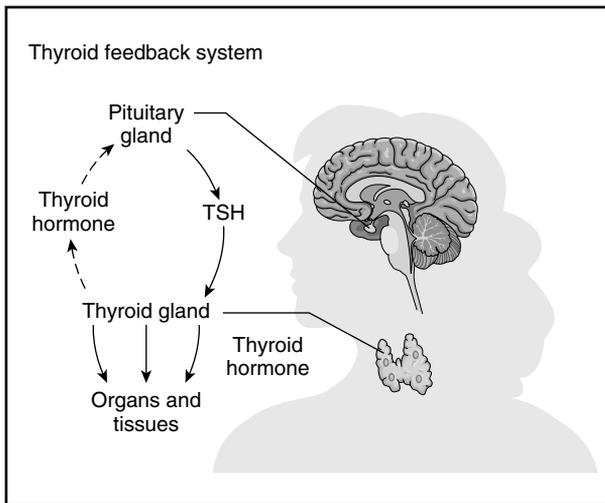
T3 and T4 hormones

The primary function of the thyroid gland is to produce and secrete T4 and T3, which are hormones involved in many aspects of growth, development, and metabolism. T4 and T3 are produced from thyroglobulin attached to iodide. Iodine obtained from the diet is absorbed through the **small intestine**, converted into iodide, and transported through the **blood** stream to the thyroid. The iodide absorbed by the thyroid attaches to thyroglobulin and forms monoiodotyrosine (MIT) and diiodotyrosine (DIT). T4 is formed when two DITs join together and T3 is formed when one MIT joins to one DIT. At this point the T3/T4 are still attached to the thyroglobulin. The thyroglobulin containing T4 and T3 is then transported to the center of the follicle where it forms colloid. When there are low levels of T4 and T3 in the blood, the follicular cells are stimulated to ingest colloid, and digest the thyroglobulin. This ultimately results in the release of T4 and T3 into the blood stream.

REGULATION OF T3 AND T4 SYNTHESIS AND RELEASE. Thyroid stimulating hormone (TSH), which is also called thyrotropin, is the main regulator of thyroid hormone synthesis and release. TSH is produced by the **pituitary gland**. Binding of TSH to receptors on the thyroid gland stimulates the synthesis and release of T4 and T3. High concentrations of TSH result in increased thyroid hormone synthesis and release into the blood stream, and low levels of TSH result in decreased synthesis and decreased release into the blood stream. The amount of TSH secreted is controlled by the thyroid-releasing hormone, which is produced by an organ called the hypothalamus. When the amount of thyroid hormones in the blood exceeds a certain level, the hypothalamus stops secreting thyroid-releasing hormone. This stops the secretion of TSH, which stops the secretion of T3 and T4. This is called a negative feedback loop. When the levels of thyroid hormones in the blood stream decrease to below a predetermined level then the negative feedback is stopped and the secretion of thyroid-releasing hormone resumes. This ultimately results in resumed secretion of T4 and T3. The amount of T4 and T3 produced can also be influenced by dietary factors such as the amount of iodine consumed and the total caloric intake and can also be affected by inhibitory drugs such as the thionamides.

Calcitonin

The thyroid gland also secretes calcitonin. The thyroid's C-cells are stimulated to secrete calcitonin when there is a high concentration of **calcium** in the blood stream. The function of calcitonin is to inhibit the amount



The thyroid gland produces T4 and T3 in response to a production of thyroid stimulating hormone (TSH) from the pituitary gland. (Delmar Publishers, Inc. Reproduced by permission.)

of resorption of calcium from the bone and to regulate the amount of calcium in the blood stream.

Role in human health

The hormones T4 and T3 produced by the thyroid gland are involved in growth, development and metabolism, and it is likely that most cells are targets for these hormones. Some researchers feel that T4 is only an inactive prohormone while T3 is the biochemically active form of the thyroid hormone. Some T3 is produced in the thyroid but most of it is produced from the conversion of T4 outside of the **liver**. Receptors on cells bind some T4 but preferentially bind T3. The thyroid hormones stimulate the metabolic activities of most tissues and cause an increase in basal metabolic rate. Normal levels of T4 and T3 are necessary for normal development of the **brain** and normal growth in childhood. The thyroid hormones are also involved in regulating **heart** rate and increasing cardiac contractility and output. These hormones also have effects on the **central nervous system**, since decreased thyroid hormone levels are associated with decreased ability to concentrate and think, and increased levels are associated with **anxiety**. The reproductive system also requires normal thyroid hormone levels, and decreased levels of these hormones can result in **infertility**.

Common diseases and disorders

Iodine deficiency or excess

Dietary intake of iodine is necessary for the normal synthesis of T3 and T4. A deficiency or excess consumption of iodine can result in a deficiency in these hormones

(hypothyroidism) or an excess of these hormones (hyperthyroidism). Iodine deficiency is less common in developed countries where table salt contains iodine. Disorders which lead to a deficiency of iodide in the thyroid can also cause hypothyroidism.

Hypothyroidism

Hypothyroidism is the most common disease of the thyroid and results in deficient production of T4/T3 by the thyroid, or defects, which result in the inability of the body to respond to T4/T3. The clinical manifestations of hypothyroidism include:

- goiter
- fatigue
- constipation
- weight gain
- memory and mental impairment and decreased concentration
- depression
- loss of libido
- coarseness or loss of hair
- dry skin and cold intolerance
- irregular or heavy menses
- infertility
- hoarseness
- myalgias
- hyperlipidemia
- reflex delay
- bradycardia
- hypothermia
- ataxia

Hypothyroidism is usually confirmed when serum levels of T4 are decreased and serum levels of TSH are increased. In some cases, patients with hypothyroidism can have normal T4 or TSH levels or even low TSH levels. Hypothyroidism is typically treated by oral administration of a synthetic form of T4 called levothyroxine. Hypothyroidism can be classified into primary hypothyroidism, central hypothyroidism and peripheral hypothyroidism.

PRIMARY HYPOTHYROIDISM. Primary hypothyroidism is the most common form of hypothyroidism. Primary hypothyroidism is caused by factors affecting the thyroid gland itself such as thyroid dysgenesis, environmental damage to the thyroid, inherited metabolic defects and environmental factors such as medications

which affect thyroxin synthesis. Primary hypothyroidism generally results in low serum levels of T4 and high serum levels of TSH.

The most common cause of primary hypothyroidism in adults in developed countries is autoimmune thyroiditis (Hashimoto's thyroiditis). Hashimoto's thyroiditis results when the body forms antibodies against the TSH receptors in the thyroid gland. This results in a decreased stimulation of T4/T3 production by the thyroid gland.

CENTRAL HYPOTHYROIDISM. Central hypothyroidism results from insufficient stimulation of the thyroid gland by the thyroid-stimulating hormone (TSH). Central hypothyroidism can result from abnormalities that interfere with the pituitary release of TSH or factors that affect the regulation of TSH by thyrotropin releasing hormone (TRH). Central hypothyroidism generally results in low serum levels of T4 and normal to low serum levels of TSH.

PERIPHERAL HYPOTHYROIDISM. Peripheral hypothyroidism is extremely rare and results when the body is unable to respond to thyroxin. The most common cause is thyroid hormone resistance, a rare, autosomal dominant disorder that results from mutations in the thyroid hormone receptor (Trbeta). Increased secretions of T4 and increased T4 in sera and increased levels of TSH characterize this disorder. Patients with this disorder have a 50% percent chance of passing it on to their offspring. Peripheral hypothyroidism can also be caused by massive infantile hemangiomas that excrete high levels of type 3 deiodinase which inactivates T4.

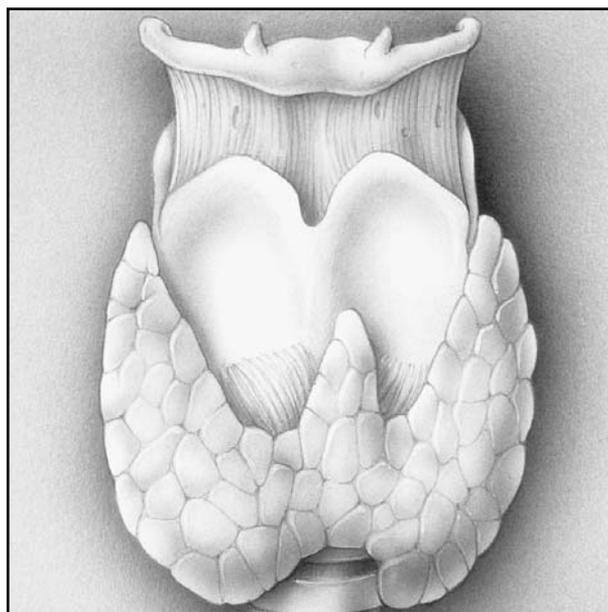
Congenital hypothyroidism

Infants born with hypothyroidism are said to be affected with congenital hypothyroidism. In addition to the typical manifestations of hypothyroidism, congenital hypothyroidism, if untreated, can cause stunted growth, apathy, distended abdomen, swollen tongue, and mental retardation.

Eighty to 90% of cases of congenital hypothyroidism are caused by thyroid dysgenesis. Ten to 15% are due to inherited inborn errors of thyroid hormonogenesis, which are usually autosomal recessive and have a 25% recurrence risk. Congenital hypothyroidism can sometimes be caused by maternal radiation treatment during **pregnancy** or uncontrolled maternal hypothyroidism or hyperthyroidism during pregnancy.

Hyperthyroidism

Hyperthyroidism results from an excess amount of T4 and T3 in the blood stream. The major symptoms of hyperthyroidism include nervousness, tremors, sweating,



The thyroid gland releases hormones that are involved in growth, development, and metabolism. It lies on top of the trachea in the throat. (K. Sommerville/Custom Medical Stock Photo. Reproduced by permission.)

heat intolerance, palpitations, weight loss with normal caloric intake, amenorrhea, and muscle weakness. In the presence of clinical symptoms the diagnosis of hyperthyroidism can be confirmed when serum measurements indicate increased T4 and/or decreased TSH levels. Hyperthyroidism can be treated through medications such as thionamides, which inhibit the synthesis of T4 and T3, and beta blockers which block the action of thyroid hormones on peripheral cells. Patients who cannot be treated through medications are treated through radioiodine destruction of the thyroid or surgical removal of the thyroid. Surgical removal of the thyroid and sometimes radioiodine treatment can leave the patient permanently hypothyroid.

GRAVES' DISEASE. Graves' disease, the most common cause of hyperthyroidism, is an autoimmune disease resulting from the formation of antibodies against the TSH receptors in the thyroid gland. The only difference between Hashimoto's thyroiditis and Graves' disease is that Graves disease results when these antibodies stimulate thyroid hormone synthesis rather than inhibiting it. Graves' disease results in increased synthesis of T4 and T3, and can result in exophthalmos, thyroid enlargement and goiter, and vitilago. People with Graves' disease may pass on a genetic predisposition and a slightly increased chance of developing Graves' disease to their offspring.

KEY TERMS

Adenoma—A benign glandular epithelial tumor.

Autosomal dominant—Mutation of only one gene of a pair is required to cause abnormal functioning.

Autosomal recessive—Mutations in both genes of a pair are required to cause abnormal functioning.

Basal metabolic rate—The number of calories that the body consumes when at rest.

Bradycardia—Slowing of the pulse.

Colloid—The gelatinous material made up primarily of thyroglobulin which is found in the follicles of the thyroid.

Cardiac contractility—The ability of the muscles of the heart to contract in the presence of a stimulus.

Endocrine system—A group of organs that secrete hormones directly into the circulatory system that affect metabolism and other body functions.

Exophthalmos—Protrusion of the eyeball.

Goiter—An enlarged thyroid gland resulting in a swelling on the front of the neck.

Hemangioma—Benign tumor made of newly formed blood vessels.

Hormone—A chemical produced by the body which is involved in regulating specific bodily functions such as growth, development, and reproduction.

Hormonogenesis—The production of hormones.

Lobe—Well defined segment of an organ.

Metabolism—Activity by which cells obtain energy from nutrients or use energy to perform basic body functions.

Thyroglobulin—Protein found in the follicles of the thyroid which is involved in the formation of the T4 and T3 hormones produced by the thyroid.

Trachea—Windpipe.

Vitiligo—A skin disorder characterized by depigmented white patches that can have a hyperpigmented border.

OTHER CAUSES OF HYPERTHYROIDISM. Toxic adenoma of the thyroid results from a thyroid nodule that produces additional T4 and T3. This excess production of

thyroid hormones results in increased concentrations of T3 and/or T4 in the blood stream and suppression of TSH. Toxic adenoma can be treated through surgical removal of the thyroid, treatment with radioactive iodine, and injection of ethanol into the nodule.

Hyperthyroidism can also be caused by a toxic multinodular goiter. Toxic multinodular goiter is common in areas of iodine deficiency. The multinodular goiter usually results from a goiter caused by hypothyroidism which eventually develops multiple nodules. These nodules produce excess T4 and T3 hormone independent of the TSH levels. Treatment usually involves radioactive iodine or surgery. Hyperthyroidism can also occasionally be caused from abnormalities such as adenomas of the pituitary gland which result in an increased production of TSH. Infections of the thyroid gland can also result in hyperthyroidism. Uncontrolled maternal hyperthyroidism in pregnancy can cause hyperthyroidism in the fetus. In the past hyperthyroidism was occasionally induced when individuals ingested hamburgers containing ground up bovine thyroid gland.

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Thyroid radionuclide scan

Definition

A thyroid nuclear medicine scan is a diagnostic imaging procedure to evaluate the **thyroid gland**, which is an endocrine gland consisting of two lobes located in the front of the neck anterior to the trachea. The two lobes are connected by a thin band of tissue called the isthmus. The thyroid gland is stimulated by hormones, and secretes other hormones that govern the body's **metabolism**. In a radionuclide scan, a radioactive tracer that is selectively absorbed by the thyroid is administered either orally or intravenously. Special equipment that can detect radioactive emissions from the thyroid is used to image the gland, or to measure the concentration of the radioactive tracer in the thyroid gland. The data collected are interpreted to evaluate thyroid function and to diagnose the presence of thyroid disease.

The radionuclides that are used in thyroid scans are two isotopes of iodine, I-131 and I-123, and an isotope of technetium known as ^{99m}Tc . Technetium scanning is preferred for some diagnostic workups because it is relatively fast and does not require the patient to fast beforehand. Some professionals prefer to reserve I-131 for follow-up evaluations of **cancer** patients, and use I-123 for thyroid uptake tests and routine thyroid scans. The reason for the distinction is the higher radiation burden of I-131.

Purpose

Thyroid scans are performed to determine the size, shape, location, and relative function of the thyroid gland. More specifically, a thyroid scan may be ordered by a physician to assess thyroid nodules; to diagnose the cause of thyrotoxicosis (excessive thyroid secretion); to evaluate patients with a history of radiation therapy of the head or neck; or to assess a goiter. A thyroid scan is also used to detect the presence of ectopic thyroid tissue. If the patient had abnormal results from a **blood** test that measures circulating thyroid hormone levels, a scan may be required to aid in diagnosis of the presence of thyroid disease. In some instances, an additional study performed in conjunction with a thyroid scan, called a radioactive iodine uptake, or RAIU, is required to determine the level of glandular functioning.

Precautions

Although thyroid scans use only low doses of radioactive substances, women who are pregnant are cautioned not to have these tests unless the physician indicates that the benefit outweighs the risk. If the patient is

breast feeding, she may be advised to interrupt nursing, depending upon the radionuclide used and the dose administered for the test.

Description

Thyroid scans are most often performed in a nuclear medicine or radiology facility, either in an outpatient x-ray center or a hospital department. If radioactive iodine is given, it is administered either in the form of a tasteless liquid or a capsule. If radioactive technetium is used, the patient is given an intravenous injection. Images of the thyroid gland are obtained at a specified amount of time afterward, depending on the radionuclide administered.

Typically, if radioactive iodine is used, a RAIU is also performed. Uptakes are usually obtained at two and 24 hours after administration of the radioactive iodine. The patient is positioned in front of a piece of equipment that measures the concentration of radioactive substance in the thyroid gland. The uptake procedure takes only a few minutes and the scan is most often performed at twenty-four hours after administration. If technetium is administered, the scan is performed approximately 20–30 minutes after the injection.

For the thyroid scan, the patient is positioned lying down on his or her back, with the head tilted slightly backward. The radionuclide scanner, also called a gamma camera, is positioned above the thyroid area. This procedure takes 30–60 minutes. There is no discomfort involved with either the uptake test or the scan.

Preparation

Some medications may interfere with thyroid studies. If a patient is taking thyroid replacement hormone or anti-thyroid medication, the medication must be discontinued for a specified period of time, usually several weeks. Other recent nuclear medicine scans can affect thyroid studies if there is any residual radiation in the patient's body. In these cases the thyroid scan is postponed for a specified period of time, depending upon the other radioactive material that was used.

X-ray studies using contrast material containing iodine that were performed within the previous 60–90 days will affect thyroid studies using radioactive iodine. Patients should tell their doctors if they have had either of these types of studies before a thyroid scan.

Some over-the-counter medications, herbal supplements and **vitamins** contain large amounts of iodine or such iodine-rich substances as kelp (a type of seaweed), and therefore should be discontinued for a specified time prior to a thyroid scan.

KEY TERMS

Ectopic thyroid—Congenital thyroid tissue found outside the normal location of the thyroid gland, usually under the breastbone or the tongue.

Endocrine—A type of gland that secretes internally into the blood or lymph.

Goiter—Enlargement of the thyroid gland along the front and sides of the neck.

Isotope—One of two or more forms of a chemical element having the same atomic number but having different atomic weights.

Nodule—A small, rounded lump or mass of tissue.

Radionuclide—A substance that emits radiation as it disintegrates.

Technetium—A synthetic element obtained from the fission of uranium. Technetium is used for some types of radionuclide thyroid scans.

Thyrotoxicosis—A disorder characterized by an enlarged thyroid, rapid pulse, and increased basal metabolism due to excessive thyroid secretion. Thyrotoxicosis is sometimes called Graves' disease.

Some institutions prefer that the patient have nothing to eat or drink after midnight on the day before the scan. Most departments provide detailed written instructions regarding preparation for the scan, including dietary restrictions. A normal diet can usually be resumed two hours after the radioisotope is taken. Jewelry and other metallic objects worn around the neck must be removed before the scanning. No other physical preparation is necessary. Patients should understand that there is no danger of radiation exposure to themselves or others. Only very small amounts of the radioactive tracer are used. The total amount of radiation absorbed is often less than the dose received from ordinary x-rays. The scanner or camera does not emit any radiation, but detects and records it from the patient.

Aftercare

No isolation or special precautions are needed after a thyroid scan. The patient should check with his or her physician about restarting any medications that were stopped before the scan. Nursing mothers should inquire about resumption of breast feeding.

Complications

There are no complications with this type of diagnostic study.

Results

Normal findings will show a thyroid gland of normal size, shape, and position. The amount of radionuclide concentrated by the thyroid will be within established laboratory guidelines. There should be no areas where the concentration of radionuclide is increased or decreased. An area of increased radionuclide uptake may be called a hot nodule or "hot spot," and may represent a hyperfunctioning nodule. An area of decreased radionuclide uptake may be called a cold nodule or "cold spot." This finding indicates that a particular area of the thyroid gland is underactive or low-functioning. A variety of conditions, including cysts, localized inflammation, or cancer may produce a cold spot.

Abnormal findings for an RAIU would include abnormally high and abnormally low uptake of the radioactive iodine. A low RAIU suggests hypothyroidism; a high RAIU points to a hyperthyroid condition.

A thyroid scan is rarely sufficient to establish a clear diagnosis by itself. The data collected from a thyroid scan are usually combined with data from blood tests that measure circulating thyroid hormone levels to establish the diagnosis. If nodules are present, a **thyroid ultrasound** may be performed.

The data collected are typically stored in a computer, and the images of the thyroid gland are made on film or paper. The results for an RAIU are expressed as a mathematical equation and are reported as a percentage.

Health care team roles

A nuclear medicine technologist administers the radioactive substance to the patient and operates the equipment that produces the scan. The nuclear medicine technologist obtains pertinent medical history from the patient and will explain the nature of the test. All data collected by the technologist are interpreted by a physician who is a specialist in nuclear medicine or a radiologist. Patients usually obtain the test results from their physician or the physician who requested the thyroid tests.

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Thyroid sonogram *see* **Thyroid ultrasound**

Thyroid ultrasound

Definition

A thyroid ultrasound, or sonogram, is a diagnostic imaging technique used to evaluate the structure of the **thyroid gland**. The thyroid is an endocrine gland, which means that it releases its secretions directly into the bloodstream or lymph. It consists of two lobes located in the front of the neck that are connected by a thin band of tissue called the isthmus, which lies in front of the trachea (windpipe). Ultrasound procedures utilize high frequency sound waves to obtain images of various anatomical structures. Ultrasonography is the most common imaging technique used to evaluate the thyroid because it is not invasive, does not expose patients to radioactive materials, is less expensive than **CT scans** or MRI, and is more effective in detecting small lesions on the thyroid.

Purpose

An ultrasound of the thyroid is performed to evaluate thyroid nodules discovered during a **physical examination** or revealed by a radionuclide study (thyroid scan). A sonogram is most useful when the physician must distinguish between cystic lesions and solid ones, or evaluate any mass in the neck. In many cases the ultrasound examination identifies additional nodules in the thyroid that are too small for the doctor to feel during the external physical examination.

Most thyroid cysts are benign; however, ultrasound imaging cannot be used to differentiate between benign cysts or nodules and **cancer**. Specialized thyroid sonograms, such as color Doppler flow studies, can add valuable information. By showing an image of the **blood** circulation in the gland, this study can assess some ambiguous masses in greater detail. The shade and intensity of the color indicate the direction and the velocity of

the flow. The physician may insert a needle in order to remove some tissue for laboratory evaluation (needle biopsy or fine needle aspiration). Ultrasound is used during this procedure to help the physician guide the needle into the mass under evaluation. The use of color Doppler flow helps the physician to avoid puncturing a blood vessel while collecting the tissue sample.

Thyroid ultrasound can measure the size of the gland with great precision, and may be done periodically to assess the results of treatment. An enlarged thyroid gland or a benign nodule should decrease in size with appropriate medication. In addition, patients who have had **radiotherapy** of the head or neck may be monitored at regular intervals using thyroid ultrasound. Patients who had radiation treatment in these areas in childhood or adolescence have a 30% risk of developing thyroid cancer or other glandular abnormalities in adult life. In the early stages, these conditions may not cause symptoms or be discovered during a physical examination. They may, however, be detected by ultrasound.

Precautions

Thyroid ultrasound is safe for people of all ages. It is the preferred procedure to evaluate suspected disease in pregnant women because no radioactive materials are involved.

Description

Thyroid ultrasonograms may be performed in an outpatient facility or in a hospital department. The patient usually lies on his or her back, although the procedure can also be done with the patient in a sitting position. A pillow or rolled towel is placed under the shoulders and upper back, allowing the head to tilt back (hyperextend). A gel that enhances sound transmission is spread over the thyroid area. The technologist then gently places a transducer, an instrument that both emits and receives sound waves, against the skin. The transducer is about the size of an electric shaver and is moved over the thyroid area. The most common frequencies used for thyroid ultrasound are between 7.5 and 10 megahertz (mHz). The patient should not experience any discomfort from the procedure. The examination takes 15–30 minutes.

The high-frequency sound waves emitted by the transducer are transmitted or reflected differently by different body tissues and structures. Bone and cartilage block the passage of the sound waves, producing a very bright signal. The windpipe, which is filled with air, does not transmit ultrasound waves. Most tissues do, however, transmit the sound waves to a greater or lesser extent. Fluid-filled structures, such as cysts, have a uniform

KEY TERMS

Endocrine—A type of gland that secretes internally into the blood or lymph.

Fine needle aspiration (FNA)—A technique for diagnosing thyroid nodules by withdrawing, or aspirating, a sample of thyroid tissue cells through a 22–29-gauge needle.

Goiter—Enlargement of the thyroid gland along the front and sides of the neck.

Nodule—A small, rounded lump or mass of tissue.

Sonogram—Another word that is sometimes used for an ultrasound examination.

Thyroiditis—Inflammation of the thyroid gland. Chronic thyroiditis is sometimes called Hashimoto's disease.

Transducer—A device that converts a signal from one form of energy to another. In an ultrasound examination, the transducer converts an electrical current to sound waves and echoes from the sound waves back into electrical current.

appearance. Muscles, organs, and other fleshy structures have a ground-glass appearance; that is, they appear to diffuse light.

Preparation

Some facilities recommend limiting food and drink for one hour before the study to prevent discomfort. No other preparation is needed.

Aftercare

No special restrictions or procedures are needed after a thyroid ultrasound.

Complications

There are no risks or complications with this procedure.

Results

A normal study will demonstrate a thyroid gland of normal size, shape, position, and uniform echotexture. A thyroid gland that measures outside of the normal limits suggests a goiter. If the overall echotexture or pattern of reflected sound waves is mottled and uneven, the pattern may indicate the presence of thyroiditis or other inflam-

matory disease. Lesions, both solid and cystic, are easily visualized on ultrasound examination.

Health care team roles

The ultrasound examination is performed by an ultrasound technologist, or diagnostic medical sonographer. The sonographer will review any medical history provided and may need to obtain additional information from the patient. All information obtained from the ultrasound is interpreted by a physician who is a radiologist or, in some cases, an endocrinologist. Patients typically receive the results of the examination from the doctor who ordered the test. This physician will correlate the results of the sonogram with the patient's history as well as findings from the physical examination, **thyroid function tests**, and nuclear medicine tests.

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Thyroid x ray see **Thyroid radionuclide scan**

Thyroxine test see **Thyroid function tests**

Tics see **Movement disorders**

Tilt table test

Definition

Tilt table testing is a medical test designed to study how the human **heart** adapts to changes in position.

Purpose

The American College of Cardiology considers the use of head-up tilt table testing to be the best means of evaluating symptoms and potential treatment for vasovagal **syncope**. More than 7 million Americans suffer from common fainting spells, but only recently has this standardized method been used to determine the root cause of these episodes. Syncope accounts for about 3% of all emergency room visits and nearly 6% of hospital admissions. Overall, it is believed that 6 million Americans are affected, and that vasovagal fainting (common fainting) is the most common type of syncope.

Syncope can be described as a pathological brief loss of consciousness caused by a temporary deficiency of oxygen in the **brain**. It is called by many other names, including:

- neurally-mediated hypotension
- fainting reflex
- neurocardiogenic syncope
- vasodepressor syncope
- vasovagal reflex
- autonomic dysfunction

The **autonomic nervous system** normally compensates for the fact that **blood** pools in the legs when a person suddenly stands up, decreasing the volume of blood available to the heart and eventually the brain. Communication between the brain and the rest of the body causes a rush of adrenaline to be sent into the bloodstream. This speeds up the heart rate and causes the blood to be pumped rapidly and efficiently to necessary areas, especially the heart and brain. When the necessary communication from the brain does not occur or is not received, the person feels light-headed or faint and may actually faint. This is basically what happens when someone gets out of bed or a hot tub too fast. When this occurs, it can often lead to difficulty in functioning and to injuries.

Tilt table testing is designed to study the human body's heart rate and **blood pressure** adaptations to changes in position. To perform the test, patients lie on their back on a table, which is then tilted to a 60° angle, and then an 80° angle. This positioning is an attempt to bring on an episode of fainting to determine whether the fainting spells are common or malignant. Malignant syncope, possibly caused by a heart arrhythmia or flutter, cannot be reproduced by a tilt table test.

The application of the tilt test as a diagnostic tool in the United States has doubled in the past decade. However, it is often not paid for by insurers, including **Medicare**.

Precautions

Precautions are few with the tilt table test, as the person is constantly monitored. However, when any drug is used with this test, the appropriate precautions for that particular drug should be observed. The physician should also be informed of any **allergies** to any sympathomimetic drugs, including several of the diet pills on the market, or of any serious heart-rhythm disorders, or that the person is not feeling well during the test.

Description

The tilt table test takes approximately one hour. Patients lie on their backs and are secured to the table by three straps, under the arm and across the abdomen, across the pelvis, and across the knees. While the person is in a prone position, blood pressure and pulse are taken and electrodes are put in place to monitor the heart. An intravenous line is started in order to provide fluids as necessary during the test. Special electrodes that measure the amount of oxygen going to the brain are placed on the forehead. The head of the table is then tipped upward to a maximum of 75° angle while heart rhythm, pulse, blood pressure, and oxygen saturation at the brain are continuously monitored. Isoproterenol, or Isuprel, a medication with similar properties to adrenaline, is often injected intravenously during the test to duplicate the normal reaction of the body.

Preparation

In order for a patient to make informed decisions about any diagnostic test or procedure, detailed information and description of the test to be performed need to be provided. The patient should understand the purpose of the tilt table test and the diagnosis that the physician is trying to confirm or rule out.

Aftercare

After the procedure, the patient is asked to move from the supine position to a sitting position, and is observed for a short period of time. When ready, the individual transfers from the sitting position to standing. After additional observation and taking of **vital signs**, the individual is allowed to go home.

Complications

Complications as a result of a tilt table test are very infrequent, but could potentially include significant changes in blood pressure while in the supine position, and any adverse reactions to any drugs administered during the tilt table test.

KEY TERMS

Sympathomimetic—A drug that mimics the effects of stimulation of organs and structures by the sympathetic nervous system.

Syncope—A loss of consciousness over a short period of time, caused by a temporary lack of oxygen in the brain.

Results

Normal results of the tilt table test should help the physician in assessing what may or may not be the cause of the syncope. Abnormal results include any pathologic reactions to the position changes or sensitivity enhancing techniques such as the administration of isoproterenol or other related drugs.

Health care team roles

In most cases, a licensed physician will be in charge of conducting a tilt table test; the physician may be a cardiologist or neurologist. Both registered nurses (RNs) and licensed practical nurses (LPNs) may assist the patient in understanding and preparing for the test, and monitor vital signs during the test. An RN may start the intravenous infusion, or attach and monitor electrocardiogram leads and oxygenation-measuring equipment.

Resources

PERIODICALS

Benditt, D. G., D. W. Ferguson, and B. P. Grubb. "Tilt Table Assesses Common Fainting Spells." *Journal of American Cardiology* 28 (1996): 263-75.

ORGANIZATIONS

National Dysautonomia Research Foundation. P. O. Box 211153, Eagan, MN 55121-2553.

OTHER

"Neurally-Mediated Hypotension Working Group." *Johns Hopkins Hospital*.

Joan M. Schonbeck

Tissue typing *see* **Human leukocyte antigen test**

TMJ *see* **Temporomandibular joint disorders**

Tocopherol *see* **Vitamin E**

Tongue *see* **Dental anatomy**

Tonsillitis *see* **Sore throat**

Tooth bleaching *see* **Cosmetic dentistry**

Tooth decay *see* **Dental caries**

Tooth development, permanent

Definition

Permanent teeth, which are also known as adult teeth, are the second and final set of teeth in the human mouth. There are generally 32 permanent teeth in an adult mouth—16 in the upper jaw and 16 in the lower jaw. The permanent teeth replace the 20 primary teeth, which are also known as baby teeth, milk teeth, or deciduous teeth.

Description

In the mouth, a combination of hard and soft tissue areas form the occlusion (bite). The teeth, along with upper and lower jaw bones, are among the hard tissues. The soft tissue includes the gums, tongue, and salivary glands.

Teeth, both primary and permanent, are used to chew and swallow food. Each tooth is divided into a crown and root. The crown is visible. The root grows below the gum and is attached to the jawbone. A pulp chamber located in the center of the crown houses pulp tissue.

The crown is covered with enamel, the hardest substance in the body. It is 95% calcified (mineralized). Cementum, a thinner material, surrounds a portion of the root.

Types of teeth

The shape of the crown determines the purpose of the tooth:

- Incisors have a straight edge to incise or cut food. The two central incisors in each jaw are also known as the front teeth, indicating their location in the mouth. A lateral incisor is located on each side of the front teeth. There is one root in each incisor.
- The canine teeth are located in the corners of the mouth, with two in each jaw. The canine teeth have pointed crowns and are longer than the other teeth. These teeth are used to grip and tear food. They are also known as cuspids or eye teeth. Each canine tooth has a single heavy root.

- On each side of the six front teeth (incisors and canines) are five molars known as the back teeth. The crowns have wider surfaces that are used to chew food. On the surface of the molar are two or more cusps, slight elevations in the crown that are used to grind and pulverize food before it is swallowed.
- The premolars, which are also known as bicuspid, are located behind the cuspid (canine teeth). They help the canine teeth to grip and tear food. There are eight premolars in the adult mouth, with half in the upper jaw and half in the lower jaw. A premolar has one or two roots.
- The remaining molars in each jaw are used to grind food. The first molar, also known as the six-year molar, is adjacent to the second bicuspid. On the other side of the first molar is the second molar, the twelve-year molar. At the back of the mouth are the third molars, which are also known as wisdom teeth. The upper molars generally have three roots, and there are usually two or three roots in the lower molars. These roots help bolster the teeth for the heaviest pressure of chewing and grinding food.

Permanent tooth development

The development of both primary and permanent teeth starts long before these teeth are visible. When a child is born, the primary teeth are partially formed, and development of permanent teeth has started in the jaw bone.

At about the age of six, a child begins losing primary teeth and permanent teeth erupt (appear). The primary teeth fall out (exfoliate) to make room for the permanent teeth to erupt. Generally, girls' teeth develop before boys, and lower teeth grow through the gums before upper teeth. Development of this second set of teeth can sometimes continue into adulthood. A delay in the development process of two years or more could be a symptom of hormonal deficiencies.

TOOTH DEVELOPMENT IN THE UPPER JAW.

According to the American Dental Association (ADA), permanent teeth in the upper jaw generally erupt in this order:

- Between the ages of 6 and 7, the permanent first molars erupt. These teeth erupt behind the child's primary second molars.
- Between the ages of 7 and 8, central incisors appear.
- Lateral incisors erupt between the ages of 8 and 9.
- Between the ages of 10 and 11, the first premolars (first bicuspid) appear.

Permanent teeth: development and eruption

		Hard tissue formation begins	Eruption (years)	Root completed (years)
Maxillary	Central incisor	3-4 mos.	7-8	10
	Later incisor	10 mos.	8-9	11
	Canine	4-5 mos.	11-12	13-15
	First premolar	1.5-1.75 yrs.	10-11	12-13
	Second premolar	2-2.25 yrs.	10-12	12-14
	First molar	at birth	6-7	9-10
	Second molar	2.5-3 yrs.	12-13	14-16
Mandibular	Third molar	7-9 yrs.	17-21	18-25
	Central incisor	3-4 mos.	6-7	9
	Lateral incisor	3-4 mos.	7-8	10
	Canine	4-5 mos.	9-10	12-14
	First premolar	1.75-2 yrs.	10-12	12-13
	Second premolar	2.25-2.5 yrs.	11-12	13-14
	First molar	at birth	6-7	9-10
	Second molar	2.5-3 yrs.	11-13	14-15
	Third molar	8-10 yrs.	17-21	18-25

SOURCE: Ash, M.M. *Wheeler's Dental Anatomy, Physiology, and Occlusion*. 6th ed. Philadelphia: W.B. Saunders Co., 1984.

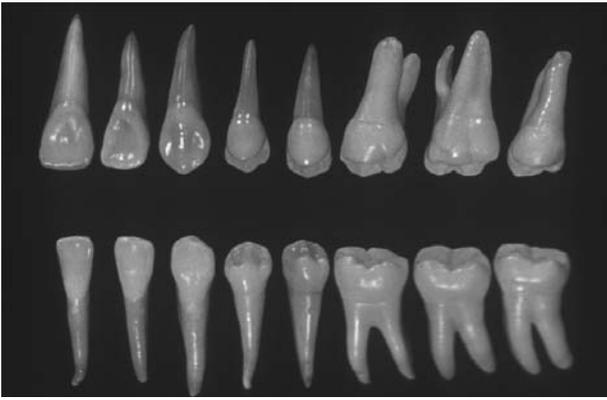
- The second premolars appear between ages of 10 and 12.
- Between the ages of 11 and 12, the canine teeth (cuspid) erupt.
- Between the ages of 12 and 13, second molars erupt.
- Between the ages of 17 and 21, the molars known as wisdom teeth appear.

TOOTH DEVELOPMENT IN THE LOWER JAW.

According to the ADA, permanent teeth in the lower jaw generally erupt in this order:

- Between the ages of 6 and 7, the permanent first molars and central incisors erupt.
- Between the ages of 7 and 8, lateral incisors appear.
- Between the ages of 9 and 10, the canine teeth (cuspid) erupt.
- Between the ages of 10 and 12, the first premolars (bicuspid) appear.
- Between the ages of 11 and 12, second premolars (bicuspid) erupt.
- Between the ages of 11 and 13, second molars erupt.
- Between the ages of 17 and 21, third molars (wisdom teeth) erupt.

CHARACTERISTICS OF PERMANENT TOOTH DEVELOPMENT. Permanent teeth tend to have a yellowish color and are generally larger than primary teeth. Since permanent teeth are larger, their development could crowd other teeth. For example, permanent incisors may be



The permanent teeth consist of four incisors, two canines, four premolars, and six molars in each jaw. Shown here are the upper and lower teeth from one side of the mouth. (Photograph by VideoSurgery. Science Source/Photo Researchers. Reproduced by permission.)

more closely spaced together than primary teeth, particularly in the lower jaw.

There could be space between the upper incisors. The eruption of the upper canine teeth will generally push those incisors together.

The premolars are smaller than the primary premolars. After the adult teeth erupt, the permanent first molars move and fill the space left by the exfoliated premolar.

The third molars are the last teeth to erupt, and there may not be room in the mouth for some or all four of the wisdom teeth. These molars have a tendency to be impacted (out of alignment) and may be unable to erupt. Extraction (removal) of unerupted wisdom teeth may be required.

MISSING PERMANENT TEETH. Some people may not develop all permanent teeth. This lack of teeth is believed to be genetic. The teeth most often missing include the lateral incisors, second premolars, and third molars. The absence of wisdom teeth is generally not a problem unless the third molars in the opposite jaw over-erupt.

EXTRA PERMANENT TEETH. Supernumerary teeth are those teeth in excess of the usual 32 permanent teeth. Most frequently, a supernumerary tooth erupts between the two central incisors in the upper jaw. This extra incisor is called a mesiodens (middle tooth). The presence of these extra teeth has been linked to two hereditary conditions, Gardner's syndrome and cleidocranial dysostosis. Because extra teeth can cause orthodontic problems, dentists generally remove them.

Function

Humans are omnivores, which means they eat meat and vegetables. Permanent and primary teeth make this possible. The location and shape of the tooth indicates its role in separating food into smaller pieces that can be swallowed and digested. The incisors incise or cut food; the canine teeth tear the food; premolars crush the food; and permanent molars grind it into pieces that can be swallowed.

Role in human health

Teeth allow a person to bite and chew food. Without them, a person could eat only soft foods. Teeth also contribute to understandable speech. For example, when a person speaks, the sound of a letter such as a "t" is conveyed by the tongue striking the back teeth.

Common diseases and disorders

Tooth decay and injury can result in the loss of or damage to permanent teeth. Dentists should advise patients about how to prevent decay and injury, advice that includes cautions about sugar and the use of protective athletic gear.

Dental health

As permanent teeth develop, it is advisable for the dentist to see the patient every six months. The dental appointment includes the application of fluoride because newly erupted teeth are prone to tooth decay. The areas most susceptible to tooth decay are the chewing surface of the back teeth, the area where adjacent teeth meet, and the surface closest to the gumline.

The dentist may use a sealant (plastic coating) on the permanent back teeth (molars and premolars). The sealant protects against plaque, which produces tooth decay. If the dentist finds tooth decay, the patient's cavities should be treated with fillings. Small tooth-colored composites are recommended.

An adolescent patient also may experience gum inflammation known as **gingivitis**. Most cases are mild. However, the dental staff needs to remind the patient about the importance of a nutritional diet and **oral hygiene**. In addition, some teenagers may smoke and should be cautioned that tobacco can harm the teeth and gums.

Accidents and injuries

Accidents and injuries can result in the loss of permanent teeth. As with oral hygiene, prevention is the best method of combating injury. Children and teenagers

should be advised to wear sports equipment such as a baseball catcher's mask and a football helmet with a mouth guard.

If a tooth is broken or knocked out, the patient and tooth should be taken to the dentist as soon as possible. In some cases, the tooth can be repaired or reinserted.

Irregular development

Teeth may not develop according to the traditional pattern. A difference in the shape or size of teeth can affect the spacing of teeth. In addition to problems with the alignment of adjacent teeth, there may be a misalignment in the meshing of teeth in the upper and lower jaws. Common problems include large central incisors, or the "peg" lateral incisor that is thinner and has a sharper point than the normal incisor.

Missing teeth may also affect the alignment of teeth. Adjacent teeth can drift towards the empty area. This situation can also cause over-eruption of the opposing teeth in the other jaw. If several side teeth are missing, the person may have a collapsed bite.

Health care team roles

In the case of irregular tooth development or missing teeth, orthodontic treatment could provide adjustments. Regular dental appointments and daily oral hygiene that includes brushing the teeth and flossing can help fight tooth decay. Patients should also be advised to play safely.

Resources

BOOKS

- Guerini, Vincenzo. *A History of Dentistry From the Most Ancient Times Until the End of the Eighteenth Century*. Boston, MA: Longwood Press, 1977.
- Leonardi Darby, Michele, ed. *Mosby's Comprehensive Review of Dental Hygiene*. St. Louis, MO: Mosby, Harcourt Health Sciences, 1998.
- Taintor, Jerry, and Mary Jane Taintor. *The Complete Guide to Better Dental Care*. New York: Facts on File, Inc., 1997.
- Teabord, Mark, et al, eds. *Development, Function, and Evolution of Teeth*. New York: Cambridge University Press, 2000.

ORGANIZATIONS

- Academy of General Dentistry. 211 E. Chicago Ave., Chicago, IL 60611. (312) 440-4300. <<http://www.agd.org>>.
- American Dental Association. 211 E. Chicago Ave., Chicago, IL 60611. (312) 440-2500. <<http://www.ada.org>>.
- American Dental Hygienists' Association. 444 N. Michigan Ave., Suite 3400, Chicago, IL 60622. (312) 440-8900. <<http://www.adha.org>>.
- Centers for Disease Control and Prevention. National Center for Chronic Disease Prevention and Health Prevention.

KEY TERMS

Fluoride—A mineral that helps fight tooth decay.

Gingivitis—The inflammation of the gingiva (gums).

Plaque—A transparent material in the mouth that contains bacteria and causes tooth decay.

Division of Oral Health, MS F-10, 4770 Buford Highway, NE, Atlanta, GA 30341. (888) CDC-2306. <<http://www.cdc.gov>>.

National Institute of Dental & Craniofacial Research. National Institutes of Health. Building 45, Room 4AS-18, 45 Center Drive MSC 6400, Bethesda, MD 2089-6400. <<http://www.nidr.nih.gov>>.

Liz Swain

Tooth development, primary

Definition

Primary dental development involves the development of the primary, first, or baby teeth.

Description

The primary teeth usually begin to appear about six months after birth. Most children have all 20 primary teeth by age two. The eruption of teeth is associated with teething, a process often causing symptoms such as drooling, disturbed sleep, irritability, swollen gums, and, sometimes, a low-grade **fever**. While there are typical patterns of tooth eruption, these patterns can vary greatly from child to child.

Tooth development in the upper jaw

The primary teeth in the upper jaw are:

- Central incisors, which erupt between ages 7 and 12 months and fall out around 6 to 8 years of age.
- Lateral incisors, erupting between 9 and 13 months of age and falling out by the time a child reaches 7 or 8 years of age.
- Canines or cuspids, which appear around 16 to 22 months of age and fall out at 10 to 12 years old.

Primary teeth: development and eruption

		Hard tissue formation begins (weeks in utero)	Eruption (months)	Root completed (years)
Maxillary	Central incisor	14	8–12	1.5
	Lateral incisor	16	9–13	2
	Canine	17	16–22	3.25
	First molar	15.5	13–19 boys 14–18 girls	1.5
	Second molar	19	25–33	3
Mandibular	Central incisor	14	6–10	1.5
	Lateral incisor	16	10–16	1.5
	Canine	17	17–23	3.25
	First molar	15.5	14–18	2.25
	Second molar	18	23–31 boys 24–30 girls	3

SOURCE: Lunt, R.C. and D.B. Law. "A review of the chronology of eruption of deciduous teeth." *J. Am. Dent. Assoc.* 89 (Oct. 1974): 872.

- First molars, emerging between 18 and 19 months and falling out at 9 to 11 years of age.
- Second molars, which come in at 25 to 33 months old and fall out at 10 to 12 years of age.

Tooth development in the lower jaw

The primary teeth in the lower jaw are:

- Central incisors, which erupt at 6 to 10 months and fall out at 6 to 6 years.
- Lateral incisors, erupting at 7 to 16 months and falling out between 7 to 8 years of age.
- Canines, which come in at 16 to 23 months of age and fall out between 9 and 12 years of age.
- First molars, emerging at 12 to 18 months and falling out at 9 to 11 years of age.
- Second molars, which erupt between 20 and 31 months and fall out at 10 to 12 years of age.

Function

Teeth are for chewing and crunching food. They are attached to the tooth root, which anchors them to the jaw bone. The visible part of the tooth is the crown and its hard covering is enamel, which is the hardest substance in the body. The enamel covers a material, called dentin, which makes up the majority of each tooth. Deeper inside the tooth is the pulp, which includes nerve sensations and provides nutrients to the tooth. Baby teeth, like permanent teeth, include pointier incisor and cuspid teeth capable of tearing meats and rounder, flatter molars for grinding foods such as vegetables.

Role in human health

Primary teeth have many roles. They allow children to chew properly, helping them to maintain sound **nutrition**. Primary teeth are important for good pronunciation and speech and are a key aesthetic facial feature. Another function of primary teeth is that they guide permanent teeth and contribute to healthy jaw development.

Common diseases and disorders***Premature primary tooth loss***

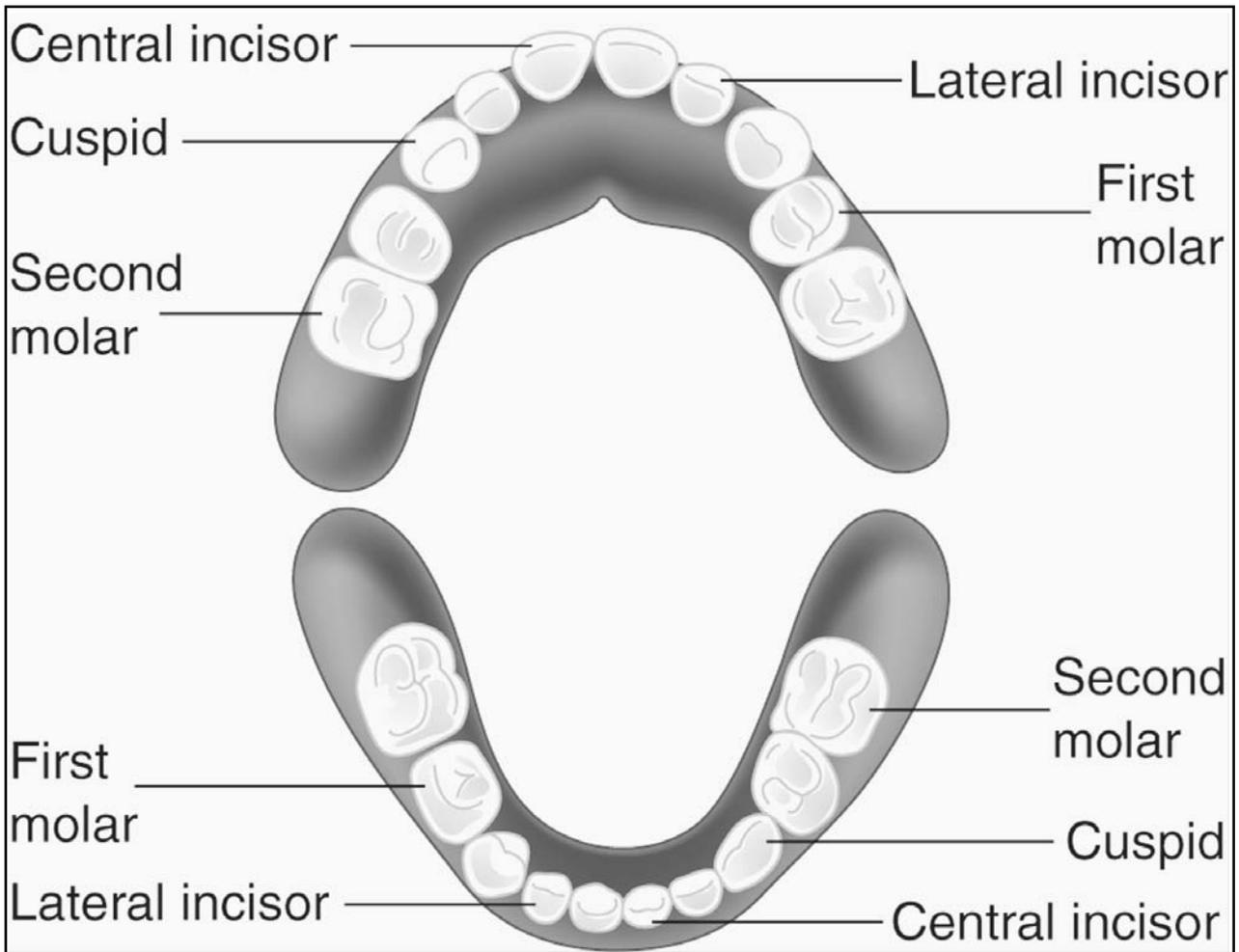
At times, primary teeth fall out or are knocked out too early. The resulting space might become too small for the erupting tooth, so dentists often fill the space with a space maintainer to ensure adequate room for permanent tooth eruption.

Dental decay or caries

Dental decay often begins in childhood. Caries, also known as cavities, start as an interaction between **bacteria**, which normally occurs on teeth, and sugars in the diet. The bacteria and sugars produce an acid, which causes teeth that are exposed to it to lose mineral. Cavities that form in the primary teeth can spread into the developing permanent teeth below. To treat the decay, the dentist has to remove it and fill the tooth with silver- or tooth-colored materials. The fluoride found in drinking water helps prevent cavities and has resulted in far fewer children developing **dental caries**. Dentists also use sealants to prevent decay. Sealants are clear or shaded plastic materials, which dentists apply to the chewing surfaces of the back teeth. The sealants coat the teeth and form a barrier to protect against bacteria.

Early childhood dental caries

Early childhood dental caries is a dental problem that frequently develops in infants that are put to bed with a bottle containing a sweet liquid. Bottles containing liquids such as milk, formula, fruit juices, sweetened drink mixes, and sugar water continuously bathe an infant's mouth with sugar during naps or at night. The bacteria in the mouth use this sugar to produce acid that destroys the child's teeth. The upper front teeth are typically the ones most severely damaged; the lower front teeth receive some protection from the tongue. Pacifiers dipped in sugar, honey, corn syrup, or other sweetened liquids also contribute to early childhood dental caries. The first signs of damage are chalky white spots or lines across the teeth. As decay progresses, the damage to the child's teeth becomes obvious.



Primary, or “baby,” teeth. (Illustration courtesy of Gale Group.)

Injuries, such as falls

Falls and athletic injuries can result in damage to the primary teeth and gums. Dentists should examine these injuries as soon as possible after they occur because they can often save teeth even if they have been knocked out of the socket.

Amelogenesis imperfecta

Amelogenesis imperfecta is a genetic defect in tooth enamel formation. It can appear as a localized row or pits of linear depressions or as generalized tooth discoloration, varying from white to translucent brown. Some children have no enamel at all, or their teeth might look hard or rough on the surface. Sometimes, the enamel of children with amelogenesis imperfecta looks soft and mottled. It can also appear honey-colored, yellow, orange, or brown. Dentists often treat amelogenesis imperfecta by placing crowns or fillings to restore the

primary teeth. Fluoride supplements can help. Regular dental care to monitor amelogenesis imperfecta is important. It is not known how this condition affects the permanent teeth.

Bite problems and growth and development disturbances

Bite problems, or malocclusions, can be hereditary or caused by missing or extra teeth from birth, thumb sucking, or early loss of baby teeth. Bite problems can affect a child’s appearance, as well as his or her ability to talk, eat, and digest foods properly. Dentists or orthodontists can help correct malocclusions.

Developmental abnormalities

Discoloration or deformation of teeth can occur in the primary dentition. The problem might affect a few of the teeth or the entire dentition. These defects can affect

KEY TERMS

Amelogenesis imperfecta—An enamel formation defect.

Canines or cuspids—Second to last primary teeth on each side of the back of the upper and lower jaw.

Caries—Another word for dental cavity or decay.

Dentition—Development and eruption of teeth.

Fluoride—A chemical compound containing fluorine that is used to treat water or applied directly to teeth to prevent decay.

Malocclusions—Bite problems caused by malpositioned teeth.

Sealant—A thin plastic substance that is painted over teeth as an anti-cavity measure to seal out food particles and acids produced by bacteria.

normal chewing, disrupt normal tooth development, and adversely affect appearance. Illness, high fevers, or some medications can cause unerupted teeth to erupt discolored.

Resources

ORGANIZATIONS

American Academy of Pediatric Dentistry. 211 East Chicago Ave., Suite 700, Chicago, IL 60611-2663. (312) 337-2169. <<http://www.aapd.org>>.

American Dental Association. 211 E. Chicago Ave., Chicago, IL 60611. (312) 440-2806. <<http://www.ada.org>>.

Dental Health Foundation. 26, Harcourt Street. Dublin 2. Ireland. 01-473-0466. <<http://www.dentalhealth.ie>>.

OTHER

“Dental Development.” Dr. Sean McSorley’s Web site. <<http://www.gatewest.net/~mcsorley/tooth.html>>.

Lisette Hilton

Tooth extraction

Definition

Tooth extraction is the removal of a tooth from its socket in the bone. It is performed to control disease, improve function, or treat **malocclusion**.

Purpose

Tooth extraction is performed for many reasons. Teeth are often removed because they are impacted, that is, they cannot erupt normally on their own. Teeth become impacted when they are prevented from growing into their normal position in the mouth by gum tissue, bone, or other teeth. Wisdom teeth sometimes are impacted and require extraction. Teeth might also require extraction if they cause **pain** or cause crowding of other teeth.

Teeth may also be extracted to make more room in the mouth prior to straightening the remaining teeth (orthodontic treatment), or to make room for the placement of dental implants or dentures. Sometimes, teeth are extracted because they are so badly positioned that straightening is impossible. Extraction may be necessary because of severe gum disease or because the teeth are so badly decayed or broken that they cannot be restored. Patients also sometimes choose extraction as a less expensive alternative to filling or placing a crown on a severely decayed tooth.

Precautions

Tooth extractions may sometimes need to be postponed temporarily. Such situations include:

- When an **infection** has progressed from the tooth into the bone. Infections may make anesthesia difficult and can be treated with **antibiotics** before the tooth is extracted.
- When a patient takes blood-thinning medications (anti-coagulants), such as warfarin (Coumadin) or aspirin. The patient may need to stop using these medications for three days prior to extraction if medically advisable.
- When patients have had any of the following procedures in the previous six months: **heart** valve replacement, open-heart surgery, prosthetic joint replacement, or placement of a medical shunt. Such patients may be given antibiotics to reduce the risk of bacterial infection.

Description

Once the area has been numbed with a local anesthetic, an instrument called an elevator is used to loosen (luxate) the tooth, widen the space in the bone, and break the tiny elastic fibers that attach the tooth to the bone. When the tooth is dislocated from the bone, it can be lifted and removed with forceps.

If the extraction is likely to be difficult, the dentist may refer the patient to an oral and maxillofacial surgeon, a specialist trained to give intravenous sedatives or

general anesthesia to relieve pain. Examples of difficult procedures are extracting an **impacted tooth** or a tooth with curved roots. This typically requires cutting through gum tissue to expose the tooth and may also require removing portions of bone to free the tooth. Some teeth must be cut and removed in sections. The extraction site may require one or more stitches to close the incision.

Preparation

Before an extraction, the dentist takes the patient's medical history, noting **allergies** and prescription medications. A dental history is also taken, with particular attention to previous extractions and reactions to anesthetics. The dentist may then prescribe antibiotics, or consult with the physician and recommend stopping certain medications prior to the extraction. The tooth is x-rayed to determine its full shape and position, especially if it is impacted.

If the patient is going to have deep anesthesia, loose clothing should be worn that allows access for an intravenous line. The patient should not eat or drink anything for at least six hours before the procedure. Arrangements should be made for a friend or relative to drive the patient home afterwards.

Women who take oral contraceptives are twice as likely to develop dry socket, a common complication in which a **blood** clot does not properly fill the empty socket after extraction. Women taking birth control pills should try to schedule their extractions during the last week of their cycle to coincide with low estrogen levels.

Aftercare

An important goal of aftercare is achieving clot formation at the extraction site. The patient should put pressure on the area by biting gently on a roll or wad of gauze for several hours after surgery. Once the clot is formed, it should not be disturbed. The patient should not rinse, spit, drink with a straw, or smoke for at least 24 hours after the extraction and preferably longer. Vigorous **exercise** should be avoided for the first three to five days.

For the first two days after the procedure, the patient should drink liquids without using a straw and eat only soft foods. Any chewing should be done on the side away from the extraction site. The mouth may be gently cleaned with a toothbrush, but the extraction area should not be scrubbed.

Facial swelling is a normal part of the healing process and is most pronounced in the first 48 to 72 hours. Wrapped ice packs can be applied to help it. As swelling subsides, the patient may experience muscle



A close-up view inside a person's mouth following the extraction of the lower right molar. (Custom Medical Stock Photo. Reproduced by permission.)

stiffness. Moist heat and gentle exercise usually restores normal jaw movement. The dentist may prescribe medications to relieve postoperative pain.

Complications

Potential complications of tooth extraction include temporary numbness from nerve irritation and jaw joint pain, which usually resolve with time but can be treated with over-the-counter pain-killing medications. Antibiotics are given if postoperative infection develops. If dry socket occurs, the dentist must wash out the area and pack the socket with an antiseptic paste and cover it with a dressing. These dressings must typically be changed a few times by the dentist before the problem resolves. Jaw fracture or bone fragments left behind in the gum are unusual complications that may require further surgical intervention.

Results

After an extraction, the wound usually closes in about two weeks. It takes three to six months for the bone and soft tissue to restructure. Complications such as infection or dry socket may prolong the healing time.

Health care team roles

Dental assistants and dental hygienists can assist with taking pre-extraction x-rays. Dental assistants usu-

KEY TERMS

Dental implants—Anchors placed on bone, which are used to secure bridges, partials or dentures.

Dry socket—A painful condition following tooth extraction in which a blood clot does not properly fill the empty socket. Dry socket leaves the underlying bone exposed to air and food.

Extraction site—The empty tooth socket following removal of the tooth.

Impacted tooth—A tooth that is in an abnormal position or is growing against another tooth or a bone so that it cannot erupt normally.

Luxate—To loosen or dislocate the tooth from the socket.

Oral and maxillofacial surgeon—A dentist who specializes in surgical procedures of the mouth, including extractions.

Orthodontic treatment—The process of straightening teeth to correct orofacial appearance and function.

Wisdom teeth—The third molars.

ally prepare the room for the procedure and assist the dentist during the extraction, as well as educate patients about post-operative **home care**.

Resources

ORGANIZATIONS

Academy of General Dentistry, 211 East Chicago Ave.,
Chicago, IL 60611. (312) 440-4800.
<<http://www.agd.org>>.

American Association of Oral and Maxillofacial Surgeons.
9700 West Bryn Mawr Avenue, Rosemont, IL 60018-
5701. (847) 678-6200. <<http://www.aaoms.org>>.

Lisette Hilton

Tooth grinding *see* **Bruxism**

Tooth numbering *see* **Dental and periodontal charting**

Tooth polishing

Definition

Tooth polishing is the smoothing of all exposed tooth surfaces with a rubber cup, a brush, or by an air polisher driven by a slow-speed hand piece or water unit.

Purpose

According to the *Journal of Periodontology* an oral prophylaxis is the removal of plaque, calculus, and stains from the exposed and unexposed surfaces of the teeth by scaling and polishing as a means to prevent periodontal disease. A cleaning involves removing debris and extraneous matter from the teeth. Polishing makes the surfaces of teeth smooth. As a result of these procedures, the teeth are smooth and clean at the end of treatment.

Precautions

Historically polishing has been part of the oral prophylaxis appointment. Dental polishing was considered important for the removal of plaque and stain prior to a fluoride treatment to insure adequate uptake of fluoride in the enamel. Recent research by the American Dental Association has shown that polishing does not improve the uptake prior to a professionally applied fluoride treatment. Polishing prior to a sealant application has also been considered important, but recent research by the ADA again has shown that other methods of plaque removal are equally efficient.

The American Dental Hygienist Association (ADHA) considers that polishing of the teeth is a cosmetic procedure with little therapeutic benefit. Some have argued that continuous polishing over time can cause morphological changes in the teeth by abrading tooth structure and removing fluoride in the outer layers of the enamel. In some cases, polishing is required where there is heavy staining that cleaning with hand instruments will not take care of, but polishing should not be considered a routine part of the oral prophylaxis and the dentist and dental hygienist must assess each patient for the amount, type, and location of stain present to determine the need for polishing.

Air polishing was introduced in the mid-1980s. It is a technique for cleaning tooth surfaces efficiently removing stain and soft tissue deposits. The technique consists of directing a stream of air, water, and sodium bicarbonate particles at the tooth surface to be cleaned. Compared with conventional polishing methods using a rotating rubber cup or brush, together with a polishing paste, air polishing is less abrasive on the teeth, more efficient,

faster, and allows better access to difficult-to-reach areas. Concerns over airborne pathogens associated with the air polisher have arisen causing the ADA to study data on the matter. Data suggests that an aerosol reduction device attached to the air polishing unit is effective in reducing the number of aerosol microorganisms generated during air polishing and that the air polisher is a safe unit to use.

Description

Dental polishing, or more commonly called coronal polishing, is performed when scaling has removed the hardened tartar buildup. The patient is assessed by the dentist and hygienist to determine whether coronal polishing is necessary. If it is deemed necessary, a coronal polishing will remove any stain build up not removed by the scaling procedure. The duration of a polishing appointment can vary, depending on the amount of plaque and tartar build up. Commonly, prophylaxis is scheduled for 45 minutes of the hygienist's time and 10 minutes of the dentist's time. The coronal polishing is billed as part of the oral prophylaxis and is considered a preventive measure, most commonly covered by major insurance companies at 100%.

Preparation

Premedication with **antibiotics** prior to the polishing treatment is required for those patients with **heart** disease or a history of rheumatic **fever**. This is a preventive measure, since toxins released during the cleaning and polishing may enter the **blood** stream and travel to the heart. Premedication prescriptions can be written by the dentist or obtained from the patient's medical doctor.

Aftercare

The patient is advised not to eat or drink for 30 minutes following a cleaning/polishing appointment, to allow sufficient time for fluoride uptake.

Complications

There are usually no complications associated with coronal polishing.

Results

The results of coronal polishing are smooth teeth free of tartar and plaque build up. The results with the air polisher are smooth teeth, above and below the gum tissue.



A hygienist polishes a patient's teeth after they have been cleaned and checked for cavities. (Science Source/Photo Researchers. Reproduced by permission.)

Health care team roles

Licensed dental hygienists and dentists are best qualified to perform polishing procedures. Currently, 23 states in the U.S. allow dental assistants to perform coronal polishing. This raises concerns by the ADA and the ADHA because only half of these states require education or an examination in polishing for dental assistants. There is also a lack of standardization for education, examination, or certification for dental assistants among states. The ability to judge appropriately which patients should or should not be polished, is compromised if the practitioner is not knowledgeable about the procedure.

Air polishing should only be performed by a dental hygienist or dentist, as the direct flow and the exact amount of water used is crucial, depending on how much staining and tartar buildup is present.

Patients need to be made aware that coronal polishing research has changed today's procedures. Patients expecting to have their teeth polished after scaling might feel neglected and unsatisfied with the treatment. **Patient education** with literature and pamphlets relating to the research and the effects of coronal polishing, will help alleviate any concerns and greatly improve patient relationships.

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KEY TERMS

Abrade—To rub off or wear away by friction.

Enamel—Outer most layer or coat of a tooth.

Pathogen—An agent such as bacteria that causes disease.

Registered dental assistant (RDA)—An individual trained for the specific purpose of assisting the dentist in dental procedures.

Registered dental hygienist (RDH)—An individual trained for the specific purpose of oral hygiene who performs teeth cleanings and gives home care instructions.

Scaling—The removal of food and debris from the portion of the tooth above the gum line.

Sealant—A clear coating placed over permanent premolars and molars to guard against tooth decay.

(September 1999): 1354.

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ORGANIZATIONS

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Toothbrush see **Oral hygiene aids**

Toothpicks see **Oral hygiene aids**

Topical anesthetic see **Anesthesia, local**

Topical antifungal drugs see **Antifungal drugs, topical**

Topical medicine application

Definition

A topical medicine is a form of medication meant to be administered externally onto the body rather than ingested or injected into the body. Medicines administered to the eye, ear, and nose are considered topical medicines, will be discussed in separate articles. Topical medicine in this article refers to medicines applied externally onto the skin. Topical medicines available for external application include lotions, creams, ointments, powders (talc), and solutions (liquids). A specific dose of medication is prepared and suspended into a transport media such as a lotion. Topical lotions are water based and thin. They are absorbed quickly into the skin and are often invisible after application. Topical creams are thicker and are visible on the skin after application. They require more time for the medication to be absorbed into the skin. Ointments or unguents are the thickest form of topical medication. The medicine is suspended in a greasy substance that adheres to the skin until the medicine is absorbed.

Purpose

The purpose of using topical medicine is to deliver medication directly onto areas of the skin that are irritated, inflamed, itching, or infected. Topical medicines are often applied directly onto a rash or a irritated area on the skin for rapid relief of symptoms.

Precautions

Topical skin medicines should not be applied near the eyes or the mouth. They can cause stinging and irritation in the eyes and are not meant to be taken orally.

Description

To apply topical medicine, the health care provider places a small amount on gloved finger tips or a sterile gauze pad and spreads a thin layer of lotion, cream, or ointment across the affected area. Cover the affected area and overlap slightly onto the unaffected skin. A thin layer is usually sufficient. A thick coating may prevent air that is necessary for healing from reaching the wound.

Preparation

The health care provider should wash his or her hands and put on a glove before applying topical medicine. The medication label should be checked each time to avoid medication errors. Be sure it is the right medi-

cine, the right dose (strength), the right time, the right person and the right method. Look at the expiration on the label. Do not use outdated medicine. Cleanse the affected area on the skin with warm water or a gentle soap and water. This will remove drainage and the residue of old medication. Rinse and allow the skin to air dry.

Aftercare

After applying topical medicine, the health care provider should place the glove and/or gauze used to apply the medicine in a trash bag that can be closed and discarded. The hands should be washed. If topical medicines are applied to skin on the hands, the hands may need to be wrapped in gauze to prevent the patient from accidentally rubbing the medicine into their eyes or mouth. **Wounds** or rashes with a lot of drainage may require special dressings after the topical medicine is applied. Wrapping the area with a sealed dressing such as saran wrap will increase the absorption of the medicine. Follow the physician's or advanced practice nurse's directions in these matters.

Complications

Applying excessive amounts of topical medicine can cause adverse skin reactions such as redness, itching, and inflammation.

Results

Most topical medicines, when applied properly, will produce the desired results within a few days. Contact the leader of the health care team if the skin condition deteriorates or the original condition does not improve.

Health care team roles

Administering any medicine is generally the responsibility of a licensed nurse (R.N. or L.P.N.). Unlicensed staff can be trained to administer topical medicine under the direction of a **registered nurse** in some health care settings. A licensed nurse, however, must observe the affected area routinely to evaluate the outcome of medication application. The patient or a patient family member can be instructed on how to apply topical medicine in the home setting.

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TORCH test

Definition

The TORCH test, which is sometimes called the TORCH panel, consists of tests for antibodies to four organisms that cause congenital infections transmitted from mother to fetus. The name of the test is an acronym for the organisms detected by this panel: *Toxoplasma gondii* (toxoplasmosis), rubella (German measles), cytomegalovirus (CMV), and herpes simplex virus (HSV).

Purpose

Although the four diseases are not particularly serious for adults who are exposed and treated, women who are become affected with any of these diseases during **pregnancy** are at risk for **miscarriage**, still birth, or for a child with serious birth defects and/or illness. Thus, this test is performed before or as soon as pregnancy is diagnosed to determine the mother's history of exposure to these organisms. The test is also performed on neonatal serum when the newborn presents with symptoms consistent with a congenitally acquired **infection** by one of the organisms above.

Precautions

TORCH screening can be associated with both false negative and false positive results. False negative IgM

tests can result from IgG antibodies to the organism binding to the antigen used in the test or from **immunodeficiency** syndromes that reduce the antibody response to these organisms. False positive test results can result from rheumatoid, autoimmune, or heterophile antibodies in the mother's serum. When testing neonates, the IgG antibody levels may be detected as a result of prior infection or current maternal infection, and therefore does not mean the neonate is infected. Maternal antibodies to HSV and CMV may not adequately protect the fetus. TORCH screening requires **blood** from the mother and if needed, the neonate. The nurse or phlebotomist performing the venipuncture should observe **universal precautions** for the prevention of transmission of bloodborne pathogens.

Description

The TORCH panel is performed on women before or during pregnancy and on newborns if warranted by risk of infection during pregnancy. Samples from infants are usually obtained by the heelstick procedure when only a small quantity of blood is needed. The baby's foot is wrapped in a warm cloth for five minutes, to make the blood flow more easily. The foot is then wiped with an alcohol swab and a lancet is used to stick the baby's heel on one side. Blood is collected from adults by venipuncture. The blood is collected by a nurse or phlebotomist from a vein located in the crease of the arm. Serum, the liquid portion of the blood after it clots, is used for the test.

When a person is infected with a pathogen, the normal **immune response** results in the production of immunoglobulin M (IgM) antibodies followed by immunoglobulin G (IgG) antibodies. IgM antibodies against TORCH organisms usually persist for about three months, while IgG antibodies remain detectable for a lifetime, providing immunity and preventing or reducing the severity of reinfection. Thus, if IgM antibodies are present in a pregnant woman, a current or recent infection with the organism has occurred. If IgM antibodies are absent and IgG antibodies are present and do not demonstrate an increase on serial testing several weeks later, it can be assumed that the person has had a previous infection by the corresponding organism, or has been vaccinated to prevent an infection. If the serum of a person has no evidence of either IgM or IgG antibodies specific for the organism, then the person is at risk of infection if exposed because they do not have any demonstrable immunity.

TORCH testing is most often performed by enzyme linked immunosorbent assay (ELISA). These are double antibody sandwich enzyme immunoassays in which the

antigens or organisms are bound to a solid phase such as the bottom of a plastic well. Dilutions of the patient's serum are prepared and incubated with the antigens. Any specific antibodies to the antigen will bind forming antibody-antigen complexes. The wells are washed to remove unbound serum **proteins**, and enzyme-conjugated antihuman immunoglobulin is added. The wells are washed again to remove any unbound reagent antibody and a substrate is added. If antibodies to the organism are present, the enzyme converts the substrate to a colored product that can be measured. Assays for IgM or IgG antibodies are available. Alternative procedures include latex agglutination, indirect immunofluorescence assay for toxoplasma antibodies, chemiluminescence immunoassay, DNA amplification, and viral culture.

The TORCH panel is used to determine the immune status of a pregnant female for *Toxoplasma gondii*, rubella, cytomegalovirus, and herpes simplex virus. If IgG antibodies are present at a concentration that indicates immunity against each of these organisms, the female is in no danger of contracting a toxoplasma or rubella infection during pregnancy and transmitting it to the fetus. In addition, there is a low probability of transmitting a herpes simplex or CMV infection although the antibodies detected by the test may not be fully protective. If antibodies are absent, the patient will be observed closely during the pregnancy for any sign of suspected infection. Should an infection occur, it will need to be treated aggressively to prevent transmission to the fetus.

The organisms which comprise the TORCH panel are commonly encountered. Most people are exposed to them during childhood. In most healthy persons exposed to *Toxoplasma gondii*, the organism causes an asymptomatic infection or mild self-limiting illness resembling infectious mononucleosis. The same pattern occurs for CMV infection. Rubella causes an acute infection with **fever** and rash, but is self-limiting with symptoms subsiding in two to three days. Children and young adults are typically infected. Herpes simplex 1 typically causes fever blisters. The infections caused by TORCH organisms are grouped together because they may all result in stillbirth or serious birth defects when transmitted from an infected mother to her fetus during pregnancy.

The symptoms of the TORCH infections in neonates include:

- small size for gestational age (SGA)
- enlarged **liver** and spleen
- low level of platelets in the blood
- skin rash

- **central nervous system** involvement, including encephalitis, **calcium** deposits in the **brain** tissue, and seizures
- jaundice

This group of defects is called the TORCH syndrome. As such, other organisms causing serious congenital infections such as **syphilis**, human immunodeficiency virus, parvovirus, and enterovirus are sometimes considered part of this group. A newborn baby with these symptoms will be given a TORCH test and may be tested for some of these other infections as well.

In addition to these symptoms, each of the TORCH infections has its own characteristic symptoms in newborns.

Toxoplasmosis

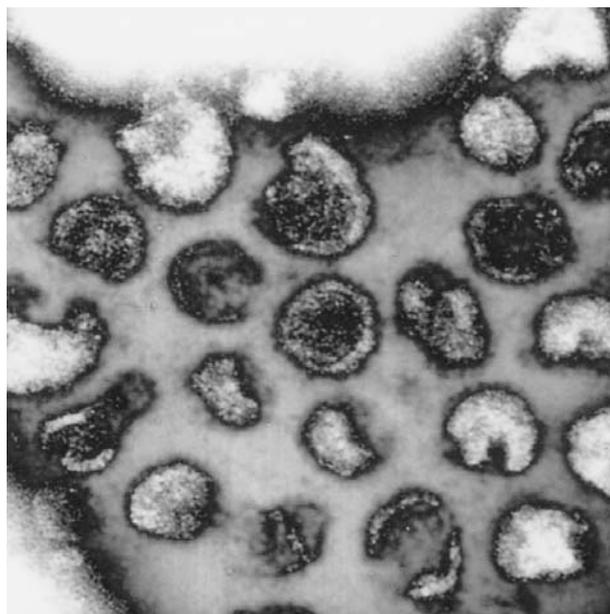
Toxoplasmosis is caused by *Toxoplasma gondii*, a parasite that can be acquired from ingesting cysts from the feces of infected cats, drinking unpasteurized milk, or eating contaminated meat containing the cyst or trophozoites. The infection is transmitted to the infant through the placenta, and can cause eye deformity, eye infections and mental retardation by invading brain tissue. The later in pregnancy the mother is infected, the higher the probability that the fetus will be affected. On the other hand, toxoplasmosis exposure early in pregnancy is more likely to cause a miscarriage or serious birth defects. The incidence of toxoplasmosis in newborns is between one to eight per 1,000 live births in the United States.

Rubella

Prior to the 1970s the incidence of congenital rubella infection was approximately 6.3 per 10,000 births. Ten years following the introduction of the vaccine the rate dropped six-fold to approximately one in 10,000 births. The rate of fetal infection varies depending on when in gestation the exposure occurred. Approximately 85% of neonates who develop birth defects as a result of infection during pregnancy contract the virus during the first eight weeks of gestation. Infants born with rubella may show signs of **heart** disease, retarded growth, ocular defects, or **pneumonia** at birth. They may also develop problems later in childhood, including autism, **hearing loss**, brain involvement, **immune system** disorders, or thyroid disease.

Cytomegalovirus

Cytomegalovirus belongs to the herpes virus group of infections. It can be transmitted through body secretions, as well as by sexual contact; some newborns acquire CMV through breast milk. Of newborns in the



A digitized image of rubella virus particles. (Custom Medical Stock Photo. Reproduced by permission.)

United States infected with CMV, 10% will have measurable symptoms. The mortality rate for these symptomatic newborns is 20-30%. Surviving infants with CMV may suffer from **hearing loss** (15%) or mental retardation (30%). Newborns that acquire CMV during the birth process or shortly after birth may develop pneumonia, hepatitis, or various blood disorders.

Herpes simplex virus

Herpes virus infections are among the most common viral infections in humans. They are spread by oral, as well as genital, contact. It is estimated that between one in 1,000 and one in 5,000 infants are born with HSV infections. About 80% of these infections are acquired during the birth process itself; the virus enters the infant through its eyes, skin, mouth, and upper respiratory tract. Of infants born with HSV infection, about 20% will have localized infections of the eyes, mouth, or skin. About 50% of infected infants will develop disease spread throughout the body (disseminated) within nine to 11 days after birth. Disseminated herpes infections attack the liver and **adrenal glands**, as well as other body organs. Without treatment, the mortality rate is 80%. Even with antiviral medication, the mortality rate is still 15-20%, with 40-55% of the survivors having long-term damage to the central nervous system. It is critical for the doctor to diagnose HSV infection in the newborn as soon as possible, for effective treatment.

TORCH testing is most effectively utilized to determine the mother's immune status and monitor those

KEY TERMS

Antibody—A protein molecule produced by the immune system that is specific to a disease agent, such as CMV. The antibody combines with the antigen on the organism and facilitates its destruction or removal from the host.

Perinatal—Referring to the period of time surrounding an infant's birth, from the last two months of pregnancy to the first 28 days of life. The TORCH panel tests for perinatal infections.

Small-for-gestational-age (SGA)—A term used to describe newborns who are below the 10th percentile in height or weight for their estimated gestational age. The gestational age is based upon the date of the mother's last menstrual period. SGA is one of the symptoms of TORCH syndrome.

Titre (titer)—The concentration of a substance in a given sample of blood or other tissue fluid.

pregnant females who do not demonstrate immunity. TORCH testing of neonates is difficult to evaluate, since maternal IgG from either present or past exposure crosses the placenta and will often produce higher levels in the neonate than in maternal serum. The infant's IgM response may or may not be developed sufficiently at birth to be definitive, and false positive and negative results are known to occur. When neonates are tested, the TORCH screen should include testing for specific IgM antibodies, and should be repeated within two to three weeks to demonstrate a rise in concentration indicative of active infection. Viral cultures or DNA probe tests are required to make a definitive diagnosis of the specific infection. CMV can be cultured from urine and white blood cells; herpes simplex can be cultured from vesicles on the skin or conjunctiva (mucus membranes inside the eyelids); both CMV and rubella may be cultured from cerebrospinal fluid, but culture time for rubella can take several weeks. Cultures are performed by inoculating living cells such as primary monkey kidney.

Preparation

No special preparation, other than sterile technique, is required.

Aftercare

There is no special aftercare specific to the test itself. Discomfort or bruising may occur at the puncture site, or

the person may feel dizzy or faint. Pressure to the puncture site until the bleeding stops reduces bruising. Applying warm packs to the puncture site relieves discomfort.

Complications

For the mother, minor temporary discomfort may occur with any blood test, but there are no complications specific to TORCH testing. For the infant, complications associated with the TORCH test are those resulting from the heelstick technique/venipuncture. These risks include scarring, infection, cellulitis (inflammation of cellular tissue), and small lumpy calcium deposits. Results of serological tests (antibody tests) on the neonate may be inconclusive. Follow-up testing may be needed to demonstrate a rise in antibody titre (concentration). Additional diagnostic testing and/or treatment is determined on a case-by-case basis, depending on results.

Results

A normal result is undetectable IgM antibody in the blood of either mother or neonate. The presence of IgM indicates recent or current infection. When specific IgM antibodies to TORCH antigens are found in the neonate, this indicates a very high probability of infection with the respective organism, and should be followed up by subsequent testing to demonstrate either a rise in titre or by viral culture or DNA tests.

For rubella and *Toxoplasma gondii*, the presence of a significant IgG titer in maternal serum indicates immunity for both mother and fetus. The presence of IgG antibody to CMV and herpes simplex in maternal serum may or may not be fully protective. When neonatal infection is suspected, TORCH testing of the neonate may not be definitive. IgG antibodies in fetal serum may result from either current or prior maternal infection or **vaccination**. In such cases, an IgM level should be measured in both maternal and neonatal serum, and viral cultures or DNA testing should be performed.

Results for TORCH antibodies may be interpreted as negative, equivocal, or positive. Equivocal results occur when antibody levels fall within an index value below the low positive standard but above the negative standard. Testing by another method is recommended. In addition, serum from the patient should be collected and retested after waiting an additional 10-14 days.

Health care team member roles

The test is typically ordered and interpreted by a physician. Blood samples for the TORCH screen are col-

lected by a nurse or phlebotomist. Pregnant women found to be exposed should receive treatment and a thorough explanation of potential consequences by their obstetrician. Counseling may be helpful. TORCH testing is performed by a clinical laboratory scientist/medical technologist.

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Rachael T. Brandt

Total body hydraulic lift usage

Definition

Devices used to transfer patients from a bed to a wheelchair, bedside commode, bathtub, etc. are known as total body, or Hoyer, lifts. (Hoyer was one of the first companies to manufacture the lifts, which are still known by that name.)

Purpose

Total body hydraulic lifts are typically used with patients who cannot bear weight, have physical limitations such as amputations or quadriplegia, or who are extremely heavy and cannot be safely transferred by members of the health care team or the patient’s caregivers. These portable lifts support all of the patient’s weight using a sling that is attached to a stand on wheels.

Precautions

Several precautions should be taken prior to using a total body lift. The weight capacity of the lift should be taken into consideration before using it with any patient.

Proper positioning of the sling must be insured, as well as proper positioning of the patient, maintaining good body alignment.

Description

Total body lifts are used in many maximal assistance patient transfers. Most lifts work through hydraulic devices that involve pumping or cranking the lift by hand. Many of the newer lifts, however, have an electric motor that is controlled by a hand control, eliminating the need for hand pumping. Consisting of a metal frame with a heavy canvas swing capable of suspending the patient, total body lifts are often a safer patient transferring option for both the patient and the caregiver.

When a patient is manually lifted, the health care professional or other caregiver must rely on their own strength to carry out the transfer. This frequently means that the caregiver is working beyond their physical capabilities. This increases the risk for mishandling or even dropping the patient during a manual lift. The majority of Hoyer lifts used are quite stable, require little force to move the lift with the patient in it, and are designed with slings that decrease the potential for skin tears or abrasions. In addition, most lifts can be operated by one person, which can free up other staff members to care for other patients.

The health care professional or other patient caregiver can safely transfer a patient utilizing a total body, or Hoyer, lift by following these steps:

- Assess the patient’s weight, making sure it falls within the weight limits of the particular lift being used.
- Obtain assistance from another caregiver if needed. Move the lift to the bedside and the object the patient is being transferred into to a convenient location.
- Raise the bed. Turn the patient on the side and place the canvas sling under the body, from head to knees.
- Instruct the patient to keep the arms crossed over the body. Position the lift with the legs spread and under the bed. Attach the lift chains to the sling, and adjust the sling, evenly distributing the patient’s weight.
- Raise the lift, elevating the sling just off of the bed.
- Maneuver the patient’s legs over the side of the bed. Insure that the patient’s head and extremities are protected from injury.
- Guide the lift over the object so the patient is positioned appropriately. Release the lift valve slowly, and lower the patient. Release the lift chains.

KEY TERMS

Hoyer lift—Hoyer was one of the first manufacturers to make portable total body lifts, and the devices continue to be called by that name.

Preparation

Prior to transferring a patient using a total body lift, instruct the patient on the procedure, and how he or she can assist by keeping their arms folded.

Aftercare

Assess the patient after the transfer is completed, noting how the patient tolerated the procedure.

Health care team roles

Many members of the health care team may use a total body lift to transfer a patient, including nurses and nursing assistants, and physical therapists. Health care professionals are responsible for knowing how to correctly and safely use the lift device to transfer patients.

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Total protein test see **Plasma protein tests**

Toxemia see **Preeclampsia and eclampsia**

Toxicology

Definition

Toxicology is the scientific study of poisons or toxins. The National Library of Medicine describes toxicol-

ogy as "the study of the adverse effects of chemicals or physical agents on living organisms." How these toxins affect humans is based in understanding these basic relationships.

Description

The Swiss physician and alchemist Philippus Aureolus, also known as Paracelsus (1493–1541) and said to be the father of the modern science of toxicology, wrote, "All things are poison, and nothing is without poison, the dose alone makes a thing not a poison." In other words, if **poisoning** is to be caused, an exposure to a potentially toxic chemical must result in a dose that exceeds a physiologically determined threshold of tolerance. Smaller exposures do not cause poisoning.

The dose of toxin is a crucial factor to consider when evaluating effects of a toxin. Small quantities of a substance like strychnine taken daily over an extended period of time might have little to no effect, while one large dose in one day could be fatal. In addition, some toxins may only affect a particular species of organism, such as pesticides and **antibiotics** killing insects and microorganisms with significantly less harmful effects to humans.

Organisms vary greatly in their tolerance of exposure to chemicals. Even within populations of the same species great variations in sensitivity can exist. In rare cases, some individuals may be extremely sensitive to particular chemicals or groups of similar chemicals, a phenomenon known as hypersensitivity. Organisms are often exposed to a wide variety of potentially toxic chemicals through medicine, food, water, and the atmosphere.

The study of the disruption of biochemical pathways by poisons is a key aspect of toxicology. Poisons affect normal physiology in many ways; but some of the more common mechanisms involve the disabling of enzyme systems, induction of cancers, interference with the regulation of **blood** chemistry, and disruption of genetic processes.

Toxic agents may be physical (for example, radiation), biological (for example, poisonous snake bite), or chemical (for example, arsenic) in nature. In addition, biological organisms may cause disease by invading the body and releasing toxins. An example of this is tetanus, in which the bacterium *Clostridium tetanus* releases a powerful toxin that travels to the nervous system.

Toxic agents may also cause systemic or organ-specific reactions in the body. Cyanide affects the entire body by interfering with the body's capacity for utilizing oxygen. Lead has three specific target organs: the **central nervous system**, the **kidneys**, and the hematopoietic

(blood-cell generating) system. The target organ is affected by the dose and route of the toxin. For example, the initial effects of a chemical may affect the nervous system; repeated exposure over time might cause chronic damage to the **liver**.

Function

The toxicologist employs the tools and methods of science to understand more completely the consequences of exposure to toxic chemicals. Toxicologists typically assess the relationship between toxic chemicals and environmental health by evaluating such factors as:

- **Risk**—To assess the risk associated with exposure to a toxic substance, toxicologists first measure the exposure characteristics and then compute the doses that enter the human body. Then they compare these numbers to derive an estimate of risk, sometimes based on animal studies. In cases where human data exist for a toxic substance, such as benzene, more straightforward correlations with human risk of illness or death are possible.
- **Precautionary strategies**—Given recommendations from toxicologists, government agencies sometimes decide to regulate a chemical based on limited evidence from animal and human epidemiological studies that the chemical is toxic.
- **Clinical data**—Some toxicologists devise new techniques and develop new applications of existing methods to monitor changes in the health of individuals exposed to toxic substances. For example, one academic research group in the United States has spent many years developing new methods for monitoring the effects of exposure to oxidants (for example, free radicals) in healthy and diseased humans.
- **Epidemiological evidence**—Another way to understand the environmental factors contributing to human illness is to study large populations that have been exposed to substances suspected of being toxic. Scientists then attempt to tie these observations to clinical data. Ecological studies seek to correlate exposure patterns with a specific outcome. Case-control studies compare groups of persons with a particular illness with similar healthy groups, and seek to identify the degree of exposure required to bring about the illness. Other studies may refine the scope of environmental factor studies; or, examine a small group of individuals in which there is a high incidence of a rare disease and a history of exposure to a particular chemical.
- **Evidence of bio-accumulation**—When a chemical is nonbiodegradable, it may accumulate in biosystems, resulting in very high concentrations accumulating in

animals at the top of food chains. Chlorinated pesticides such as dieldrin and DDT, for example, have been found in fish in much greater concentrations than in the seawater where they swim.

Role in human health

Humans are exposed to complex mixtures of chemicals, many of which are synthetic and have been either deliberately or accidentally released into the environment. In some cases, people actively expose themselves to chemicals that are known to be toxic, such as smoking cigarettes, drinking alcohol, or taking recreational drugs. Voluntary exposure to chemicals also occurs when people take medicines to deal with illness, or when they choose to work in an occupation that involves routinely dealing with dangerous chemicals. Most exposures to potentially toxic chemicals are inadvertent, and involve living in an environment that is contaminated with small concentrations of pollutants, such as those associated with pesticide residues in food, lead from gasoline combustion, or sulfur dioxide and ozone in the urban atmosphere.

Drugs given to improve health can lead to toxicity even when given in appropriate doses. Conditions such as **dehydration** and other forms of physiological compromise can make the patient more vulnerable to toxicity. Drugs like digoxin, lidocaine, and lithium are common examples of drugs with potentially toxic effects. Interactions of substances in the body may also produce toxic effects. For example, if two central nervous system depressants are taken at once, as in the case of combining alcohol and a tranquilizer, the effects are additive and could lead to extreme depression of the central nervous system functions.

The health care system's role related to toxicology includes education and prevention as well as treatment of both acute and chronic effects of toxins. Agencies such as the Food and Drug Administration (FDA) and the Occupational Safety and Health Administration (OSHA) work with health care and industry to offer guidelines and restrictions on the manufacture and use of pharmaceuticals, foods, and other substances.

Health care workers are involved by being aware of these regulations, and staying informed. They also provide education, such as, teaching new parents about the dangers of lead paint consumption by children, and help prevent exposure to toxins, such as, tetanus **vaccination**, or monitoring for signs of lithium toxicity. The Poison Control Center uses nurses and other allied health workers to inform the public of immediate actions to take in the event of a poisoning emergency. Emergency interventions at the hospital include blood and urine tests,

KEY TERMS

Antidote—A substance that combats the effects of a poison or toxin.

Gastric lavage—The act of emptying out the stomach via orogastric or nasogastric tube.

gastric lavage with administration of absorbent activated charcoal, and administration of antidotes when available.

Common diseases and disorders

Toxicologists have ranked the most commonly encountered toxic chemicals in the United States. In descending order of frequency of encounter, they are as follows:

- **Arsenic**—Toxic exposure occurs mainly in the workplace, near hazardous waste sites, or in areas with high natural levels. A powerful poison, arsenic can, at high levels of exposure, cause death or illness.
- **Lead**—Toxic exposure usually results from breathing workplace air or dust, or from eating contaminated foods. Children may be exposed to lead from eating lead-based paint chips or playing in contaminated soil. Lead damages the nervous system, kidneys, and the immune systems.
- **Mercury**—Toxic exposure results from breathing contaminated air, ingesting contaminated water and food, and possibly having dental and medical treatments. At high levels, mercury damages the **brain**, kidneys, and developing fetuses.
- **Vinyl chloride**—Toxic exposure occurs mainly in the workplace. Breathing high levels of vinyl chloride for short periods can produce dizziness, sleepiness, unconsciousness, and, at very high levels, death. Breathing vinyl chloride for long periods of time can give rise to permanent liver damage, immune reactions, nerve damage, and liver **cancer**.
- **Benzene**—Benzene is formed in both natural processes and human activities. Breathing benzene can produce drowsiness, dizziness, and unconsciousness. Long-term exposure affects the bone marrow and can produce anemia and leukemia.
- **Polychlorinated biphenyls (PCBs)**—PCBs are mixtures of chemicals. They are no longer produced in the United States, but remain in the environment. They can irritate the nose and throat, and cause acne and rashes. They have been shown to cause cancer in animal studies.

- **Cadmium**—Toxic exposure to cadmium occurs mainly in workplaces where cadmium products are made. Other sources of exposure include cigarette smoke and cadmium-contaminated foods. Cadmium can damage the **lungs**, cause kidney disease, and irritate the digestive tract.

Resources

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ORGANIZATIONS

American Association of Poison Control Centers (AAPCC).
<<http://www.aapcc.org>>.

OTHER

National Library of Medicine Toxicology Tutor Web site.
<<http://sis.nlm.nih.gov/ToxTutor>> and, TOXNET,
<<http://www.nlm.nih.gov/toxnet>>.

Katherine Hauswirth, A.P.R.N.

Toxoplasmosis test see **TORCH test**

Trace metal tests

Definition

Trace metals are a group of metals that include both heavy and transitional elements present in submilligram quantities in the **blood**. There are two groups, the micronutrients that are essential for health and those that have no known biological function. The essential micronutrients that may be measured include arsenic, chromium, cobalt, **copper**, **iron**, manganese, nickel, selenium, and **zinc**. Rarely, molybdenum, tin, and vanadium may also be measured. The nonessential metals that may be measured are lead, mercury, aluminum, thallium, and cadmium.

Purpose

All trace metals have the potential to be toxic when present in excessive concentrations. Trace metal tests are required when the patient has symptoms of toxicity or when the patient is in a high risk category for environmental exposure to a toxic metal. Excessive amounts of a trace metal can cause specific diseases or abnormalities that will require medical intervention and removal of the metal by chelation therapy. Deficiencies of micronutrients including iron, zinc, copper, and selenium are common and can lead to significant medical problems. Tests

for these metals are sometimes needed in order to diagnose essential trace metal deficiency and its cause.

Precautions

A blood sample or urine sample is required for trace metal testing. When performing venipuncture, the nurse or phlebotomist collecting the sample should observe **universal precautions** for prevention of transmission of bloodborne pathogens. Trace metal contamination is a potentially serious problem with samples for trace metal analysis. Metals are present in the materials used to manufacture rubber stoppers and lubricants used in blood collection tubes. Therefore, special tubes with lubricant-free stoppers are required. Samples for lead analysis require whole blood because the lead is primarily within the red blood cells. Special tubes containing heparin or EDTA (ethylenediaminetetraacetic acid) are used for this purpose. These have a tan colored stopper and are certified to be lead free. Other trace metals are usually measured in serum or urine. If serum is used, the blood must be collected in a tube having a navy blue stopper. The only exception is iron which is present in sufficient concentration in serum or plasma to allow use of regular blood collection tubes. In addition, when performing analysis of any trace metal, the water used must be Type I purity, and the reagents must meet or exceed American Chemical Society (ACS) purity standards.

Description

Measurement techniques

With the exception of iron, the method of choice for routine trace metal measurement is atomic absorption spectrophotometry with a graphite furnace atomizer. The instrument should be capable of background absorbance correction. Iron is the trace metal in highest concentration in plasma and can be measured by colorimetric methods. Other suitable methods for trace metal analysis include inductively coupled plasma mass spectroscopy and emission spectroscopy.

The following list represents both essential and nonessential trace metals that are measured in the medical laboratory. The most commonly measured metal and the only one routinely measured as part of a comprehensive metabolic profile is iron. The principal reason for measuring iron is to detect iron deficiency states that lead to anemia, or excessive iron ingestion that leads to tissue damage caused by excessive deposition of iron in tissues such as the **liver**. The most commonly measured nonessential metal is lead. There are many environmental sources of lead, but it is especially prevalent in paint chips, lead pipes, car exhaust, and cigarette smoke.

Young children are at greatly increased risk because they absorb up to five times more lead from the intestinal tract than adults. Since lead exposure during childhood can result in diminished intellectual ability, many medical centers have established lead screening programs in high prevalence areas.

A brief description of the major effects of the trace metals listed above follows:

- **Aluminum (Al):** Toxic levels are found in patients with **chronic kidney failure** who have received hemodialysis over long periods of time; the dialysis solutions contain aluminum. Also at risk are diabetic patients (aluminum is present in medications) and those who ingest large quantities of **antacids** containing aluminum. Excess aluminum is deposited in the **brain** and in bone. Aluminum is a potent inhibitor of parathyroid hormone and induces osteomalacia. **Central nervous system** toxicities include convulsions, behavior, and speech disturbances.
- **Arsenic (As):** The organic form of arsenic is nontoxic but the ionic form is toxic. Arsenic is found in some herbicides, pesticides, insecticides, and seafood. Excessive amounts usually result from ingestion of poisons containing arsenic. Symptoms vary depending upon whether exposure is acute or chronic. Acute toxicity causes nausea, vomiting, abdominal **pain, diarrhea**, cardiac arrhythmia, and kidney damage, and very high doses can induce **coma**. Chronic exposure causes dermatitis, abnormal nail growth pattern, headache, drowsiness, confusion, and bone marrow failure.
- **Cadmium (Cd):** Cadmium is used to manufacture batteries and is used extensively in automotive spray painting. It is also prevalent in industrial pollution and in cigarette smoke. Breathing excessive amounts can cause lung damage (**emphysema**). Ingestion or inhalation causes dizziness, headache, and intestinal irritation. Chronic exposure causes damage to the renal tubules known as heavy metal nephrosis.
- **Chromium (Cr):** Chromium is used to manufacture stainless steel, tan leather, and dye fabrics. Breathing excessive amounts can cause **lung cancer**. Chromium is also a skin irritant and excessive exposure to skin leads to ulceration.
- **Cobalt (Co):** Cobalt is used in various industrial processes, and inhalation of cobalt in dust can cause **asthma**. Symptoms include goiter, nerve damage, excessive blood cell production, and cardiomyopathy.
- **Copper (Cu):** Copper is the third most abundant trace metal and deficiency is more common than toxicity. The most common cause of copper deficiency is total **parenteral nutrition**. This leads to anemia, bone loss,

hyperlipidemia, impaired immune function, and glucose intolerance. Copper toxicity is associated with a genetic deficiency of ceruloplasmin, Wilson's disease. This results in copper accumulation in the liver, eyes, kidney, and brain which is fatal without chelation therapy.

- **Iron (Fe):** Iron is the most abundant trace metal and is needed to make hemoglobin. Iron deficiency results in anemia and is most commonly seen in children with inadequate dietary intake; adults who exhibit chronic blood loss; and multiparous females who have not received iron supplementation. Iron excess is most often caused by increased ingestion and absorption of iron supplements or exposure from iron pots used for cookware. Some persons absorb excessive iron for unknown reasons. Accumulation of iron in the tissues leads to hemochromatosis which results in renal damage, cirrhosis, and an enlarged spleen and liver. The **pancreas** may become damaged leading to **diabetes mellitus** and deposition in other tissues causes inflammatory damage (e.g., deposits in joints cause arthritis).
- **Lead (Pb):** Lead is found in old paint, some ceramic products, lead-soldered water pipes, industrial waste, car exhaust, and cigarette smoke. Excessive amounts cause anemia, renal tubular nephrosis, diminished intellectual capacity and developmental delays in children, headache, drowsiness, and gastrointestinal upset.
- **Manganese (Mn):** Manganese is found in paint, cleaners for laboratory glass, and red brick. Excessive exposure to manganese dust in miners can cause pneumonitis. Chronic **poisoning** usually results from industrial exposure. Manganese accumulates in the brain causing symptoms similar to Parkinson's disease.
- **Mercury (Hg):** Mercury is used in the manufacture of paper, plastics, paint, and dental amalgams. The two most common sources of exposure are industrial pollution and ingestion of seafood containing methyl mercury, which is toxic. Excessive exposure can cause pulmonary, brain, kidney, liver, and gastrointestinal damage.
- **Nickel (Ni):** Nickel is used in industrial processes as a catalyst and as an alloy for steel and other metals. Skin contact causes eczema in sensitive individuals. Ingestion of toxic levels can result in headache, vomiting, vertigo, and nausea. Inhalation of toxic levels can cause asthma and a pneumonia-like condition.
- **Selenium (Se):** Selenium is a micronutrient needed for normal **heart** function, and deficiency leads to cardiomyopathy. Selenium deficiency is seen in regions where soil and water are depleted of **minerals**. It occurs in persons with gastrointestinal malabsorption, patients with kidney disease receiving dialysis, and patients

receiving total parenteral **nutrition**. Excess toxicity is most commonly caused by excessive dietary supplementation and causes cirrhosis, enlarged spleen, hair loss, and gastrointestinal bleeding.

- **Thallium (Tl):** Thallium is used during the lead smelting process and as a rodent killer. Excessive amounts can cause hair loss, confusion, seizures, **paralysis**, and kidney failure.
- **Zinc (Zn):** Zinc is the second most abundant trace metal. Zinc deficiency is usually associated with total parenteral nutrition and drugs that prevent absorption, but a genetic deficiency causing reduced gastrointestinal absorption is also a rare cause. Deficiency causes dermatitis, diarrhea, impaired growth, hypogonadism, anemia, enlarged liver, hair loss, and decreased immune function. Zinc is used in metal plating and excessive exposure can cause **fever**; and skin, throat, and gastrointestinal irritation.

Lead poisoning

Children are often screened for lead poisoning since even very low levels of lead in their body can impact growth, learning, and intelligence. Before 1970, high levels of lead were routinely found in paints. A child has an increased risk of lead exposure if he or she lives in an older, dilapidated house that contains lead paint. As the paint chips and peels, young children, especially those six months to six years old, are at particular risk since they are young enough to put chips, dust, or their contaminated fingers in their mouths. The daily diet normally contains a small amount of lead, approximately 300 micrograms per day. Adults absorb 1-10% of ingested lead, but children absorb lead more efficiently putting them at greater risk for toxicity.

Suspected cases of lead poisoning can be presumptively diagnosed with two surrogate tests. Lead blocks the incorporation of iron into protoporphyrin, resulting in the inability to form heme, the iron-containing component of hemoglobin. This results in increased levels of erythrocyte protoporphyrin (ZPP) in which protoporphyrin is bound to zinc instead of iron and free erythrocyte protoporphyrin (FEP). Both ZPP and FEP can be measured by fluorometric analysis. However, both are also increased in iron deficiency, aluminum poisoning, and erythropoietic porphyria as well as lead poisoning.

Preparation

Usually, there is no special preparation for the patient before testing.

Aftercare

Since only a small sample of blood (or urine) is collected, no complex aftercare is required. The patient should be comforted (especially young children), and direct pressure should be applied to the venipuncture or finger stick site for several minutes or until the bleeding has stopped.

Complications

In normal circumstances, a blood draw for a heavy metal test takes only a few minutes, and the patient experiences minor discomfort and a minute puncture wound at the site of the needle stick.

Results

Reference ranges for specific metals are provided based on the type of testing performed by the laboratory, the specimen provided, and the type of metal tested. Representative ranges are shown below:

- Aluminum: less than 6 micrograms per liter.
- Arsenic: in urine less than 100 micrograms per liter (in whole blood less than 70 micrograms per liter).
- Cadmium: less than 5 micrograms per liter.
- Chromium: 0.5-2.1 micrograms per liter (urine 0.5-5.0 mcg/L).
- Copper: 75-150 micrograms per liter.
- Iron: 500-1500 micrograms per liter.
- Lead: Normal in children: less than 100 micrograms/L; Normal in adults: less than 300 micrograms/L.
- Lead (in ZPP testing for lead poisoning): Normal in children and adults: 15–77 micrograms/dL; Average: less than 35 micrograms/dL.
- Manganese: less than 7.9 micrograms per liter.
- Mercury: less than 5 micrograms per liter.
- Nickel: less than 5.2 micrograms per liter urine.
- Selenium: 95-160 micrograms per liter.
- Thallium: less than 10.1 micrograms per liter.
- Zinc: 50-150 micrograms per liter.

Health care team roles

A physician orders trace metal tests and interprets the results. The nurse, physician assistant, or nurse practitioner may participate in the medical examination of the patient, and should perform a careful history in order to document any environmental source of metal exposure (such as working in a battery manufacturing plant, auto-

KEY TERMS

Edematous—The state of swelling (edema) caused by the collection of excess fluid within tissues.

Hematoma—Swelling and subsequent bruising when blood leaks from a vein into local tissues; can be caused by improper venipuncture when the needle has gone through a vein or when the needle has been inserted incorrectly.

Hemodialysis—Procedure used to filter toxins and waste products from the blood while the blood circulates outside the body; dialysis is used for patients with kidney failure.

Venipuncture—Puncture of a vein with a needle for the purpose of withdrawing a blood sample for analysis.

mobile paint shop, etc.) that could be linked to the symptoms. A nurse or phlebotomist collects the specimen for trace metal tests. Trace metal analysis is performed by clinical laboratory scientists/medical technologists with special training in the use of atomic absorption spectrophotometry.

Additionally, health care providers should contact community health officials if the poisoning is acquired by an industrial or environmental exposure that may affect other people.

Patient education

The health care provider's role in educating patients about trace metal poisoning is crucial, especially in cases of suspected lead poisoning in children. The health care provider should explain how lead poisoning is acquired, and work with the parents to determine the lead source. Since the health complications for children are serious, it is vital that the parents understand that treatment may be needed immediately and further testing will be required to monitor the lead level and its effects. The health care provider can work with adult patients to determine the source of metal in their homes or work environments and inform them about treatment and follow-up testing requirements.

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ORGANIZATIONS

- Alliance to End Childhood Lead Poisoning. 227 Massachusetts Ave., N.E., Suite 200, Washington, D.C. (202) 543-1147. <<http://www.aeclp.org>>.
- Lead Poisoning Prevention Branch, Division of Environmental Hazards and Health Effects, National Center for Environmental Health, Centers for Disease Control and Prevention. 1600 Clifton Rd., Mailstop E25, Atlanta, GA. (404) 498-1420. <<http://www.cdc.gov/nceh/lead>>.

Linda D. Jones, B.A., PBT (ASCP)

Tracheostomy see **Tracheotomy**

Tracheostomy care

Definition

A tracheostomy is a surgically created opening in the trachea. A tracheostomy tube is placed in the incision to secure an airway and to prevent it from closing. Tracheostomy care is generally done every eight hours and involves cleaning around the incision, as well as replacing the inner cannula of the tracheostomy tube. After the site heals, the entire tracheostomy tube is replaced once or twice per week, depending on the physician's order.

Purpose

The goals of tracheostomy care are to maintain the patency of the airway, prevent breakdown of the skin surrounding the site, and prevent **infection**. Sterile technique should be used during the procedure.

KEY TERMS

Inner cannula—Smaller tube that fits inside the tracheostomy tube, which can be removed quickly if it becomes obstructed. This is often used for patients who have copious secretions.

Tracheostomy tube—An indwelling tube used to maintain patency of the tracheostomy. It can be made of metal (for long term use) or disposable plastic. The tube can be cuffed (a balloon is inflated to keep the tube in place) or uncuffed (air is allowed to flow freely around the tube). It can also be fenestrated, which allows the patient to speak.

Precautions

Extra precautions should be taken when performing site care during the first few days after the tracheostomy is surgically created. The site is prone to bleeding and is sensitive to movement of the tracheostomy tube. It is recommended that another health care professional securely hold the tube while site care is performed. Tracheostomy care should not be done while the patient is restless or agitated, since this increases the chance that the tube may be pulled out and the airway lost.

Description

Tracheostomy care starts with suctioning the patient's airway, both via the tracheostomy and orally. Sterile technique must be used when suctioning the tracheostomy. The gauze dressing is removed from the tracheostomy site, and the amount and color of drainage should be noted. Using sterile technique, the skin and external portion of the tube are cleaned with hydrogen peroxide. Cotton-tipped applicators should be used to clean closely around the stoma. The condition of the skin and stoma should be noted. The area is then wiped with gauze dampened in 0.9% sodium chloride and a new tracheostomy dressing is applied.

If the patient has a disposable inner cannula, the old cannula can simply be removed and discarded. A new cannula is inserted using sterile technique. If the inner cannula is not disposable, it must be cleaned with hydrogen peroxide, rinsed with 0.9% sodium chloride, and reinserted. Sterile technique must be used, and the cannula should be tapped against the side of the sterile container to remove excess fluid. It should not be completely dried, as the film of saline facilitates reinsertion.



A health care professional changes tracheostomy dressings as a part of patient care. (Delmar Publishers, Inc. Reproduced by permission.)

Preparation

All supplies needed for tracheostomy care should be at the bedside prior to beginning the procedure. There are prepackaged tracheostomy care kits available that contain gauze pads, cotton-tipped applicators, a tracheostomy dressing, and hydrogen peroxide. In addition, a container of 0.9% sodium chloride solution, a suction kit, and sterile gloves are needed. The velcro strap that holds the tracheostomy tube in place may be soiled and need to be replaced as well.

The patient should be preoxygenated with 100% oxygen prior to suctioning. If the patient is agitated, a sedative should be given or the procedure should be rescheduled for a later time when the patient is calm. **Pain** medication may be offered, especially during the first few days after surgery when manipulating the incision can cause discomfort.

Aftercare

After tracheostomy care is finished, the soiled dressing and supplies should be discarded, either in the garbage or in a biohazard container if there is a large amount of

blood. The patient may need to be suctioned again, and his or her respiratory status should be reassessed. Again, pain medication should be offered as appropriate.

Complications

Tracheostomy care is a relatively benign procedure. The greatest risk is that the tube may be inadvertently removed and the airway lost.

Results

The anticipated outcomes of tracheostomy care include continual patency of the airway, prevention of skin breakdown around the stoma, and prevention of infection.

Health care team roles

The nurse has the primary role in tracheostomy care, as he or she is responsible for doing it in the acute care setting. The respiratory therapist may assist the nurse during the procedure and during respiratory assessment. Some patients may be sent home with a tracheostomy. In

this case, the nurse and respiratory therapist are both responsible for teaching the patient and the family how to perform site care at home.

Resources

BOOKS

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Abby Wojahn, RN,BSN,CCRN

Tracheotomy

Definition

A tracheotomy is surgery in which a cut is made into the skin of the throat and then into the windpipe (trachea). The surgeon inserts a breathing tube into the opening. The purpose may be to bypass an obstruction (such as a chunk of meat stuck in the throat) and thus allow air to get into the **lungs**, or it may be to remove secretions.

Since about 1950, the term "tracheostomy" has been preferred to "tracheotomy," but many surgeons still use the older term. The suffix "-tomy" is derived from the Greek for "cutting," and thus "tracheotomy" means simply "cutting the trachea." The Latin for "mouth," is *os*, *oris*, and so "tracheostomy" comes to mean "cutting an (artificial) mouth into the trachea." "Tracheostomy" thus has the advantage of being more specific than "tracheotomy."

Purpose

A tracheotomy is performed if there is a blockage in the pharynx or in the upper trachea, or if the patient is having problems with mucus and other secretions getting into the windpipe (trachea). There are many reasons why the pharynx or the upper trachea may be blocked. The patient's windpipe may be blocked by a swelling, by a severe injury to the neck, nose, or mouth, by a large foreign object, by **paralysis** of the throat muscles, or by a tumor. Patients who need help to breathe may be in a **coma**, or, because of spinal injury affecting the cervical nerves that control breathing, the patients may need a ventilator to pump air into the lungs for a long time.

Precautions

Doctors perform emergency tracheotomies as last-resort procedures. They are only done if the patient's windpipe is obstructed and the situation is life-threatening.

Description

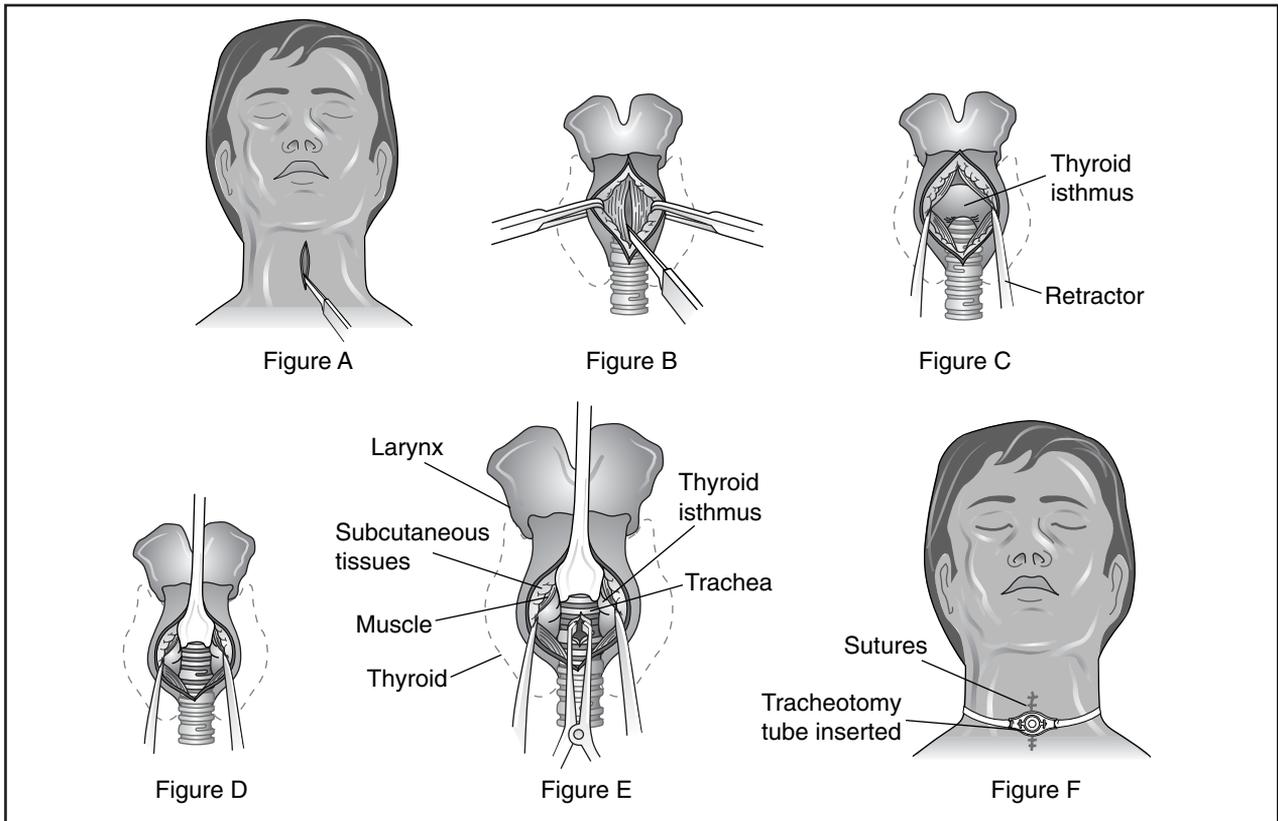
Emergency tracheotomy

There are two different procedures that are called tracheotomies: emergency tracheotomies and non-emergency (elective) tracheotomies. The first is done only in extreme emergency situations and must be performed quite rapidly. It may be done anywhere, even in a restaurant, if the person would likely die while being transported to a proper operating room. The surgeon (sometimes, a non-surgeon must perform the tracheotomy) makes a cut into a thin part of the voice box (larynx) called the cricothyroid membrane. A tube is inserted and connected to an oxygen bag. This emergency procedure is sometimes called a cricothyrotomy. Cricothyrotomy is associated with a few immediate complications, such as hemorrhage and collapsed lung (pneumothorax).

Non-emergency (elective) tracheotomy

The second type of tracheotomy takes more time and is usually done in an operating room. The most common reason for performing a non-emergency (elective) tracheotomy is the need for the patient to undergo long-term mechanical ventilation. In this situation, the tracheotomy replaces a tube which had been inserted into the trachea through the patient's nose or mouth (an endotracheal tube). Other valid reasons for non-emergency (elective) tracheotomy include life-threatening aspiration **pneumonia**, poor clearance of bronchial secretions, and sleep apnea.

The surgical procedure itself is basically the same in the emergency and non-emergency (elective) tracheotomy. The surgeon first makes a cut (incision) into the skin of the neck that lies over the trachea. This incision is made in the lower part of the neck, between the Adam's apple and the top of the breastbone. The neck muscles are separated, and the **thyroid gland**, which overlies the trachea, is usually cut down the middle. The surgeon identifies the rings of cartilage that make up the trachea and cuts into the tough walls. A metal or plastic tube, called a breathing tube (tracheotomy tube), is inserted through the opening. This tube acts as an artificial windpipe and thus allows the patient to breathe. Oxygen or a mechanical ventilator may be hooked up to the tube to bring oxygen more effectively to the lungs. A dressing is placed around



Tracheotomy is a surgical procedure in which an opening is made in the windpipe or trachea. As shown in the illustration above, the physician or surgeon will follow these steps in performing this procedure: **Figure A:** A vertical incision is made through the skin. **Figure B:** Another incision is made through the subcutaneous tissues and muscles of the neck. **Figure C:** The neck muscles are separated using retractors. **Figure D:** The thyroid isthmus is either cut or retracted. **Figure E:** The surgeon identifies the rings of cartilage that make up the trachea and cuts into the walls. **Figure F:** A metal or plastic tube is inserted into the opening and sutures are used to hold the tube in place (Illustration by Electronic Illustrators Group.)

the opening. Tape or stitches (sutures) are used to hold the tube in place.

After a non-emergency tracheotomy, the patient usually stays in the hospital for one or two days, unless there is a complicating condition.

Preparation

Emergency tracheotomy

In the emergency tracheotomy, there is no time to explain the procedure or the need for it to the patient. The patient is placed on his or her back with face upward (supine), with a rolled-up towel (if available) between the shoulders. This positioning of the patient makes it easier for the doctor to feel and see the structures in the throat. A local anesthetic (if available, for example in the emergency room of a hospital, but not in a proper operating room) is injected across the cricothyroid membrane. In a setting such as a restaurant, one just cuts, without anes-

thesia. If the person would otherwise die within five minutes from lack of oxygen, the **pain** and risks are justified.

Non-emergency (elective) tracheotomy

In a non-emergency tracheotomy, there is time for the doctor to discuss the surgery with the patient, to explain what will happen and why it is needed, and to get the patient's **informed consent**. The patient is then given anesthesia (sometimes general, sometimes local or topical). The neck area and chest are then disinfected as preparation for the operation, and surgical drapes are placed over the area, setting up a sterile field.

Aftercare

Postoperative care

A **chest x ray** is often taken, especially in children, to check whether the tube has become displaced, or, of course, in any patient when complications are known to

KEY TERMS

Cartilage—A tough, fibrous connective tissue that forms various parts of the body, including the trachea and the larynx.

Cricothyrotomy—An emergency tracheotomy that consists of a cut through the cricothyroid membrane to open the patient's airway as quickly as possible.

Larynx—A structure in the throat made basically of cartilage, ligaments, and muscle, that connects the pharynx with the trachea. The larynx contains the vocal cords.

Maceration—Softening and eventual disintegration of tissue because of constant exposure to moisture.

Stoma—Artificially created opening between a body cavity and the surface of the body. ("Stoma" is Greek for the mouth.)

Trachea—The tube made of cartilage and other connective tissue that leads from the voice box (larynx) to two major air passages (the main bronchi) that bring oxygen to the lungs. The trachea is sometimes called the windpipe.

Ventilator—A machine that helps patients to breathe. It is sometimes called a respirator.

have occurred. The doctor may prescribe **antibiotics** to reduce the risk of **infection**. If the patient can breathe on his or her own, the whole room is humidified; otherwise, if the tracheotomy tube is to remain in place, the air entering the tube from a ventilator is humidified. During the hospital stay, the patient and his or her family members will learn how to handle the problems that the tracheotomy tube causes, including mechanically sucking mucus out of the throat and keeping the tube itself clear. Tracheotomy initially prevents easy swallowing because the larynx is no longer elevated. Secretions are removed by passing a smaller, sterile tube (catheter) into the tracheotomy tube and extending it down into one of the two main bronchi. The tracheotomy tube itself generally requires several cleanings every day. An aseptic, or preferably a sterile, technique must be used. It is important that the skin around the opening (stoma) be carefully maintained to prevent secondary infection and disintegration caused by moisture (such softening and disintegration is called "maceration").

It takes most patients several days to adjust to breathing through the tracheotomy tube. At first, it will be hard even to make non-speech sounds. If the tube allows some air to escape and pass over the vocal cords, then the patient may be able to speak by holding a finger briefly over the tube. A patient on a ventilator will not be able to talk at all.

The tube will be removed if the tracheotomy is temporary. Then the wound will heal quickly, and only a small scar may remain. If the tracheotomy is intended to be permanent, the hole stays open. If eventually it is no longer needed, it will be surgically closed.

Home care

After the patient is discharged, he or she will need help at home to manage the tracheotomy tube. Warm compresses can be used briefly to relieve pain at the incision site. However, in general, the patient is advised to keep the area dry, lest prolonged moisture cause disintegration of the skin (maceration).

It is recommended that the patient wear a loose scarf over the opening when going outside. He or she must drink fluids to avoid **dehydration** and must eat to maintain proper **nutrition**. At the same time, he or she must keep water, other fluids, small food particles, and powdery substances from entering the tube and thus causing serious breathing problems. The doctor may prescribe pain medication and antibiotics to minimize the risk of infections.

If the tube is to be kept in place permanently, the patient can be referred to a speech therapist in order to learn to speak with the tube in place. The tracheotomy tube may be changed four to ten days after surgery.

Patients are encouraged to resume most of their normal activities once they leave the hospital. Vigorous activity is restricted for about six weeks. However, swimming and rough contact sports would be life-threatening. Even when taking a shower, the patient must keep the tracheotomy covered. If the tracheotomy is permanent, further surgery may be needed to widen the opening, which narrows with time.

Risks

Immediate risks

There are several short-term risks associated with tracheotomies. Severe bleeding is one possible complication. The voice box or the esophagus may be damaged during surgery. Air may become trapped in the tissues surrounding a lung, causing it to collapse. The tracheotomy tube can be blocked by **blood** clots, mucus, or the

pressure of the airway walls. Blockages can be prevented by suctioning, humidifying the air, and selecting the appropriate tracheotomy tube. Serious infections are rare unless suction tubes are inserted without aseptic (or preferably sterile) technique. In cases of such carelessness, one is introducing **bacteria** into the suction catheter.

Long-term risks

Over time, other complications may develop following a tracheotomy. The windpipe itself may become damaged for a number of reasons, including pressure from the tube, bacteria that cause infections and form scar tissue, or friction from a tube that moves too much. Sometimes the opening does not close on its own after the tube is removed. This risk is higher in tracheotomies with tubes remaining in place for 16 weeks or longer. In these cases, if the breathing tube is to be removed because it is no longer necessary, the wound is surgically closed.

High-risk groups

The risks associated with tracheotomies are higher in the following groups of patients:

- children, especially newborns and infants
- smokers
- alcoholics and other substance-abusers
- obese adults
- persons over 60
- persons with chronic respiratory diseases or respiratory infections
- persons taking **muscle relaxants**, sleeping medications, tranquilizers, or cortisone

The overall risk of death from a tracheotomy is less than 5%.

Results

Normal results include uncomplicated healing of the incision (even in an emergency tracheotomy) and successful maintenance of long-term tube placement in a non-emergency (elective) tracheotomy.

Health care team roles

A variety of allied-health personnel is likely to be involved in the care of patients requiring a tracheotomy. In the case of an emergency tracheotomy, an emergency-room nurse or **nurse anesthetist** will assist the surgeon. A respiratory nurse or therapist will provide information

to the patient and family about how to properly clean and maintain the tracheotomy tube if the tube is to be used long-term. This specialist will also provide information about administration of food and water and other issues. A nurse will likely provide information to the patient about how to prevent infection at the site of tube placement. A nurse specializing in the healing of **wounds** may work with the patient whether the tube is intended to be short-term or long-term. In many cases, a speech therapist is used to help the patient resume verbal communication following the trauma of the tracheotomy. This is more likely to occur in patients who will need long-term mechanical ventilation.

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Mark Mitchell

Traction *see* **Spinal traction**

Tranquilizers, major *see* **Antipsychotic drugs**

Tranquilizers, minor *see* **Antianxiety drugs**

Transcranial Doppler ultrasonography

Definition

Transcranial **Doppler ultrasonography** (TCD) is a noninvasive method of evaluating cerebrovascular **blood** flow (CBF), the flow of blood in the vessels of

the **brain**. The TCD technology allows changes in the rate of blood flow (velocity) over time to be easily followed, documented, and analyzed. Ultrasonography (ultrasound) is a diagnostic imaging technology that directs high-frequency sound waves into the body, where they either bounce off or pass through body tissues and fluids. Echoes from the tissues and fluids return to the ultrasound machine, where changes in pitch and direction are instantly measured and displayed on a monitor as a picture (image) of the tissue or body organ being scanned. Doppler ultrasonography measures what is called the Doppler effect, the frequency change that occurs when ultrasound is directed toward **blood vessels** and reflected back to the source. Unlike reflected ultrasound signals that are received as an image, reflected Doppler waves make an audible sound that corresponds to the **heart** beat.

The Doppler principle is a wave theory first described by an Austrian physicist, Christian Doppler, in 1842. It relates to the velocity of objects and wave frequencies either transmitted or received by these objects. In Doppler ultrasound, the rate and direction of blood flow in the vessels can be determined by the frequency of the reflected sound, which indicates the rate of blood flow in the reflecting vessel (blood vessel sending back the sound waves). While Doppler ultrasound has been in use since 1965 to monitor fetal heart rates and blood flow in the carotid artery in the neck, it has only been in use since 1981 to measure blood flow velocity in the arteries of the head.

Purpose

TCD has proven to be a safe, fast, and reliable procedure for measuring the rate of CBF, especially as an assessment of risk for stroke. Individuals at risk for stroke usually have high blood velocities in the vessels of the brain. The rates of flow can be up to three or four times normal. Restrictions in blood flow may occur with the narrowing of blood vessels (stenosis), clot formation (thrombosis), blockage of blood vessels (embolism), or blood vessel rupture (hemorrhage). Lack of sufficient blood flow (ischemia) threatens brain tissue and may cause a stroke or other types of brain damage.

While ultrasonography typically receives inaudible echoes from tissues or organs and displays them as images, TCD measures changes in the frequency of transmitted waves, which are received as audible sounds. Just as a siren's pitch sounds higher when its source is moving toward the listener and lower as it moves away, so will ultrasound waves change pitch, or frequency, as they bounce off the blood flow in veins and arteries. Faster blood flow causes a greater change in frequency.

These frequency shifts can be used to measure both the direction and the speed of blood flow in even the smallest of blood vessels.

Combined with other tests, this information can be used to locate restrictions in the blood vessels in the brain, and to track changes in blood flow over time. Ultrasound images can also be produced by the TCD equipment (as in ultrasound exams that view other body tissues or organs) from the reflected sound so that a vascular lesion (site of damage, blockage, or blood clot) can be found and examined. In this way, TCD can offer valuable information about the location of blockage or a clot that has caused a stroke and can help monitor the patient's response to therapy after a stroke. TCD is also used to evaluate the contraction of blood vessels that may occur if a blood vessel ruptures. Besides helping to diagnose stroke, TCD is used to evaluate brain death, **head injury**, abnormalities in veins and arteries, detection of blockage or rupture of vessels, and in surgical procedures such as heart bypass surgery or procedures requiring anesthesia.

Precautions

Ultrasonography procedures, including TCD, are noninvasive and painless. They are considered to be safe procedures with no known side effects. There are no special precautions.

Description

A TCD machine is an ultrasound scanner with Doppler capability. It is usually portable and is easy to set up in an examining room or at the patient's bedside. The first step in a TCD exam is to find an ideal location on the head (called an acoustic window) where the ultrasound beam can pass through the **skull** and allow the best transmission of sound waves. Because bone absorbs sound waves, areas where the bone is thinner are best for TCD exams. Children have thinner bones, and it is possible to obtain good signals from a large area of the head. The elderly have thicker bones, making it more difficult to obtain a good evaluation of blood flow velocity.

TCD is done with probes called transducers, which transmit and receive the ultrasound signals. These probes are placed against the skin of the head at the selected windows. The sonographer spreads a clear gel on the areas where a probe will be placed. Typical sites are the temple, the base of the skull at the back of the neck, and over the closed eyelid. These sites have the least amount of thick protective bone and will allow the best sound wave transmission. The sonographer adjusts the probe position and orientation to direct the sound waves toward

the blood vessels of interest. Finding the best approach may take some time. A compression test may be performed during the exam. In this test, the main artery in the neck (carotid artery) is briefly compressed, and changes in blood flow patterns are observed. A full TCD exam may last 30 to 45 minutes, although a longer examination may be necessary in patients with known cerebrovascular disease.

Preparation

No special preparation is needed. The patient should remove **contact lenses**, and may wish to avoid the use of eye makeup, since the gel is likely to smear it. For convenience and comfort during the procedure, the patient should wear loose, comfortable clothing and no earrings or hair ornaments.

Aftercare

The gel is washed off with soap and water. No other aftercare is needed.

Complications

TCD is noninvasive and has no notable complications. A compression test is occasionally, though very rarely, hazardous for a patient with narrowed arteries (atherosclerosis), since the increased pressure may dislodge a piece of the substance that causes the narrowing (plaque).

Results

Normal results

TCD ultrasonography calculates blood flow velocity, which, in turn, helps determine direction of flow and restrictions in flow. The sound being measured will vary depending on the direction and rate of flow through the vessel being examined. Each of the vessels in the brain has a characteristic direction of flow, which can be altered in various conditions. Flow rates are variable from person to person depending upon the condition of the vessels in the brain and the rate of blood flow from the heart. A normal result will correspond to typical flow rates and direction of flow for each of the brain's blood vessels. Blood flow velocity may be measured in several sites, after which a peak flow velocity and an average velocity will be calculated.

Abnormal results

Diminished blood flow indicates that a vessel has been blocked to some extent. Lack of a signal may mean

KEY TERMS

Cerebrovascular—The blood vessels that make up the vascular system of the brain, including all veins and arteries that carry blood.

Doppler ultrasonography—Measures frequency changes that occurs when ultrasound signals are directed toward blood vessels and reflected back to their source. Transcranial Doppler ultrasonography (TCD) pertains to frequency changes measured in the blood vessels of the brain.

Frequency—The number of cycles of a wave over time, such the frequency of a sound wave.

Transcranial—Scanning through the skull.

Transducer—Also called a probe, a hand-held instrument that transmits and receives sound waves, which can then be measured by electronic equipment. In an ultrasound examination, a transducer is used to scan the body.

Ultrasonography—Also called ultrasound scanning or sonography; a safe, non-radiologic, non-invasive diagnostic imaging technology in which high frequency sound waves are bounced off or passed through body tissues to obtain a visual image of the tissue or body organs being evaluated.

Ultrasound image—Also called a scan or a sonogram; created on a computer monitor when high frequency sound waves are transmitted into the body and the resulting echoes are recaptured and displayed by the ultrasound system.

no blood flow due to complete blockage, although absence of a signal may also mean that sound waves have been absorbed by bone. If blood in a certain vessel flows in the wrong direction or alternates between normal and reverse flow, it may indicate a blockage elsewhere in the brain. This happens because blood is rerouted when a blockage causes differences in intracranial pressure.

An increased rate of flow may mean that blood is flowing through a restricted area just “upstream” from the probe. Although it seems that a restricted blood vessel would cause the speed of blood flow to slow down, the opposite is true. This is because the same amount of blood going through a narrower opening must go faster. Increased speed is also seen if a vessel is carrying rerouted blood.

Health care team roles

Ultrasound procedures, including TCD, are usually performed by a sonographer in an ultrasound or radiology department in a hospital or in a separate diagnostic imaging facility. When these procedures are performed during surgery, they may be performed by an anesthesiologist or other physician. The sonographer will explain the procedure to the patient, describing each step in a reassuring manner. A radiologist, who is a physician experienced in diagnostic imaging examinations, such as radiology (x ray) and ultrasound exams, will usually analyze the Doppler results and simultaneous images of the vessels examined. The testing physician will use the information to aid in diagnosis and treatment of the patient.

Training

Sonographers are specifically trained to understand and use ultrasound equipment, including Doppler equipment, and to perform a broad range of ultrasound exams. They will have a good understanding of ultrasound electronics, of computer functions in the ultrasound scanning equipment, and they will be able to observe ultrasound images and interpret results, although they will neither diagnose nor advise patients.

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Society for Diagnostic Medical Sonographers (SDMS). 12770 Coit Road, Ste. 708, Dallas, TX 75251. (800) 229-9506.

L. Lee Culvert

Transcutaneous electrical nerve stimulation
see **Electrotherapy**

Transcutaneous electrical nerve stimulation unit

Definition

A transcutaneous electrical nerve stimulation (TENS) unit is used to apply electrical currents through

the skin to the nerves via electrodes in order to reduce chronic and acute **pain** from various causes.

Purpose

TENS is a noninvasive therapeutic **pain management** modality that is used alone or in conjunction with pain medications or other pain-management techniques. A TENS unit is used to transmit low-voltage electrical currents through the skin to the underlying nerves at the area where pain occurs. TENS is used to treat both chronic and acute pain associated with musculoskeletal problems (e.g., arthritis, low back pain), dental problems and procedures, **bursitis**, menstruation, urinary incontinence, surgical procedures, labor and delivery, fracture pain, and traumatic injuries. TENS is also used as an adjunct treatment for chemotherapy-induced nausea and vomiting.

Description

A TENS unit consists of an electronic stimulus generator, which transmits electrical current to electrodes placed directly on the patient's skin. Most TENS units use two or four electrodes to transmit electrical impulses. The number of impulses (frequency), the pulse duration, and intensity can be adjusted. Some TENS units offer modulation, which allows the frequency, duration, and intensity to be intermittently changed, and a burst mode, which allows groups of rapid pulses to be applied at regular intervals. The treatment parameters (i.e., rate of stimulation, pulse intensity and duration, other settings) are based on the type of TENS unit used, the patient's medical condition, and response to stimulation.

The physiological mechanism of TENS pain relief is not fully understood, but two theories have been proposed to explain it: gate control and endorphin release.

According to the gate-control theory, pain is experienced when certain small unmyelinated fibers are stimulated (the "gate" is opened). Pain is not felt when larger myelinated fibers that inhibit the feeling of pain are stimulated (the gate is closed). The electrical currents produced by a TENS unit stimulate these large myelinated fibers, blocking pain stimuli transmitted by the smaller unmyelinated fibers.

According to the endorphin release theory, TENS is believed to stimulate the release of endorphins, peptides in the body that help inhibit the transmission of painful stimuli.

TENS units are available in desktop, handheld, portable, and wearable configurations, depending on the manufacturer and clinical applications for which the unit is designed. For example, some TENS units dedicated to



The transcutaneous electrical nerve stimulation (TENS) unit is used to help relieve pain through electrical impulses. The main unit is powered by a battery. The electrodes are placed on the skin after a gel has been applied to aid conductivity. (Photograph by Faye Norman. Science Source/Photo Researchers. Reproduced by permission.)

treating premenstrual pain and dysmenorrhea are smaller and configured with a belt clip and battery operation so the patient can wear the unit for the duration of pain treatment.

TENS is used in **physical therapy**, rehabilitation, primary care, hospital, chiropractic care, long-term care, and home-care settings, and is initially administered with close supervision of the patient to evaluate their response to treatment. Depending on their pain and associated medical condition, the patient may then given instructions on how to use the TENS unit at home according to a prescribed schedule.

Operation

To use a TENS unit, electrodes are placed on the patient's skin in the painful area, on either side of the spine, in peripheral nerve areas, or at trigger points, depending on the nature of the patient's pain. Electrodes should be kept at least 3 centimeters (1.18 inches) apart. The most common type of electrode supplied with the TENS unit is made of soft rubber that may require conducting gel before application. Other types of electrodes

include those made of disposable foam or sponge that must be moistened with water, conductive self-adhesive polymer, or reusable pregelled material. Leads are then plugged into one end of each electrode and into output sockets on the electronic generator unit. Pulse rate, intensity, and duration are then adjusted according to the patient's condition; a vibration or tingling sensation may be felt and the muscles may twitch as the electrical pulses are delivered.

TENS should not be used in patients with **tuberculosis**, malignant tumors, high or low **blood pressure**, high **fever**, carotid sinus hypersensitivity, or acute inflammatory disease. Electrodes should not be applied over the eyes, the front of the throat, directly over a wound, on skin wet from bathing or sweating, over broken skin, or over psoriasis and similar skin conditions. Because TENS may interfere with pacemaker operation, electrodes should not be applied in the vicinity of a pacemaker, and TENS use in patients with **pacemakers** should be carefully supervised.

There are very few side effects associated with the use of a TENS unit. Minor skin irritation may occur from

KEY TERMS

Dysmenorrhea—Painful menstruation.

Electrode—A conductor used to complete the electrical circuit between the TENS unit and the patient.

Endorphins—A group of naturally occurring peptides that, when released, act like a painkiller by inhibiting the transmission of pain impulses.

Lead—Insulated wires that connect the TENS unit to the electrode.

Trigger points—Areas on the skin that, when stimulated electrically, produce sensations at that point or elsewhere on the body.

the electrodes; proper cleaning of the patient's skin and changing the electrodes daily can alleviate irritation. Some sensitive patients may have an allergic reaction to gel or the electrode material. If TENS is applied in areas with poor sensation, skin **burns** may occur.

Maintenance

TENS units are, in general, low-maintenance systems that need only periodic battery checks to ensure effective delivery of the electrical pulses. Many TENS units have self-testing features that detect defective leads and electrodes; if the unit does not have self-testing features, leads and electrodes should be checked frequently to avoid potential shocks. Rubber electrodes can last years with proper cleaning and use; the leads should not be detached between uses, as this increases wear on the rubber and the connection. Pregelled reusable electrodes can be used for approximately one month or 100 hours.

Health care team roles

Depending on where the patient is being treated for pain and how TENS treatment is prescribed, a number of healthcare professionals could be involved. In physical therapy and rehabilitation settings, the therapist, nurse, or clinical assistant could administer TENS. In the hospital and primary care settings, physicians and/or nurses could administer TENS. Chiropractors, naturopathic physicians, and pain-management professionals (e.g., anesthesiologists) may also prescribe and administer TENS. The nurse or other clinician trained in the use of TENS can instruct patients using TENS at home, ensuring that they

understand how to apply TENS and are compliant with their pain-management protocol.

Training

Training in the use of the TENS unit is provided by the manufacturer for administration by clinical staff. Detailed manuals on maintenance and use are provided with the unit.

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Jennifer E. Sisk, M.A.

Transesophageal echocardiography

Definition

Transesophageal **echocardiography** (TEE) is a diagnostic test in which an **endoscope** with an ultrasound transducer at its tip is inserted into the patient's esophagus by means of a catheter (thin tube). Sound waves are transmitted and received by the transducer to

produce a clear image of the **heart** muscle and other parts of the heart.

Purpose

Since the esophagus is located directly behind the heart, transesophageal echocardiography provides a very clear image of the heart. It can provide information on the size of the heart, its pumping strength, and the location and extent of any damage to its tissues. TEE can also detect the presence of abnormal tissue growth around the heart valves. It is useful for identifying abnormalities in the pattern of **blood** flow, such as the backward flow of blood through partly closed heart valves (regurgitation). TEE is especially useful in cases in which conventional echocardiography (a test in which the transducer is moved across the patient's chest) cannot offer a good image, as when the patient is obese or has a thick chest wall. TEE is also used to monitor heart function during cardiac surgery; to detect blood clots in the left atrium of the heart; and to diagnose infections in pacemaker lead infections.

TEE is performed with portable devices and equipment, and it is safer and less expensive than aortography, an invasive procedure performed in a **cardiac catheterization** laboratory. TEE is less expensive than computed tomography and **magnetic resonance imaging**, two diagnostic imaging modalities commonly used for cardiac studies; in addition, it allows a more direct evaluation of the heart. Finally, results from a TEE examination are available within 15 minutes, which offers the physician another advantage over **CT scans**.

The convenience, safety, and promptness of TEE make it the diagnostic procedure of choice in patients suspected of aortic dissection, especially those who are in unstable condition. TEE can also be used for long-term follow-up of these patients.

Precautions

Transesophageal echocardiography should be performed only by physicians who have received the necessary postgraduate training. It is a highly specialized technique requiring advanced skills in interpreting results as well as performing the procedure.

TEE should not be performed in patients with **dysphagia** (difficulty swallowing), indications of gastroesophageal disease, or injuries to the esophagus. Before the procedure, the patient should be asked about any drug **allergies** and current medications, since some medications may entail risks during the procedure. For example, patients on anticoagulant therapy are at risk for bleeding complications.

Patients should avoid consuming alcohol for a day or so before and after TEE, since alcohol may amplify the effects of the sedative used with the procedure.

Description

TEE uses the same principles as conventional echocardiography to produce images of the heart, namely high-frequency sound waves. TEE produces sharper images, however, because the transducer is positioned directly behind the heart, not on the chest wall as in conventional echocardiography.

A TEE examination generally lasts 15–30 minutes. The patient is given a mild sedative intravenously, and the back of the throat is sprayed with a local anesthetic in order to suppress the gag reflex. The patient is positioned on the left side. A special viewing tube called an endoscope, which contains a transducer at the tip, is inserted through the mouth and into the esophagus. The instrument is carefully moved until it is positioned directly next to the heart. Essentially a modified microphone, the transducer directs ultrasound waves into the heart, some of which are reflected (or echoed) back to the transducer. Tissues of different densities and blood all reflect ultrasound waves differently. These sound waves can be translated into an image of the heart, displayed on a monitor, or recorded on paper or tape. The transducer may be moved several times during the test to help the doctors get a better view of the heart.

TEE can be performed as an outpatient procedure in an echocardiography laboratory; as an inpatient procedure in an operating room; or as an emergency procedure in an intensive care unit or emergency department.

Preparation

The patient is asked not to eat or drink for six hours before the TEE examination. Patients who wear dentures must remove them before the test. The patient may be given a mild sedative intravenously before the procedure, and an anesthetic is sprayed into the back of the throat in order to suppress the gag reflex.

Aftercare

After the test, the patient must refrain from eating or drinking until the gag reflex has returned—otherwise, he or she may accidentally inhale some of the food or beverage. In addition, patients should not drive or operate heavy machinery for at least 10–12 hours if they have been given a sedative. They should avoid consuming alcohol for a day or so, since alcohol may amplify the effect of the sedative.

KEY TERMS

Aneurysm—A dilatation of the aorta or other artery, caused by a weakening of the vessel wall.

Aorta—The main artery of the circulatory system, conveying blood from the left ventricle of the heart.

Dissection—Separation of the layers of arterial tissue in the aorta, resulting from blood being forced out into the wall of the aorta through a tear in the innermost layer of tissue.

Dysphagia—Difficulty in swallowing.

Endoscope—An instrument used to visualize and examine the inside of a body cavity or organ.

Gag reflex—A normal reflex consisting of elevation of the palate, retraction of the tongue, and contraction of the throat muscles.

Regurgitation—The backward flow of blood through a partly closed valve.

Transducer—A device that converts electrical signals into ultrasound waves and the echoes back into electrical impulses.

Ultrasound—Sound waves at a frequency of 2–10 megahertz (mHz), often used for diagnostic imaging.

Complications

Transesophageal echocardiography may cause gagging and discomfort when the endoscope is inserted down into the throat. Patients may also experience a **sores throat** for a few days after the test. In rare cases, the procedure may cause bleeding or perforation of the esophagus, or an inflammatory condition known as infective **endocarditis**. The patient may also have an adverse reaction to the sedative or local anesthetic.

Results

A normal transesophageal echocardiogram shows a normal heart structure and normal patterns of blood flow through the valves and chambers of the heart.

In terms of abnormal findings, a transesophageal echocardiogram may show a number of abnormalities in the structure and function of the heart, such as thickening of the wall of the heart muscle (especially the left ventricle). Other abnormal findings may include aneurysms or

dissections of the aorta; regurgitation; or blood clots in the left atrium of the heart.

Health care team roles

TEE is performed by a cardiologist trained and experienced in the applications of cardiac sonography. A cardiac ultrasonographer may assist during the procedure. Nurses are present during TEE to monitor the patient's **vital signs**. During cardiac surgery, TEE may be performed by the cardiac surgeon or by a cardiovascular anesthesiologist.

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American Heart Association National Center. 7272 Greenville Avenue, Dallas, TX 75231. (800) AHA-USA1. <<http://www.americanheart.org>>.

American Society of Echocardiography. 1500 Sunday Drive, Suite 102, Raleigh, NC 27607. (919) 787-5181. <<http://asecho.org>>.

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Transferrin test *see* **Iron tests; Plasma protein tests**

Transfusion therapy

Definition

Transfusion therapy refers to the process of administering whole **blood** or blood components to a patient through an intravenous (IV) needle or catheter placed in a patient's vein. Blood and blood products may be autologous (comprised of the patient's own blood), homologous (blood donated from another person), or synthetic (blood products developed in a laboratory). Some of the types of blood products available for transfusion include: whole blood, plasma, platelets, packed red blood cells (RBCs), leukocyte-poor RBCs, white blood cells (WBCs), clotting factors (II, VII, VIII, IX and X complex), anti-inhibitor coagulant complex, human antithrombin III, and human Rh (D) immune globulin.

Purpose

The most common purpose for administering a transfusion is to replace lost blood volume. Transfusions are also given to increase the blood's ability to carry oxygen to the tissue, to improve immunity, or to correct blood-clotting problems. Some specific purposes of transfusions include:

- Replacement of blood volume lost due to trauma or surgery.
- Correction of anemia caused by chronic conditions.
- Treatment of immune suppression.
- Treatment of thrombocytopenia.
- Replacement of missing clotting factors.
- Correction of coagulation deficiencies.
- Treatment of **hemophilia** or other congenital clotting deficiencies.
- Treatment of chronic hypoproteinemia.
- Suppression of active antibody response in Rh negative patients exposed to Rh positive blood.

Precautions

Donor blood must be compatible to the recipient of the transfusion. Compatibility blood testing (type and cross match) must be performed before administering homologous blood to avoid serious transfusion reactions. This blood test assures that the donor blood matches and is compatible with the recipient blood (including the blood type and the **Rh factor**). In an emergency when there is no time for matching blood, type O, Rh-negative blood (universal donor) is used until compatibility testing can be performed.

To minimize the chance of giving a patient the wrong product and causing a severe transfusion reaction, blood and blood products are labeled with patient name, number, type, and Rh factor by the blood bank. The clinician should check and record the blood bag name, number, type, and Rh factor against the patient's identification armband and the lab slip numbers twice with another nurse before administering blood products. The nurse should recheck the physician's order and the expiration date on the blood product before giving the blood product.

Patients must understand and sign an **informed consent** form before receiving a blood transfusion. Blood is never given without the patient's consent. When a patient is unable to give consent, the closest family member should sign the form. The consent assures that the patient or family member is aware of the risks involved in blood transfusions including the potential for an allergic reaction, transfusion reaction, and/or the possibility of contracting an **infection** from the transfusion.

Special equipment is used for blood transfusions to assure proper flow of the blood product and to filter out impurities or small clots. Use appropriate blood tubing, filter tubing, and/or needle filters as directed in the policy of the medical setting. The tubing may vary according to the blood product being administered. Blood and blood products require a separate IV line, separate IV lumen in a multi-lumen central line, or an IV line that has been thoroughly flushed with normal saline. Blood and blood products are not compatible with IV solutions other than normal saline. Drugs should not be administered through the IV line while blood or blood products are running. Drugs may be given in some medical settings through a separate lumen of a multi-lumen central IV line if the lumen is flushed with normal saline before and after drug administration.

Blood should be given to the patient within 30 minutes of receiving it from the blood bank. If there is a delay because of IV line issues or other patient needs, the blood should be returned to the blood bank until the staff is ready to administer the blood. This decreases the chance of **bacteria** growing in the blood bag and helps prevent confusion and errors. Never transfuse blood for longer than four hours to minimize risks of infection.

Nurses monitor patients receiving blood or blood products closely by checking their **vital signs** every 15 minutes during the first hour of the transfusion and hourly thereafter or as dictated by the policy of the medical setting. Transfusion reactions most often occur within the first 15 minutes of the blood administration. If signs such as high **fever**, rapid pulse, wheezing, shortness of breath, flushed face, chest **pain**, flank pain, hematuria or restlessness occur, the nurse should stop the

KEY TERMS

Antipyretic—A medication used to reduce fever.

Autologous transfusion—The collection, filtration and re-administration of a person's own blood. The blood for an autologous transfusion is collected, filtered, and stored for a patient prior to surgery or may sometimes be salvaged after a traumatic injury or during major surgery.

Clotting factors—Plasma proteins normally found in the blood that work with platelets to help blood clot.

Coagulation—The process of thickening or clotting of the blood.

Hematuria—The appearance of blood or blood cells in the urine.

Hemolytic reaction—A serious transfusion reaction that occurs when donor blood type or Rh factors are not compatible with the recipient's blood. Red blood cell destruction within the body causes symptoms such as shaking, chills, fever, chest pain, difficulty breathing, flank pain, and abnormal bleeding. Hemolytic reactions can lead to major organ failure, shock, and death.

Homologous transfusion—The intravenous delivery of blood or blood products donated by one person (donor) to another person (recipient).

Hyperkalemia—An excess of potassium in the blood which can cause heart muscle irritability and arrhythmias.

Hypocalcemia—A deficiency of calcium in the blood which can cause symptoms of muscle tin-

gling or cramps, nausea, vomiting, lowered blood pressure, and seizures.

Hypoproteinemia—A deficiency of protein in the blood.

Hypothermia—An abnormally low body temperature, usually below 92°F (33.3°C).

Non-hemolytic febrile reaction—An antigen antibody reaction that occurs in 1% of all transfusions. Symptoms include a temperature elevation, chills, palpitations, back pain, chest pain, or headache.

Plasma—The liquid portion of the blood.

Platelets—Small disc-shaped substances found in the blood that assist in blood clotting.

Red blood cells—Cells found in the blood that contain hemoglobin, transport oxygen to body tissue, and are responsible for the red coloring of the blood.

Rh factor—An antigen found on the membrane of red blood cells that will mount an immune response to transfused blood or blood products if not matched correctly before transfusion.

Thrombocytopenia—A persistent deficiency of blood platelets that leads to problems with blood clotting.

White blood cells—White or colorless cells found in the blood that do not contain hemoglobin, but contain a nucleus and help protect the body from infections and disease.

transfusion, change the IV tubing, and run in normal saline slowly. The nurse should keep the line open in the event that drug therapy is needed to reverse the reaction. He or she should elevate the head of the bed, administer oxygen if needed, monitor the patient's vital signs, and contact the physician immediately. The reaction should be documented and the blood bag and tubing returned to the blood bank for testing. There is usually a transfusion reaction protocol in the medical setting for collecting post-reaction blood or urine specimens. If the patient develops itching and a rash during a transfusion, the nurse should slow the flow rate down and contact the physician before stopping the blood. The physician may elect to administer **antihistamines** and continue the

blood transfusion. If the patient develops a low-grade fever during transfusion, the nurse should slow the flow rate and contact the physician before stopping the blood. The physician may elect to administer an antipyretic and continue the transfusion.

Fluid overload can occur (especially in children or the elderly) as a result of a transfusion running too rapidly. The nurse should run blood in slowly (generally over two hours) and monitor the patient closely for restlessness, rapid pulse, or respiratory distress. The flow rate should be adjusted according to the physician's order or the policy of the medical setting. Flow rates may vary according to the product. For instance, the rate for whole blood may be different than the rate for packed cells.

Description

The blood or blood product is checked by two nurses, two times to be sure the label on the bag matches the patient and the lab slip. The patient should state his name, and the armband should be checked to avoid errors. The nurse should check the expiration date on the unit, to make sure to not give blood products past their expiration dates. He or she should gently rotate the bag in the hands to mix the blood or blood components and then connect the blood or blood product to the IV line in place of the normal saline. If a Y-tubing is in use, the saline line is shut off and the blood product line is opened. Blood products are usually started slowly at 5-10 ml per minute for the first 15 minutes. The line and the patient should be checked frequently during the first 15 minutes of the transfusion to assure that the line is intact, the rate is correct, and the patient is not displaying signs of a reaction. After 15 minutes, vital signs should be obtained and compared to pre-transfusion vital signs to detect any changes. The blood flow rate can then be increased to the correct flow rate for the product being delivered. The patient's vital signs, affect, IV site, and transfusion flow rate should be checked and recorded every 15 minutes for the first hour of the transfusion and then hourly until the completion of the transfusion or according to the medical setting policy.

Preparation

A blood specimen is drawn from the patient, so that the blood bank can type, match, and prepare the appropriate blood product. In most settings an armband is placed on the patient's wrist at the time of the blood draw with a number and name that will later match the blood product label. A physician or nurse will explain the procedure to the patient and obtain a signed informed consent for the transfusion. A physician or nurse will insert either a peripheral or central IV line and connect it to a normal saline drip with appropriate blood tubing and filters in place. If the patient has a peripherally inserted central catheter (PICC), it is better to start another peripheral IV to deliver blood because a PICC line has such a long narrow tubing that blood flows slowly through it and has a tendency to clog the line. Blood will flow most easily through a large bore (#18 or #19) needle or catheter. A blood pump, pressure bag, or blood warmer should be obtained if necessary. Blood warmers are most often used in the surgical or neonatal setting. Most IV pumps will pump blood without damaging the cells, but the medical center's policy should be checked for using blood pumps. The nurse should take and record a set of base-line vital signs, including the patient's **blood pressure**, temperature, pulse, and respirations prior to transfusion. The

patient should be placed in a comfortable position in bed during a transfusion to enhance **relaxation** and decrease resistance to the blood flow.

Aftercare

When the transfusion is complete, the IV line is flushed with normal saline and discontinued or changed to other IV solutions with new IV tubing for ongoing IV therapy. The patient should be observed for 30 minutes after a transfusion for delayed reactions. A final set of vital signs is taken and recorded 30 minutes after the transfusion is finished. Blood slips are returned to the lab. Fresh IV tubing should be used for subsequent units of blood or blood products. Gloves should be worn when handling used blood supplies. Blood bags, tubing, and catheters are placed in a contaminated trash bag that can be sealed and discarded. Needles are placed (without recapping) in a puncture-proof contaminated needle box.

Complications

Complications of transfusion therapy are not frequent but can include:

- allergic reactions
- hemolytic reactions
- non-hemolytic febrile reactions
- circulatory overload
- hypothermia
- hypocalcemia
- hyperkalemia
- microbial contamination
- disease transmission (AIDS, hepatitis C or bacterial infection)

Results

The results of transfusion therapy are usually rapid and positive. Blood volume is expanded, missing factors are replaced, clotting problems are corrected, or immunity is improved. In some cases, a patient may need multiple transfusions to reach desired effect. Most transfusions are safe; however, mild febrile and allergic reactions occur in about 1-2% of all transfusions. Severe or fatal transfusion reactions are rare. Autologous transfusions are the safest type of transfusion and pose the least risk for infection or reaction. Autologous blood, however, is not always available when needed.

Health care team roles

Transfusion therapy is usually performed by a **registered nurse** in a controlled medical setting because of the need for ongoing assessment and the potential for transfusion reaction. Transfusions are occasionally administered in the home by a registered nurse who has access to appropriate equipment, emergency medical back-up, and immediate contact with a physician.

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Transplant reaction screening test see

Cytomegalovirus antibody screening test

Traumatic amputations

Definition

Traumatic amputation is the accidental severing of some or all of a body part. A complete amputation totally detaches a limb or appendage from the rest of the body. In a partial amputation, some soft tissue remains attached to the site.

Description

Trauma is the second leading cause of amputation in the United States. About 30,000 traumatic amputations occur in this country every year. Four of every five traumatic amputation victims are male, and most of them are between the ages of 15 and 30.

Traumatic amputation most often affects limbs and appendages such as the arms, ears, feet, fingers, hands, legs, and nose.

Causes and symptoms

Farm and factory workers have greater-than-average risks of suffering injuries that result in traumatic amputation. Automobile and motorcycle accidents and the use of lawnmowers, saws, and power tools are also common causes of traumatic amputation.

Blood loss may be massive or minimal, depending on the nature of the injury and the site of the amputation. Persons who lose little blood and have less severe injuries sometimes feel more **pain** than those who bleed heavily and whose injuries are life-threatening.

Diagnosis

When an injured person and the amputated part(s) reach the hospital, an emergency department physician will assess the probability that the severed tissue can be successfully reattached.

The mangled extremity severity score (MESS) assigns numerical values to such factors as body temperature, circulation, numbness, **paralysis**, tissue health, and the person’s age and general health. This is one of the diagnostic tools used to determine the probability of success for reattachment surgery. The total score is doubled if blood supply to the amputated part has been absent or diminished for more than six hours.

A general, emergency, or orthopedic surgeon makes the final determination about whether surgery should be performed. The surgeon also considers an injured person’s wishes and lifestyle. Additional concerns are how and to what extent the amputation will affect an individual’s quality of life and ability to perform everyday activities.

Treatment

First aid or emergency care given immediately after the amputation has a critical impact on both a physician’s ability to salvage and reattach the severed part(s) and a person’s ability to regain feeling and function.

Muscle tissue dies quickly, but a well-preserved body part can be successfully reattached as much as 24 hours after the amputation occurs. Tissue that has not been preserved will not survive for more than six hours.

Initial response

The most important steps to take when a traumatic amputation occurs are:

- Contact the nearest emergency services provider, clearly describe what has happened, and follow any instructions given.
- Make sure the injured person can breathe. If not, clear an airway and administer **CPR** as necessary.
- Use direct pressure to control bleeding, but minimize or avoid contact with blood and other body fluids.
- Persons should not be moved if back, head, leg, or neck injuries are suspected or if motion causes pain. If none are found by an emergency medical technician (EMT), put the injured person in a supine (back down) position flat with the feet raised 1 ft (0.3 m) above the surface.
- Cover the person with a coat or blanket to prevent shock.

The injured site should be cleansed with a sterile solution and wrapped in a clean towel or other thick material that will protect the wound from further injury. Tissue that is still attached to the body should not be forced back into place. If it cannot be gently replaced, it should be held in its normal position and supported until additional care is available.

Saving a person's life is always more important than recovering the amputated part(s). Transporting the injured person to a hospital or emergency center should never be delayed until missing pieces are located.

Preserving tissue

No amputated body part is too small to be salvaged. Debris or other contaminating material should be removed, but the tissue should not be allowed to get wet.

An amputated body part should be wrapped in bandages, towels, or other clean, protective material and sealed in a plastic bag. Placing the sealed bag in a cooler or in a container that is inside a second container filled with cold water or ice will help prevent tissue deterioration.

Prognosis

Possible complications of traumatic amputation include:

- excessive bleeding



This man's hand was surgically reattached following a traumatic amputation. (Photograph by Michael English, M.D., Custom Medical Stock Photo. Reproduced by permission.)

- infection
- muscle shortening
- pulmonary embolism

Improved medical and surgical care and rehabilitation have improved the long-term outlook for persons experiencing a traumatic amputation.

Phantom pain

About 80% of all amputees over the age of four experience tingling, itching, numbness, or pain in the place where the amputated part used to be. Phantom sensations may begin immediately after the amputation, or they may develop months or years later. They often occur after an injury to the site of the amputation.

These intermittent feelings may:

- occur frequently or infrequently
- be mild or intense
- last for a few minutes or several hours
- help injured persons adjust more readily to an artificial limb (prosthesis)

Health care team roles

Emergency medical technicians often provide initial assistance to persons experiencing traumatic amputation. These people are evaluated by emergency room physicians and surgeons (trauma, plastic and neurosur-

KEY TERMS

Orthotist—A person who makes, fits, and adjusts prosthetic limbs.

Phantom pain—Discomfort felt by a person who has experienced an amputation. The brain interprets nerve impulses as coming from the body part that has been removed.

Physiatrist—A physician trained in physical medicine and rehabilitation.

Pulmonary embolism—A blockage of an artery in a lung. The source of the embolism may be a blood clot from a leg that was stationary for a prolonged period of time (many hours).

Supine—Lying on one's back.

geons) to establish a plan for treatment. During surgery, they are supported by anesthesiologists, nurses, and surgical assistants. Plastic surgeons may perform many other operations to restore injured body parts to a more normal condition and appearance. Infectious disease specialists may be called upon to treat infections that may accompany an accident and subsequent traumatic amputation.

After surgery, rehabilitation professionals begin to assist. Doctors trained in physical medicine and rehabilitation (physiatrists) design a general course of therapy. Physical therapists work to regain lost physical functions. Occupational therapists may assist with redeveloping fine motor coordination and control.

If a prosthetic limb (arm or leg) is needed, an orthotist may be called upon to fit such a device to an injured person. Physical and occupational therapists will assist recovering amputees to learn how to use their new artificial limbs.

Most persons who experience a traumatic amputation require some form of counseling to help them adjust to their loss and altered appearance. Psychiatrists, counselors and other therapists may conduct therapy sessions. These may continue for many months.

Physiatrists monitor and evaluate the status of reattached limbs over time. They may also be called upon to treat phantom pain.

Prevention

The best way to prevent traumatic amputation is to observe common-sense precautions such as using seat belts and obeying speed limits and other traffic regula-

tions. It is important to take special precautions when using potentially dangerous equipment. Guards should be securely fastened over blades, belts, gears, and other moving parts. Machinery should be turned off and disconnected before attempting to service or repair it. Appropriate protective clothing should be worn at all times. Personal clothing such as scarves, ties, and other loose items of jewelry that might become entangled in machinery should not be worn.

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ORGANIZATIONS

- American Academy of Emergency Medicine. 611 E. Wells St., Milwaukee, WI 53202. (800) 884-2236. <<http://www.aaem.org>>.
- American Academy of Physical Medicine and Rehabilitation. One IBM Plaza, Suite 2500, Chicago, IL 60611-3604. (312) 464-9700. <<http://www.aapmr.org/consumers/public/amputations.htm>>.
- American Amputee Foundation. P.O. Box 250218, Little Rock, AR 72225-0218. (501) 666-2523.
- American College of Emergency Physicians. 1125 Executive Circle, Irving, TX 75038-2522. (800) 798-1822. <<http://www.acep.org>>.

Amputee Coalition of America, 900 E. Hill Ave., Suite 285,
Knoxville, TN 37915. (888) 267-5669.
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National Amputation Foundation, 38–40 Church St.,
Malverne, NY 11565. (516) 887-3600.
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Treadmill stress test *see* **Stress test**

Trench mouth *see* **Periodontitis**

Triglyceride test *see* **Lipid tests**

Triiodothyronine test *see* **Thyroid function tests**

Triple marker screen test

Definition

The triple marker screen test (also called the maternal serum screening test or multiple marker test), is a **blood** test that is performed usually between the 14th and 18th week of **pregnancy**. This screening test measures the levels of three substances, alpha-fetoprotein (AFP), human chorionic gonadotropin (hCG), and unconjugated estriol (uE3) in the maternal blood. Each level is then divided by the median concentration of that substance for the given week of pregnancy to generate a multiple of the median value (MOM). These values, along with other maternal characteristics, such as maternal age, are analyzed by a computer program to indicate the probability that the fetus has **Down syndrome**. Down syndrome is a condition that includes mental retardation, skeletal abnormalities such as upslanted eyes and cleft palate, and organ abnormalities such as **heart** disease and intestinal obstruction. Approximately 80-95% of cases are caused by a nondisjunction of chromosome 21 in the developing gamete resulting in the presence of an additional chromosome 21.

Purpose

Triple marker testing is a screening test that is used to identify the risk that a pregnant woman will give birth to an infant with Down syndrome. The test will also detect pregnancies at increased risk for Edward syndrome (trisomy 18) and Turner syndrome (monosomy X) and developmental defects associated with increased leakage of alpha fetoprotein from the fetus. The criterion used to define cutoff concentrations of the three markers is a risk for Down syndrome of one in 190. This is equal to the risk of **miscarriage** from **amniocentesis**. Women who screen “positive” (risk of 1:190 or higher) are recommended for amniocentesis. This procedure provides cells from the fetus that are cultured and analyzed to determine the number of chromosomes within each cell and detect structural chromosome abnormalities. This is the definitive method for diagnosing Down syndrome and other genetic conditions caused by an abnormal number of chromosomes (aneuploidy).

Precautions

It is very important that the correct gestational age be determined by last menstrual period dating and recorded for the risk calculation. Errors in determining the age of the fetus lead to errors when interpreting the test results. Since an AFP test is only a screening tool, an abnormal test result is not necessarily indicative of a birth defect. Accurate gestational dating lowers the false-positive and false-negative rates associated with this screening test.

The nurse or phlebotomist collecting the blood sample for these tests should observe **universal precautions** for the prevention of transmission of bloodborne pathogens.

Description

Prior to 1964, when the association between low levels of AFP and an increased risk for Down syndrome was reported risk assessment for chromosomal diseases was based upon maternal age. At age 35, the risk of carrying a Down syndrome pregnancy is approximately one in 270, and this was deemed sufficient to warrant amniocentesis. However, three of four Down syndrome pregnancies occur in women under 35 years old. When AFP testing was used along with maternal age, the rate of detection of Down syndrome increased to about 45%, but this level of sensitivity did not justify the screening of younger women because of the risk of miscarriage. The inclusion of uE3 and hCG testing has improved the detection rate to approximately 65-80% of cases for all age groups.

KEY TERMS

Acetylcholinesterase—A chemical found only inside neural tissue. Its presence in the amniotic fluid indicates an opening in the neural tube.

Amniotic fluid—Fluid within the uterine sac in which the fetus lives until birth.

Anencephaly—A severe and usually fatal brain abnormality caused by failure of the neural tube to close at its cranial end.

Embryo—The stage of human development prior to the second month of pregnancy.

Fetus—The stage in human development from the second month of pregnancy until birth.

Karyotyping—Chromosome analysis.

Neural tube—Tube that becomes the brain and spinal cord.

Oligohydramnios—Low amniotic fluid level.

Alpha fetoprotein

Alpha-fetoprotein (AFP) is a glycoprotein similar in size and structure to albumin. It is made principally by the fetal **liver** and is present at very low levels after birth. In several developmental defects the most prevalent of which is an open **neural tube defect**, spina bifida, the AFP leaks from fetal **blood vessels** into the amniotic fluid. The AFP crosses the placenta and can be measured reliably in the maternal circulation by week 14. Increased maternal serum AFP also occurs in the following conditions:

- abdominal wall defects (omphalocele and gastroschisis)
- anencephaly
- Turner syndrome
- trisomy 13
- renal diseases (congenital nephrosis, polycystic **kidneys**, renal agenesis)
- oligohydramnios (decreased amount of amniotic fluid)
- more than a single fetus
- maternal **liver cancer** and other malignancies

The cutoff for a positive screen is 2.5 MOM. A positive test should be repeated, and if positive the second time, should be followed by ultrasound. If ultrasound does not explain the high level (which may be caused by twins, anencephaly, or inaccurate dating), then amnio-

centesis is recommended. AFP and acetylcholinesterase levels in amniotic fluid along with high resolution ultrasound are used to predict the probability of an open neural tube defect. Decreased AFP levels, below 0.75 MOM, are seen in approximately 25% of Down syndrome pregnancies. AFP is measured by double antibody sandwich radioimmunoassay or enzyme immunoassays.

Human chorionic gonadotropin and unconjugated estriol

Human chorionic gonadotropin (hCG) and unconjugated estriol are hormones. Estriol is the major estrogen of pregnancy and is produced by the placenta from dihydroepiandrosterone sulfate that is made in the fetal **adrenal glands**. Estriol levels rise steadily throughout pregnancy increasing about threefold from week 24 to full term. Human chorionic gonadotropin is also made by the placenta, and it supports the corpus luteum during gestation. The corpus luteum produces progesterone, which maintains the uterus during pregnancy. Chorionic gonadotropin peaks at about 10 weeks gestation and then falls to about 20-25% of peak levels for the remainder of pregnancy. During pregnancy, both hormones diffuse from the placental membranes into the maternal blood. Abnormal levels can be indicative of potential fetal distress and stillbirth. Like AFP, uE3 is lower than normal for the time of gestation. Conversely, hCG is increased above normal by about 25% for the time of gestation. Both hormones may be measured by radioimmunoassay or fluorescent or chemiluminescent enzyme immunoassay.

When any one test exceeds the cutoff, testing should be repeated on a new sample and ultrasound should be performed in an attempt to explain the results and determine an accurate gestational age. If results are still positive and not explained by ultrasound, amniocentesis for chromosome karyotyping (chromosome counting and analysis) is recommended. When AFP, hCG, and uE3 are low for the gestational age, this may indicate trisomy 18. This condition is caused by an additional chromosome 18, and is associated with severe birth defects, mental retardation and death. The sensitivity for trisomy 18 is approximately 60-80% using cutoffs of 0.75 MOM for AFP; 0.60 MOM for uE3; and 0.55 MOM for hCG.

Preparation

There is no specific physical preparation for this test. Fasting is not required.

Aftercare

After the blood sample is drawn, pressure should be applied to the puncture site until the bleeding stops to reduce bruising, and a bandage may be applied to the site. A warm pack may be applied to the site to relieve discomfort.

Complications

The complications associated with drawing blood are minimal, but may include bleeding from the puncture site, feeling faint or lightheaded after the blood is drawn, or blood accumulating under the puncture site (hematoma).

Results

The various immunoassays for these analytes are associated with different normal ranges because the antibody specificity and assay detection limits are somewhat different. In order to allow for interlaboratory comparison of results, the results of analytes are expressed as multiples of the median value used by the laboratory. Normal ranges expressed in concentration (e.g. ng/mL) are dependent upon gestational age, but MOMs are age adjusted and do not change. These values are used to calculate risk. If the multiple of the median value is above 2.0 MOM or 2.5 MOM (depending on the laboratory), the fetus is considered to be at a higher risk for a neural tube defect. The MOM value for amniotic fluid is then used to calculate the exact probability the fetus is affected (1:100, for example).

With respect to Down syndrome and trisomy 18, the MOM values are also used in the calculation of probability. The woman is considered to be “high risk” or “screen positive” for Down syndrome if the risk is greater than the standard risk for women who are 35 years old or older (one in 270). For trisomy 18, the cut-off is one in 150. In one study the triple marker screen test had a detection rate for Down syndrome of 67% and a false positive rate of 5%.

Health care team roles

The obstetrician orders the triple marker screen test, and explains its purpose and results to the patient. The nurse or phlebotomist collects the blood sample and transports it to the laboratory. Typically, a nurse calls the patient with her result. If abnormal, the pregnant patient is referred to a genetic counselor, who explains the test, the result, and diagnostic testing options.

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ORGANIZATIONS

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Rachael Brandt

Triplet pregnancy see **Multiple pregnancy**

Trisomy 21 see **Down syndrome**

Tropical sprue see **Malabsorption syndrome**

Troponins test see **Cardiac marker tests**

Tube feeding management see **Nasogastric intubation and feeding**

Tuberculin skin test

Definition

Tuberculosis (TB) is an airborne infectious disease caused by the **bacteria** *Mycobacterium tuberculosis*. The two most common types of tests that are used to screen for this disease are the Mantoux PPD tuberculin skin test, which is generally considered the most reliable, and the TB tine test. These tests are sensitive screening tools that are designed to help identify individuals who may have been infected by tuberculosis bacteria. A diagnosis of tuberculosis is never made based on the results of a TB

skin test, but requires further testing including a **sputum culture** and a **chest x ray**.

Purpose

Because TB is spread through the air, especially in poorly ventilated areas, it is more commonly found among people living in crowded conditions, such as jails, **nursing homes**, and homeless shelters. It is estimated that between 10 and 15 million people in the United States have latent tuberculosis. Many new cases of tuberculosis are multi-drug resistant making early detection of exposure a high **public health** priority. Often, a TB skin test will be given as part of a **physical examination** when an organization is hiring a new employee, particularly for those individuals seeking employment in the healthcare or food service professions.

People can be exposed to TB without showing any symptoms or necessarily developing the disease. Individuals with normally functioning immune systems generally prevent the spread of the bacteria by “walling off” or encysting the bacteria within the body. Such a structure in the **lungs** is called a “Ghon” body. Anyone who has had close contact with another person who has tuberculosis (such as a friend or family member); has been around someone with active TB; has a weakened **immune system** (immunocompromised), either from a chronic disease, such as HIV **infection**, or as a result of a tissue or organ transplant or other medical treatment designed to suppress the immune system; or displays symptoms of the disease should be tested. Symptoms of TB include a persistent cough, **fever**, weight loss, night sweats, fatigue, and loss of appetite. Often, individuals must receive the test in order to enter school or begin work.

Precautions

Although generally considered safe, it is important for the person being tested to inform a tester about any possibility of **pregnancy**, any previous positive TB test, or of any active tuberculosis in the past. People who previously have had a positive TB test will probably always have a positive test and should not be tested again. Also, anyone who is known to have active TB should not be tested because the local reaction to the test may be so severe that it requires surgical care.

There are several situations when TB test results might not be accurate. These includes situations involving people who:

- Have had vaccinations (such as those for measles, polio, rubella or mumps) within the last four weeks.

- Currently have, or recently recovered from a viral infection.
- Are taking steroids.
- Have severe malnutrition.

Description

TB skin tests are usually given at a clinic, hospital, or physician’s office. Sometimes the tests are given at schools or workplaces. Many cities provide free TB skin tests and follow-up care. The Mantoux PPD tuberculin skin test involves injecting 0.1 mL of PPD tuberculin standardized to a dose of five units just under the top layer of the skin (intracutaneously). Tuberculin is a mixture of antigens obtained from the culture of *M. tuberculosis*. Antigens are foreign particles or **proteins** that stimulate the immune system to produce antibodies. Two different tuberculin preparations are available, Old Tuberculin (OT) and Purified Protein Derivative (PPD). The test is usually given on the inside of the forearm about halfway between the wrist and the elbow, where a small bubble (wheal) will form as the tuberculin is injected. The skin test takes just a minute to administer and feels more like a pinprick than a shot.

After 48-72 hours, the test site must be examined by a trained person for evidence of swelling. People who have been exposed to tuberculosis will develop an **immune response**, causing a slight redness and swelling at the injection site. This is called a delayed hypersensitivity reaction, and it is mediated by immune T lymphocytes and macrophages rather than antibody. Immune lymphocytes enter the site and release products that stimulate inflammation and the migration of macrophages into the area. This results in erythema and accumulating cells, and cause the lesion to become hard (induration). Reactions may not peak until after 72 hours in elderly individuals or those who are being tested for the first time. If there is a lump or swelling, a health care provider will use a ruler to measure the size of the reaction.

The other method of TB skin test is called the multi-puncture test or tine test because the small test instrument has several small tines that lightly prick the skin. The small points of the instrument are either coated with dried tuberculin or are used to puncture through a film of liquid tuberculin. The test is read by measuring the size of the largest papule. Because it is not possible to precisely control the amount of tuberculin used in the tine test, a positive test should be verified using the Mantoux

test. For this reason, the tine test is not as widely used as the Mantoux test and is considered to be less reliable.

It is possible that a person who has TB may receive a negative test result (called a “false negative”) or a person who does not have TB may receive a positive test result (called a “false positive”). If there is some doubt, the test may be repeated or the person may be given a diagnostic test using a chest x ray or have sputum cultured to determine whether TB is present or active in the lungs. It is often recommended that a two-step PPD test be given to health care workers and persons whose response to PPD may be diminished. The test is given in the usual manner and if negative, repeated within one to three weeks. A positive reaction on the second test is considered an indication of exposure to TB even if the first result is negative.

Preparation

There is no special preparation needed before a TB skin test. A brief personal history will be taken to determine whether a person has had tuberculosis or a TB test before, has been in close contact with anyone with TB, or has any significant risk factors. Directly before the test, the skin on the arm at the injection site is cleaned with an alcohol swab and allowed to air dry. Health care workers administering the PPD injection should follow standard precautions for the prevention of exposure to bloodborne pathogens.

Aftercare

After having a TB skin test, it is extremely important to make sure that a person being tested keeps the appointment to have the test reaction read. The person is instructed to keep the test site clean, uncovered, and to not scratch or rub the area. Should severe swelling, itching, or **pain** occur, or if the person has trouble breathing, a clinic or health care provider should be contacted immediately.

Complications

The risk of an adverse reaction is very low. Occasionally, an individual who has been exposed to the TB bacteria will develop a local reaction in which the arm swells and is uncomfortable. This reaction usually disappears in two weeks. A sore may develop where the injection is given, or a fever can occur, but these are extremely rare reactions.

Results

Normal results

Among people who have not been exposed to TB, there will be little or no swelling at the test site after 48-72 hours. This is a negative test. Negative tests can be interpreted to mean that a person has not been infected with tuberculosis bacteria or that an individual has been recently infected and not enough time has elapsed for the body to react to the skin test. Persons become sensitive between two and ten weeks after the initial infection. As a result, if an individual has been in contact with someone with tuberculosis, the test should be repeated in three months. Also, because it may take longer than 72 hours for an elderly individual to develop a reaction, it may be useful to repeat the TB skin test after one week to adequately screen these people. Immunocompromised persons may be unable to react sufficiently to the Mantoux test, and either a chest x ray or sputum sample may be required.

Abnormal results

A reaction consisting of a reddened circle of 5 mm is considered positive for the following groups:

- household contacts of persons with active tuberculosis
- individuals with AIDS
- persons with old or healed tuberculosis

A reaction consisting of a reddened circle of 10 mm is considered positive in individuals with one or more of the following risk factors:

- foreign-born from Asia, Africa, or Latin America
- intravenous drug users
- medically under-served low income populations
- residents of long-term care facilities
- individuals with certain medical conditions that increase the risk of developing tuberculosis (These medical conditions include being 10% or more below ideal body weight, chronic renal failure, **diabetes mellitus**, receiving high dose corticosteroid or other immunosuppressive therapy, some **blood** disorders such as leukemia and lymphomas, and other cancers.)

Finally, a reaction consisting of a reddened circle of 15 mm is considered positive in those with no risk factors.

A positive reaction to tuberculin may be the result of a previous natural infection with *M. tuberculosis*, infection with a variety of non-tuberculosis mycobacteria (cross-reaction), or tuberculosis **vaccination** with a live, but weakened (attenuated) mycobacterial strain. Cross-

KEY TERMS

Antibody—A specific protein produced by the immune system in response to a specific foreign protein or particle called an antigen.

Antigen—Any foreign particle or protein that causes an immune response.

Attenuated—A live, but weakened microorganism that can no longer produce disease.

Cross-reaction—Positive reactions that occur as a result of a person's exposure to other non-tuberculosis bacteria.

Immunocompromised—A state in which the immune system is suppressed or not functioning properly.

Intracutaneous—Into the skin, in this case directly under the top layer of skin.

Mantoux or PPD test—Other names for a tuberculin skin test. PPD stands for purified protein derivative.

Percutaneous—Onto the skin; without breaking the skin.

Tuberculin—A mixture of antigens obtained from the cultured bacteria that cause tuberculosis, *Mycobacterium tuberculosis*.

reactions are positive reactions that occur as a result of a person's exposure to other non-tuberculosis bacteria. These tend to be smaller than those caused by *M. tuberculosis*. There is no reliable way of distinguishing whether a positive TB skin test is due to a previous vaccination against tuberculosis. Generally, however, positive results are not due to vaccination exposure because few negative results convert to positive after vaccination. Reactions in vaccinated people tend to be less than 10 mm, and an individual's sensitivity to tuberculin steadily declines after vaccination. If a skin test is interpreted as positive, a chest x ray will be performed to determine whether the person has active tuberculosis or whether the body has controlled the infection.

Health care team roles

Health care team members who are involved with tuberculin skin testing include nurses or physician assistants who typically administer and read the TB test. A physician may also read the test and provide follow-up care if it is needed. Laboratory technologists culture samples of sputum and perform DNA tests which con-

firm the diagnosis. Radiologic technicians take chest x rays, and radiologists evaluate the films.

Resources

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ORGANIZATIONS

American Lung Association, 1740 Broadway, NY, NY 10019. (212)-315-8700. <<http://www.lungusa.org/diseases/lungtb.html>>. info@lungusa.org.

Centers for Disease Control and Prevention, 1600 Clifton Road, Atlanta, GA 30333. (404) 639-3534 or (800) 311-3435. <<http://www.cdc.gov/nchstp/tb/faqs/qa.htm>>.

Francis J. Curry National Tuberculosis Center, 3180 Eighteenth Street, Suite 101, San Francisco, California 94110-2028. (415) 502-4600. Fax: (415) 502-4620. <<http://www.nationaltbcenter.edu/>>. tbcenter@nationaltbcenter.edu.

National Tuberculosis Center, University of Medicine and Dentistry of New Jersey, 65 Bergen Street, Newark, NJ 07107-3001. (973) 972-3270. Fax: (973) 972-3268. Information Line: (800) 482-3627. <<http://www.umdnj.edu/ntbcweb/>>. leusmq@umdnj.edu.

OTHER

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Tuberculosis

Definition

Tuberculosis (TB) is a potentially fatal contagious disease that can affect almost any part of the body but is mainly an **infection** of the **lungs**. It is caused by a bacterial microorganism: the tubercle bacillus or *Mycobacterium tuberculosis*. Although TB can be treated and cured, and can be prevented if persons at risk take certain drugs, medical science has never succeeded in eradicating the disease. Few diseases have caused so much distressing illness for centuries and claimed so many lives.

Description

Overview

Tuberculosis was popularly known as consumption for many years. Scientists now know that it is an infection caused by *M. tuberculosis*. In 1882, one of every seven deaths in Europe was caused by TB. In that year, the microbiologist Robert Koch discovered the tubercle bacillus. Because **antibiotics** were unknown, the only means of controlling the spread of infection was to isolate patients in private sanitariums or hospitals limited to treating persons with TB. In many countries, this practice continues to this day. The net effect of this approach to treatment was to separate the study of tuberculosis from mainstream medicine. Entire organizations were set up to study not only the disease as it affected individual persons, but also its impact on society as a whole. At the turn of the twentieth century, more than 80% of the population in the United States was infected with TB before age 20, and tuberculosis was the single most common cause of death. By 1938, there were more than 700 TB hospitals in the United States.

When the industrial revolution began in the late nineteenth century, tuberculosis spread much more widely in Europe. Later, the disease began to spread throughout the United States, primarily due to the population migration to large cities that made overcrowded housing so common. When streptomycin, the first antibiotic effective against *M. tuberculosis*, was discovered in the early 1940s, the infection began to come under control. Although other, more effective anti-tuberculosis drugs were developed in the following decades, the number of cases of TB in the United States began to rise again in the mid-1980s. In part, this upsurge was again a result of overcrowding and unsanitary conditions in poor areas of large cities, prisons, and homeless shelters. Infected visitors and immigrants to the United States also contributed to the resurgence of TB. An additional factor was the emergence of acquired **immunodeficiency** syndrome

(AIDS). Persons with AIDS are much more likely to develop tuberculosis because of their weakened immune systems than are others in the general population. As of 2001, experts estimate that between 8 and 11 million new cases of TB are reported each year throughout the world. These are estimated to cause approximately 3 million deaths. This situation is worsening. The World Health Organization estimates that by 2020, there will be 1 billion TB cases worldwide and 35 million deaths each year.

High-risk populations

THE ELDERLY. Tuberculosis is more common in elderly persons. More than one-fourth of the 19,855 cases of TB (7.4 cases per 100,000 population) reported in the United States in 1997 developed in people above the age of 65. Many elderly individuals developed the infection some years ago when the disease was more widespread. There are additional reasons for the vulnerability of older people. Those living in **nursing homes** and similar facilities are in close contact with others who may be infected. The aging process itself may weaken the body's **immune system**, which is then less able to successfully eliminate the tubercle bacillus. Finally, **bacteria** that have been dormant for some time in elderly persons may be reactivated and cause illness.

RACIAL AND ETHNIC GROUPS. TB also is more common among members of minority groups who may be likely to live under conditions that promote infection. As of 2001, approximately two-thirds of all cases of TB in the United States affect African Americans, Hispanics, Asians, and persons from the Pacific Islands. Another one-fourth of cases affect persons born outside the United States. The risk of TB has not diminished among members of these groups.

PERSONS WITH RELEVANT LIFESTYLE FACTORS. The high risk of TB in AIDS patients extends to those infected by human immunodeficiency virus (HIV) who have not yet developed clinical signs of AIDS. Alcoholics and intravenous drug abusers are also at increased risk of contracting tuberculosis. Until the economic and social factors that influence the spread of tubercular infection are addressed and eliminated, there is no real possibility of completely eliminating the disease.

Causes and symptoms

Transmission

Tuberculosis is spread by droplet infection. This type of transmission means that when a TB patient exhales, coughs, or sneezes, tiny droplets of fluid containing tubercle bacilli are released into the air. This mist, often referred to as aerosol, can be taken into the nasal

passages and lungs of a nearby susceptible person. Compared to some other infectious diseases, TB is not highly contagious. Only about one in three close contacts of a person with TB is likely to become infected. Fewer than 15% of more remote contacts are likely to become infected. As a rule, close, frequent, or prolonged contact is needed to spread the disease. Of course, if a severely infected patient emits huge numbers of bacilli, the chance of transmitting infection is much greater. Unlike many other infections, TB is not passed on by contact with a patient's clothing, bed linens, or dishes and cooking utensils. The most important exception is **pregnancy**. The fetus of an infected mother may contract TB by inhaling or swallowing bacilli that may be present in amniotic fluid.

Progression

Once inhaled, tubercle bacilli may reach the small breathing sacs in the lungs (alveoli), where they are taken up by cells called macrophages. The bacilli multiply within these cells and then spread through lymph vessels to nearby lymph nodes. Sometimes the bacilli move through **blood vessels** to distant organs. At this point they may either remain alive but inactive (quiescent), or they may cause active disease. Actual tissue damage is not caused directly by the tubercle bacillus, but by the reaction of a person's tissues to its presence. In a matter of weeks, the host develops an **immune response** to the bacillus. Cells attack the bacilli, permit the initial damage to heal, and permanently prevent future disease.

Exposure and infection does not always mean that active TB disease will develop. In fact, most people who are infected do not develop TB. At least nine out of ten people who harbor *M. tuberculosis* do not develop symptoms or physical evidence of active disease, and their x rays remain negative. They are not contagious. However, they do form a pool of infected people who may get sick at a later date and then pass their TB on to others. It is thought that more than 90% of active tuberculosis cases come from this pool. In the United States, this group numbers 10 to 15 million persons. Whether or not a particular infected person will become ill is impossible to predict with certainty. An estimated 5% of infected persons develop active cases of TB within 12-24 months of being infected. Another 5% heal initially, but after years or decades develop active tuberculosis either in the lungs or elsewhere in the body. This form of the disease is called reactivation TB, or post-primary disease. On rare occasions, a previously infected person gets sick again after a later exposure to the tubercle bacillus.

Pulmonary tuberculosis

Pulmonary tuberculosis is TB that affects the lungs. Its initial symptoms are easily confused with those of other diseases. An infected person may at first feel vaguely unwell or develop a cough blamed on smoking or a cold. A small amount of light green or yellow sputum may be coughed up when the person gets up in the morning. In time, more sputum is produced that is streaked with **blood**. Persons with pulmonary TB do not run a high **fever**, but they often have a low-grade one. They may wake up in the night drenched with cold sweat when the fever breaks. A person often loses interest in food and may lose weight. Chest **pain** is sometimes present. If the infection allows air to escape from the lungs into the chest cavity (pneumothorax) or if fluid collects in the pleural space (pleural effusion), an affected person may have difficulty breathing. If a young adult develops a pleural effusion, the probability of tubercular infection being the cause is very high. TB bacilli may travel from the lungs to lymph nodes in the sides and back of the neck. Infection in these areas can break through the skin and discharge pus. Before the development of effective antibiotics, many patients became chronically ill with increasingly severe lung symptoms, lost a great deal of weight, and developed a wasted appearance. This outcome is uncommon today—at least where modern methods of treatment are available.

Extrapulmonary tuberculosis

Although the lungs are the major site for damage caused by tuberculosis, many other organs and tissues in the body may be affected. The usual progression is for the disease to spread from the lungs to locations outside the lungs (extrapulmonary sites). In some cases, however, the first sign of disease appears outside the lungs. The many tissues or organs that tuberculosis may affect include:

- **Bones.** TB is particularly likely to attack the spine and the ends of the long bones. Children are especially prone to spinal tuberculosis. If not treated, the spinal bones (vertebrae) may collapse and cause **paralysis** in one or both legs.
- **Kidneys.** Along with bones, the kidneys are probably the most common site of extrapulmonary TB. There may, however, be few symptoms even though part of a kidney is destroyed. TB may spread to the bladder. In men, it may spread to the prostate gland and nearby structures.
- **Female reproductive organs.** The ovaries in women may become infected as TB can spread from them to the peritoneum, which is the membrane lining the abdominal cavity.

- **Abdominal cavity.** Tuberculous peritonitis may cause pain ranging from the vague discomfort of **stomach** cramps to intense pain that may mimic the symptoms of appendicitis.
- **Joints.** Tubercular infection of joints causes a form of arthritis that most often affects the hips and knees. The wrist, hand, and elbow joints also may become painful and inflamed.
- **Meninges.** The meninges are tissues that cover the **brain** and the **spinal cord**. Infection of the meninges by TB bacillus causes tuberculous **meningitis**, a condition that is most common in young children but is especially dangerous in the elderly. Affected people develop headaches, become drowsy, and may eventually fall into a **coma**. Permanent brain damage is the rule unless prompt treatment is given. Some people with tuberculous meningitis develop a tumor-like brain mass called a tuberculoma that can cause symptoms that resemble those of a stroke.
- **Skin, intestines, adrenal glands, and blood vessels.** All these parts of the body can be infected by *M. tuberculosis*. Infection of the wall of the body's main artery (the aorta) can cause it to rupture with catastrophic results. Tuberculous pericarditis occurs when the membrane surrounding the **heart** (the pericardium) is infected and fills up with fluid that interferes with the heart's ability to pump blood.
- **Miliary tuberculosis.** Miliary TB is a life-threatening condition that occurs when large numbers of tubercle bacilli spread throughout the body. Huge numbers of tiny tubercular lesions develop, causing marked weakness and weight loss, severe anemia, and gradual wasting of the body.

Diseases similar to tuberculosis

There are many forms of mycobacteria other than *M. tuberculosis*, the tubercle bacillus. Some cause infections that may closely resemble tuberculosis, but usually do so only when an infected person's immune system is defective. People who are HIV-positive are a good example. The most common mycobacteria that infect AIDS patients are a group known as *Mycobacterium avium* complex (MAC). People infected by MAC are not contagious but may develop a serious lung infection that is highly resistant to antibiotics. MAC infections typically start with an affected person coughing up mucus. The infection progresses slowly, but eventually blood is brought up and the person has trouble breathing. Among people with AIDS, MAC disease can spread throughout the body, with anemia, **diarrhea**, and stomach pain as common features. Often, these people die unless their immune systems can be strengthened. Other mycobacte-

ria grow in swimming pools and may cause skin infections. Some of them infect **wounds** and artificial body parts such as a breast implant or mechanical heart valve. The organism that causes leprosy, *M. leprae*, is also related to TB.

Diagnosis

The diagnosis of TB is made on the basis of laboratory test results. The standard test for tuberculosis, the so-called **tuberculin skin test**, detects the presence of infection, not of active TB. Tuberculin is an extract prepared from cultures of *M. tuberculosis*. It contains substances belonging to the bacillus (antigens) to which an infected person has been sensitized. When tuberculin is injected into the skin of an infected person, the area around the injection becomes hard, swollen, and red within one to three days. Today, skin tests utilize a substance called purified protein derivative (PPD) that has a standard chemical composition and is therefore is a good measure of the presence of tubercular infection. The PPD test is also called the Mantoux test. The Mantoux PPD skin test is not, however, 100% accurate; it can produce false positive as well as false negative results. These terms have specific meanings. People who have a skin reaction and are not infected are referred to having a false positive result. Those who do not react but are in fact infected are classified as having a false negative result. The PPD test is, however, useful as a screening device. Anyone who has suspicious findings on a **chest x ray** or any condition that makes TB more likely should have a PPD test. In addition, those in close contact with someone who has active TB or persons who come from a country where TB is common should be tested, as should all healthcare personnel and those living in crowded conditions or institutions.

Because the symptoms of TB encompass a wide range of severity and affect many parts of the body, diagnosis on the basis of external symptoms is not always possible. Often, the first indication of TB is an abnormal chest x ray or other test result rather than physical discomfort. On a chest x ray, evidence of the disease appears as numerous white, irregular areas against a dark background, or as enlarged lymph nodes. The upper parts of the lungs are most often affected. A PPD test is always performed to show whether an individual has been infected by the tubercle bacillus. To verify test results, a physician obtains a sample of sputum or a tissue sample (biopsy) for culture. Three to five sputum samples should be taken early in the morning. If necessary, sputum for culture can be produced by spraying salt solution into the windpipe. Culturing *M. tuberculosis* is useful for diagnosis because the bacillus has certain distinctive character-

istics. Unlike many other types of bacteria, mycobacteria can retain certain dyes even when exposed to acid. This so-called acid-fast property is characteristic of the tubercle bacillus.

Body fluids other than sputum can be used for culture. If TB has invaded the brain or spinal cord, culturing a sample of spinal fluid will make the diagnosis. If TB of the kidneys is suspected because of pus or blood in the urine, culture of the urine may reveal tubercular infection. Infection of the ovaries in women can be detected by placing a tube having a light on its end (a **laparoscope**) into the area. Samples also may be taken from the **liver** or bone marrow to detect the tubercle bacillus.

Treatment

Supportive care

In the past, treatment of TB was primarily supportive. People being treated for TB were kept in isolation, encouraged to rest, and fed well. If these measures failed, their affected lungs were collapsed surgically so that they could “rest” and heal. Today, surgical procedures still are used when necessary, but contemporary medicine relies on drug therapy as the mainstay of **home care**. Given an effective combination of drugs, individuals with TB can be treated at home as well as in a sanatorium. Treatment at home does not pose the risk of infecting other household members.

Drug therapy

Most people with TB can recover if given appropriate medication for a sufficient length of time. Three principles govern modern drug treatment of TB:

- Lowering the number of bacilli as quickly as possible. This measure minimizes the risk of transmitting the disease. When sputum cultures become negative, this has been achieved. Conversely, if the sputum cultures remain positive after five to six months, treatment has failed.
- Preventing the development of drug resistance. For this reason, at least two different drugs and sometimes three are always given at first. If drug resistance is suspected, at least two different drugs should be tried.
- Long-term, continuous treatment to prevent relapse.

Five drugs are most commonly used today to treat tuberculosis: isoniazid (INH, Laniazid, Nydrazid); rifampin (Rifadin, Rimactane); pyrazinamide (Tebrazid); streptomycin; and ethambutol (Myambutol). The first three drugs may be given in the same capsule to minimize the number of pills in the dosage. As of 2001, many persons are given isoniazid and rifampin together for six

months, with pyrazinamide added for the first two months. Hospitalization is rarely necessary because most persons are no longer infectious after about two weeks of combination treatment. Follow-up involves monitoring for the presence of side effects and having monthly sputum tests. Of the five medications, isoniazid is the most frequently used drug for both treatment and prevention of TB.

Surgery

Surgical treatment of TB may be used if oral medications are ineffective. There are three surgical treatments for pulmonary TB: pneumothorax, in which air is introduced into the chest to collapse the lung; thoracoplasty, in which one or more ribs are removed; and removal of a diseased lung, in whole or in part. It is possible for individuals to survive with one healthy lung. Spinal TB may result in a severe deformity that can be surgically corrected.

Prognosis

The prognosis for recovery from TB is good for most patients, if the disease is diagnosed early and given prompt treatment with appropriate medications on a long-term regimen. Modern surgical methods have good outcomes in most cases in which they are needed. Miliary tuberculosis is still fatal in many cases but is rarely seen today in developed countries. Even in cases in which the bacillus proves resistant to all of the commonly used medications for TB, other seldom-used drugs may be tried because the tubercle bacilli have not yet developed resistance to them.

Health care team roles

Screening for tuberculosis may be conducted by nurses, physicians, physician assistants, or other trained health workers. The test is read or evaluated by a nurse, physician, or physician assistant. Treatment for TB must be prescribed and supervised by a physician. A surgeon may provide surgical intervention, often assisted by a physician assistant trained in surgery. Administration of TB medications is often supervised by nurses, although other non-medical personnel may observe TB drug ingestion. Epidemiologists collect data from many individual caregivers, and are key members of the health care team even though they do not directly provide clinical services. Pharmaceutical scientists are constantly searching for new drugs for use in treating TB.

Prevention

General measures

General measures such as avoiding overcrowded and unsanitary conditions are important aspects of prevention. Hospital emergency rooms and similar locations that are used to treat or house TB patients can be treated with ultraviolet light, which has an antibacterial effect.

Vaccination

Vaccination is one major preventive measure against TB. A vaccine called BCG (Bacillus Calmette-Guérin, named after its French developers) is made from a weakened mycobacterium that infects cattle. Vaccination with BCG does not prevent infection by *M. tuberculosis*, but it does strengthen the immune system of first-time TB patients. As a result, serious complications are less likely to develop. BCG is used widely in developing countries but is not used in the United States. This is because it protects only 75% of recipients, and because everyone who receives the vaccine reacts positively to future TB screening tests. The problem is identifying the one person in four who has a false negative test result. The effectiveness of vaccination is still being studied. It is not clear whether the vaccine's effectiveness depends on the population in which it is used or on variations in its formulation.

Prophylactic use of isoniazid

Isoniazid can be given for the prevention as well as the treatment of TB. Isoniazid is effective when given daily over a period of six to 12 months to people in high-risk categories. The drug appears to be most beneficial to persons under the age of 25. Because isoniazid carries the risk of side effects (liver inflammation, nerve damage, changes in mood and behavior), it is important to administer the drug only to persons at special risk.

High-risk groups for whom isoniazid prevention may be justified include:

- Close contacts of persons with active TB, including health care workers.
- Newly infected patients whose skin test has turned positive in the past two years.
- Anyone who is HIV-positive with a positive PPD skin test. Isoniazid may be given even if PPD results are negative if there is a risk of exposure to active tuberculosis.
- Intravenous drug users, even if they are negative for HIV.

KEY TERMS

Alveoli—Several small, sac-shaped cavities. In the lungs, alveoli (plural of alveolus) are found at the ends of airways, the sites where oxygen and carbon dioxide are exchanged in the blood.

Bacillus Calmette-Guérin (BCG)—A vaccine made from a damaged bacillus that is related to the tubercle bacillus, which may help prevent serious pulmonary TB and its complications.

Macrophage—A large, phagocytic cell that is found in the blood system and loose connective tissue.

Mantoux test—Another name for the PPD test.

Miliary tuberculosis—The form of TB in which the bacillus spreads through all body tissues and organs, producing many thousands of tiny tubercular lesions. Miliary TB is often fatal unless promptly treated.

Mycobacteria—A group of bacteria that includes *Mycobacterium tuberculosis*, the bacterium that causes tuberculosis, and other forms that cause related illnesses.

Peritonitis—An infection in the peritoneum (abdominal cavity).

Pleural effusion—Fluid that collects in the space normally occupied by a lung.

Pneumothorax—Air inside the chest cavity, which may cause a lung to collapse. Pneumothorax is both a complication of pulmonary tuberculosis and a means of treatment designed to allow an infected lung to rest and heal.

Pulmonary—Refers to the lungs.

Purified protein derivative (PPD)—An extract of tubercle bacilli that is injected into the skin to find out whether a person presently has or has ever had tuberculosis.

Resistance—A property of some bacteria that have been exposed to a particular antibiotic and have changed sufficiently to survive in its presence.

Sputum—Secretions produced in an infected lung and coughed up. A sign of illness, sputum is routinely used as a specimen for culturing the tubercle bacillus in a laboratory.

Tuberculoma—A tumor-like mass in the brain that sometimes develops as a complication of tuberculous meningitis.

- Persons who have never been treated for TB, have positive PPD results, and show evidence of old disease on a chest x ray.
- People who have an illness or are taking a drug that can suppress the immune system.
- Persons with positive PPD results who have had intestinal surgery, have diabetes or **chronic kidney failure**, have any type of **cancer**, or are more than 10% below their ideal body weight.
- People from countries with high rates of TB who have positive PPD results.
- People from low-income groups with positive skin test results.
- Persons with a positive PPD reaction who belong to high-risk ethnic groups (African-Americans, Hispanics, Native Americans, Asians, and Pacific Islanders).

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ORGANIZATIONS

- American Lung Association. 1740 Broadway, New York, NY 10019. (212) 315-8700. <<http://www.lungusa.org/diseases/lungtb.html>>.

Centers for Disease Control and Prevention. 1600 Clifton Rd., Atlanta, GA 30333. (404) 639-3534 or (800) 311-3435. <<http://www.cdc.gov/nchstp/tb/faqs/qa.htm>>.

Francis J. Curry National Tuberculosis Center. 3180 18th St., Suite 101, San Francisco, CA 94110-2028. (415) 502-4600. <<http://www.nationaltbcenter.edu>>.

National Tuberculosis Center, University of Medicine and Dentistry of New Jersey. 65 Bergen St., Newark, NJ 07107-3001. (973) 972-3270 or (800) 482-3627. <<http://www.umdnj.edu/ntbcweb>>.

World Health Organization. Communicable Diseases. 20 Avenue Appia, 1211 Geneva 27, Switzerland. +41 (22) 791 4140. <<http://www.who.int/gtb>>.

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Tuberculosis culture see **Acid-fast culture**

Tumor marker tests

Definition

Tumor markers are **proteins**, hormones, enzymes, receptors and other cellular products that are overexpressed by malignant cells. Tumor markers are usually normal cellular constituents that are present at normal or very low levels in the **blood** of healthy persons. If produced by the tumor, the substance will be increased either in the blood or in the tissue of origin.

Purpose

The majority of tumor markers are used to monitor the patient for recurrence of the tumor following treatment. In addition, some markers are associated with a more aggressive course and higher relapse rate and have value in staging and prognosis of the **cancer**. Most tumor markers are not useful for screening because levels found in early malignancy overlap those found in healthy persons. Most are elevated in conditions other than malignancy.

nancy, and therefore, are not useful for the purpose of establishing a diagnosis.

Precautions

Tumor markers may be elevated in nonmalignant conditions. Not every tumor will cause an elevation of its associated marker, especially in the early stages of some cancers. When a marker is used for cancer screening or diagnosis, the physician must confirm a positive test result using imaging, biopsy, and other procedures. False positive results may occur in immunoassays when the patient has heterophile antibodies that interfere with the test. Tumor markers at very high concentrations may give erroneously low results caused by the “hook effect.” This occurs when the concentration of antigen is so great that all of it cannot be bound by the antibody used in the test system.

Description

Physicians use changes in tumor marker levels to follow the course of the disease, to measure the effect of treatment, and to check for recurrence of certain cancers. Tumor markers have been identified in several types of cancer including **malignant melanoma**, multiple myeloma, and bone, breast, colon, gastric, **liver**, lung, ovarian, pancreatic, prostate, renal, and uterine cancer. Serial measurements of a tumor marker are often an effective means to monitor the course of therapy. Some tumor markers can provide physicians with information about the stage of the cancer, and some help predict the response to treatment. A decrease in the amount of the tumor marker during treatment indicates that the therapy is having a positive effect on the cancer, while an increase indicates that the cancer is growing and not responding favorably to the therapy.

There are five types of tumor markers. Many enzymes that are rich in certain tissues are found in plasma at higher levels when the cancer involves that tissue. Enzymes are usually measured by determining the rate at which they convert substrate to product, while most tumor markers of other types are measured by immunoassay. Some examples of enzymes increase in cases of malignant diseases are acid phosphatase, alkaline phosphatase, amylase, creatine kinase, gamma glutamyl transferase, lactate dehydrogenase, and terminal deoxynucleotidyl transferase.

Tissue receptors, proteins associated with the cell membrane, are another type of tumor marker. These bind to hormones and growth factors, and therefore, affect the rate of tumor growth. Some tissue receptors must be measured in biopsied tissue, while others are secreted

into the extracellular fluid and may be measured in the blood. Some important receptor tumor markers are estrogen receptor, progesterone receptor, interleukin-2 receptor, and epidermal growth factor receptor.

Oncofetal antigens are proteins made by genes that are very active during **fetal development**, but which function at a very low level after birth. The genes become activated in malignancy and produce large amounts of protein. This is the largest class of tumor marker and includes the tumor associated glycoprotein antigens (designated by the letters CA). Important tumor markers of this class are alpha-fetoprotein (AFP), carcinoembryonic antigen (CEA), prostate specific antigen (PSA), cathepsin-D, HER-2/neu, CA-125, CA-19-9, CA-15-3, nuclear matrix protein, and bladder tumor-associated antigen.

Some tumor markers are the product of oncogenes. These are genes that are active in fetal development and induce tumor growth when they become active in mature cells. Some important oncogenes are BRAC-1, myc, p53, RB (retinoblastoma) gene (RB), and Ph¹ (Philadelphia chromosome).

The fifth type of tumor marker consists of hormones. This includes hormones that are normally secreted by the tissue in which the malignancy arises and those which are produced by tissues that do not normally make the hormone (ectopic production). Some hormones associated with malignancy are adrenal corticotropic hormone (ACTH), calcitonin, catecholamines, gastrin, human chorionic gonadotropin (hCG), and prolactin.

Currently, there are over 60 analytes that are measured as tumor markers. All of the enzymes and hormones mentioned above are FDA approved as tumor markers, but most of the others are not. These are designated for investigational purposes only. The following list describes the most common tumor markers approved by the Food and Drug Administration for screening, diagnosis, or monitoring of cancer.

- Alpha-fetoprotein (AFP): AFP is a glycoprotein produced by the developing fetus, but levels decline after birth. Healthy non-pregnant adults rarely have detectable levels of AFP in their blood. The AFP test is primarily used for the diagnosis of spina bifida and other abnormalities associated with cerebrospinal fluid leakage during embryonic development. In adult males and non-pregnant females, an AFP above 300 ng/L is often associated with cancer although levels in this range may be seen in nonmalignant liver diseases. Levels above 1,000 ng/L are almost always associated with cancer. AFP is FDA-approved for the diagnosis and monitoring of patients with non-seminoma testicular cancer. It is elevated in approximately 100% of yolk sac tumors and 80% of hepatomas.

- **CA125:** This test is FDA-approved for the diagnosis and monitoring of women with ovarian cancer. Approximately 75% of persons with ovarian cancer shed CA-125 into the blood and have elevated levels. This includes approximately 50% of persons with Stage I disease and 90% with Stage II or higher. It is also found in approximately 20% of persons with pancreatic cancer. Other cancers detected by this marker include liver, colon, breast, lung, and digestive. **Pregnancy** and menstruation affect test results. Benign diseases detected by the test include endometriosis, ovarian cysts, fibroids, inflammatory bowel disease, cirrhosis, peritonitis, and **pancreatitis**. CA-125 levels correlate with tumor mass, and therefore, this test is used to determine whether recurrence of the cancer has occurred following **chemotherapy**. However, in some patients, recurrence occurs without an increase in the level of CA-125.
- **Carcinoembryonic antigen (CEA):** A glycoprotein that is part of the normal cell membrane. CEA is shed into serum and reaches very high levels in **colorectal cancer**. Over 50% of persons with breast, colon, lung, gastric, ovarian, pancreatic, and uterine cancer have elevated levels of CEA. CEA levels in plasma are monitored in patients with CEA secreting tumors to determine if second-look surgery should be performed. CEA levels may also be elevated in inflammatory bowel disease, pancreatitis, and liver disease. CEA is also elevated in smokers, and about 5% of healthy persons have an elevated plasma level.
- **Prostate specific antigen (PSA):** A small glycoprotein with protease activity that is specific for prostate tissue. The antigen is present in low levels in all adult males. Therefore an elevated level may require additional testing to confirm that cancer is the cause of the elevated result. High levels are seen in **prostate cancer**, benign prostatic hypertrophy, and inflammation of the prostate. PSA is approved as a screening test for prostatic carcinoma. PSA has been found to be elevated in more than 60% of persons with Stage A and more than 70% with Stage B cancer of the prostate and has replaced the use of prostatic acid phosphatase for prostate cancer screening because it is far more sensitive. Most PSA is bound to antitrypsins in plasma but some PSA circulates unbound to protein (free PSA). Persons with a borderline total PSA (between 4-10 ng/L), but who have a low free PSA are more likely to have malignant prostate disease.
- **Estrogen receptor (ER):** A protein found in the nucleus of breast and uterine tissues. The level of ER in the tissue is used to determine whether a person with **breast cancer** is likely to respond to estrogen therapy with tamoxifen, which binds to the receptors blocking the action of estrogen. Women who are ER negative have a greater risk of recurrence than women who are ER positive. Tissues levels are measured using one of two methods. The tissue can be homogenized into a cytosol, and a sandwich immunoassay used to measure the concentration of ER receptor protein. Alternatively, the tissue is frozen and thin-sectioned. An immunoperoxidase stain is used to detect and measure the estrogen receptors in the tissue.
- **Progesterone receptor (PR):** Two proteins, like the estrogen receptor, which are located in the nuclei of both breast and uterine tissues. PR has the same prognostic value as ER, and is measured by similar methods. Tissue which does not express the PR receptors is less likely to bind estrogen analogs used to treat the tumor. Persons who test negative for both ER and PR have less than a 5% chance of responding to endocrine therapy. Those who test positive for both markers have greater than a 60% chance of tumor shrinkage when treated with hormone therapy.
- **Human chorionic gonadotropin (hCG):** A glycoprotein produced by cells of the trophoblast and developing placenta. Very high levels are produced by trophoblastic tumors and choriocarcinoma. About 60% of testicular cancers secrete hCG. hCG is also produced by a large number of other tumors, but at a lower frequency. Some malignancies cause an increase in alpha and/or beta hCG subunits in the absence of significant increases in intact hCG. For this reason, tests have evolved for alpha and beta hCG, and most labs use these assays as tumor marker tests. Most EIA sandwich tests for pregnancy are specific for hCG, but detect the whole molecule and are called intact hCG assays.
- **Nuclear matrix protein (NMP22) and bladder tumor associated analytes (BTA):** NMP22 is a structural nuclear protein that is released into the urine when bladder carcinoma cells die. Urine is tested using an immunochemical method. Approximately 70% of bladder carcinomas are positive for NMP22. BTA is comprised of type IV collagen, fibronectin, laminin, and proteoglycan, which are components of the basement membrane that are released into the urine when bladder tumor cells attach to the basement membrane of the bladder wall. These products can be detected in urine using a mixture of antibodies to the four components. BTA is elevated in about 30% of persons with low-grade bladder tumors and over 60% of persons with high-grade tumors.

Preparation

Determination of the circulating level of tumor markers involves a blood test performed by a laboratory scientist. A nurse or phlebotomist usually collects the

blood by venipuncture, following standard precautions for prevention of exposure to bloodborne pathogens. Tissues are collected by a physician at the time of surgical or needle biopsy. Urine is collected by the patient using the midstream void technique.

Aftercare

Aftercare consists of routine care of the area around the puncture site. Pressure is applied for a few seconds and the wound is covered with a bandage. If a bruise or swelling develops around the puncture site, the area is treated with a moist warm compress.

Complications

Risks of venipuncture include mild dizziness, bruising, swelling, or excessive bleeding from the puncture site. As previously mentioned, results should be interpreted with caution. A single test result may not yield clinically useful information. Several results over a period of months may be needed to evaluate treatment and identify recurrence. Positive results must be interpreted cautiously because some tumor markers are increased in nonmalignant diseases and in a small number of apparently healthy persons. In addition false negative results may occur because the tumor does not produce the marker, and because levels seen in healthy persons may overlap those seen in the early stages of cancer. A false positive result occurs when the value is elevated, but cancer is not present. A false negative result occurs when the value is normal, but cancer is present.

Results

Reference ranges for tumor markers will vary from one laboratory to another because different antibodies and calibrators are used by various test systems. The values below are representative of normal values or cutoffs for commonly measured tumor markers.

- Alpha-fetoprotein (AFP): Less than 15 ng/L in men and non-pregnant women. Levels greater than 1,000 ng/L indicate malignant disease (except in pregnancy).
- CA125: Less than 35 U/mL.
- Carcinoembryonic antigen (CEA): Less than 3 µg/L for nonsmokers and less than 5 µg/L for smokers.
- Estrogen receptor: Less than 6 fmol/mg protein is negative; greater than 10 fmol/mg protein is positive.
- Human chorionic gonadotropin: Less than 20 IU/L for males and non-pregnant females. Greater than 100,000 IU/L indicates trophoblastic tumor.
- Progesterone receptor: Less than 6 fmol/mg protein is negative. Greater than 10 fmol/mg protein is positive.
- Prostate specific antigen (PSA): Less than 4 ng/L.

Health care team roles

Tumor marker tests are ordered and interpreted by a physician. In difficult cases, an oncologist may be needed. A phlebotomist, or sometimes a nurse, collects the blood, and a clinical laboratory scientist CLS (NCA)/medical technologist MT (ASCP) or clinical laboratory technician CLT (NCA)/medical laboratory technician MLT (ASCP) performs the testing.

Tumor marker tests must be correlated to other diagnostic evidence including the patient's history, physical exam, imaging, biopsy, and other laboratory results to confirm a diagnosis and provide accurate clinical staging of cancer. Consequently, many other members of the health care team, especially radiologists and radiologic technicians, are often involved.

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Abbott Laboratories. <http://www.abbottdiagnostics.com/medical_conditions/cancer/index.htm/>.

Victoria E. DeMoranville

24-hour fecal fat test see **Malabsorption tests**

Twin pregnancy see **Multiple pregnancy**

Tympanometry see **Audiometry**

Type and screen

Definition

Blood typing is a laboratory test that identifies blood group antigens (substances that stimulate an **immune response**) belonging to the ABO blood group system. The test classifies blood into four groups designated A, B, AB, and O. Antibody screening is a test to detect atypical antibodies in the serum that have been formed as a result of transfusion or **pregnancy**. An antibody is a protein produced by lymphocytes that binds to an antigen, facilitating its removal by phagocytosis or lysis. The type and screen (T&S) is performed on persons who may need a transfusion of blood products. These tests are followed by the compatibility test (cross-match). This test insures that no antibodies are detected in the recipient's serum that will react with the donor's red blood cells.

Purpose

Blood typing and screening are most commonly performed to ensure that a person who needs a transfusion will receive blood that matches (is compatible with) his or her own; and that clinically significant antibodies are identified if present. People must receive blood of the same blood type; otherwise, a severe transfusion reaction may result.

Prenatal care

Parents who are expecting a baby have their blood typed to diagnose and prevent hemolytic disease of the newborn (HDN), a type of anemia also known as erythroblastosis fetalis. Babies who have a blood type different from their mothers are at risk for developing this disease.

Determination of paternity

A child inherits factors or genes from each parent that determine his blood type. This fact makes blood typing useful in paternity testing. The blood types of the child, mother, and alleged father are compared to determine paternity.

Forensic investigations

Legal investigations may require typing of blood or such other body fluids as semen or saliva to identify criminal suspects.

Description

Blood typing and screening tests are performed in a blood bank laboratory by technologists trained in blood bank and transfusion services. The tests are performed on blood after it has been separated into cells and serum (the yellow liquid left after the blood cells are removed). Costs for both tests are covered by insurance when the tests are determined to be medically necessary.

Blood bank laboratories are usually located in blood center facilities, such as those operated by the American Red Cross, that collect, process, and supply blood that is donated, as well as in facilities, such as most hospitals, that prepare blood for transfusion. These laboratories are regulated by the United States Food and Drug Administration (FDA) and are often inspected and accredited by a professional association such as the American Association of Blood Banks (AABB).

Blood typing and screening tests are based on the reaction between antigens and antibodies. An antigen can be anything that triggers the body's immune response. The body produces a special protein called an antibody that has a uniquely shaped site that combines with the antigen to neutralize it. A person's body normally does not produce antibodies against its own antigens.

The antigens found on the surface of red blood cells are important because they determine a person's blood type. When red blood cells having a certain blood type antigen are mixed with serum containing antibodies against that antigen, the antibodies combine with and stick to the antigen. In a test tube, this reaction is visible as clumping or aggregating.

Although there are over 600 known red blood cell antigens organized into 22 blood group systems, routine blood typing is usually concerned with only two systems: the ABO and Rh blood group systems. Antibody screening helps to identify antibodies against several other groups of red blood cell antigens.

Blood typing

THE ABO BLOOD GROUP SYSTEM. In 1901, Karl Landsteiner, an Austrian pathologist, randomly combined the serum and red blood cells of his colleagues. From the reactions he observed in test tubes, he discovered the ABO blood group system. This discovery earned him the 1930 Nobel Prize in Medicine. A person's ABO blood type—A, B, AB, or O—is based on the presence or absence of the A and B antigens on his red blood cells. The A blood type has only the A antigen and the B blood type has only the B antigen. The AB blood type has both A and B antigens, and the O blood type has neither the A nor the B antigen.

FREQUENCY (%) OF ABO AND Rh BLOOD TYPES IN U.S. POPULATION

Racial Group	ABO Blood Type				Rh Blood Type	
	O	A	B	AB	Positive	Negative
Whites	45%	40%	11%	4%	85%	15%
Blacks	49%	27%	20%	4%	90%	10%

(Illustration by Standley Publishing. Courtesy of Gale Group.)

By the time a person is six months old, he or she will have developed antibodies against the antigens that his or her red blood cells lack. That is, a person with A blood type will have anti-B antibodies, and a person with B blood type will have anti-A antibodies. A person with AB blood type will have neither antibody, but a person with O blood type will have both anti-A and anti-B antibodies. Although the distribution of each of the four ABO blood types varies among racial groups, O is the most common and AB is the least common in all groups.

FORWARD AND REVERSE TYPING. ABO typing is the first test done on blood when it is tested for transfusion. A person must receive ABO-matched blood because ABO incompatibilities are the major cause of fatal transfusion reactions. To guard against these incompatibilities, typing is done in two steps. In the first step, called forward typing, the patient's blood is mixed with serum that contains antibodies against type A blood, then with serum that contains antibodies against type B blood. A determination of the blood type is based on whether or not the blood clots in the presence of these sera.

In reverse typing, the patient's blood serum is mixed with blood that is known to be type A and type B. Again, the presence of clotting is used to determine the type.

An ABO incompatibility between a pregnant woman and her baby is a common cause of HDN but seldom requires treatment. This is because the majority of ABO antibodies are IgM, which are too large to cross the placenta. It is the IgG component that may cause HDN, and this is most often present in the plasma of group O mothers.

Paternity testing compares the ABO blood types of the child, mother, and alleged father. The alleged father cannot be the biological father if the child's blood type requires a gene that neither he nor the mother have. For example, a child with blood type B whose mother has blood type O requires a father with either AB or B blood type; a man with blood type O cannot be the biological father.

In some people, ABO antigens can be detected in body fluids other than blood, such as saliva, sweat, or semen. ABO typing of these fluids provides clues in legal investigations.

THE RH BLOOD GROUP SYSTEM. The Rh, or Rhesus, system was first detected in 1940 by Landsteiner and Wiener when they injected blood from rhesus monkeys into guinea pigs and rabbits. More than 50 antigens have since been discovered that belong to this system, making it the most complex red blood cell antigen system.

In routine blood typing and cross-matching tests, only one of these 50 antigens, the D antigen, also known as the **Rh factor** or Rh₀[D], is tested for. If the D antigen is present, that person is Rh-positive; if the D antigen is absent, that person is Rh-negative.

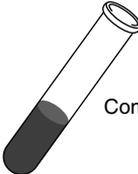
Other important antigens in the Rh system are C, c, E, and e. These antigens are not usually tested for in routine blood typing tests. Testing for the presence of these antigens, however, is useful in paternity testing, and when a technologist screens blood to identify unexpected Rh antibodies or find matching blood for a person with antibodies to one or more of these antigens.

Unlike the ABO system, antibodies to Rh antigens don't develop naturally. They develop only as an immune response after a transfusion or during pregnancy. The incidence of the Rh blood types varies between racial groups, but not as widely as the ABO blood types: 85% of whites and 90% of blacks are Rh-positive; 15% of whites and 10% of blacks are Rh-negative.

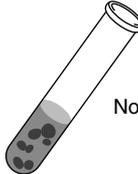
The distribution of ABO and Rh blood groups in the overall United States population is as follows:

- O Rh-positive, 38%
- O Rh-negative, 7%
- A Rh-positive, 34%
- A Rh-negative, 6%
- B Rh-positive, 9%
- B Rh-negative, 2%
- AB Rh-positive, 3%

Recipient's blood			Reactions with donor's red blood cells			
ABO antigens	ABO antibodies	ABO blood type	Donor type O cells	Donor type A cells	Donor type B cells	Donor type AB cells
None	Anti-A Anti-B	O				
A	Anti-B	A				
B	Anti-A	B				
A & B	None	AB				



Compatible



Not compatible

Blood typing is a laboratory test done to discover a person's blood type. If the person needs a blood transfusion, crossmatching is done following blood typing to locate donor blood that the person's body will accept. (Illustration by Electronic Illustrators Group.)

- AB Rh-negative, 1%

In transfusions, the Rh system is next in importance after the ABO system. Most Rh-negative people who receive Rh-positive blood will develop anti-D antibodies. A later transfusion of Rh-positive blood may result in a severe or fatal transfusion reaction.

Rh incompatibility is the most common and severe cause of HDN. This incompatibility may occur when an Rh-negative mother and an Rh-positive father have an Rh-positive baby. Cells from the baby can cross the placenta and enter the mother's bloodstream, causing the mother to make anti-D antibodies. Unlike ABO antibodies, the structure of anti-D antibodies makes it likely that they will cross the placenta and enter the baby's bloodstream. There, they can destroy the baby's red blood cells, causing a severe or fatal anemia.

The first step in preventing HDN is to find out the Rh types of the expectant parents. If the mother is Rh-negative and the father is Rh-positive, the baby is at risk for developing HDN. The next step is performing an antibody screen of the mother's serum to make sure she doesn't already have anti-D antibodies from a previous

pregnancy or transfusion. Finally, the Rh-negative mother is given an injection of Rh immunoglobulin (RhIg) at 28 weeks of gestation and again after delivery, if the baby is Rh positive. The RhIg attaches to any Rh-positive cells from the baby in the mother's bloodstream, preventing them from triggering anti-D antibody production in the mother. An Rh-negative woman should also receive RhIg following a **miscarriage**, abortion, or ectopic pregnancy.

OTHER BLOOD GROUP SYSTEMS. Several other blood group systems may be involved in HDN and transfusion reactions, although they are much less frequent than ABO and Rh. Some of the other groups are the Duffy, Kell, Kidd, MNS, and P systems. Tests for antigens from these systems are not included in routine blood typing, but they are commonly used in paternity testing.

Like Rh antibodies, antibodies in these systems do not develop naturally, but as an immune response after transfusion or during pregnancy. An antibody screening test is done before a cross-match to check for unexpected antibodies to antigens in these systems. A person's serum is mixed in a test tube with commercially-prepared cells

containing antigens from these systems. If hemagglutination, or clumping, occurs, the antibody is identified.

Antibody screening

Antibody screening is done to look for unexpected antibodies to other blood groups, such as certain Rh (e.g. E, e, C, c), Duffy, MNS, Kell, Kidd, and P system antigens. The recipient's serum of the recipient is mixed with screening reagent red blood cells. The screening reagent red blood cells are cells with known antigens. This test is sometimes called an indirect antiglobulin or Coombs test. If an antibody to an antigen is present, the mixture will cause agglutination (clumping) of the red blood cells or cause hemolysis (breaking of the red cell membrane). If an antibody to one of these antigens is found, only blood without that antigen will be compatible in a cross-match. This sequence must be repeated before each transfusion a person receives.

Testing for infectious disease markers

As of 2001, pretransfusion testing includes testing blood for the following infectious disease markers:

- Hepatitis B surface antigen (HBsAg). This test detects the outer envelope of the hepatitis B virus.
- Antibodies to the core of the hepatitis B virus (Anti-HBc). This test detects an antibody to the hepatitis B virus that is produced during and after an **infection**.
- Antibodies to the hepatitis C virus (Anti-HCV).
- Antibodies to human **immunodeficiency** virus, types 1 and 2 (Anti-HIV-1, -2).
- HIV-1 p24 antigen. This test screens for antigens of HIV-1. The advantage of this test is that it can detect HIV-1 infection a week earlier than the antibody test.
- Antibodies to human T-lymphotropic virus, types I and II (Anti-HTLV-I, -II). In the United States, HTLV infection is most common among intravenous drug users.
- Syphilis. This test is performed to detect evidence of infection with the spirochete *Treponema pallidum*.
- Nucleic acid amplification testing (NAT). NAT uses a new form of blood testing technology that directly detects the genetic material of the HCV and HIV viruses.
- Confirmatory tests. These are done to screen out false positives.

Cross-matching

Cross-matching is the final step in pretransfusion testing. It is commonly referred to as compatibility testing, or "type and cross." Before blood from a donor and

Blood typing

Blood type	Antigen	Antibody
Group A	A	B
Group B	B	A
Group AB	A, B	None
Group O	None	A, B
Rh factor: negative	None	
Rh factor: positive	Rh	

the recipient are cross-matched, both are ABO and Rh typed. To begin the cross-match, a unit of blood from a donor with the same ABO and Rh type as the recipient is selected. Serum from the patient is mixed with red blood cells from the donor. The cross-match can be performed either as a short (5–10 minutes) incubation intended only to verify ABO compatibility or as a long (45 minutes) incubation with an antihuman globulin test intended to verify compatibility for all other red cell antigens. If clumping occurs, the blood is not compatible; if clumping does not occur, the blood is compatible. If an unexpected antibody is found in either the patient or the donor, the blood bank does further testing to ensure the blood is compatible.

In an emergency, when there is not enough time for blood typing and cross-matching, O red blood cells may be given, preferably Rh-negative. O-type blood is called the universal donor because it has no ABO antigens for a patient's antibodies to combine with. In contrast, AB blood type is called the universal recipient because it has no ABO antibodies to combine with the antigens on transfused red blood cells. If there is time for blood typing, red blood cells of the recipient type (type-specific cells) are given. In either case, the cross-match is continued even though the transfusion has begun.

Autologous donation

The practice of collecting a patient's own blood prior to elective surgery for later transfusion is called autologous donation. Since the safest blood for transfusion is the patient's own, autologous donation is particularly useful for patients with rare blood types. Three to four units of blood are collected several weeks before surgery, and the patient is given **iron** supplements.

Preparation

To collect the 10 mL of blood needed for these tests, a healthcare worker ties a tourniquet above the patient's elbow, locates a vein near the inner elbow, cleans the skin overlying the vein, and inserts a needle into that

vein. The blood is drawn through the needle into an attached vacuum tube. Collection of the sample takes only a few minutes.

Blood typing and screening must be done three days or less before a transfusion. A person does not need to change diet, medications, or activities before these tests. Patients should tell the healthcare provider if they have received a blood transfusion or a plasma substitute during the last three months, or have had a radiology procedure using intravenous contrast media. These can give false clumping reactions in both typing and cross-matching tests.

Aftercare

The possible side effects of any blood collection are discomfort, bruising, or excessive bleeding at the site where the needle punctured the skin, as well as dizziness or fainting. Bruising and bleeding is reduced if pressure is applied with a finger to the puncture site until the bleeding stops. Discomfort is treated with warm packs to the puncture site.

Complications

Aside from the rare event of infection or bleeding, there are no risks from the blood collection. Blood transfusions always have the risk of an unexpected transfusion reaction. These complications may include an acute hemolytic transfusion reaction (AHTR), which is most commonly caused by ABO incompatibility. The patient may complain of **pain**, difficult breathing, **fever** and chills, facial flushing, and nausea. Signs of **shock** may appear, including a drop in **blood pressure** and a rapid but weak pulse. If AHTR is suspected, the transfusion should be stopped at once.

Other milder transfusion reactions include a delayed hemolytic transfusion reaction, which may occur one or two weeks after the transfusion. It consists of a slight fever and a falling **hematocrit**, and is usually self-limited. Patients may also have allergic reactions to unknown components in donor blood.

Results

The blood type is labeled as A+, A-, B+, B-, O+, O-, AB+, or AB-, based on both the ABO and Rh systems. If antibody screening is negative, only a cross-match is necessary. If the antibody screen is positive, then blood that is negative for those antigens must be identified. The desired result of a cross-match is that compatible donor blood is found. Compatibility testing procedures are designed to provide the safest blood product possible for

the recipient, but a compatible cross-match is no guarantee that an unexpected adverse reaction will not appear during the transfusion.

Except in an emergency, a person cannot receive a transfusion without a compatible cross-match result. In rare cases, the least incompatible blood has to be given.

Health care team roles

A physician orders the type and screen test if there is only a small chance (e.g. less than 10%) of a need for blood transfusion. The technologist types and screens the recipient (patient). If a transfusion is required, then a cross-match is performed with the patient's blood and a specific unit of donated blood. A nurse monitors the patient for signs of AHTR or other transfusion reactions during the entire procedure.

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- American Association of Blood Banks. 8101 Glenbrook Road, Bethesda, MD 20814. (301) 907-6977. <<http://www.aabb.org>>.
- American College of Obstetricians and Gynecologists. 409 12th Street SW, Washington, DC 20024-2188. (202) 638-5577. <<http://www.acog.org>>.
- American Red Cross Blood Services. 430 17th Street NW, Washington, DC 20006. (202) 737-8300. <<http://www.redcross.org>>.

KEY TERMS

ABO blood type—Blood type based on the presence or absence of the A and B antigens on the red blood cells. There are four types: A, B, AB, and O.

Acute hemolytic transfusion reaction (AHTR)—A severe transfusion reaction with abrupt onset, most often caused by ABO incompatibility. Symptoms include difficulty breathing, fever and chills, pain, and sometimes shock.

Antibody—A protein produced by B-lymphocytes that binds to an antigen facilitating its removal by phagocytosis or lysis.

Antigen—Any substance that stimulates the production of antibodies and combines specifically with them.

Autologous donation—Donation of the patient's own blood, made several weeks before elective surgery.

Blood bank—A laboratory that specializes in blood typing, antibody identification, and transfusion services.

Blood type—Any of various classes into which human blood can be divided according to immunological compatibility based on the presence or absence of certain antigens on the red blood cells. Blood types are sometimes called blood groups.

Cross-match—A laboratory test done to confirm that blood from a donor and blood from the recipient are compatible. Serum from each is mixed with red blood cells from the other and observed for hemagglutination.

Gene—A piece of DNA, located on a chromosome, that determines how such traits as blood type are inherited and expressed.

Hemagglutination—The clumping of red blood cells due to incompatibility.

Indirect Coombs' test—A test used to screen for unexpected antibodies against red blood cells. The patient's serum is mixed with reagent red blood cells, incubated, washed, tested with antihuman globulin, and observed for clumping.

Rh blood type—In general, refers to the blood type based on the presence or absence of the D antigen on the red blood cells. There are, however, other antigens in the Rh system.

Serum (plural, sera)—The clear, pale yellow liquid that separates from the clot when blood coagulates.

Transfusion—The therapeutic introduction of blood or a blood component into a patient's bloodstream.

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Mark A. Best

Types I and II diabetes see **Diabetes mellitus**

Tzanck preparation

Definition

Tzanck preparation is a rapid test used to help physicians diagnose infections caused by herpes **viruses**. This test cannot detect the virus, but can detect the characteristic changes in cells that herpes **infection** produces.

Purpose

Herpes viruses are responsible for several superficial infections. Varicella zoster virus causes chickenpox and shingles, herpes simplex type 1 causes the **common cold sore** or **fever blister**, and herpes simplex type 2 causes the sexually transmitted disease (STD) **genital herpes**. All forms of herpes are associated with production of vesicles (blisters) and ulcers.

Physicians usually can diagnose herpes infections by looking at the type of vesicles and ulcers, and their distribution on the person's body. Sometimes laboratory evidence of herpes is needed to confirm the diagnosis. When a sample is available from a vesicular lesion, the Tzanck preparation can be done more rapidly and less expensively than other tests. It is important to note that herpes infection may be present in such lesions, and not produce a positive Tzanck test result. A positive finding is diagnostic of herpes infection, but is seen in only about 67% of herpes infections. Consequently, other lab-

KEY TERMS

Herpes—A family of viruses including herpes simplex types 1 and 2, and herpes zoster (also called varicella zoster). Herpes viruses cause several infections, all characterized by blisters and ulcers, including chickenpox, shingles, genital herpes, and cold sores or fever blisters.

oratory tests may be required to diagnose herpes infections. Some herpes infections are present in tissues that cannot be tested by a Tzanck preparation. For example, herpes can be devastating to a newborn or a person with a weakened **immune system**. The virus may invade the **central nervous system** causing **meningitis**. Laboratory culture, tests for herpes DNA, antigens, and antibodies may be needed for diagnosis in such circumstances.

Precautions

Cell collection can be performed in minutes with only minor discomfort to the patient. Health care providers should use appropriate protective measures to avoid infection when collecting the samples.

Description

Tzanck preparation is also called a Tzanck smear, herpes stain for inclusion bodies, or an inclusion bodies stain. The Tzanck preparation is performed by smearing cells taken from a fresh blister or ulcer onto a **microscope** slide. A fresh blister is opened with a scalpel or sterile needle. The physician scrapes the base of the blister with the scalpel, gathers as much cellular material as possible, and gently spreads it on a microscope slide. The cells are fixed with alcohol and stained with Giemsa stain. The cells are examined under a microscope for characteristic changes caused by herpes virus. Herpes causes formation of giant cells with multiple nuclei. The shape of each nucleus appears molded to fit together with those adjacent to it. The nuclei may also contain red inclusions characteristic of herpes infection.

Preparation

There is no special preparation required before this procedure.

Aftercare

There are no special aftercare requirements associated with this procedure.

Complications

There are no complications associated with this procedure. However, health care professionals should be careful not to expose themselves to the potentially infectious material during specimen collection.

Results

A normal smear shows no evidence of a herpes infection. However, this test may also produce false negatives. Studies have shown that the Tzanck preparation shows signs of infection in only 50–79% of people with a herpes infection. A negative Tzanck preparation may have to be confirmed by a herpes culture or other laboratory test. A smear that shows evidence of herpes infection does not distinguish between the various infections caused by herpes virus. The physician uses the person's symptoms and other clinical findings to distinguish between these infections and will often order a culture for confirmation. Newer antigen detection tests and serologic tests are available to assist in diagnosing herpes viruses, but viral cultures are still considered the best and most cost efficient diagnostic tool available.

Health care team roles

A physician, nurse, or physician assistant collects the cell samples from the patient. The Tzanck preparation and microscopic examination may be performed by the physician, by a clinical laboratory scientist/medical technologist, or laboratory specialist with specific training in clinical diagnostic virology.

Patient education

The health care provider can be an important resource for patients with herpes infection, especially those with genital herpes. Patients with genital herpes may be embarrassed about their condition or hesitant to seek medical attention. Health care providers counsel patients, and explain prevention and treatment of sexually transmitted diseases.

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Linda D. Jones, B.A., PBT (ASCP)

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U

UGI *see* **Upper GI exam**

Ulcer drugs *see* **Antiulcer drugs**

Ultrasonic encephalography

Definition

Ultrasonic encephalography, or echoencephalography, is the use of ultrasound to produce a noninvasive diagnostic image of the **brain** and its structures, including the alignment down the midline, the size of ventricles, and the presence of bleeding or tumors.

Purpose

Ultrasonic encephalography is a noninvasive way to create images of the brain. Also called intracranial ultrasound or head ultrasound, the test is most commonly used on children under the age of two to diagnose hemorrhage or hydrocephalus (enlargement of the head due to accumulation of fluid). It is particularly useful in the neonatal intensive care unit to provide bedside monitoring of premature babies who are at higher risk for hemorrhage. A series of tests are commonly ordered for babies born earlier than 34 weeks of gestation.

Ultrasonic encephalography can also detect the swelling inside the head (cerebral **edema**), as shown by an increase in the size of the lateral ventricles, sometimes seen in diabetic children. The test can be used in adults to monitor the size of the ventricles or to determine a shift in the structure of the brain from midline due to swelling or a tumor. However, for adults and older children, this test has been largely replaced by computed tomography (CT).

Precautions

There are no contraindications to ultrasonic encephalography.

Description

Ultrasonic encephalography uses ultrasound to produce diagnostic images of the brain. Ultrasonic waves are sound in the range above what normally can be heard by the human ear, anything above 20,000 Hertz (cycles per second) in frequency. Ultrasonic encephalography generally uses high frequency sounds waves, in the ranges of 5 to 10 MHz.

Sound waves can produce an image of the brain because of the different densities present in the tissue of the brain, **blood**, or tumor and the cerebrospinal fluid within the ventricles. Matter of different density reflects, or echoes, the sound waves differently, allowing the machine to distinguish between the structures.

The fineness of the distinguishing process is known as resolution. Resolution is affected by the frequency of sound waves used. As frequency increases, resolution increases. However, an increase in frequency reduces the ability of the sound waves to penetrate into the brain. Because of this relationship, successful ultrasonic encephalograms often zero in on the structures of interest, maximizing the resolution by using the highest frequency that penetrates sufficiently into the head.

A main reason why ultrasonic encephalography is used in newborns and children under the age of two is the presence of the anterior and posterior fontanelle, triangular structures at the top and back of the head where bones of the **skull** have not yet fused. As bone is a poor conductor of ultrasonic waves, the fontanelles provides convenient conduits into and out of the brain for the ultrasound pulses. Once the bones have fused together, the resolution of the ultrasound is greatly reduced by having to pass through bone in order to visualize the brain.

Ultrasonic encephalography involves sending ultrasonic waves through the top of the head, bouncing them off the brain structures, and recording the resulting echo. The results of the test can be produced in a plotted graphic form, known as an A-mode echo or in a two-dimensional mode. In A-mode, one axis represents the time required for the return of the echo and the other corresponds to the strength of the echo. A 2-D echo produces a cross-sectional image of the brain. As of mid-2000, 3-D imaging of the neonatal brain was still in experimental stages, with poor visualization as compared to 2-D images.

The **ultrasound unit** used for echoencephalography includes a TV monitor (cathode ray tube or CRT), a transducer for sending and receiving the ultrasonic waves, the transmitter, the receiver, the amplifier, and recording devices. The transducer is a hand-held instrument that is generally used both to transmit sound waves and to receive the echoes. The transducer includes the element, electrode connections to the transmitter and the receiver, backing material, a matching layer, and a protective face.

The element is the core of the transducer, the material that actually produces the sound waves. Elements are built around piezoelectric ceramic (e.g. barium titanate or lead zirconate titanate) chips. (Piezoelectric refers to electricity that is produced when pressure is put on certain crystals such as quartz.) These ceramic chips react to electric pulses by producing sound waves (they are transmitting waves) and react to sound waves by producing electric pulses (receiving). Bursts of high-frequency electric pulses supplied to the transducer by the transmitter cause it to produce the scanning sound waves. The transducer then receives the returning echoes, translates them back into electric pulses, and sends them to the receiver. The backing material helps to focus the sound energy into the element, while the matching layer helps to reduce reflection of the sound from the transducer surface. The protective face shields the internal components of the transducer. Electrodes connect the transmitter and the receiver to the transducer. The amplifier boosts the returning signals and prepares them to be displayed on the TV monitor (CRT).

Preparation

The patient who is undergoing an ultrasonic encephalogram is laid on his or her back or side and must be still during the test. It is suggested that children two months to one year of age do not eat or drink for three hours before the test, so a bottle can be drunk during the exam. Particular care must be taken if the child is con-

nected to a respirator. Warmed conducting gel is placed on the head to ensure an air-free contact between the transducer and the head (air is a very poor conductor of ultrasound) and to allow the transducer to slide easily.

The area that provides the least amount of interference with the ultrasound waves is called the acoustic window. For infants and young children, the best acoustic windows are transfontanelle, that is, through either the posterior or anterior fontanelle. Some standard views from the anterior fontanelle include midline sagittal (viewed from the side, through the midline, or middle of the head), lateral sagittal (viewed from the side, displaced from the midline), and coronal views (viewed from the front, angled toward the back, middle, and front). Axial views (across the temple) can be used, despite the reverberation artifacts caused by the skull, to follow lateral ventricle size.

An ultrasonic encephalogram is noninvasive, causes no **pain**, and takes about 20–30 minutes.

Aftercare

After the test, the patient can return to regular daily activities and meals.

Complications

There are no complications or side effects of ultrasonic encephalography.

Results

Ultrasonic encephalograms are mainly performed for the diagnosis and follow-up of neonatal hemorrhage, hydrocephalus, and congenital malformations. **Premature infants** often develop bleeding in the germinal matrix of the caudate nucleus. The caudate nucleus is an elongated, arched gray mass in the center of the brain next to the lateral ventricles, and the germinal matrix is a group of brain cells in that area that is still developing. Bleeding can also occur in the choroid plexus (spongy tissue of the ventricles) and rarely, the cerebellum. If the bleeding is severe it can leak into the ventricle, a problem known as intraventricular hemorrhage (IVH). All of these bleeding problems can be seen initially as echogenic areas (white areas) that later can be replaced by fluid-filled cysts that scan as dark areas.

Bleeding in the neonate is sometimes associated with the later development of **cerebral palsy**, although other risk factors, such as bronchopulmonary dysplasia (BPD), appear to be equally predictive.

When looking for hydrocephalus, measurements of the ventricles are done. On a lateral sagittal view, the dis-

tance from the curve of the choroid plexus to the tip of the occipital horn generally should not be more than 16 mm. Using a coronal view, the body of the lateral ventricle should generally not be more than 3 mm. Finally, an axial view is often used to determine the lateral ventricular ratio, the lateral ventricular width divided by the hemispheric width (both widths measured from the outer border to the midline). The ratio is compared to previous measurements to see if swelling is developing.

There are many congenital malformations of the brain that can be either diagnosed or the severity determined with ultrasonic encephalography. Some representative examples include microcephaly, holoprosencephaly, Dandy-Walker Syndrome, and encephalocele. These conditions can have serious prognoses, so ultrasound is an effective means of determining what treatment, such as placement of a shunt or surgery, should take place.

Health care team roles

Ultrasonic encephalograms are often produced by specially trained ultrasound technologists. Training for such a position usually involves study at a two-year college or vocational program. A typical program would include:

- elementary principles of ultrasound
- ultrasound transducers
- pulse-echo principles & instrumentation
- ultrasound image storage & display
- artifacts (erroneous results)
- quality assurance
- bioeffects and safety

Certification of ultrasound technologists specializing in neurological work such as ultrasonic encephalography is available through the American Registry of Diagnostic Medical Sonographers as a registered diagnostic medical sonographer with a specialty in neurosonology. Certification requires passing both a general and a specialized test.

A physician such as pediatrician, neonatologist, or radiologist does the final review and diagnosis based on the results of an ultrasonic encephalogram. The doctor can be present for the exam or may review saved images.

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KEY TERMS

Acoustic window—Area through which ultrasound waves move freely.

Congenital malformation—A deformity present at birth.

Echogenic—Highly reflective of ultrasound waves; shows as a white area in the scan.

Hemorrhage—Bleeding, the escape of blood from the vessels.

Hydrocephalus—A congenital or acquired condition characterized by an increase in size of the cerebral ventricles. Without treatment it can cause enlargement of the head, brain shrinkage, mental deterioration, and convulsions.

Intracranial—Inside the skull.

Ventricle—A small cavity in the brain. Humans have two lateral ventricles, a third ventricle, and a fourth ventricle.

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Michelle L. Johnson, M.S., J.D.

Ultrasound technology see **Diagnostic medical sonography**

Ultrasound unit

Definition

An ultrasound unit is a noninvasive medical device used to produce images of body tissues and organs from

differential reflections of ultrasonic sound waves. The technique of diagnostic imaging performed by ultrasound units is called ultrasonography. Ultrasonic waves are sound waves of a higher frequency than the human ear can detect. The frequency of a sound wave is the number of times per second that it cycles, and the number of cycles is measured in hertz (Hz). For example, one kilohertz (kHz) is one thousand cycles per second. Human **hearing** can detect sound in the range between 20 hertz to about 20 kilohertz (20kHz), or 20,000 cycles per second. Ultrasound images are generally produced using sound waves in the range between 1.6 to 10 million megahertz (MHz). Body tissues of different density reflect, or echo, sound waves differently, allowing the sonographer to distinguish between the structures.

Purpose

The first account of diagnostic ultrasound was published in 1942 by Dr. Karl Dussik, an Austrian psychiatrist. Dr. Dussik used ultrasound to locate **brain** tumors. Although ultrasound is better known as a technique of diagnostic imaging, it is also used at present in a variety of therapeutic applications.

Diagnostic applications

Ultrasonographic imaging can be used to visualize most soft-tissue organs. Dr. Dussik used ultrasound to visualize the cerebral ventricles in his pioneering use of the technique. Ultrasound is now used routinely to examine the **kidneys** or **liver** for the presence of tumors or cysts. The gall bladder can be checked for gallstones. Ultrasonography can also be used to examine **blood vessels** in the abdomen, extremities, or neck for evidence of swelling or blockage. One of the best-known diagnostic applications of ultrasound is its use during **pregnancy** to monitor the development, position, sex, and number of babies present in the mother's uterus.

Diagnostic ultrasound units are used to guide instruments during such invasive treatments as needle biopsies. Intraoperative sonography is used during many other procedures and even in combination with other medical imaging techniques. For example, intraoperative ultrasound is used during neurosurgery to detect brain tissue movement that can compromise the use of other more detailed imaging systems, such as computed tomography (CT) or **magnetic resonance imaging** (MRI).

Therapeutic applications

Ultrasonography also has therapeutic applications, although the frequencies used for therapy are usually in

different frequency ranges than those used in diagnostic ultrasound.

BODY FLUID SAMPLING. A technique developed at MIT uses ultrasound to draw samples of tissue fluid through the skin without the use of needles. Ultrasound waves disorganize the fatty layers in the outer layer of human skin, thus increasing the skin's permeability sufficiently to allow molecules of tissue fluid to travel through into a vacuum cylinder. The researchers apply ultrasound to the skin at 20 kHz frequency for two minutes. This frequency is much lower than that used to visualize fetuses in the womb. The technique shows promise as a noninvasive way for diabetics to monitor their **blood** sugar levels.

PHYSIOTHERAPY. Ultrasound waves produce heat as well as sound echoes. The low levels of heat produced by ultrasound appear to speed up wound healing, first by facilitating the release of histamine, a chemical that attracts white blood cells to the injured tissue. Second, ultrasound stimulates fibroblasts to secrete collagen, a fibrous protein found in connective tissue that increases the strength of the healing tissue. Ultrasound can also be applied to the area around the wound to provide mild heat in order to stimulate blood circulation in the area. A frequency of 3 MHz is used for most skin **wounds**, 1 MHz for deeper wounds or the area around the wound.

A British study indicates that ultrasound therapy applied to the wrist provides good short-term relief of mildly to moderately severe **carpal tunnel syndrome**. The beneficial effects of the treatment last for at least six months. It is thought that the ultrasound waves relieve the symptoms of the syndrome by relieving inflammation.

TUMOR DETECTION AND TREATMENT. Ultrasound can be used to scan for endometrial **cancer** in postmenopausal women without the need for a surgical biopsy. The ultrasound captures a detailed image of the lining of the uterus, which allows not only for immediate evaluation of the results, but is also more accurate than a biopsy.

Focused high-intensity ultrasound is being tested as a technique for destroying cancerous tumors within the body. The high-intensity beam, which is about 10,000 times as powerful as the ultrasound beams used to monitor pregnancies, appears to work by heating the cancer cells to nearly the temperature of boiling water. The cancer cells die within seconds. In 1999, the FDA granted approval for the use of focused ultrasound to treat enlarged prostate glands in men.

Description

An ultrasound unit includes a television monitor (cathode ray tube or CRT), a transducer for sending and receiving the ultrasonic waves, a transmitter, receiver, amplifier, and a strip chart recorder.

The transducer

The transducer, which is also called a probe, is a hand-held instrument used to both generate the sound waves and receive the echoes. The transducer typically functions as a generator about 10% of the time and as a receiver the other 90%. The transducer includes an element, electrode connections to the transmitter and the receiver, backing material, a matching layer, and a protective face.

The element is the core of the transducer—the material that actually produces the sound waves. Elements are usually made of such ceramic materials as barium titanate or lead zirconate titanate. These materials change shape when electrical current is applied, which produces the ultrasonic waves. When ultrasonic waves are absorbed by the element, electrical energy is produced. The transducer of a real-time scanner typically contains over 300 crystals arranged in a row, each emitting and receiving an ultrasound beam in rapid succession.

The remaining parts of the transducer help to focus the sound waves for most effective function. The backing material directs the sound energy into the element, while the matching layer reduces reflection of the sound from the transducer surface. The protective face shields the internal components of the transducer.

There are three fundamental types of transducer used in medical applications: convex, linear, and phased array. Transducers come in different shapes and sizes for use in different scanning applications. Obstetrical scans often use a convex probe that is shaped like a curved soap bar. Probes for vaginal scans are long and slender. There are specially designed probes that couple biopsy needles with the transducer, so that the ultrasound can be easily used to guide the needle.

Remaining parts of the unit

The remaining parts of the ultrasound unit initiate or receive the signals collected by the transducer or are involved in reconstructing the electronic signals into an image. The transmitter creates the impulses sent to the transducer to generate the sound energy. The receiver accepts the electric current generated in the transducer by returning sound energy. Electrodes connect the transmitter and the receiver to the transducer. The amplifier boosts the returning signals and prepares them for display on the monitor (CRT).



An ultrasound unit consists of a scanhead, which is placed on a patient's body, and a monitor, which displays the ultrasound image. (Photograph by Will & Deni McIntyre. Science Source/Photo Researchers. Reproduced by permission.)

One of the advantages of ultrasound is the compactness of the actual unit. Although most portable units are stored on a wheeled cart, completely portable ultrasounds weighing just over 5 lbs (2 kg) and carried by a handle built into the unit, are also available.

The compactness and portability of ultrasound has made it the diagnostic method of choice for isolated medical settings. Remote linkups can allow doctors to review ultrasound images taken many miles away. The space shuttle is equipped with an ultrasound, both for monitoring the effects of weightlessness on astronauts and experimental animals and for emergency use.

Ultrasound modes

The ultrasound monitor is used to display the images produced. Depending on the kind of transducer, the monitor has several basic modes of display, including A-

mode, B-mode, M-mode, and Doppler. A-mode is the simplest form of ultrasound; it analyzes a single beam. The A-mode display is a series of peaks indicating the distance of the structure being scanned from the transducer as time elapses. Isolated use of A-scans is now rare, but this display mode can be used to ensure that the time-gain compensation is set correctly and to check the accuracy of the distance measurements between echoes.

B-mode is the image that results from converting the peaks of A-mode into dots whose brightness varies with the strength of the signal. Stronger signals appear more nearly white and weaker signals more nearly black. In a real-time system, B-mode scans repeat about 30 times a second, thus capturing such movements within the patient as the beating of the **heart** or a fetus sucking its thumb.

M-mode displays B-mode dots on a moving-time basis. Before the development of real-time systems, M-mode was used to monitor the opening and closing of heart valves. It is still useful in determining the precise timing of valve opening as well as coordinating valve motion with **electrocardiography**, phonocardiography (the study of heart sounds), and Doppler.

Doppler ultrasound depicts the movement of fluid, usually blood, within the body. The technique is based on the fact that sound waves change in frequency when bounced off a moving target, called a sample volume. If the sample volume is moving away from the transducer, the frequency of the bounced sound wave is increased after the echo, while the frequency is decreased if the sample volume is moving toward the transducer. There are two kinds of Doppler analysis, pulsed wave (PW) and continuous wave (CW). Pulsed wave has proved very useful for analyzing blood flow in a particular area of the heart or group of vessels, while continuous wave is better suited for evaluation of a single valve or vessel. Doppler output is often enhanced with a color display. With most of these systems, shades of red indicate that blood is flowing toward the transducer, while shades of blue represent flow away from the transducer.

Operation

To perform an ultrasound scan, the patient is placed on an examination table with the area to be imaged uncovered. A gel, warmed for comfort, is applied to the skin to prevent air bubbles between the transducer and the body. The sonographer sweeps the transducer across the area of interest, keeping contact with the patient's skin.

In order to obtain the best possible images, the sound waves are sent within a particular area called the acoustic

window. For example, a commonly used acoustic window for an echocardiograph (ultrasound of the heart) is the left parasternal approach, which allows visualization of all the valves and chambers. Acoustic windows avoid bone and such air-filled organs as the **lungs**, as both bone and air are poor media for ultrasonic waves.

The level of detail of the imaging process is known as resolution. Resolution is affected by the frequency of sound waves used. As frequency increases, resolution increases. Increase in frequency, however, reduces the sound waves' depth of penetration into body tissue. Because of this inverse relationship, sonographers usually focus on the structures of interest, maximizing the resolution by using the highest frequency that will penetrate the tissue to the required depth.

Settings

The settings of an ultrasound unit include the power output (gain or attenuation) and the time gain compensation (gain curve or swept gain), controlled by four variables: the slope rate (slope), the slope start (delay), and the near and far gain (initial gain). Each of these controls affects the way the echoes are sent or received. The power output alters the echoes throughout the ultrasonic field by varying the amount of sound sent (gain) or the strength of the signal after it comes back to the transducer (attenuation), measured in decibels. Excessive gain can produce too many echoes and differentiation between tissues can be lost.

One major source of interference is echoes from the skin and subcutaneous tissues. These can be eliminated by altering the slope delay value by 2–3 cm. Near gain alters the power of the echoes in the near field. This value is adjusted so that enough information about the near field is present in the image, but not so much as to swamp out signals from small structures farther from the transducer. Far gain governs the strength of the echoes from distant structures, and must be adjusted to ensure all parts of the organ or structure being studied are well represented in the image.

Preprocessing and postprocessing controls can be used to clarify an image for a more detailed look at a particular section. Preprocessing controls assign values to returning echoes before they are displayed and can help accentuate borders between structures. Postprocessing assigns values to echoes after they have been displayed, thus helping to accentuate low-level echoes.

Real-time scanners have such special controls as calipers (to measure distances); cineloop (a replay function to help select an image for a photo); frame rate; freeze frame; and record (to videotape the image).

Doppler ultrasound units have an additional set of controls. The range gate cursor is used to indicate the depth and area placement of the sample volume, overlaid on a B-scan. A second control is inversion, which allows flow away from the transducer to become a positive rather than negative value for easier viewing. Velocity scale allows changes for different rates of cardiac output; sweep speed changes the rate at which the information is displayed. Wall filter settings are used to eliminate signal noise and artifacts caused by the patient's movement. The angle correct bar aligns the blood flow and the ultrasound beam because the angle must be no greater than 60 degrees. The size of the angle is important because the smaller the angle between beam and flow, the greater the Doppler shift. Finally, Doppler gain adjustments ensure that the image of color flow is set so that variations are seen within the vessel and any artificial flow outside the vessel is eliminated.

Safety

Ultrasound appears to be one of the safest imaging technologies as well as one of the least expensive. As of 2001, there are no confirmed biological effects on patients or instrument operators with exposure to ultrasound for the time periods and frequencies used in diagnostic procedures. The current position of the American Institute of Ultrasound in Medicine (AIUM) is that the benefits to patients with diagnostic ultrasound outweigh any known risks—although the possibility always exists that adverse biological effects may be identified in the future.

Ultrasound during pregnancy is regarded as appropriate when performed to help the physician determine the baby's health and due date. Ultrasound examination can also determine the baby's position in the womb or the existence of a **multiple pregnancy**. Ultrasound also may be used to detect some birth defects. The AIUM, however, does not condone the use of ultrasound solely to determine fetal sex.

Maintenance

Maintenance of ultrasound equipment is performed by specially trained technicians who may belong to the hospital engineering staff or an outsource company. Maintenance includes visual inspections, periodic cleaning, and system performance checks. Performance checks ensure that all power supply voltages are within tolerance and image performance is maintained.

Health care team roles

Ultrasound units are operated by specially trained ultrasound technologists. Nurses assist with patient preparation and education about the procedure. A physician, who may be a radiologist, surgeon, internist, or gynecologist performs the final review and diagnosis based on the results of the ultrasound. The physician may be present during the examination or may make the final review and diagnosis based on saved images.

Training

Ultrasound technologists have usually completed a training program in a two-year college or vocational program. A typical course list includes:

- elementary principles of ultrasound
- ultrasound transducers
- pulse-echo principles and instrumentation
- ultrasound image storage and display
- artifacts (erroneous results)
- quality assurance
- bioeffects and safety

The American Registry of Diagnostic Medical Sonographers certifies ultrasound technologists as registered diagnostic medical sonographers (RDMS); registered diagnostic cardiac sonographers (RDCS); registered vascular technologists (RVT); and registered ophthalmic ultrasound biometrists. Specialty areas within these credentials include abdominal sonography, neurosonology, obstetrics and gynecology, and ophthalmology (RDMS); adult and pediatric **echocardiography** (RDCS); and noninvasive vascular technology (RVT).

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KEY TERMS

Acoustic window—The area through which ultrasound waves move freely.

Attenuation—Reduction of the strength of the sound signal as it travels through body tissues.

Decibel—A unit used to express differences in acoustic power. A decibel (dB) is equal to 10 times the common logarithm of the ratio of two sound signals.

Frequency—The number of cycles per second of a sound wave, measured in hertz. One thousand cycles per second is equal to one kilohertz (kHz).

Gain—The strength of the ultrasound signal as it leaves the transducer.

Hertz—A unit of measurement of the frequency of sound waves, equal to one cycle per second. It is named for Heinrich R. Hertz (1857-1894), a German physicist.

Real-time—A type of ultrasound that involves computerized images that respond immediately to user input, in order to record movement.

Sample volume—The area of blood flow analyzed by Doppler ultrasound.

Sonographer—A technician who operates ultrasound units.

Transducer—The handheld part of the ultrasound unit that produces the ultrasound waves and receives the echoes.

Ultrasonography—A diagnostic imaging technique that utilizes reflected ultrasonic waves to delineate, examine, or measure internal body tissues or organs.

Ultrasound—Sound above what can be heard by the human ear, generally above 20,000 Hz (cycles per second).

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American Registry of Diagnostic Medical Sonographers (ARDMS), 600 Jefferson Plaza, Suite 360, Rockville, MD 20852-1150. (301) 738-8401 or (800) 541-9754. <<http://www.ardms.org>>.

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Universal precautions

Definition

Universal precautions are safety procedures established by the Centers for Disease Control and Prevention (CDC) and the American Dental Association (ADA).

Purpose

These precautions are used in medical and dental offices to prevent the transmission of infectious diseases to patients and health care workers.

Description

Universal precautions are standards of **infection control** practices designed to reduce the risk of transmission of bloodborne infections.

Personal protective equipment

Protective equipment includes gloves, gowns, masks, and eyewear worn by health care workers to reduce the risk of exposure to potentially infectious materials.

Examination gloves are used for procedures involving contact with mucous membranes. They reduce the incidence of contamination to the hands, but they cannot prevent penetrating injuries from needles or other sharp instruments. Gloves are changed after each patient and discarded, and must never be washed or disinfected for reuse. Washing with surfactants may cause wicking (the enhanced penetration of liquids through undetected holes in the glove). Disinfecting agents may cause deterioration of the gloves. Petroleum jelly may also break down latex. Utility gloves may be used when handling contaminated instruments and cleaning of the treatment area or sterilization room.

Fluid-resistant gowns, laboratory coats, or uniforms should be worn when clothing is likely to be soiled with **blood** or other bodily fluids. Reusable protective clothing should be washed separately from other clothes, using a normal laundry cycle. Protective clothing should

be changed daily or as soon as visibly soiled. They should be removed before personnel leave areas of the dental office used for laboratory or patient-care activities.

Masks and protective eyewear, or chin-length, plastic face shields should be worn when splashing or spattering of blood or other body fluids is likely. A mask should be changed between patients or during patient treatment if it becomes wet or moist. A face shield or protective eyewear should be washed with appropriate cleaning agents when visibly soiled.

Careful handling and disposal of sharps

Sharp disposable items, such as needles, saliva ejectors, rubber prophylaxis cups and scalpels that cannot be sterilized and are contaminated with blood or other body fluids need to be discarded in puncture resistant containers. Special delivery companies pick up the containers once they are full and replace them with empty containers.

Careful handling and cleaning of contaminated equipment

Dental instruments must be cleaned and sterilized after each use. Recommended sterilization methods include autoclaving or using a dry heat oven or “chemiclave,” a unit that cleans with the use of chemicals. Sterilization equipment is commonly found in a special area of the building away from the treatment areas.

Cleaning and disinfecting of all surfaces such as lights, drawer handles, and countertops is accomplished by a chemical solution formulated to kill infectious **bacteria**, spores, and **viruses** after each patient is seen. Medical facilities follow specific heat sterilization procedures, which are outlined by the CDC. Plastic barriers cover items that are not easily disinfected by chemical spray, such as light handles, chair control buttons, and instrument trays. Many offices and hospitals have seamless floors with linoleum or a laminate surface so that spills can be contained and cleaned quickly.

Non-critical items that cannot be heat sterilized are sterilized by chemical immersion formulated to kill infectious bacteria and viruses.

Universal precautions are intended to supplement rather than replace recommendations for routine **infection** control, such as hand washing.

Preparation

Proper planning and management of supplies needed for universal precautions are essential in reducing the occupational risk of infectious diseases. Such measures should include, but are not limited to:

- risk assessment
- setting of standards and protocols
- risk reduction
- post-exposure measures
- first aid

Complications

Complications include the possible increase of medical and dental fees to the patient to offset costs associated with the equipment, disinfectants, and sterilization procedures needed for universal precautions.

Results

Universal precautions are designed to result in the reduction of the transmission of infectious diseases to patients and health care workers.

Health care team roles

Universal precautions require all medical and dental staff personnel involved in patient care to use appropriate personal protective equipment. Guidelines for health care settings for discarding of waste material are under a separate code by individual state agencies and governmental departments.

The environment in which health care is provided is greatly affected by universal precautions, both for the patient and care providers. Measures that promote a safe work environment include:

- education of employees about occupational risks and methods of prevention of HIV and other infectious diseases
- provision of protective equipment
- provision of appropriate disinfectants to clean up spills of blood or other body fluids
- easy accessibility of puncture-resistant sharps containers
- maintaining appropriate staffing levels
- measures that reduce and prevent **stress**, isolation, and burnout
- controlling shift lengths
- providing post-exposure counseling, treatment, and follow-up

The U.S. Department of Labor Occupational Safety and Health Administration (OSHA) requires employers in the medical and dental fields to make hepatitis B virus (HBV) vaccines available without cost to employees who may be exposed to blood or other infectious materials. In

KEY TERMS

Autoclave—A sterilization unit that uses steam under pressure.

Chemiclave—A sterilization unit that uses chemicals under pressure.

Dry heat oven—A sterilization unit that uses dry heat.

Sharps—Needles and cutting instruments such as curets and scalpel blades.

In addition, the CDC recommends that all workers be vaccinated against HBV, as well as **influenza**, measles, mumps, rubella, and tetanus, both for the protection of personnel and patients.

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Centers for Disease Control and Prevention 1600 Clifton Rd., Atlanta, GA 30333 (404) 639-3311. <<http://www.cdc.gov>>.

U.S. Department of Labor Occupational Safety and Health Administration (OSHA) 200 Constitution Avenue, N.W., Washington, DC 20210. <<http://www.osha.gov>>.

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Cindy F. Ovard, RDA

Upper GI exam

Definition

An upper GI examination is a fluoroscopic examination (a type of x-ray imaging) of the upper gastrointestinal

tract, including the esophagus, **stomach**, and upper **small intestine** (duodenum).

Purpose

An upper GI series is frequently requested when a patient experiences unexplained symptoms of abdominal **pain**, difficulty in swallowing (**dysphagia**), regurgitation, **diarrhea**, or unexplained weight loss. It is used to help diagnose disorders and diseases of, or related to, the upper gastrointestinal tract, including cases of hiatal hernia, diverticula, ulcers, tumors, obstruction, enteritis, gastroesophageal reflux disease, **Crohn's disease**, abdominal pain, and pulmonary aspiration.

Precautions

Because of the risks of radiation exposure to the fetus, pregnant women are advised to avoid this procedure. In addition, children having to undergo this exam must be shielded with lead, when possible. Patients with an obstruction or perforation in their bowel should not ingest barium (a radiopaque substance used to visualize the GI tract) for an upper GI, but may still be able to undergo the procedure if a water-soluble contrast medium is substituted for the barium.

Glucagon, a medication sometimes given prior to an upper GI procedure, may cause nausea and dizziness. It is used to relax the natural movements of the stomach, which will enhance the overall study.

Description

An upper GI series takes place in a hospital or clinic setting and is performed by an x-ray technologist and a radiologist. Before the test begins, the patient is sometimes administered an injection of glucagon, a medication which slows stomach and bowel activity, to allow the radiologist to get a clearer picture of the gastrointestinal tract. In order to further improve the clarity of the upper GI pictures, the patient may be given a cup of fizzing crystals to swallow, which distend the stomach by producing gas.

Once these preparatory steps are complete, the patient stands against an upright x-ray table, and a fluoroscopic screen is placed in front of him. The patient will be asked to drink from a cup of flavored barium sulfate, a thick and chalky-tasting liquid that allows the radiologist to see the digestive tract, while the radiologist views the esophagus, stomach, and duodenum on the fluoroscopic screen. The patient will be asked to change positions frequently in order to coat the entire surface of the gastrointestinal tract with barium, to move overlapping

loops of bowel to isolate each segment, and to obtain multiple views of each segment. The technician or radiologist may press on the patient's abdomen in order to spread the barium through the folds within the lining of the stomach. The x-ray table will also be moved several times throughout the procedure. The radiologist will ask the patient to hold his breath periodically while exposures are being taken. After the radiologist completes his or her portion of the exam, the technologist will take several additional films of the GI tract. The entire procedure takes approximately 30 minutes.

In addition to the standard upper GI series, a doctor may request a detailed small bowel follow-through (SBFT), which is a timed series of films. After the preliminary upper GI series is complete, the patient will be given some additional barium sulfate to drink, and escorted to a waiting area while the barium moves through the small intestines. X rays are taken at 15-minute intervals until the barium reaches the colon (the only way to be sure the terminal ileum is fully seen is to see the colon or ileocecal valve). Then the radiologist will obtain additional views of the terminal ileum (the most distal segment of the small bowel, just before the colon). This procedure can take from one to four hours.

Esophageal radiography, also called a barium esophagram or a barium swallow, is a study of the esophagus only, and is usually performed as part of the upper GI series (though sometimes only a barium swallow is done). It is commonly used to diagnose the cause of difficulty in swallowing (dysphagia) and for detecting hiatal hernia. A barium sulfate liquid and sometimes pieces of food covered in barium are given to the patient to drink and eat while a radiologist examines the swallowing mechanism on a fluoroscopic screen. The test takes approximately 30 minutes.

Preparation

Patients must not eat, drink, or smoke for eight hours prior to undergoing an upper GI examination. Longer dietary restrictions may be required, depending on the type and diagnostic purpose of the test. Patients undergoing a small bowel follow-through exam may be asked to take **laxatives** the day prior to the test. Upper GI patients are required to wear a hospital gown, or similar attire, and to remove all jewelry, so the camera has an unobstructed view of the abdomen.

Aftercare

No special aftercare treatment or regimen is required for an upper GI series. The patient may eat and drink as soon as the test is completed. The barium sulfate may

make the patient's stool white for several days, and can cause constipation; therefore patients are encouraged to drink plenty of water in order to eliminate it from their system.

Complications

Because the upper GI series is an x-ray procedure, it does involve minor exposure to ionizing radiation. Unless the patient is pregnant, or multiple radiological or fluoroscopic studies are required, the small dose of radiation incurred during a single procedure poses little risk. However, multiple studies requiring fluoroscopic exposure that are conducted in a short time period have been known, on very rare occasions, to cause skin death (necrosis) in some individuals. This risk can be minimized by careful monitoring and documentation of cumulative radiation doses administered to these patients.

Results

A normal upper GI series shows a healthy, normally functioning, and unobstructed digestive tract. Hiatal hernia, obstructions, inflammation, including ulcers, polyps of the esophagus, stomach, or small intestine, or irregularities in the swallowing mechanism are just a few of the possible abnormalities that may show up on an upper GI series. Additionally, abnormal peristalsis, or digestive movements of the stomach and intestines can often be visualized on the fluoroscopic part of the exam, and in the interpretation of the SBFT.

Health care team roles

The radiologist and technologist are a team, in the compliance and completion of an optimal upper GI study. The well-prepared technologist will promote efficiency of the radiologist's portion of the exam. Having all supplies available, and being ready for anything, is essential in doing barium studies.

Patient education

The technologist, and to some degree the radiologist, can ease a patient through this exam by giving the patient a brief overview of what he or she will need to do and what to expect while having this exam. Although the exam is painless and simple, there will still be some concern by the patient who is unfamiliar with the procedure. Keeping the positioning directions simple makes it easy for the patient to comply, and creates for a positive experience for all concerned.

KEY TERMS

Crohn's disease—A chronic, inflammatory bowel disease usually affecting the ileum, the colon, or both.

Diverticula—Pouchlike herniations through the muscular wall of an organ such as the stomach, small intestine, or colon.

Enteritis—Inflammation of the mucosal lining of the small intestine.

Gastroesophageal reflux disease—A painful, chronic condition in which stomach acid flows back into the esophagus causing heartburn and, in time, erosion of the lining of esophagus.

Hiatal hernia—Protrusion of the stomach up through the diaphragm.

Training

The technologist will have had a minimum of two years training in **radiologic technology**, and extensive experience in barium studies, as this is one area that a student radiographer will show early competence in. The technologist is also fully educated on the anatomy and physiology of the gastrointestinal tract, and must demonstrate this on written exams, as well as a clinical evaluation prior to completing the program.

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Debra Novograd, B.S.,R.T.(R)(M)

Upper limb orthoses

Definition

An orthosis is a device that is applied to the body in order to protect and stabilize body parts, to prevent or correct scarring and deformities, or to aid in performance of certain functions. Upper limb orthoses are applied to

the shoulder, elbow, arm, wrist, or hand. These devices may be called orthoses, orthotic devices, or splints.

Purpose

Upper limb orthoses can be used for a wide variety of purposes. Some of the more common uses include:

- stabilizing **fractures** or unstable joints
- immobilizing joints to promote healing
- preventing or correcting joint contractures
- correcting subluxation of joints or improper alignment of tendons
- preventing formation of burn scar tissue
- maintaining correct joint alignment
- assisting movement of joints
- reducing muscle tone in spastic muscles

Description

Materials and construction

Although ready-made orthoses are available for some applications, many are custom made to fit the specific needs of each patient. Orthoses can be constructed of plaster, wood, metal, cloth, or plastic. Since the 1960s, most orthoses have employed lightweight thermoplastic materials, which are plastics that become pliable when they are heated and retain their shape once they cool. They come in sheets of varying thickness, and they can be composed of any of several polymer compounds. The thermoplastic sheets can be molded to fit body parts exactly, and some can be reshaped repeatedly as the treated body part changes shape. The resulting orthotic device is lightweight and relatively easy to use and maintain.

Thermoplastic materials are usually classified into high- and low-temperature types, based on the temperature at which they become pliable. High-temperature thermoplastic materials must be molded at a temperature that is too high to come in contact with human skin. These materials must be molded over a plaster model of the body part, but have the advantage of being stronger and more durable than low-temperature thermoplastics. They are used in situations where the orthosis will undergo a lot of stress or will be used for a long time. High-temperature thermoplastics require special tools for cutting and shaping, and orthoses made from these materials are usually constructed by an orthotist, a technician who specializes in constructing these devices.

Many upper limb orthoses are constructed of low-temperature thermoplastics. This material becomes pliable below 180°F (80°C), and it can be molded directly



This woman is wearing a brace to help reduce repetitive stress while computing. (Photograph by Will & Deni McIntyre. Science Source/Photo Researchers. Reproduced by permission.)

against the body. It is relatively easy to cut and shape, and many therapists construct orthoses using these materials. Precut shells made from low-temperature thermoplastics are also available. The therapist can use a precut thermoplastic shell as the base for a device and then modify it to fit by trimming and adding pads and straps. Orthoses made from low-temperature thermoplastics are commonly used in situations in which the orthosis will receive relatively little stress or is intended for temporary use. These orthoses are especially important when a device is needed quickly, such as in postsurgical or trauma treatment.

Both high- and low-temperature orthoses must be attached to the body. Most modern orthoses use straps made of hook-and-loop tape for this purpose. This material is lightweight, durable, and readily adjustable, and it comes in a variety of widths and colors. Orthoses can also include padding to cushion sensitive areas, as well as specialized linings. Patients often use a separate interface that absorbs perspiration and protects the skin, and which can be washed or replaced as needed.

Types of orthoses

The upper limbs comprise a complex system of muscles, joints, ligaments, and tendons, which are capable of a number of distinct movements. For this reason, a wide variety of upper limb orthoses have come into existence. These devices often go by multiple names, reflecting the name of the manufacturer, the name of the person who developed the device, or the anatomy and function it serves. No single naming system has become dominant. Most authors today refer to the devices in terms of anatomy or function rather than using more obscure historical names, but users must be careful to distinguish one device from another.

Orthoses are usually classified as either static or dynamic, depending on the amount of joint movement each device allows. Static orthoses hold a body part in a fixed position and do not allow joint movement. Some static orthoses do not contain joints, as with fracture orthoses that stabilize the long bones of the arm after a fracture. Most others simply maintain the joint at a particular angle, providing support and proper positioning. For example, a static wrist orthosis can be used to hold the wrist in a neutral position to promote healing and

KEY TERMS

Contracture—An abnormal condition that prevents the full extension or flexion of a joint. Contractures are usually caused by tight or shortened soft tissues around the joint.

Dynamic orthosis—An orthosis that allows or promotes movement of a joint.

Orthotic device—An orthosis.

Orthotist—A technician who specializes in building and fitting orthoses.

Outrigger—A device that is attached to a dynamic orthosis in order to facilitate joint motion. The outrigger serves as a point of attachment for springs, rubber bands, or other energy-storing materials.

Progressive orthosis—An orthosis that can be adjusted to increase the amount of stretch in tissues surrounding a joint. Progressive orthoses are often used to treat joint contractures.

Serial orthoses—A set of orthoses used in a series to gradually increase the range of motion of a joint. Serial orthoses are used to treat joint contractures.

Splint—An orthosis.

Static orthosis—An orthosis that does not allow movement of a joint.

prevent injury during activities. Sometimes static orthoses include attachments that help patients perform functional activities. For example, a hand-wrist orthosis may include an attachment for pens or eating utensils.

Static orthoses sometimes serve the function of promoting eventual joint movement. Serial or progressive orthoses loosen joints that have become frozen due to contractures or arthritis. Serial orthoses involve several similar devices used in a series, with each successive device gradually increasing the range of motion of the affected joint by providing a gentle stretching action. Progressive orthoses accomplish similar goals, but do so by allowing adjustments in the device so that it gradually increases the amount of stretch created in the joint. Serial and progressive orthoses must be designed and used carefully to provide the correct amount of stretching in the joint. Excessive stretching can damage the tissues, and inadequate stretching will be ineffective.

Dynamic orthoses allow or create joint movement. These devices hold the joint in the proper position while

assisting movement using springs, rubber bands, or other mechanical features. Dynamic orthoses are useful for patients who have weakened muscles or limited neuromuscular control, because they allow the patient to perform actions that would be difficult or impossible without assistance. These devices promote independence in patients who have handicapping conditions, and they are common in rehabilitation settings. Since no single device can perform all the movements that the human hand can perform, the patient may need to use several different dynamic devices in order to carry out activities of daily living.

Operation

Although there is a wide variety of upper limb orthoses, most of these devices operate on similar principles. The general goal of most orthoses is to provide stability and support while allowing as much motion as possible. Immobilizing joints for long periods has proven deleterious for most patients. Muscles atrophy, joints stiffen, skin tightens, and the healing process is ultimately slowed. By allowing movement while restricting motion that would create stress on joints, muscles, or tendons, orthotic devices allow healing and preserve range of motion and function.

Exact fit is a key element for many upper limb orthoses. In order to work properly, the orthosis must hold the body part in an exact position. If the orthosis does not fit exactly, it may not work and may actually cause harm. This can become a problem in situations where the patient has experienced swelling and may require a new fitting for the orthosis once the swelling has resolved. Poor fit can also lead to discomfort and the development of pressure sores.

Dynamic orthoses usually operate with the aid of attached outriggers. These provide a place to attach rubber bands, springs, or other materials that assist motion. They also provide leverage and help to ensure that the joint stays in proper position during movement. These devices require exact fit, as well as adjustment to ensure that the device works properly.

Many upper limb orthoses require a period of training for the patient to learn how to use the device properly. This is especially true with devices that assist motion, because the patient must initiate the motion properly in order for the orthosis to work. Patients with a long history of **paralysis** or immobilization may require considerable time in order to learn how to use the device.

It is very important to consider the patient's motivation and attitude toward the orthosis as part of the treatment plan. Since most upper limb orthoses are remov-

able, patients can choose whether or not to use these devices. Patients may object to orthoses because of discomfort, unattractive appearance, or restrictiveness of the device. Health care professionals must work closely with the patient to ensure that the patient will accept the orthosis and use it properly.

Maintenance

Many upper limb orthoses require little or no maintenance. This is especially true for static orthoses and for those intended for temporary use. The plastic shell can be wiped clean, and materials worn underneath the orthosis can be washed or replaced. The patient may need to be checked periodically to ensure that the orthosis fits. Dynamic orthoses may require adjustments and replacement of worn springs, rubber bands, and the like.

Health care team roles

Creating and employing upper limb orthoses often involves a team approach, especially in rehabilitation settings. A physician who specializes in physical medicine and rehabilitation may prescribe the orthosis, which is then built by an orthotist. An occupational therapist or physical therapist may help the patient learn to use the orthosis. In other instances, the physician may refer the patient to an occupational therapist, who then determines that an orthosis would be helpful. Many occupational therapists design and build orthoses themselves, but they may also recommend ready-made devices or refer the patient to an orthotist. Physicians from other disciplines, especially orthopedics, may employ orthoses, as do physical therapists. These professionals may refer the patient for a custom-made device or prescribe a ready-made one.

Training

Health care professionals who create and fit upper limb orthoses must have a good understanding of the anatomy and physiology of the upper limbs. They must also understand the mechanics and forces involved in making various body movements, and they must be familiar with the materials and tools involved in constructing orthoses. Certified orthotists are specialists who focus exclusively on fitting and building orthoses. Certification as an orthotist requires a baccalaureate degree in the field of orthotics and **prosthetics**, or a degree in another field followed by a six-month to one-year certificate training program. Orthotists must also pass a certification exam.

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Denise L. Schmutte, Ph.D.

Upper limb prostheses

Definition

A prosthesis is an artificial device that substitutes for a missing part of the body. Upper limb prostheses can be applied anywhere from the shoulder joint through the fingers, including the fingers, the hand, the wrist, the forearm, the elbow, the upper arm, and the shoulder.

Purpose

Most patients require prostheses as the result of amputation. The affected body part must be removed due to severe damage or disease that threatens the patient's survival or is too damaged to be repaired. Amputations of upper limbs are usually due to accidents, particularly in industrial settings. Victims tend to be younger and in good health otherwise, and often have a normal life expectancy. It is particularly important for them to regain



Individuals who have lost an upper limb can relearn basic functions with the help of arm and hand prostheses. (SIU BioMed/Custom Medical Stock Photo. Reproduced by permission.)

substantial upper-limb function to maintain independence. Upper limb prostheses are also important for those who are missing upper limbs due to congenital conditions. This group includes children, who may use prostheses from very early in life and require regular refitting and revision of their prostheses as they grow.

Patients use upper limb prostheses for two general purposes: to improve their appearance and to increase their ability to perform tasks. Unfortunately, these two purposes often conflict with one another. Prostheses that look like normal hands are often limited in their functionality, while highly functional devices may look unattractive. Many patients use two different prostheses: one for situations in which appearance is most important, and another for situations in which adequate function is desired.

The most important goal for function-oriented upper limb prostheses is reproducing actions performed by the hands. The human hand is capable of many distinct and complex actions, which are often crucial for independent functioning. The patient must be able to grasp and manipulate objects of varying sizes and shapes in order to carry out basic activities such as dressing, grooming, and

eating, as well as work-related activities. Most prosthetic devices can perform only one or two distinct actions, and so a large number of specialized prostheses have come into being, each designed for a particular purpose. These include devices designed for particular work functions, such as using tools, and also devices intended for leisure activities, such as holding a golf club or throwing a bowling ball. New developments in the field of **prosthetics** are raising hopes for a “bionic hand” that is capable of multiple actions, but devices of this type are still experimental.

Description

Materials and construction

Upper limb prostheses can be constructed of a variety of materials, depending on the purpose of the prosthesis. Prostheses used for cosmetic purposes are usually constructed of lightweight plastics, and are designed to match the color and shape of the patient’s intact hand. Prostheses used to perform work usually need to be much more durable. These devices usually include components made out of different materials, such as soft plastic or silicon for the socket that fits the device to the patient’s

body, hardened plastic or wood for the body of the device, and metal for joints and the functional tool at the end of the prosthesis.

Prostheses can be classified as endoskeletal or exoskeletal. Endoskeletal prostheses consist of a hard inner core covered by a soft outer material. These devices tend to be lightweight, but they are usually less durable than exoskeletal prostheses. Cosmetic prostheses are often constructed with an endoskeletal design. Exoskeletal prostheses have a hard outer shell, which can usually withstand considerable force. Exoskeletal designs are usually preferred for prostheses designed to perform work.

Amputations are usually classified according to the point at which the limb is removed. In general, amputations below the elbow require simpler devices than those that occur above the elbow, because above-the-elbow prostheses require some sort of substitute for the elbow joint. Amputations at or above the shoulder joint add yet another level of complexity to the prosthesis.

TERMINAL DEVICES. Virtually all upper limb prostheses involve some sort of terminal device, which is the most distal part (farthest from the patient's trunk). The simplest terminal devices include a hook, a cosmetic hand, or some other element that has no moving parts, and are referred to as passive terminal devices.

Active terminal devices, which involve moving parts, are much more common. These devices can be shaped like a hook, a hand, or any specialized tool. They often involve one stationary part and one moving part. The patient controls the moving part using a body control device or a myoelectric control, allowing the patient to grasp things between the stationary part and the moveable part. Some devices allow the patient to have voluntary control over closing the device, while others allow voluntary control over opening the device. Patients are able to perform a variety of work-related and self-care activities using these devices.

CONTROLS. The most common control system is the body-powered or mechanical system. With this system, the user operates the terminal device by flexing a muscle near the stump of the amputated limb. The energy from the user's movement is transferred to the prosthesis by means of a stainless steel cable. Body-powered prostheses are popular and are used by about 90 percent of amputees who use a prosthesis. These devices are simple, durable, and easy to use. These systems are also preferred because they provide some feedback to the user, who can detect the action of the terminal device through the cable.

An alternative control system involves myoelectric control of the terminal device. Myoelectric devices detect the electrical potential of contracting muscles and use the

potential to control an electric motor that operates the terminal device. Myoelectric devices allow a stronger grip than body-powered devices, and they also provide the ability to regulate the amount of force in the grip. Despite these advantages, myoelectric systems are less popular than body-powered systems. They are expensive, they break down more easily, and they force the user to rely on battery power. These systems also provide less feedback to the user, who must rely on **vision** to regulate his or her activity. Technological improvements are making these devices more reliable, and they may become more popular in the future. Some devices combine myoelectric controls for the terminal device with body-powered controls for the elbow joint.

SOCKETS AND HARNESES. The fit between the prosthesis and the body is an important element in assuring that the prosthesis is comfortable and functional. Most upper limb prostheses have a pliable socket that is custom molded over the stump to assure an exact fit. Many above-the-elbow systems depend on a harness to hold the prosthesis in place and provide an attachment point for control devices. Harnesses are usually made of Dacron straps that fit over the shoulders or around the upper arm. Some upper limb prostheses can be attached without a harness.

Operation

Fitting

Prompt fitting is very important. Research has shown that patients are more likely to reject an upper limb prosthesis if it is fitted more than 30 days after amputation surgery. Early fitting also helps control swelling and **pain** in the stump. If the patient's surgeon feels it is appropriate, the mold for a temporary prosthesis can be made immediately after surgery. The patient can begin adjusting to the prosthesis and can begin to make decisions about the features he or she wants in a permanent device. The patient may wear the temporary prosthesis for several weeks while the size and shape of the stump are stabilizing.

Patient adaptation

Patients require considerable time and training in order to accept and use upper limb prostheses. They must learn to detect and control fairly subtle movements in or near the stump in order to control the prosthesis. They must also learn how to care for the stump and how to prevent pressure sores. Finally, they must adjust to the changes in their lives brought about by the loss of an upper limb. Training usually takes place over the course of several weeks, during which the patient increases wearing time and begins to use the prosthesis for func-

KEY TERMS

Body-powered prosthesis—A prosthesis that is controlled by mechanical action. The user flexes a muscle and the energy from this action is transferred to the prosthesis by means of a cable.

Endoskeletal prosthesis—A prosthesis that is constructed with a hard core and a soft outer covering.

Exoskeletal prosthesis—A prosthesis that is constructed with a hard outer layer.

Myoelectric prosthesis—A prosthesis that is controlled by electrical impulses. The patient flexes a muscle and the electrical potential of the activity is used to control an electric motor that operates the prosthesis.

Prosthetist—A technician who specializes in the fitting and building of prosthetic devices.

Terminal device—A device attached to the distal end of a prosthesis. The patient uses the terminal device to perform functional activities.

tional activities. The training and adjustment period can be lengthy, and it is important for the patient to have a continuing relationship with supportive therapists.

Use

Patients can use upper limb prostheses to perform a variety of functions, but motivation is often a limiting factor. The biggest obstacle to using the prosthesis may be the patient's reliance on the intact hand. If the patient becomes used to doing things with one hand, it will be much more difficult to adjust to using a prosthesis. Patients who refuse an upper limb prosthesis may eventually suffer from overuse injuries in the intact limb. Patients with bilateral amputations are forced to rely on prostheses in order to perform the functions of daily living, and tend to accept the prostheses readily, since they are a means of restoring function.

Maintenance

The maintenance needs for upper limb prostheses vary with the complexity of the device. Devices that incorporate electric motors require regular battery changes and tend to need more maintenance than body powered or passive devices. Cosmetic gloves that are used to make the prosthesis look more like a hand also require maintenance. The gloves can become stained or

torn and may need frequent cleaning and replacement. Patients also need periodic adjustments to their prostheses to ensure that they work and fit properly.

Health care team roles

The process of creating and employing upper limb prostheses involves several health care professionals. Physicians who specialize in physical medicine and rehabilitation usually prescribe the prostheses, and patients learn to use the devices in a rehabilitation setting. Prostheses are fitted and custom-built by prosthetists, who are specially trained technicians in this field. Occupational therapists help patients learn to perform adaptive tasks using the prostheses. Patients tend to respond best when the professionals involved work as a team and provide the patients with ongoing support.

Training

Prosthetics is a specialized field with a complex body of knowledge. Certification as a prosthetist requires a baccalaureate degree in the field of orthotics and prosthetics, or a degree in another field, followed by a six-month to one-year certificate training program. Prosthetists must also pass a certification exam, and may require additional certification in order to fit certain specialized devices.

Resources

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- American Academy of Orthotists and Prosthetists. 526 King St., Ste. 201, Alexandria, VA 22314. (703) 836-0788. <<http://www.oandp.org>>.
- National Rehabilitation Information Center. 1010 Wayne Ave., Ste. 800, Silver Spring, MD 20910. (800) 346-2742. <<http://www.naric.com>>.

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Denise L. Schmutte, Ph.D.

Upper respiratory infection see **Common cold**

Uric acid tests see **Kidney function tests**

Urinalysis

Definition

A urinalysis is a group of manual and/or automated qualitative and semi-quantitative tests performed on a urine sample. A routine urinalysis usually includes the following tests: color, transparency, specific gravity, pH, protein, glucose, ketones, **blood**, bilirubin, nitrite, urobilinogen, and leukocyte esterase. Some laboratories include a microscopic examination of urinary sediment with all routine urinalysis tests. If not, it is customary to perform the microscopic exam, if transparency, glucose, protein, blood, nitrite, or leukocyte esterase is abnormal.

Purpose

Routine urinalysis is performed for several reasons:

- general health screening to detect renal and metabolic diseases
- diagnosis of diseases or disorders of the **kidneys** or urinary tract
- monitoring of patients with diabetes

In addition, quantitative urinalysis tests may be performed for diagnosis of many specific disorders, such as endocrine diseases, bladder **cancer**, **osteoporosis**, and porphyrias. This often requires the use of a timed urine sample. Examples include the d-xylose absorption test for malabsorption, creatinine clearance test for glomerular function, the 24-hour urinary metanephrine test for pheochromocytoma, and the microalbumin test. The urinary microalbumin test measures the rate of albumin excretion in the urine using immunoassay. This test is used to monitor the renal vascular function of persons with **diabetes mellitus**. In diabetics, the excretion of greater than 200 µg/mL albumin is predictive of impending glomerular disease.

Precautions

Voided specimens

All patients should avoid intense athletic training or heavy physical work before the test, as these activities may cause small amounts of blood to appear in the urine. Many urinary constituents are labile, and samples should be tested within one hour of collection or refrigerated. Samples may be stored at 2-8°C for up to 24 hours for chemical urinalysis tests; however, the microscopic exam should be performed within four hours, if possible. To minimize sample contamination, women who require a urinalysis during menstruation should insert a fresh tampon before providing a urine sample.

Over two-dozen drugs are known to interfere with various chemical urinalysis tests. These include:

- ascorbic acid
- chlorpromazine
- L-dopa
- nitrofurantoin (Macrochantin, Furadantin)
- penicillin
- phenazopyridine (Pyridium)
- rifampin (Rifadin)
- tolbutamide

Preservatives used to prevent loss of glucose and cells may affect biochemical test results. The use of preservatives should be avoided whenever possible.

Description

Routine urinalysis consists of three testing groups, physical characteristics, biochemical tests, and microscopic evaluation.

Physical tests

Physical tests are color, transparency (clarity), and specific gravity. In some cases, volume (daily output) may be measured. Color and transparency are determined from visual observation.

Color: Normal urine is straw to amber in color. Abnormal colors include bright yellow, brown, black (gray), red, and green. These pigments may result from medications, dietary sources, or diseases. For example, red urine may be caused by blood or hemoglobin, beets, medications, and some **porphyrias**. Black-gray urine may result from melanin (melanoma) or homogentisic acid (alkaptonuria). Bright yellow urine may be caused by bilirubin. Green urine may be caused by biliverdin or medications. Orange urine may be caused by some med-

Common drugs that may affect urine color

Generic and brand names	Urine color
Anisindione (Miradon)	Red-orange in alkaline urine
Cascara sagrada	Red in alkaline urine; yellow-brown in acid urine
Chloroquine (Aralen)	Rusty yellow or brown
Chlorzoxazone (Paraflex)	Orange or purple-red
Docusate calcium (Doxidan, Surfak)	Pink to red to red-brown
Furazolidone (Furoxone)	Brown
Iron preparations (Ferrotran, Imferon)	Dark brown or black on standing
Levodopa	Dark brown on standing
Methylene blue (Urolene Blue)	Blue-green
Nitrofurantoin (Macrochantin, Nitrodan)	Brown
Phenazopyridine (Pyridium)	Orange to red
Phenindione (Eridione)	Red-orange in alkaline urine
Phenolphthalein (Ex-Lax)	Red or purplish pink in alkaline urine
Phenothiazines (e.g., prochlorperazine [Compazine])	Red-brown
Phenytoin (Dilantin)	Pink, red, red-brown
Riboflavin (vitamin B)	Intense yellow
Rifampin	Red-orange
Sulfasalazine (Azulfidine)	Orange-yellow in alkaline urine
Triamterene (Dyrenium)	Pale blue fluorescence

SOURCE: Pagana, K.D. and T.J. Pagana. *Mosby's Diagnostic and Laboratory Test Reference*. 3rd ed. St. Louis: Mosby, 1997.

ications or excessive urobilinogen. Brown urine may be caused by excessive amounts of urobilin, or urobilin.

Transparency: Normal urine is transparent. Cloudy or turbid urine may be caused by both normal or abnormal processes. Normal conditions giving rise to turbid urine include precipitation of crystals (usually urates or phosphates), mucus, or vaginal discharge. Abnormal causes of turbidity include the presence of blood cells, yeast, and **bacteria**. Turbidity is typically graded by visual comparison to standard solutions of barium sulfate.

Specific gravity: The specific gravity of urine is a measure of the concentration of dissolved solutes, and it reflects the ability of the renal tubules to concentrate the urine (conserve water). It is usually measured by determining the refractive index of a urine sample (refractometry) or by chemical analysis. Specific gravity varies with fluid and solute intake. It will be increased (above 1.035) in persons with diabetes mellitus and persons taking large amounts of medication. It will also be increased after radiologic studies of the kidney owing to the excretion of x ray contrast dye. Consistently low specific gravity (1.003 or less) is seen in persons with diabetes insipidus. In renal failure, the specific gravity remains equal to that of the plasma (1.008-1.010) regardless of changes in salt and water intake. Urine volume below 400 mL per day is termed oliguria, and may occur in persons who are dehydrated and those with glomerular disease owing to

reduced glomerular filtration. Volume in excess of 2 liters per day is termed polyuria and is common in persons with diabetes mellitus and diabetes insipidus.

Biochemical tests

Biochemical testing of urine is performed using dry reagent strips, often called dipsticks. A urine dipstick consists of a white plastic strip with absorbent microfiber cellulose pads attached to it. Each pad contains dried reagents needed for a specific test.

When performing dry reagent strip testing, one should adhere strictly to the manufacturer's instructions. General instructions for performing the test manually are as follows:

- Mix the sample by inverting the container several times.
- Insert the reactive portion of the dipstick, completely, but briefly.
- Remove the dipstick from the container by sliding the back of the dipstick along the rim to remove excess urine.
- Adhere to the reaction time stated on the package insert; and note that not all the tests are to be read at the same time.
- Compare the color of the test areas on the dipstick with the color chart on the bottle label by holding the strip close to the color blocks.
- Record the results for each test using the concentration given by the closest color match.

A dry reagent strip reader may be used as an alternative to visual comparison of color reactions. This device consists of a special colorimeter that measures the optical density of each reagent pad by reflectance. All reactions are read at the precise timed interval, resulting in greater precision than visual interpretation of color intensity.

Additional tests are available to measure bilirubin, protein, glucose, ketones, and urobilinogen in urine. In general, these individual tests provide greater sensitivity, and therefore, permit detection of a lower concentration of the respective substance. A brief description of the most commonly used dry reagent strip tests follows.

1. pH: A combination of pH indicators (methyl red and bromthymol blue) react with hydrogen ions (H⁺) to produce a color change over a pH range of 5.0 to 8.5. pH is useful in determining metabolic or respiratory disturbances in acid-base balance. For example, kidney disease often results in retention of H⁺ (reduced acid excretion). pH varies with a person's diet, tending to be acidic in those who eat meat but more alkaline in vegetarians. It is also useful for the classification of urine crystals.

Crystals commonly found in acid urine are uric acid, urate, and oxalate, while those commonly found in alkaline urine include phosphates and carbonates.

2. **Protein:** Based upon a phenomenon called the “protein error of indicators,” this test uses a pH indicator, such as tetrabromophenol blue, that changes color (at constant pH) when albumin is present in the urine. The protein affects the ionization constant (pKa) of the dye, making it behave as if it were exposed to a more alkaline solution. The test for protein is far more sensitive to albumin than to globulins. Albumin is important in determining the presence of glomerular damage. The glomerulus is the network of capillaries that filters low molecular weight solutes such as urea, glucose, and salts, but normally prevents passage of protein or cells from blood into filtrate. Albuminuria occurs when the glomerular membrane is damaged, a condition called glomerulonephritis.

3. **Glucose:** Glucose is measured by the glucose oxidase reaction. Glucose oxidase catalyzes the oxidation of glucose by oxygen. This produces hydrogen peroxide and gluconic acid. The peroxide reacts with potassium iodide or another chromogen, producing iodine or other colored product. The glucose test is used to monitor persons with diabetes. When blood glucose levels rise above 160 mg/dL, glucose will be detected in urine. Consequently, glycosuria may be the first indicator that diabetes or another hyperglycemic condition is present. **Copper** sulfate tests should not be used to test urine for glucose because the reagent reacts with many nonglucose-reducing substances. The copper sulfate test may be used to screen newborns for galactosuria and other disorders of carbohydrate **metabolism** that cause urinary excretion of a sugar other than glucose.

4. **Ketones:** At alkaline pH, sodium nitroprusside or ferricyanide forms a violet-colored complex with acetoacetic acid and acetone. These ketones are produced in excess in disorders of carbohydrate metabolism, especially Type 1 diabetes mellitus. In diabetes, excess ketoacids in the blood may cause life-threatening acidosis and **coma**. These ketoacids and their salts spill into the urine causing ketonuria. Ketones are also found in the urine in several other conditions including **fever, pregnancy**, glycogen storage diseases, and in persons on a carbohydrate restricted diet.

5. **Blood:** Hemoglobin (also myoglobin) is capable of catalyzing the reduction of hydrogen peroxide. In the presence of hemoglobin, hydrogen peroxide will oxidize a dye such as benzidine to form a colored product. Red cells and hemoglobin may enter the urine from the kidney or lower urinary tract. This test detects abnormal levels of either, which may be caused by excessive red cell



A technologist fills a specialized vacutainer tube containing a bacteriostatic compound to preserve urine during transport to the laboratory. (Delmar Publishers, Inc. Reproduced by permission.)

destruction, glomerular disease, kidney or urinary tract **infection**, malignancy, or urinary tract injury.

6. **Bilirubin:** Bilirubin is a breakdown product of hemoglobin. Most of the bilirubin produced is conjugated by the **liver** and excreted into the bile, but a very small amount of conjugated bilirubin is reabsorbed by the portal circulation and reaches the general circulation to be excreted in the urine. Normally, the level of urinary bilirubin is below the detection limit of the test. Bilirubin reacts with a diazonium salt to form azobilirubin, which is violet. Bilirubin in the urine is derived from the liver, and a positive test indicates hepatic disease or hepatobiliary obstruction.

7. **Specific gravity:** Solute in the urine promote ionization of malic acid bound to a polyelectrolyte. As the malic acid residues ionize, H⁺ is released; this changes the color of a pH indicator, bromthymol blue. High ionic strength causes the indicator to behave as if the solution

were more acidic, and the indicator becomes green. Specific gravity is a measure of the concentrating ability of the kidneys.

8. Nitrite: Some bacteria including the lactose positive *Enterobacteriaceae*, *Staphylococcus*, *Proteus*, *Salmonella*, and *Pseudomonas* are able to reduce nitrate in urine to nitrite. A positive test for nitrite indicates bacteruria. Nitrite reacts with p-arsenilic acid or sulfanilamide to form a diazonium compound. The diazo group reacts with a quinoline dye to form a red product.

9. Urobilinogen: Urobilinogen reacts with p-dimethylaminobenzaldehyde (Ehrlich's reagent) or methoxybenzene-diazonium tetrafluoroborate at an acid pH to form a red or orange color. Urobilinogen is formed in the gastrointestinal tract by the bacterial reduction of conjugated bilirubin. Increased urinary urobilinogen occurs in prehepatic **jaundice** (hemolytic anemia), hepatitis, and other forms of hepatic necrosis which impair the enterohepatic circulation. The test is helpful in differentiating these conditions from obstructive jaundice which results in decreased production of urobilinogen. The Watson-Schwartz test is used to confirm the presence of urobilinogen or differentiate between urobilinogen and porphobilinogen. This is a quantitative test using Ehrlich's reagent and a timed urine sample. Urobilinogen is differentiated from porphobilinogen based upon its solubility in chloroform.

10. Leukocytes: Nonspecific esterases in polymorphonuclear white blood cells (neutrophils) will hydrolyze a pyrolole ester of alanine or indoxycarbonic acid to form a pyrolole alcohol. The product reacts with a diazonium compound forming a purple azo complex. The presence of white blood cells in the urine usually signifies a urinary tract infection, such as cystitis, or renal disease, such as pyelonephritis or glomerulonephritis.

Microscopic examination

The urine may contain cells that originated in the blood, the kidney, and lower urinary tract, and the microscopic examination of urinary sediment can provide valuable clues regarding many diseases and disorders involving these systems. The microscopic exam is performed after concentrating a 12 mL volume of urine by centrifugation. The supernatant is poured off and the sediment resuspended in a small volume of residual supernatant. A drop of the sediment is placed on a glass slide and a cover glass is applied. Alternatively, a special centrifuge tube and plastic slide may be used to achieve uniform concentration and chamber depth. The sediment is examined under low power for casts, crystals, and mucus threads. Casts are deposits of gelled protein that form in the renal tubules and are washed into the filtrate over

time. The number and type of casts per low power field is recorded, and the amount and type of crystals and mucus are graded semi-quantitatively. The magnification is increased to high power (400 x) in order to count the number of red blood cells, white blood cells, and epithelial cells per field. Bacteria, yeast, and trichomonads are identified at high power, and are reported in semi-quantitative terms (e.g., small, moderate, large).

The presence of bacteria or yeast and white blood cells differentiates a urinary tract infection from possible contamination in which case the WBCs are not seen. The presence of cellular casts (casts containing RBCs, WBCs, or epithelial cells) identifies the kidneys (versus the lower urinary tract) as the source of such cells. Cellular casts and renal epithelial cells signify the presence of renal disease. The microscopic exam also identifies both normal and abnormal crystals in the sediment. Abnormal crystals are those formed as a result of an abnormal metabolic process and are always clinically significant. These include bilirubin, cystine, tyrosine, leucine, and cholesterol crystals. Normal crystals are formed from normal metabolic processes, but may be implicated in formation of urinary tract stones (calculi).

Routine urinalysis including microscopic exam may be fully automated using the Yellow Iris workstation. This instrument uses a dry reagent strip reader, harmonic oscillation (for specific gravity), and flow-focused image analysis to perform all of the steps of the urinalysis.

Preparation

A urine sample is collected in an unused disposable plastic cup with a tight-fitting lid. A randomly voided sample is suitable for routine urinalysis although the first-voided morning urine is most concentrated and therefore, preferred. The best sample is one collected in a sterile container after the external genitalia have been cleansed using the midstream void (clean-catch) method. This sample may be cultured, if findings indicate bacteruria.

- Females should use a clean cotton ball moistened with lukewarm water (or antiseptic wipes provided with collection kits) to cleanse the external genital area, before collecting a urine sample. To prevent contamination with menstrual blood, vaginal discharge, or germs from the external genitalia, they should release some urine before beginning to collect the sample. A urine specimen obtained this way is called a midstream or clean-catch sample.
- Males should use a piece of clean cotton, moistened with to cleanse the head of the penis and the urethral meatus. They should draw back the foreskin, if not cir-

cumcised. After the area has been thoroughly cleansed, they should use the midstream void method to collect the sample.

- For infants, a parent or health care worker should cleanse the child's outer genitalia and surrounding skin. A sterile collection bag should be attached to the child's genital area and left in place until the child has urinated. It is important to not touch the inside of the bag, and to remove it as soon as a specimen has been obtained.

Urine samples can also be obtained via bladder catheterization, a procedure used to collect uncontaminated urine when the patient cannot void. A catheter is a thin flexible tube that a health care professional inserts through the urethra into the bladder to allow urine to flow out. To minimize the risk of infecting the patient's bladder with bacteria, many clinicians use a Robinson catheter, which is a plain rubber or latex tube that is removed as soon as the specimen is collected. If urine for culture is to be collected from an indwelling catheter, it should be aspirated from the line using a syringe and not removed from the bag in order to avoid contamination by urethral flora.

Suprapubic bladder aspiration is a collection technique sometimes used to obtain urine from infants younger than six months or urine directly from the bladder for culture. The doctor withdraws urine from the bladder into a syringe through a needle inserted through the skin.

Aftercare

The patient may return to normal activities after collecting the sample and may start taking medications that were discontinued before the test.

Complications

There are no risks associated with voided specimens. The risk of bladder infection from catheterization with a Robinson catheter is about 3%.

Results

Normal urine is a clear straw-colored liquid, but may also be slightly hazy. It has a slight odor and some laboratories will note strong or atypical odors on the urinalysis report. It may contain some normal crystals, squamous or transitional epithelial cells from the bladder, lower urinary tract, or vagina. Urine may contain transparent (hyaline) casts especially if collected after vigorous **exercise**. However, the presence of hyaline casts may signify renal disease when the cause cannot be attributed to exercise, running, or medications. Normal urine contains a small amount of urobilinogen, and may

KEY TERMS

Acidosis—A condition of the blood in which bicarbonate levels are below normal.

Alkalosis—A condition of the blood and other body fluids in which bicarbonate levels are higher than normal.

Cast—An insoluble gelled protein matrix that takes up the form of the renal tubule in which it deposited. Casts are washed out by normal urine flow.

Catheter—A thin flexible tube inserted through the urethra into the bladder to allow urine to flow out.

Clean-catch specimen—A urine specimen that is collected from the middle of the urine stream after the first part of the flow has been discarded.

Cystine—An amino acid normally reabsorbed by the kidney tubules. Cystinuria is an inherited disease in which the reabsorption of cystine and some other amino acids is defective. Cystine crystals form in the kidney leading to obstructive renal failure.

Ketones—Substances produced during the breakdown of fatty acids. They are produced in excessive amounts in diabetes and certain other abnormal conditions.

pH—A chemical symbol used to describe the acidity or alkalinity of a fluid, ranging from 1 (more acid) to 14 (more alkaline).

Porphobilinogen—An intermediary product in the biosynthesis of heme.

Urethra—The tube that carries urine from the bladder to the outside of the body.

Urinalysis (plural, urinalyses)—The diagnostic testing of a urine sample.

Voiding—Another word for emptying the bladder or urinating.

contain a few RBCs and WBCs. Normal urine does *not* contain detectable glucose or other sugars, protein, ketones, bilirubin, bacteria, yeast cells, or trichomonads. Normal values representative of many laboratories are given below.

- glucose: negative (quantitative less than 130 mg/day or 30 mg/dL)
- bilirubin: negative (quantitative less than 0.02 mg/dL)

- ketones: negative (quantitative 0.5-3.0 mg/dL)
- pH: 5.0-8.0
- protein: negative (quantitative 15-150 mg/day, less than 10 mg/dL)
- blood: negative
- nitrite: negative
- specific gravity: 1.015-1.025
- urobilinogen: 0-2 Ehrlich units (quantitative 0.3-1.0 Ehrlich units)
- leukocyte esterase: negative
- red blood cells: 0-2 per high power field
- white blood cells: 0-5 per high power field (0-10 per high power field for some standardized systems)

Health care team roles

Doctors, nurses, or laboratory scientists may provide the patient with instructions for sample collection. Laboratory scientists most often perform the tests, though in a physician's office, the doctor, nurse, or physician assistant may perform the visual examination of the sample and the dipstick test.

Resources

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ORGANIZATIONS

American Association of Kidney Patients. 100 S. Ashley Drive, Suite 280, Tampa, FL 33260. (800)749-2257.

American Kidney Fund. 6110 Executive Blvd., Suite 1010, Rockville, MD 20852. (301)881-3052.
<<http://www.arbon.com/kidney>>.

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Victoria E. DeMoranville

Urinary catheterization, female see
Catheterization, female

Urinary catheterization, male see
Catheterization, male

Urinary system

Definition

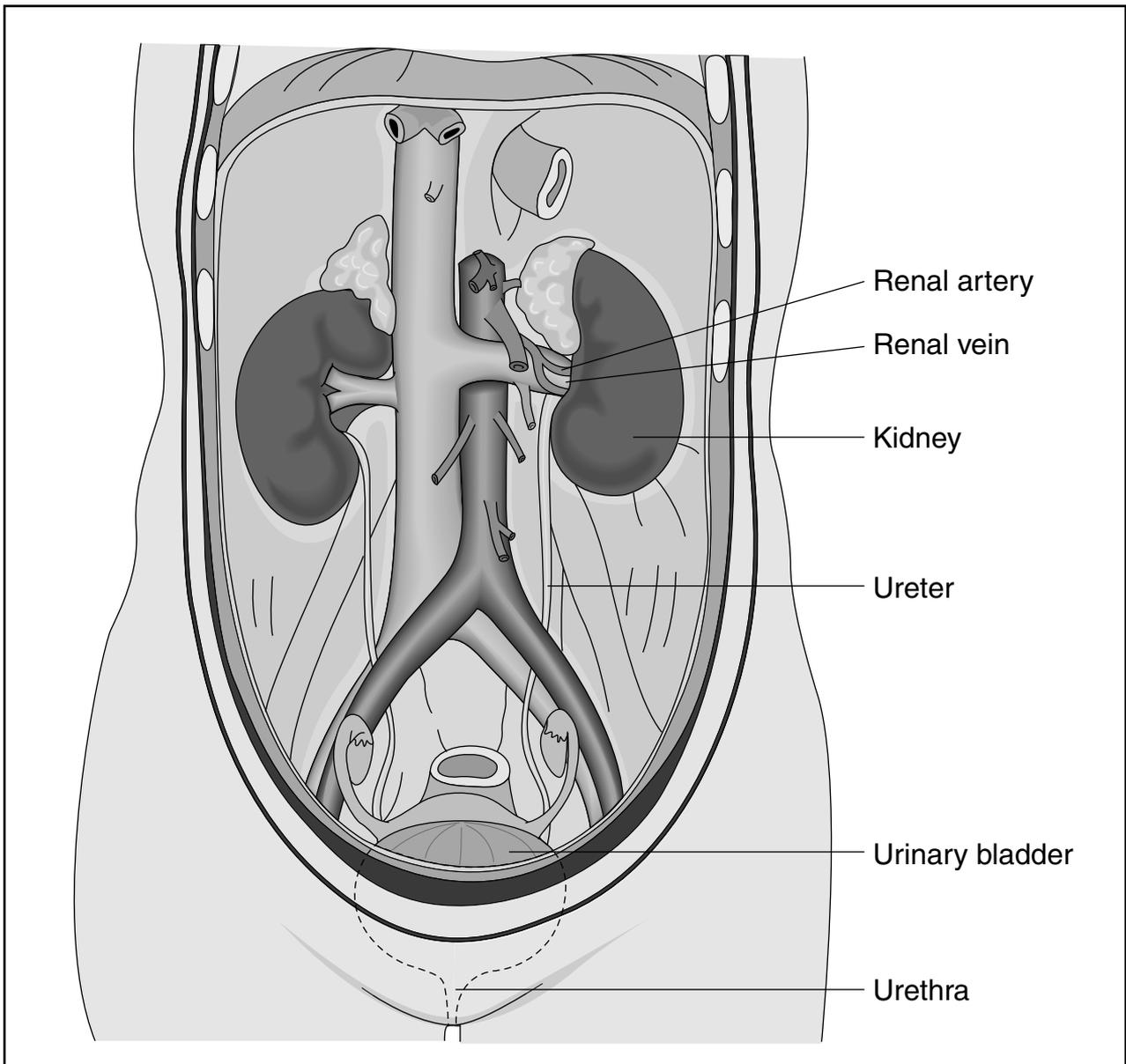
The urinary system consists of organs, muscles, tubes, and nerves that are responsible for producing, transporting, and storing urine. The major structures of the urinary system include the **kidneys**, the ureters, the bladder, and the urethra.

Description

The kidneys

The two kidneys are located lateral (to each side) to the spinal column, along the posterior (back) wall of the abdominal cavity. Each kidney is bean-shaped and approximately the size of one's fist (4 to 5 in, or 10 to 13 cm in length). The hilus is the indentation found along the medial side (the side closest to the midline of the body) of the kidney and is the point at which **blood vessels** (the renal artery and renal vein), nerves, and the ureter enter and exit the organ. The outer layer of the kidney is called the renal cortex, and the inner region of the organ is called the renal medulla.

The individual filtering unit of the kidney is called a nephron, of which there are approximately one million in each kidney. Each nephron extends from the renal cortex into the renal medulla and empties into the funnel-like reservoir of the kidney called the renal pelvis. There are three major components of the nephron: Bowman's capsule, the glomerulus (plural, glomeruli), and the renal tubule. Bowman's capsule is a structure that contains the glomerulus, a cluster of capillaries that is the main filtering device of the nephron. The afferent arteriole brings **blood** from the branches of the renal artery into Bowman's capsule, where fluid is filtered through the glomerulus. Blood exits the glomerulus by way of the efferent arteriole, passing through the peritubular capillaries and eventually entering the renal vein. The renal tubule has four main sections: the proximal tubule, the loop of Henle, the distal tubule, and the collection tubule. The end closest to Bowman's capsule is called the proximal tubule. The loop of Henle extends from the proximal tubule in the renal cortex to the medulla and back to the cortex, into the distal tubule. The distal tubule emp-



Anterior overview of the structures of the urinary system. (Delmar Publishers, Inc. Reproduced by permission.)

ties into a collecting duct which in turn empties into the renal pelvis.

The ureters

Urine is transported from the renal pelvis of each kidney to the urinary bladder by way of a thin muscular tube called the ureter. The ureter of an adult is typically 8-10 in. (21-26 cm) long and approximately 0.25 in. (0.75 cm) in diameter. The walls of the ureter are muscular and help to force urine toward the bladder, away from the kidneys.

The bladder

The urinary bladder is a hollow organ with flexible, muscular walls; it is held in place with ligaments attached to the pelvic bones and other organs. Its primary function is to store urine temporarily until urination occurs, when urine is discharged from the body. When the bladder is empty, its inner wall retracts into many folds that expand as the bladder fills with fluid. The bladder of a healthy adult can typically hold up to 2 cups (0.5 L) of urine comfortably for two to five hours. Circular muscles called sphincters are found at bladder

KEY TERMS

Cystitis—Inflammation of the urinary bladder.

Dialysis—A medical procedure in which waste products are filtered from the bloodstream by a machine.

Filtrate—The fluid that results when blood is filtered through the glomerulus; a precursor to urine.

Hilus—The indentation found along the medial side of the kidney; the point at which blood vessels (the renal artery and renal vein), nerves, and the ureter enter and exit the organ.

Nephritis—Inflammation of the kidney.

Nephron—The individual filtering unit of the kidney; consists of Bowman’s capsule, the glomerulus, and the renal tubule.

Renal cortex—The outer layer of the kidney.

Renal medulla—The inner region of the kidney.

Renal pelvis—The funnel-like reservoir of a kidney that empties to the ureter.

Sphincters—Circular muscles that control the flow of urine in/out of openings to/from the bladder.

openings—from the ureters and to the urethra—and control the flow of urine out of the bladder by closing tightly around the opening.

The urethra

The urethra is a tube that leads from the bladder to the body’s exterior. In females, the urethra is typically about 1.5 in. (4 cm) in length and carries only urine; its opening is found anterior (in front of) the opening to the vagina. In males, however, the urethra is much longer—approximately 8 in. (20 cm) in length—and extends from the bladder to the tip of the penis. It passes through the prostate gland; semen is directed into the urethra via the ejaculatory ducts of the prostate. The male urethra therefore alternately transports urine (during urination) and semen (during ejaculation).

Function

Production and transport of urine

Urine is a fluid composed of water and dissolved substances that are in excess of what the body needs to function, as well as various wastes that are by-products

of **metabolism**, such as urea, a nitrogen-based waste. These substances are transported into the bloodstream, which enters the kidney by way of the afferent arteriole, a branch of the renal artery.

The blood is filtered from there through the glomerulus, where glucose, **minerals**, urea, other soluble substances, and water pass through to the renal tubule. This fluid is called filtrate. Filtered blood leaves the glomerulus, through the efferent arteriole, which branches into the renal vein. The filtrate is transported through the renal tubule where, under normal circumstances, most of the water (about 99%), glucose, and other substances are reabsorbed into the bloodstream through the peritubular capillaries. Urine is what remains at the distal end of the renal tubule.

The urine is transported from the distal and collections tubule to a collection duct and into the renal pelvis. It enters the ureter and is transported to the bladder; a small amount of urine is carried from the renal pelvis to the bladder via the ureter every 10 to 15 seconds. As the bladder fills with urine, pressure from the accumulating fluid stimulates nerve impulses that cause the muscles in the wall of the bladder to tighten. Simultaneously, the sphincter muscle at the opening to the urethra is signaled to relax, and urine is forced out of the bladder through the urethra.

Role in human health

Kidney diseases and other urinary system disorders affect millions of Americans to some degree. An estimated 8.4 million new urinary conditions occur each year, including infections of the kidneys, urinary tract, bladder, and others. Urinary tract stones prompt over 1.3 million visits annually to the doctor’s office with over 250,000 hospital stays. Urinary incontinence is estimated to affect 13 million adults in the United States. In 1998, approximately 398,000 individuals were diagnosed with end-stage renal disease (ESRD), of which over 63,000 died. In that same year, 245,910 patients utilized dialysis services—a medical procedure in which waste products are filtered from the bloodstream by a machine.

Common diseases and disorders

- **Nephritis** (also called glomerulonephritis): Nephritis is an inflammation of the kidneys. It may be caused by a bacterial **infection** (pyelonephritis) or an abnormal **immune response**. Chronic nephritis may result in extensive damage to the kidneys and eventual kidney failure.
- **Urinary tract infection (UTI)**: This broad term includes infections of the urethra and/or bladder (lower UTI) or

the kidneys and/or ureters (upper UTI). UTIs may be caused by **bacteria, fungi, viruses**, or parasites.

- Cystitis: More commonly known as a bladder infection, cystitis is common in women and may be caused by bacteria introduced into the urethra from the vagina. Cystitis in males may result from a prostate infection. It can be treated successfully with antibiotics.
- Urinary incontinence: This is defined as involuntary urination. Urinary incontinence may involve an urgent desire to urinate followed by involuntary urine loss (urge incontinence); an uncontrolled loss of urine following actions such as laughing, sneezing, coughing, or lifting (**stress** incontinence); loss of small amounts of urine from a full bladder (overflow incontinence); continual leakage of urine (total incontinence); or a combination of problems (mixed incontinence).
- Kidney/urinary tract cancers: **Cancer** may develop in any of the structures of the urinary system. Kidney cancer accounts for approximately 2% of cancers diagnosed in adults, more often affecting males than females. Bladder cancer may also occur, with smoking being the most significant risk factor.
- Urinary tract stones: Urinary calculi or urinary tract stones may also be called **kidney stones** or bladder stones, depending on the site of their formation. They may form because of an excess of salts or a lack of stone-formation inhibitors in the urine. Urinary tract stones may cause bleeding, **pain**, urine obstruction, or infection.

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American Foundation for Urologic Disease. 1128 N. Charles Street, Baltimore, MD 21201. (800) 242-2383. <<http://www.afud.org>>.

National Institute of Diabetes and Digestive and Kidney Diseases. 31 Center Drive, MSC 2560, Bethesda, MD 20892-2560. <<http://www.niddk.nih.gov>>.

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Urine culture

Definition

A urine culture is a diagnostic laboratory test performed to detect the presence of **bacteria** in the urine (bacteriuria).

Purpose

Urine cultures are performed to isolate and identify the pathogenic microorganism(s) responsible for causing a urinary tract **infection** (UTI). Urinary tract infections are more common in females and in children than in adult males. UTI is associated with discomfort (usually burning) on urination, and may be accompanied by **fever**, malaise, and lower abdominal or back **pain**. All of the urinary structures except the urethra are normally sterile. Most organisms reach the bladder, ureters, and **kidneys** by ascending the urethra. The most commonly encountered urinary tract pathogen is *E. coli*. *Enterococcus faecalis* is the most common gram positive organism to cause UTI. Infections with *Klebsiella*, *Proteus*, and other *Enterobacteriaceae* are also common. Some organisms not as commonly encountered such as *Candida albicans*, *Haemophilus influenzae*, *Mycobacterium tuberculosis*, *Salmonella spp.*, and *Staphylococcus aureus* usually enter the **urinary system** via the **blood** or lymphatics.

Description

There are several different methods used to collect a urine sample for culture. The most common is the mid-stream clean-catch technique. Hands should be washed before beginning. For females, the external genitalia are

KEY TERMS

Bacteriuria—The presence of bacteria in the urine.

washed two or three times with a cleansing agent and rinsed with water. In males, the external head of the penis is similarly cleansed and rinsed. The patient is then instructed to begin to urinate, and the urine is collected midstream into a sterile container. In infants, a urinary collection bag (plastic bag with an adhesive seal on one end) is attached over a girl's labia or a boy's penis to collect the specimen.

Another method is the catheterized urine specimen in which a lubricated catheter (thin rubber tube) is inserted through the into the bladder. This avoids contamination from the urethra or external genitalia. If the patient already has a urinary catheter in place, a urine specimen may be collected by clamping the tubing below the collection port and using a sterile needle and syringe to obtain the urine sample; urine cannot be taken from the drainage bag, as it is not fresh and has had an opportunity to grow bacteria at room temperature. On rare occasions, the physician may collect a urine sample by inserting a needle directly into the bladder (suprapubic aspiration). Bladder puncture is warranted when repeated efforts to culture the urine grow contaminants from the urethra. This is especially common in infants. Suprapubic tap is also indicated when anaerobic UTI is suspected.

The urine must be cultured within one hour of collection if not refrigerated. However, refrigerated samples may be stored for up to 24 hours before plating the sample. Urine culture is a quantitative procedure. A calibrated inoculating loop that holds 0.01 or 0.001 mL of urine is inserted vertically into the urine sample and used to transfer the urine to a sterile agar plate. If urine is obtained by bladder puncture, 0.1 mL is transferred to the plate using a sterile pipet. The urine is spread evenly across the plate with a glass rod as opposed to streaking the plate with the loop. This procedure is usually performed on plates of 5% sheep blood agar, which detects growth of most organisms, and on a plate of MacConkey agar or other selective and differential medium for isolation of gram-negative organisms. Additionally, some labs plate urine on colistin-nalidixic acid agar (CNA) or other selective medium for gram-positive bacteria. The plates are incubated at 36°C for 18 to 24 hours and read for growth. The number of colonies is multiplied by the appropriate factor to give the colony count per mL urine. Some organisms, such as *Mycobacterium tuberculosis*,

may be isolated from urine and require special culture media and growth conditions.

Plates which show no growth at 24 hours are incubated another day and read again. Growth of more than three species indicates contamination, and the culture should be repeated with a new specimen. For one to three species, plates are held and a partial identification (e.g. gram-negative rod, lactose positive) is reported when there is less than 10,000 colony forming units (CFU) per mL. Usually, when less than 10,000 CFU/mL are recovered the organism is considered a contaminant from the urethra. Exceptions are the presence of *Staphylococcus aureus* and organisms isolated from a catheter sample or suprapubic aspiration. Common urethral contaminants include coagulase negative staphylococci, diphtheroids, and lactobaccilli. Each colony type giving 10,000 or more CFU/mL is identified and antibiotic susceptibility testing is performed. UTI is diagnosed when a species produces greater than 100,000 CFU/mL. Counts between 10,000 and 100,000 may be significant depending on the organism and patient-specific conditions (e.g. urine collected from a catheter or a patient receiving antibiotic treatment).

Preparation

Drinking a glass of water 15-20 minutes before the test is helpful if there is no urge to urinate.

Aftercare

There are no other special preparations or aftercare required for the test.

Complications

There are no risks associated with the culture test itself. If insertion of a urinary catheter is required to obtain the urine, there is a slight risk of introducing infection from the catheter. Patients receiving antibiotic treatment prior to collection may have negative culture results.

Results

Urine is normally sterile and there should be no growth. Greater than 100,000 CFU/mL of any single colony type is considered evidence of UTI. Any growth from a catheter or suprapubic sample or growth of *S. aureus* is considered significant. Greater than 10,000 CFU/mL may be significant in some patient populations and clinical settings.

Health care team roles

The patient collects his or her own sample with the aid of instructions provided by the physician or nurse. A clinical laboratory scientist, NCA (CLS)/medical technologist, MT (ASCP) usually performs the culture and sensitivity testing. A physician makes the diagnosis and treatment decision based upon the colony count, organism(s) identified, antibiotic susceptibility profile, **urinalysis** results, and patient-specific findings.

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Urine specimen collection

Definition

The urine specimen collection is a procedure used to obtain a sample of urine from a patient for diagnostic tests.

Purpose

The purpose of obtaining a urine sample is to test for any abnormalities that may be present, such as **bacteria**, ketones, or drugs.

Precautions

The skin of the genital area should be cleansed with a mild disinfectant to prevent contamination of the urine specimen or irritation of the delicate membranes of the area.

Description

A urine specimen is sometimes called a clean-catch, **urine culture**, or midstream specimen of urine, and is a method of collecting a quantity of urine for testing.

Preparation

The procedure and the reasons for it are explained to the patient. Able patients may be allowed to collect the urine sample, following the guidelines explained by the nurse.

Nurses who collect the urine sample should be sure to wash and dry their hands carefully. The items required for the procedure are as follows:

- a sterile urine cup for children and adults
- a sterile urine bag for infants
- a bedpan or urinal for patients unable to use the toilet
- sterile swabs
- sterile towels
- sterile gloves

For females, the area around the vulva is wiped and dried thoroughly with the sterile swabs and towels, working from front to back, with the nurse wearing sterile gloves. If the patient is unable to use the toilet, the bedpan is placed beneath her. When the urine begins to flow, the first part is allowed to pass into the toilet or bedpan. Then the sterile container is placed in position and filled with the mid-stream portion of the urine. The remainder of the urine is then allowed to pass into the toilet or bedpan. The lid is placed securely on the cup.

For males, the area around the penis and urethra is wiped and dried thoroughly with the sterile swabs and towels, working from front to back, with the nurse wearing sterile gloves. If the patient is uncircumcised, the foreskin should be held back during the complete procedure to prevent the skin contaminating the sample. The patient then begins to pass urine into the toilet or a urinal. Then, the sterile container is placed in position and filled with the mid-stream portion of the urine, taking care that the penis does not touch the sides of the container. The remainder of the urine is then allowed to pass into the toilet or urinal. The lid is placed securely on the cup.

KEY TERMS

Genitals—The reproductive organs.

Ketones—Substances that are present in the blood and urine and occur in large amounts in diseases such as diabetes.

Membrane—A thin layer of tissue lining a part of the body.

Urethra—The tube through which urine flows from the bladder to the outside genitalia.

Vulva—The visible external female genitalia.

For infants, the genitals are cleansed and dried thoroughly using the sterile wipes and towels. A sterile urine collection bag is placed over the area, with the adhesive tape firmly stuck onto the baby's skin. A fresh diaper is put on the child over the collecting bag and checked frequently for the child having passed urine into the bag. When the specimen is obtained, it is poured into a sterile container and sent immediately for testing.

Aftercare

The patient should be made comfortable.

All swabs, towels, and gloves should be disposed of in appropriate containers. The nurse should again wash and dry the hands thoroughly.

The specimen should be sent for testing as quickly as possible. Speed in testing the sample is essential in order to obtain an accurate result.

Complications

If there is a delay in sending the specimen for testing, some organisms present in the urine may die while others multiply, resulting in a false reading.

Patients should inform medical staff of any medications currently being taken as elements of the drugs may be present in the urine.

Results

Normal urine is free from bacteria and is a clear, amber color. It is slightly acid.

Health care team roles

The nurse should be aware of the qualities of normal urine, and note if the patient has any difficulties in passing urine.

Resources

ORGANIZATIONS

American Nurses Association. 600 Maryland Ave. SW, Suite 100 West, Washington, DC 20024. (202) 651-7000. <<http://www.ana.org>>.

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Urobilinogen test *see* **Urinalysis**

Urography *see* **Intravenous urography**

Urticaria *see* **Hives**

Uterine stimulants

Definition

Uterine stimulants (uterotonics) are medications that cause, or increase the frequency and intensity of, uterine contractions. These drugs are used to induce (start) or augment (stimulate) labor, facilitate uterine contractions following a **miscarriage**, induce abortion, or reduce hemorrhage following **childbirth** or abortion. The three uterotonics used most frequently are oxytocins, prostaglandins, and ergots. Depending upon the type of drug, uterotonics may be given intravenously (IV), intramuscularly (IM), as a vaginal gel or suppository, or in oral form.

Purpose

Uterine stimulants are used to induce, or begin, labor in certain circumstances when the mother has not begun labor naturally. These circumstances may include if the mother is post-dates, that is, gestation that is over 40 weeks—especially if tests indicate a decrease in amniotic fluid volume. They may be used in cases of premature rupture of the membranes, preeclampsia (elevated **blood pressure** in the late stage of **pregnancy**), diabetes, and intra-uterine growth retardation (IUGR) when these conditions require delivery before labor has begun. They may be recommended if the expectant mother lives a great distance from the healthcare facility and there is

concern for either her or her baby's safety if she were unable to reach the facility once labor begins. They are also used in the augmentation of existing contractions to increase strength and frequency when labor is not progressing well.

According to the American College of Obstetrics and Gynecology (ACOG), the 1990s saw an increase in the rate of induced labor—from 9% to 18%. In a May 31, 2001, statement, the ACOG reported that the increase in the cesarian rate seen over the same period of time was not due to the induction process but to other factors, such as the condition of the cervix at the time of induction and whether or not the pregnancy was the woman's first.

Oxytocin and prostaglandin (PG) are naturally occurring hormones used to induce labor. They are also available in synthetic form (Pitocin and Syntocinon are the synthetic counterparts of oxytocin). PG is also used to ripen the cervix prior to induction, which is sometimes sufficient to stimulate labor, and the woman needs no further medication for labor to progress. There are many forms of PGs, but those of greatest interest are PGE₁, PGE₂, and PGF_{2 α} . Research is investigating which are the most effective for which process. For example, PGE₂ in the form of dinoprostone (Cervidil and Prepidil) has proven superior to the PGF series in cervical ripening. Misoprostol (Cytotec), a synthetic PGE₁, also is effective in cervical ripening and labor induction, while the PGF_{2 α} analog, carboprost (Prostin 15-M, or Hemabate), is the preferred PG uterine stimulant. The ergots, which significantly increase uterine activity, have severe side effects in many women. Only one ergot, methylergonovine maleate (Methergine) is now used in the United States, and is used only to control postpartum hemorrhage (PPH).

Oxytocin is also used in a contraction stress test (CST). This is done prior to the onset of labor to evaluate the fetus's ability to handle uterine contractions. To avoid the possibility of exogenous (introduced) oxytocin putting the woman into labor, she may instead be asked to stimulate her nipples to cause the release of natural oxytocin. A negative, or normal, test is one in which there are three contractions in a 10-minute period, with no abnormal slowing of the fetal heart rate (FHR). False positives of the CST do occur, however. Also, the expectant mother should remain in the health care setting for about half an hour after a negative test to make sure the test did not stimulate labor.

If a woman has a miscarriage, oxytocin may be used to bring on contractions to assure that all the products of conception (POC) are expelled from the uterus. If the fetus died but was not expelled, prostaglandin (PGE₂) may be used to ripen the cervix to facilitate a dilatation

and evacuation, and/or to encourage more uterine contractions. In this case, prostaglandin may be used either in gel form or as a vaginal suppository.

In a routine delivery oxytocin may be ordered after the placenta has been delivered in order to increase uterine contractions and minimize bleeding. Oxytocin (Pitocin) also may be used to treat uterine hemorrhage. While hemorrhage occurs in about 4% of vaginal deliveries and 6% of cesarian deliveries, it accounts for about 35% of maternal deaths due to bleeding during pregnancy. The role of oxytocin is to bring on and strengthen uterine contractions. If the hemorrhage stems from the placental detachment site, contractions help to close off the **blood vessels** and thereby stop the excessive bleeding. Additional medications may be used, including PGF_{2 α} (Hemabate), misoprostol (Cytotec), or the ergot methylergonovine (Methergine). If the uterus is contracted but bleeding continues, the cause may be retained placenta, genital tract laceration, or uterine rupture. Large clots that remain in the lower part of the uterus can inhibit the uterus from contracting, leading to uterine atony (lack of tone or tension), a leading cause of postpartum hemorrhage. Uterine contractions also help to expel large clots and placental fragments.

Precautions

It is important to establish a clear baseline of **vital signs** before a woman is given any medication to induce labor. Consistent reevaluation and documentation of vital signs allow for faster recognition of an abnormal change in a woman's condition. Also, a clear labor and delivery record will assist the postpartum nurse in monitoring for changes as well. Documentation includes time and dosage of any medications given, as well as any side effects that might occur. Proper documentation will help avoid the chance of medication doses being given too close together. An increasing pulse and a decreasing **blood** pressure signal a potential hemorrhage. When oxytocin is given IV, it must be diluted in IV fluid and never given as a straight IV. PGs should not be given if there is any question about fetal well-being, for example, an abnormal FHR tracing. The ergot, Methergine, should never be given via IV and never to a woman with **hypertension**.

Description

Oxytocin

Oxytocin's major functions are in labor and **lactation**. In vitro, production and secretion of oxytocin is stimulated by the **pituitary gland**. Just what happens to initiate labor remains a mystery, even although much

research has focused on this area. The hormone estrogen appears to increase the number of oxytocin receptors as the gestation period increases. The degree to which uterine muscles are sensitive to oxytocin's action appears linked to the number of oxytocin receptors. Oxytocin levels increase as labor progresses, and the fetus also secretes oxytocin during labor, increasing the amount of circulating oxytocin.

In a normally progressing labor, contractions become more frequent, more intense, and last longer. In a dysfunctional labor, contractions may weaken, become further apart, or even stop. A prolonged labor puts the mother at risk of fatigue, which can increase the likelihood of a cesarian delivery or fetal distress. Oxytocin may be given to augment the labor. Some women may need only a very small amount in order to "jump start" labor once again. For others it may be necessary to continue the oxytocin in small increments. Oxytocin increases the strength, duration, and frequency of contractions, so care must be taken to prevent the contractions from becoming too strong or too frequent. If the mother has an **infection**, labor may not progress as usual. Oxytocin is less effective in such cases.

Naturally occurring oxytocin plays a role in breastfeeding by facilitating both milk ejection and the letdown reflex. When the neonate suckles at the breast, the nipple stimulation sends a message to the pituitary gland to release oxytocin. Oxytocin then causes the milk gland cells to constrict, pushing the milk forward towards the nipples. Breastfeeding immediately after delivery encourages oxytocin production and causes uterine contractions, helping the uterus to become firm and close off the blood vessels at the placental detachment site. This process limits the amount of blood lost after childbirth. Because the release of oxytocin is inhibited by fear, **pain**, embarrassment, and distraction, providing the new mother with a calm environment in which she can focus on her infant will facilitate breastfeeding and the production of oxytocin.

Prostaglandins

Prostaglandins play a major role in the stimulation of uterine contractions that begin the labor process. Research indicates that PGs also facilitate the mother's transition between phases of the labor process. Some PGs promote vasoconstriction while others promote vasodilation. One function of PGs is to promote cervical effacement and dilation during labor. Oxytocin plays a role in stimulating the release of PGs. Infection stimulates their release, also, which appears to be a factor in the initiation of up to 30% of cases of **preterm labor**. PGs serve a function in immunosuppression, but the exact mecha-

nism is unclear. They also may be a major factor in regulating umbilical blood flow by keeping the ductus arteriosus open during fetal life.

Ergots

Ergots are produced by a fungus that forms primarily on rye grain. Because of its potentially harmful side effects, one form (Ergonovine, or Ergotrate) was taken off the market in 1993 and methylergonovine maleate (Methergine) is now the only form used, and is used only as a uterine stimulant to control PPH. (There is no evidence that Methergine used as a prophylactic decreases the risk of PPH.) Even so, because of the complications it can cause, and because its use is contraindicated in a large number of women, Methergine has been replaced by the PGs as the second-line uterotonic of choice.

Preparation

Before any procedure is begun or medication administered, it is important for the nurse to review the information with the pregnant woman to ensure she understands what will take place and the potential side effects of the medication. Any **allergies** to medication need to be reviewed, as well as any prior response the mother may have had to the medications. The mother may be anxious about induction or augmentation, fearing that the contractions will come too fast or that she will feel out of control of the process. The nurse needs to address her concerns, as well as those of her partner.

Aftercare

Close supervision of the mother during induction or cervical ripening must take place. The FHR and uterine contractions are usually monitored for an hour after induction. Frequent checks of vital signs alert the nurse to any potential complications.

Complications

Oxytocin

The effect of IV oxytocin is rapid following administration. The individual response to oxytocin can vary considerably and administration is usually increased slowly and incrementally. Hyperstimulation of the uterus, which can result from oxytocin augmentation, can place the fetus at risk for asphyxia. Hyperstimulation is defined as more than five contractions in 10 minutes, contractions lasting longer than 60 seconds, and increased uterine tone either with or without significant decrease in FHR. Uterine rupture has also been linked to oxytocin administration, particularly for periods longer

than four hours. Oxytocin has a small antidiuretic effect that is usually dose related and that can lead to water intoxication (hyponatremia). Onset occurs gradually and may go unnoticed. Signs may include reduced urine output, confusion, nausea, convulsions, and **coma**. Mothers receiving oxytocin need to have their blood pressure monitored closely, as both hypotension and hypertension can occur, and—although the subject remains controversial—evidence suggests oxytocin increases the incidence of **neonatal jaundice**. Although oxytocin may put women with a classical cesarian section scar from a prior delivery at increased risk of uterine rupture, contraindications to the use of the drug are virtually the same as contraindications for labor. Other side effects of oxytocin include nausea, vomiting, cardiac arrhythmias, and fetal bradycardia. When used judiciously oxytocin is a very effective medication for the progression of labor.

Prostaglandins

Significant systemic side effects are associated with the use of PGs. These include headache, nausea, **diarrhea**, tachycardia, vomiting, chills, **fever**, sweating, hypertension, and hypotension. There is also increased incidence of uterine hyperstimulation and potential for uterine rupture. PGF_{2α} (carboprost—Prostin 15-M or Hemabate) can cause hypotension, pulmonary **edema**, and—in women with asthma—intense bronchospasms. Because it stimulates the production of steroids, carboprost may be contraindicated in women with adrenal gland disease. When used for abortion it may result in sufficient blood loss to cause anemia, necessitating a transfusion. Medical problems (or history) of diabetes, epilepsy, heart or blood vessel disease, **jaundice**, kidney disease, or **liver** disease should be brought to the attention of the health care practitioner before the use of carboprost. Also, in rare instances, ophthalmic pressure has increased in women with **glaucoma** with the use of this PG.

Ergots

Ergots have an alpha adrenergic action with a vasoconstrictive effect. They can cause hypertension, cardiovascular changes, **cyanosis**, muscle pain, tingling, other symptoms associated with decreased blood circulation, and severe uterine cramping. The health care professional should be well aware of other medications being taken by the patient; the presence or history of medical problems such as angina, hypertension, stroke, infection, kidney and liver disease, and Raynaud's phenomenon may be contraindications to the use of this drug.

KEY TERMS

Atony—In uterine atony, the uterus fails to contract after delivery, remaining relaxed. This flaccid condition can lead to hemorrhage, and puts the mother at risk of shock and death.

Augment—Drugs to augment labor are given after labor has begun, but fails to progress, or when the contractions have slowed down and are weak or ineffective, prolonging labor unnecessarily.

Hemorrhage—The loss of an excessive amount of blood in a short period of time. After childbirth, a loss of more than 500 mL over a 24-hour period is considered postpartal hemorrhage. The blood loss may be sudden and swift, or slow and continuous.

Induce, induction—To begin or start.

Post-dates—Gestation longer than approximately 40 weeks. Up to 42 weeks may still be still considered normal.

Results

Anticipated outcomes for uterine stimulants are either to prepare the cervix for childbirth, induce or stimulate uterine contractions to produce a safe delivery of a newborn, encourage a complete spontaneous or induced abortion, eliminate blood clots or other POC debris from the uterus, and decrease or stop hemorrhage following childbirth or abortion. Normal results would meet these outcomes without significant side effects—either for the mother or, in the case of childbirth, the infant.

Health care team roles

Nurses play a major role in preparing the patient for, and administering, uterine stimulants and monitoring the patient and fetus during the labor process. Because the choice of drug, its form of administration, and its side effects varies, knowledge of uterine physiology is an important aspect of caring for women and their fetuses undergoing treatment with these drugs. Nurses must be aware of potential complications and side effects, as well as dosing requirements, criteria assessment, and contraindications to these drugs. They should take a complete medical history of the patient, including prescription and over-the-counter medications, illnesses, and disease. In most instances a gynecologist or other qualified physician will perform the actual delivery, although this may occasionally be facilitated by a midwife. A pediatrician or family health care practitioner will examine

the newborn infant and administer treatment if required. The nurse can be an important source of information and comfort to women facing induction of labor or abortion, and to new mothers facing the initial responsibility of parenthood.

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Uterus x rays see **Hysterosalpingography**

V

Vaccination

Definition

Vaccination is the use of vaccines to produce immunity to specific diseases.

Purpose

Many diseases that once caused widespread illness, disability, and death now can be prevented through the use of vaccines. Vaccines are medicines that contain weakened or dead **bacteria**, **viruses**, or pollen antigens. When a person takes a vaccine, his or her **immune system** responds by producing antibodies—substances that weaken or destroy disease-causing organisms. When the person is later exposed to live bacteria or viruses of the same kind that were in the vaccine, the antibodies prevent those organisms from making the person sick. In other words, the person becomes immune to the disease the organisms normally cause. The process of building up immunity by taking a vaccine is called immunization.

Vaccines are used in several ways. Some, such as the rabies vaccine, are given only when a person is likely to have been exposed to the virus that causes the disease, such as through a dog bite, for example. Others are given to travelers planning to visit countries where certain diseases are common. Vaccines such as the **influenza** vaccine, or “flu shot,” are given mainly to specific groups of people—older adults and others whose health is at high risk if they develop influenza or its complications. Then, there are vaccines that are given to almost everyone, such as the one that prevents diphtheria.

Children routinely have a series of vaccinations that begin at birth. The American Academy of Pediatrics recommends that children be fully immunized before the age of two years in order for them to be protected during their most vulnerable period. Given according to a specific schedule that is issued every year by the Department of Health, these vaccinations protect against hepatitis B,

diphtheria, tetanus, pertussis, measles, mumps, rubella, varicella (chickenpox), polio, and *Hemophilus influenzae* type B (HiB). This series of vaccinations is recommended by the American Academy of Family Physicians, the American Academy of Pediatrics, and the Centers for Disease Control and Prevention and is required in all states before children can enter school. All states will make exceptions for children who have medical conditions such as **cancer** that prevent them from having vaccinations, and some states also will make exceptions for children whose parents object for religious or other reasons.

Vaccines are also available for preventing anthrax, cholera, hepatitis A, Japanese encephalitis, meningococcal **meningitis**, plague, pneumococcal **infection**, **tuberculosis**, typhoid **fever**, and yellow fever.

Some vaccines are combined in one injection, such as the measles-mumps-rubella (MMR) or diphtheria-pertussis-tetanus (DPT) combinations.

Precautions

Vaccines are not always effective, and there is no way to predict whether a vaccine will “take” in any particular person. To be most effective, vaccination programs depend on whole communities participating. The more people who are vaccinated, the lower everyone’s risk of being exposed to a disease. Even people who do not develop immunity through vaccination are safer when their friends, neighbors, children, and coworkers are immunized.

Like most medical procedures, vaccination has risks as well as substantial benefits. Anyone who takes a vaccine should make that sure he or she is fully informed about both the benefits and the risks. Any questions or concerns should be discussed with a physician or other health care provider. The Centers for Disease Control and Prevention, located in Atlanta, Georgia, is a good source of information.



An allergic reaction to a vaccination shot. (Photograph by Lester V. Bergman, Corbis Images. Reproduced by permission.)

Vaccines may cause problems for people with certain **allergies**. For example, people who are allergic to the **antibiotics** neomycin or polymyxin B should not take rubella vaccine, measles vaccine, mumps vaccine, or the combined measles-mumps-rubella (MMR) vaccine. Anyone who has had a severe allergic reaction to baker's yeast should not take the hepatitis B vaccine. Patients who are allergic to antibiotics such as gentamicin sulfate, streptomycin sulfate, or other aminoglycosides should check with their physicians before taking influenza vaccine, as some influenza vaccines contain these drugs. Also, some vaccines, including those for influenza, measles, and mumps, are grown in the fluids of chick embryos and should not be taken by people who are allergic to eggs. In general, anyone who has had an unusual reaction to a vaccine in the past should let his or her physician know before taking the same kind of vaccine again. The physician also should be told about any allergies to foods, medicines, preservatives, or other substances.

People with certain other medical conditions should be cautious about taking vaccines. Influenza vaccine, for example, may reactivate Guillain-Barre syndrome in people who have had it before. This vaccine also may worsen illnesses that involve the **lungs**, such as bronchitis or **pneumonia**. Vaccines that cause fever as a side-effect may trigger seizures in people who have a history of seizures caused by fever.

Certain vaccines are not recommended for use during **pregnancy**, but some may be given to women at especially high risk of getting a specific disease such as polio. Vaccines also may be given to pregnant women to prevent medical problems in their babies. For example, vaccinating a pregnant woman with tetanus toxoid can prevent her baby from getting tetanus at birth.

Women should avoid becoming pregnant for three months after taking rubella vaccine, measles vaccine, mumps vaccine, or the combined measles-mumps-rubella (MMR) vaccine as these could cause problems in the unborn baby.

Women who are breastfeeding should check with their physicians before taking any vaccine.

Description

Vaccinations can also be called shots or immunizations. Most vaccines are given as injections, but a few such as the oral polio vaccine are given by mouth.

The time involved in administering vaccinations is minimal; however, the nurse should allow time before and after the procedure for answering questions and for monitoring the patient for potential side-effects up to thirty minutes following a vaccination.

Most insurance companies cover routine vaccinations. The patient should be advised to check with their provider for their current list.

Recommended dosage

The recommended dosage depends on the type of vaccine and may be different for different patients. The health care professional who administers the vaccine will decide on the proper dose.

A vaccination health record will help parents and health care providers keep track of a child's vaccinations. The record should be started when the child has his or her first vaccination and should be updated with each additional vaccination. While most physicians follow the recommended vaccination schedule, parents should understand that some flexibility is allowed. For example, vaccinations that are scheduled for age two months may be given anytime between six and 10 weeks. When possible, follow the schedule. However, slight departures will not prevent the child from developing immunity, as long as all the vaccinations are given at around the right times. The child's physician is the best person to decide when each vaccination should be given.

Anyone planning a trip to another country should check with a health care provider to find out what vaccinations are needed. Some vaccinations must be given as

much as 12 weeks before the trip, so getting this information early is important. Many major hospitals and medical centers have travel clinics that can provide this information. The Traveler's Health Section of the Centers for Disease Control and Prevention also has information on vaccination requirements.

Complications

Most side-effects from vaccines are minor and easily treated. The most common are **pain**, redness, and swelling at the site of the injection. Some people may also develop a fever or a rash. In rare cases, vaccines may cause severe allergic reactions, swelling of the **brain**, or seizures. Anyone who has an unusual reaction after receiving a vaccine should get in touch with a physician right away.

Results

Immunity to a particular disease is expected after one or more vaccinations, depending on the formula of the vaccine used. This immunity is usually permanent, but follow-up doses are required with certain diseases such as tetanus, which requires a booster every ten years.

Vaccines may interact with other medicines and medical treatments. When this happens, the effects of the vaccine or the other medicine may change or the risk of side effects may be greater. For example, radiation therapy and cancer drugs may reduce the effectiveness of many vaccines or may increase the chance of side-effects. Anyone who takes a vaccine should inform their physician about other medicines he or she is taking and should ask whether the possible interactions could interfere with the effects of the vaccine or the other medicines.

Health care team roles

Vaccinations are the best way to be protected from life-threatening diseases. Because of the widespread use of vaccines, most of these illnesses are rarely seen in the United States. It is important that the nursing staff remain up-to-date with the current trends in immunization as outlined by the Department of Health. The immunization rates in the health department should be looked at for improvement to ensure that children and patients at risk are fully immunized. The nurse should be able to provide an overview of the principles of vaccination, general vaccination recommendations, routine vaccinations for travelers, and questions on impending flu epidemics. In addition, the nurse should explain the procedure to the patient and answer questions regarding a vaccine's efficacy and its possible side-effects. Brochures may also be available

KEY TERMS

Anthrax—An infectious disease caused by a type of bacterium. The disease can be passed from animals to people and usually is fatal. Symptoms include sores on the skin.

Antibody—A type of protein produced in the blood or in the body tissues that helps the body fight infection.

Cholera—An infection of the small intestine caused by a type of bacterium. Drinking water or eating seafood or other foods that have been contaminated with the feces of infected people can spread the disease. It occurs in parts of Asia, Africa, Latin America, India, and the Middle East. Symptoms include watery diarrhea and exhaustion.

Encephalitis—Inflammation of the brain, usually caused by a virus. The inflammation may interfere with normal brain function and may cause seizures, sleepiness, confusion, personality changes, weakness in one or more parts of the body, and even coma.

Guillain-Barre syndrome—A disease of the nerves with symptoms that include sudden numbness and weakness in the arms and legs, sometimes leading to paralysis. The disease is serious and requires medical treatment, but most people recover completely.

Pertussis—Whooping cough.

Rubella—German measles.

Tuberculosis—An infectious disease that usually affects the lungs, but may also affect other parts of the body. Symptoms include fever, weight loss, and coughing up blood.

Typhoid fever—An infectious disease caused by a type of bacterium. People with this disease have a lingering fever and feel depressed and exhausted. Diarrhea and rose-colored spots on the chest and abdomen are other symptoms. The disease is spread through poor sanitation.

Yellow fever—An infectious disease caused by a virus. The disease, which is spread by mosquitoes, is most common in Central and South America and Central Africa. Symptoms include high fever; jaundice (yellow eyes and skin); and dark-colored vomit, a sign of internal bleeding. Yellow fever can be fatal.

to give to patients to inform them about the reasons for vaccination as well as the risk of potential side-effects.

If a child is being vaccinated, the parent can bring along a favorite toy to help distract the child and make him or her more at ease if there is a delay in being seen. Seeing the same health care provider regularly will enable familiarity to become established, and the parents can hold the child in their lap while the vaccination is being given, making the situation less traumatic.

Needle-free jet injectors, which force the vaccine serum through the skin using a blast of air, are also available in some clinics. They are slightly faster than a needle and could be less painful for the patient, while eliminating the risk of needlestick injuries.

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National Immunization Information Hotline. Centers for Disease Control and Prevention. 800-232-2522.

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Centers for Disease Control National Immunization Program. <<http://www.cdc.gov/nip>>.

Global Alliance for Vaccines and Immunization. (GAVI) <<http://www.vaccinealliance.org>>.

National Vaccine Injury Compensation Program, Parklawn Building, Room 8A-46 5600 Fishers Lane, Rockville, Maryland 20857. <<http://www.bhpr.hrsa.gov/vicp>>.

Margaret Stockley

Vaccines see **Vaccination**

Vaginal medicine administration

Definition

Vaginal medicines are topical agents prepared specifically for insertion into a woman's vagina. They are compounded in the form of a cream, foam, gel, tablet, or suppository, and are absorbed through the vaginal mucousa. Vaginal medicine in the form of a cream, foam, gel, or tablet is administered using a specific applicator that is provided by the manufacturer. Suppositories have the medicine suspended in wax and are shaped like a small bullet. They are inserted into the vagina with the index finger. Vaginal medicines are most often administered at bedtime, as the reclined position enhances medication absorption.

Purpose

Vaginal medicines are most commonly used to combat **infection**, inflammation, or dryness of the vaginal mucousa. Other types of vaginal medicines include spermicides (i.e., to prevent conception), **chemotherapy** (i.e., for **cancer** treatment), and aborticides (i.e., for inducing labor).

Precautions

Vaginal tissue can be traumatized by the forceful use of applicators or fingernails during medicine administration, so medications should be introduced into the vagina gently. Patients should be encouraged to relax, as this will decrease resistance to the mode of insertion. One should not attempt to insert vaginal medication when a patient is confused and combative.

Medicine should not be delivered via the vagina if it is not labeled for vaginal use. Vaginal medicine should not be taken orally.

Description

A female staff member must be present in the room when a male nurse administers a vaginal medication. The patient should be positioned on her back, with knees bent. Her legs should be drawn up toward the hips, and the heels should be flat on the bed. A sheet across the abdomen and upper legs, falling just over the knees, will decrease the patient's feeling of exposure. Directions for filling the applicator should followed. At this point, the patient should be advised to drop her knees apart. The nurse should wash his or her hands and put on disposable gloves. Using one hand, the nurse should spread the labia and expose the vaginal opening. If there is drainage or exudate, the nurse should cleanse the area with warm, soapy water, using cotton balls or a clean washcloth. The vaginal opening should be rinsed and allowed to air dry. A small amount of water-soluble lubricant should then be placed on the tip of the applicator or suppository, the labia spread, and the suppository or applicator tipped into the vaginal opening. The suppository or applicator should be moved gently down, toward the posterior (i.e., back) wall of the vagina, toward the spine 2–4 inches (5–10 cm), or until resistance is felt. The suppository or applicator should then be angled upward. When using an applicator to deliver cream or gel, the plunger should be gently pushed to deliver the medicine. The nurse should then remove his or her finger and/or the applicator from the vagina. The disposable latex gloves should be disposed of properly.

Preparation

Before beginning to administer vaginal medicines, the door to the room should be closed to ensure privacy. (A female staff member must already be present if the nurse is a male.) The patient should empty her bladder just before administration. The nurse should check the medication label each time medicine is given; this will avoid medication errors. The medication must be checked to confirm that it is the right medicine, the right dose (i.e., strength), the right time, the right patient, and the right method of administration. The expiration date on the label should be checked; outdated medication should never be used. If the nurse has not yet put on disposable gloves, it should be done at this time. His or her hands should be washed, and gloves should be put on.

Aftercare

The used applicator should be placed on a clean paper towel to prevent the spread of microorganism. The patient should be covered and encouraged to maintain a reclined position, with knees up, for at least 10 minutes (30 minutes after a suppository). This will allow time for medicine absorption. If the applicator is reusable, it should be washed in warm soapy water, thoroughly rinsed, air dried, and placed back in the medicine box or a plastic bag until the next use. The used gloves and disposable applicator should be put into a trash bag, which can be sealed and discarded. The nurse should wash his or her hands. The patient should be given a mini-pad (or small sanitary napkins) to protect her underwear from medicine that may leak out.

The patient should not be instructed not to use tampons after vaginal medicine administration; they will absorb the medicine more rapidly than the vaginal mucosa, and the full effect of the drug will not be achieved.

Complications

Tissue irritation or allergic reactions can result from vaginal medications. If irritation, swelling, or redness of the tissue is apparent, or if the patient complains of **pain** or burning, the next dose of medicine should not be given until the physician has been consulted.

Results

Most vaginal medicines will produce the desired effects within several days to one week. Spermicides and aborticide vaginal medicines act more rapidly when used as directed. If the client experiences vaginal pain at the time of medicine instillation, or the condition does not improve, the physician should be contacted.

Health care team roles

Vaginal medicines are administered by a licensed nurse (i.e., R.N. or L.P.N.) in the health care setting. An alert and cooperative patient may be allowed to administer the medicine under the direction of the nurse. The nurse should, however, assess the site and the effectiveness of the medicine. The patient, or members of the patient's family, can be taught to administer vaginal medicines in the home setting.

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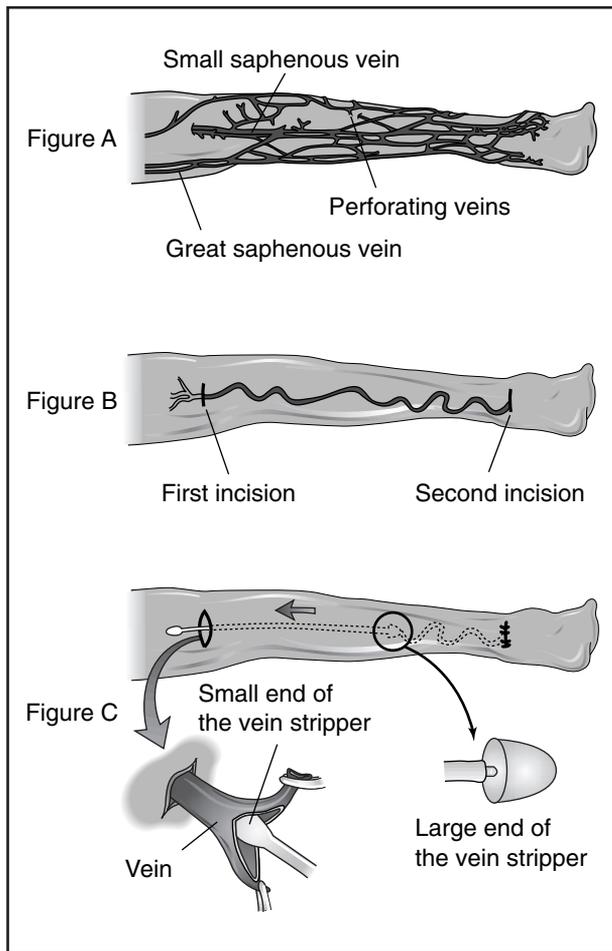
Varicose veins

Definition

Varicose veins are dilated, tortuous, elongated superficial veins that are usually seen in the legs but may be found in other bodily locations.

Description

Varicose veins, also called varicosities, are seen most often in the legs, although they can be found in other parts of the body. Most often, they appear as lumpy,



Varicose veins may be surgically removed from the body when they are causing pain and when hemorrhaging or recurrent thrombosis appear. Surgery involves making an incision through the skin at both ends of the section of vein being removed (figure B). A flexible wire is inserted through one end and extended to the other. The wire is then withdrawn, pulling the vein out with it (figure C). (Illustration by Electronic Illustrators Group.)

winding vessels just below the surface of the skin. There are three types of veins: superficial veins that are just beneath the surface of the skin, deep veins that are large **blood vessels** found deep inside muscles, and perforator veins that connect the superficial and deep veins. The superficial veins are the **blood vessels** most often affected by varicose veins and are the veins first seen when the varicose condition has developed.

The inside walls of veins have valves that open and close in response to blood flow. When the left ventricle of the **heart** pushes blood out into the aorta, it produces the high pressure pulse of a heartbeat and pushes blood throughout the body. Between heartbeats, there is a period of low **blood pressure**. During the low pressure period, blood in the veins is affected by gravity and

tends to flow backward. The valves in the veins prevent this from happening. Varicose veins start when one or more valves fail to close. The blood pressure in that section of vein increases, causing additional valves to fail. This allows blood to pool and stretch the veins, further weakening the walls of the veins. The walls of the affected veins lose their elasticity in response to increased blood pressure. As the vessels weaken, more and more valves are unable to close properly. The veins become larger and wider over time and begin to appear as lumpy, winding chains underneath the skin. Varicose veins can also develop in the deep veins. Varicose veins in the superficial veins are called primary varicosities, while varicose veins in the deep veins are called secondary varicosities.

Liver disease can cause the appearance of varicose veins in the esophagus or on the surface of the abdomen. These appear in response to increased pressure of blood that is unable to move through a diseased liver. Varicose veins in the esophagus are called esophageal varicosities. Varicose veins on the surface of the abdomen often resemble a spider or the head (caput) of the mythological character Medusa.

Causes and symptoms

The predisposing causes of varicose veins are multiple. Lifestyle and hormonal factors play a role. Some families seem to have a higher incidence of varicose veins, indicating that there may be a genetic component to this disease. Varicose veins are progressive. As one section of a vein weakens, it causes increased pressure on adjacent sections. These sections often develop varicosities. Varicose veins can appear following **pregnancy**, thrombophlebitis, congenital blood vessel weakness, or **obesity**, but are not limited to these conditions. **Edema** of the surrounding tissue, ankles, and calves, is not usually a complication of primary (superficial) varicose veins and, when seen, usually indicates that the deep veins may have varicosities or clots.

Varicose veins are a common problem. Approximately 15% of the adult population in the United States has varicose veins. Women have a much higher incidence of this disease than men. The symptoms can include aching, **pain**, itchiness, or burning sensations, especially when standing. In some cases, with chronically bad veins, there may be a brownish discoloration of the skin or ulcers (open sores) near the ankles. A condition that is frequently associated with varicose veins is spider-burst veins. Spider-burst veins are very small veins that are enlarged. They may be caused by back-pressure from varicose veins, but can be caused by other factors. They are frequently associated with pregnancy, and there may be hormonal factors associated with their

development. They are primarily of cosmetic concern and do not present any medical concerns.

Diagnosis

Varicose veins can usually be seen. In cases where varicose veins are suspected, but cannot be seen, a physician may frequently detect them by palpation (pressing with the fingers). X rays or ultrasound tests can detect varicose veins in the deep and perforator veins and rule out blood clots in the deep veins.

Treatment

There is no cure for varicose veins. Treatment falls into two classes: relief of symptoms and removal of the affected veins. Symptom relief includes such measures as wearing support stockings, which compress the veins and hold them in place. This keeps the veins from stretching and limits pain. Other measures are sitting down, using a footstool when sitting, avoiding standing for long periods of time, and raising the legs whenever possible. These measures work by reducing the blood pressure in leg veins. Prolonged standing allows the blood to collect under high pressure in the varicose veins. **Exercise** such as walking, biking, and swimming, is beneficial. When the legs are active, the leg muscles help pump the blood in the veins. This limits the amount of blood that collects in the varicose veins and reduces some of the symptoms. These measures reduce symptoms, but do not stop the disease.

Surgery is also used to remove varicose veins from the body. It is recommended for those that cause pain or are very unsightly and when hemorrhaging or recurrent thrombosis appear. Surgery involves making an incision through the skin at both ends of the section of vein being removed. A flexible wire is inserted through one end and extended to the other. The wire is then withdrawn, pulling the vein out with it. This is called “stripping” and is the most common method to remove superficial varicose veins. As long as the deeper veins are still functioning properly, a person can live without some of the superficial veins. Because of this, stripped varicose veins are not replaced.

Injection therapy is an alternate therapy used to seal varicose veins. This prevents blood from entering the sealed sections of the vein. The veins remain in the body, but no longer carry blood. This procedure can be performed on an out-patient basis and does not require anesthesia. It is frequently used if people develop more varicose veins after surgery to remove the larger varicose veins and to seal spider-burst veins for people concerned about cosmetic appearance. Injection therapy is also



Varicose veins on a man's leg. (Photograph by Keith, Custom Medical Stock Photo. Reproduced by permission.)

called sclerotherapy. At one time, a method of injection therapy was used that did not have a good success rate. Veins did not seal properly and blood clots formed. Modern injection therapy is improved and has a much higher success rate.

Prognosis

Untreated varicose veins become increasingly large and more obvious with time. Surgical stripping of varicose veins is successful for most people. Most do not develop new, large varicose veins following surgery. Surgery does not decrease a person's tendency to develop varicose veins. Varicose veins may develop in other locations after stripping.

Health care team roles

Family physicians or gynecologists often make an initial referral to a vascular surgeon for treatment. Nurses may instruct patients in practices to prevent worsening of the condition, if surgery is not warranted.

Prevention

Varicose veins in the legs can be minimized by maintaining good physical condition and engaging in exercise throughout life. This is especially important for women during pregnancy. Persons who are at risk of developing varicose veins can wear support hosiery. Refraining from standing for long periods of time is helpful. If standing is

KEY TERMS

Congenital—Existing at or before birth; a condition that developed while the fetus was in utero or as a consequence of the birth process.

Edema—Swelling caused by a collection of fluid in a tissue or body cavity.

Hemorrhage—Bleeding from blood vessels.

Palpation—The process of examining a person using the sense of touch.

Thrombosis—Blockage of a blood vessel due to a clot or thrombus.

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- Peripheral Vascular Surgery Society. 824 Munras Avenue, Suite C, Monterey, CA 93940. (831) 373-0508. <<http://www.pvss.org>> suzanne@DMCcompanies.com.

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L. Fleming Fallon, Jr., MD, DrPH

Vascular headache *see* **Migraine headache**

Vascular sonography

Definition

Vascular sonography, also called vascular ultrasound, is a diagnostic procedure that uses sound waves to produce images of the **blood vessels** and **blood flow**.

Purpose

Vascular sonography is used to evaluate blood flow in the arteries and veins. This test has many applications, including diagnosis of deep vein thrombosis (DVT), claudication, atherosclerosis, and congenital vascular malformations. In addition to its diagnostic capabilities, vascular sonography can be used to determine whether a patient is a good candidate for a vascular procedure such as **angioplasty**. It can also be used to evaluate the success of a surgical procedure such as bypass surgery or graft transplantation (adequate blood flow to the graft would indicate a successful graft transplantation). Furthermore, vascular sonography may be used to determine the blood flow to tumors and chronic **wounds** in order to aid in treatment planning.

Finally, vascular sonography can be used to identify blood clots and other blockages to blood flow. The test can reveal blood clots requiring anticoagulant therapy, blood clots that may embolize (travel) to other organs (including the **lungs**), and blockages to blood flow in the **brain** that might result in a stroke.

Vascular sonography is usually performed in a hospital's radiology department, or its vascular laboratory,

which focuses on vascular imaging and evaluation. However, because vascular ultrasound units are portable, vascular sonography can be performed at the bedside of patients in the emergency room, or anywhere else in the hospital, if necessary.

Vascular sonography may be recommended by a primary care physician after detecting sounds of abnormal blood flow (usually via **stethoscope**). It may be performed in patients with suspected narrowing of the carotid arteries in the neck (who are at increased risk of stroke), or in patients with suspected abnormalities in the superficial blood vessels in the arms and legs. It may also be used to detect narrowing of the deeper abdominal vessels (such as the renal arteries and superior mesenteric artery), or to rule out bleeding in the abdomen following trauma.

Precautions

Because smoking can cause constriction of blood vessels, patients should not smoke before vascular sonography.

Description

Medical ultrasound scanning works in a manner similar to sonar and radar. Vascular sonography relies on ultrasonic sound waves transmitted at high frequencies (approximately 2 to 10 megahertz) beyond the level of human **hearing**. The sound waves are aimed at the area of interest. Depending on the tissue or liquid the sound waves encounter, different echoes return to the scanner. The scanner then interprets these echoes to produce an image.

Vascular sonography may be performed using a handheld portable ultrasound scanner or a larger mobile scanner, both of which have an ultrasound probe with a transducer, and a computer that processes the echoed sound waves into an image. Larger scanners are usually equipped with a videotape recorder or digital image acquisition system to record the examination, as well as a medical image printer for hard copies.

For vascular sonography, the patient is positioned on a bed or table so that the area to be imaged can be easily accessed. A special gel, called acoustic coupling gel, is placed on the skin over the area to be imaged to enhance the transmission of sound waves. The probe is held over the area of interest and occasionally moved. The ultrasound probe's transducer emits sound waves that are transmitted through the body and reflected back as echoes, which are then converted into an image. The probe can be positioned along the vessel for a longitudinal scan or across the vessel for a transverse scan. During an abdom-

inal or neck examination, the patient may be asked to hold the breath or stop swallowing. Examinations of the arms and legs may require that the limb be elevated or compressed.

Vascular ultrasound images can be acquired and displayed as gray-scale or Doppler images. Gray-scale images use different shades of gray to indicate differences in the strength of echoes; echoes from blood are of lower strength and appear darker than surrounding tissue. Gray-scale images can depict the layers of the vessel wall and show real-time arterial motion.

Doppler imaging uses the frequency shift caused by the Doppler effect to produce images of blood flow. The Doppler effect is a principle of physics involving light and sound; relative to an observer, the frequency of any light or sound wave will vary as the source of the wave approaches or moves away. Ultrasound scanners with Doppler imaging capability detect and calculate the changes in frequency of the speed of blood flow relative to a computer marker placed by the sonographer. Color Doppler imaging superimposes color over moving structures on the gray-scale images. For example, red and yellow in a blood vessel image indicates flow away from the probe, while blue and green indicates flow toward the probe. Color Doppler imaging can be used to identify areas of arterial narrowing.

When areas of vessel narrowing or obstruction are detected, the sonographer can use the ultrasound scanner to take measurements and make calculations. The scanner's computer allows cursors to be placed on areas to be measured and automatic measurements to be recorded.

Preparation

If the abdominal vessels are being imaged, then the patient is required to fast for six to eight hours before the test, since bowel activity and gas can interfere with the quality of the ultrasound study. Otherwise, no special preparation is necessary.

Aftercare

There is no special aftercare for this examination.

Complications

Because vascular sonography is a noninvasive procedure that does not use radiation, there are no known complications associated with it.

KEY TERMS

Angioplasty—A procedure that seeks to increase blood flow through narrow or occluded vessels.

Atherosclerosis—“Hardening of the arteries”; a build-up of plaque in the arteries that results in vessel narrowing or blockage.

Claudication—A chronic condition caused by narrowing of the arteries to the legs characterized by pain or cramping while walking, primarily in the calf.

Deep vein thrombosis (DVT)—A blood clot in one of the deep veins of the arms or legs characterized by symptoms of pain, redness, and swelling over the affected veins; may result in pulmonary embolism (a clot in the lungs), which can be life threatening.

Graft—Grafts are tissues (or organs) which have been taken from one location and surgically transplanted to another. Grafts may be taken from one person and given to another (for example, organ transplants), or may be taken from one part of a person and placed on another part (for example, burn victims may have some unaffected skin surgically removed and then placed on the burned area). Other types of grafts also exist.

Renal arteries—The arteries that supply blood to the kidneys.

Superior mesenteric artery—One of the arteries that supplies blood to the abdominal organs.

Results

Normal results show normal blood flow in the area under examination.

Abnormal results show abnormalities in blood flow. The sonogram can identify obstructions and abnormalities in vessels, including blood clots, arterial plaques, and stenoses (narrowing). The results might indicate a diagnosis of DVT, internal bleeding (in the abdomen), or inadequate blood flow to a grafted area. Appropriate therapy or surgery is then performed.

Health care team roles

Vascular sonography is performed by an ultrasonographer with special training in vascular ultrasound techniques. The sonographer should be a registered vascular technologist, and the vascular lab should be accredited by the Intersocietal Commission for the Accreditation of

Vascular Laboratories (ICAVL). A radiologist or other physician experienced in vascular imaging techniques interprets the ultrasound examination results. During some examinations, the sonographer may print out images for consultation with the radiologist, or the radiologist may perform some of the examination.

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ORGANIZATIONS

American Institute of Ultrasound in Medicine (AIUM). 14750 Sweitzer Lane, Suite 100, Laurel, MD 20707-5906. (301) 498-4100. <<http://www.aium.org>>.

American Registry of Diagnostic Medical Sonographers (ARDMS). 600 Jefferson Plaza, Suite 360, Rockville, MD 20852-1150. (800) 541-9754. <<http://www.ardms.org>>.

American Society of Radiologic Technologists (ASRT). 15000 Central Avenue SE, Albuquerque, NM 87123-2778. (800) 444-2778. <<http://www.asrt.org>>.

Society of Diagnostic Medical Sonography (SDMS). 12770 Coit Road, Suite 708, Dallas, TX 75251-1319. (972) 239-7367. <<http://www.sdms.org>>.

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Vascular study see **Angiography**

Vasodilatory shock see **Shock**

Vasovagal faint see **Syncope**

Veganism

Definition

Veganism is a system of dietary and lifestyle practices that seeks to promote health and peace while reducing the suffering of both people and animals. Vegans (pronounced vee-guns) are vegetarians who do not eat any foods (eggs, dairy products, meat, etc.) derived from animal sources. Most vegans also do not use products that require for their production the death or suffering of animals, such as leather, fur, wool, and certain cosmetics.

Origins

The word “vegetarian” was coined in England in 1847 by the founders of the Vegetarian Society of Great Britain. “Vegetarian” has been used to describe people who do not eat meat, but do consume dairy products and eggs. The Vegan Society was founded in England in 1944 by Donald Watson and others who believed that vegetarians should strive to exist without eating or using any animal products at all. Watson stated that the crisis of World War II may have been a motivation behind his founding of the Vegan Society, because he saw so much turmoil and suffering in the world around him. The Vegan founders believed that the first step to creating a better world would be to develop a diet that did not cause the death or suffering of any living beings. The term “vegan” is derived from the Latin word *vegetus*, which means “full of life,” which the founders hoped their system would be. “Vegan” also starts with the same three letters as “vegetarian,” and ends with the last two, as its founders believed they were starting with vegetarian ideas and taking them to their logical conclusion.

The American Vegan Society (AVS) was founded in 1960 by Jay Dinshah. The same year, the AVS began to publish a journal called *Ahimsa*, which is a Sanskrit word that means “not causing harm” and “reverence for life.” Dinshah and others conceived veganism to be a philosophy of living that has nonviolence, peace, harmony, honesty, service to the world, and knowledge as its goals. In 1974, the AVS became affiliated with the North American Vegetarian Society, which was formed to bring together all of the vegetarian groups in North America.

Since the 1970s, there has been a vast amount of research concerning **nutrition** and diet. It has been discovered that diets that are centered around meat and dairy products, such as the typical American diet, are high in cholesterol and saturated fat but low in fiber. These diets have been linked to many health problems, including **heart** disease, strokes, and diabetes, which together cause 68% of all the deaths in the United States. Thus,

the interest in diets that reduce or eliminate foods that contribute to these conditions has grown considerably. In 1992, the *Vegetarian Times* magazine took a poll that estimated that 13 million Americans, or 5% of the population, consider themselves vegetarian. Of the vegetarians, 4% are vegans, which amounts to nearly 520,000 Americans.

Benefits

Vegan diets are often recommended as dietary therapy for heart disease, high cholesterol, diabetes, strokes, **cancer**, **obesity**, arthritis, **allergies**, **asthma**, environmental illness, **hypertension**, **gout**, gallstones, **kidney stones**, ulcers, colitis, digestive disorders, premenstrual syndrome, **anxiety**, and depression. At present, however, no studies exist that define the efficacy of vegan diets in treating these conditions. Nevertheless, a well-designed vegan diet is an effective weight-loss diet, and is an economical and easy preventive health practice.

Description

Veganism can be better understood by considering the ethical, ecological, and health reasons that motivate vegans.

Ethical considerations

A vegan lifestyle seeks to promote awareness, compassion, and peace. Veganism is an ethical system as well as a diet. Ethics refers to rules of conduct or the ways in which people interact with others and the world. One poll in England showed that 83% of vegans listed ethical reasons as their main consideration in their practices. Vegans believe that health encompasses not only individuals’ bodies, but also includes healthy relationships between people and their actions towards other living things, the earth, and the environment. Vegans believe that as long as animals are treated cruelly and are killed for meat, then the world’s ethical and spiritual health will suffer. Vegans believe that people should become aware of how their food choices are creating suffering and affecting the health of the world as a whole. For instance, it has been estimated that the grain that goes to feed livestock in America could feed 1.3 billion people, which would relieve a large measure of the **pain** and suffering in the world.

Vegans claim that egg and dairy production may cause animals just as much suffering as killing them for meat, because modern factory farming treats animals as unfeeling machines instead of as living beings. Eggs are produced by keeping chickens in small cages and in painful and unsanitary conditions. Vegans claim that

dairy cattle are subjected to cruel treatment as well, being bred artificially and caged for much of their lives. Dairy cattle are also injected with hormones that make them produce unnaturally high quantities of milk while weakening their immune systems and making them sick and unhealthy. Large amounts of **antibiotics** need to be used on weakened cows, which in turn affects the health of humans and creates diseases that are resistant to medicine. Dairy farming causes death to cows as well because undesirable or old cows are slaughtered for meat.

Other animal products are avoided by vegans as well. Leather, wool, and fur are not used because they result in the suffering of animals from their production. Some vegans do not use honey because they believe that the collection of honey is harmful to bees. Many vegans avoid using sugar, because some sugar is made by using charcoal made from the bones of dead cattle. Vegans also do not use products that have been tested on animals, and vegans are active in resisting the use of animals for dissection and medical experiments. Vegans are typically outspoken against hunting and the cruel treatment of animals in zoos or for entertainment (e.g., cockfighting and bullfighting).

Helping the Earth

Vegans believe that their dietary and lifestyle practices would contribute to a healthier world ecology. Vegans can cite many statistics that show that the American meat-centered diet is contributing to environmental problems. The main thrust of vegans' ecological position is that it takes many more resources to produce meat than it does to provide a grain-based diet, and people can be fed better with grain than with meat. For instance, it takes 10 lbs (4.5 kg) of grain to make 1 lb (0.45 kg) of beef. On one acre of land, 20,000 lbs (9,000 kg) of potatoes can be grown compared to 125 lbs (57 kg) of beef during the same time. In America, livestock consume six and a half times as much grain as the entire population. Different dietary habits here could improve the world, vegans argue. Environmental problems caused by the inefficient production of livestock include topsoil loss, water shortages and contamination, deforestation, toxic waste, and air pollution.

Health considerations

People who eat vegetarian diets are at lower risk for many conditions, including heart disease, certain cancers, diabetes, obesity, high **blood pressure**, gallstones, and kidney stones. A vegan diet contains no cholesterol, because cholesterol is found only in animal products. Diets high in cholesterol and saturated fat are responsible for heart disease. American men overall have a 50% risk

of having a heart attack, while vegans have only a 4% risk. Vegans consume as much as four times the amount of fiber as the average person, and high fiber intake is believed to reduce the risk of heart disease, diabetes, cancer, and digestive tract problems. Vegan diets are also high in protective nutrients that are found in fruits and vegetables, such as antioxidants.

A vegan diet can also reduce exposure to chemicals that are found in meat and dairy products, such as pesticides and synthetic additives such as hormones. Chemicals tend to accumulate in the tissue of animals that are higher in the food chain, a process called bioaccumulation. By not eating animal products, vegans can avoid the exposure to these accumulated toxins, many of which are believed to influence the development of cancer. It is important, however, for vegans to eat organically produced vegetables and grains, as vegans who eat nonorganic food get high doses of pesticides. One study showed that DDT, a cancer-causing pesticide, was present in significant levels in mother's milk for 99% of American women, but only 8% of vegetarian women had significant levels of the pesticide. The risks of women getting **breast cancer** and men contracting **prostate cancer** are nearly four times as high for frequent meat eaters as for those who eat meat sparingly or not at all. High consumption of dairy products has been linked to diabetes, anemia, **cataracts**, and other conditions.

Vegan diets may also be beneficial for those with allergic or **autoimmune disorders** such as asthma, allergies, and rheumatoid arthritis. Animal products cause allergic reactions in many people, and studies have shown that allergic responses and inflammation may be improved by eliminating animal products from the diet. Furthermore, vegan diets are effective weight loss diets, because the high levels of fiber and low levels of fat make it possible for dieters to eat until they are full and still take in fewer calories than other diets.

Preparations

Those considering veganism may wish to adopt the diet gradually to allow their bodies and lifestyles time to adjust to different eating habits. Some nutritionists have recommended "transition" diets to help people change from a meat-centered diet in stages. Many Americans eat meat products at nearly every meal, and the first stage of a transition diet is to substitute just a few meals a week with wholly vegetarian foods. Then, particular meat products can be slowly reduced and eliminated from the diet and replaced with vegetarian foods. Red meat can be reduced and then eliminated, followed by poultry and fish. For vegans, the final step would be to substitute eggs and dairy products with other nutrient-rich foods.

Individuals should be willing to experiment with transition diets, and be patient when learning how to combine veganism with such social activities as dining out.

Vegans should become informed on healthful dietary and nutrition practices as well. Sound nutritional guidelines include decreasing the intake of fat, increasing fiber, and emphasizing fresh fruits, vegetables, legumes, and whole grains in the diet, while avoiding processed foods and sugar. Vegans can experiment with meat substitutes, foods that are high in protein and essential nutrients. Tofu and tempeh are soybean products that are high in protein, **calcium**, and other nutrients. There are “vegie-burgers” that can be grilled like hamburgers, and vegan substitutes for turkey and sausage with surprisingly realistic textures and **taste**. Furthermore, there are many vegan cookbooks on the market, as cooking without meat or dairy products can be challenging for some people.

Vegans should also become familiar with food labels and food additives, because there are many additives derived from animal sources that are used in common foods and in such household items as soap. Vegans may also find social support at local health food stores or food cooperatives.

Precautions

Vegans should be aware of particular nutrients that may be lacking or need special attention in non-animal diets. These include protein, **vitamin B₁₂**, **riboflavin**, **vitamin D**, calcium, **iron**, **zinc**, and essential fatty acids. Furthermore, pregnant women, growing children, and people with certain health conditions have higher requirements for these nutrients.

Vegans should be sure to get complete **proteins** in their diets. A complete protein contains all of the essential amino acids, which are essential because the body cannot make them. Meat and dairy products generally contain complete proteins, but most vegetarian foods such as grains and legumes contain incomplete proteins since they lack one or more of the essential amino acids. Vegans can easily obtain complete proteins by combining particular foods. For instance, beans are high in the amino acid lysine but low in tryptophan and methionine. Rice is low in lysine and high in tryptophan and methionine. Thus, a combination of rice and beans makes a complete protein. In general, combining legumes such as soy, lentils, beans, and peas with grains like rice, wheat, or oats forms complete proteins. Nuts or peanut butter with grains such as whole wheat bread also forms complete proteins. Proteins do not necessarily need to be combined in the same meal, but should generally be combined over a period of a few days.

KEY TERMS

Bioaccumulation—The process in which toxic chemicals collect in the tissues of humans and other animals toward the top of the food chain.

Cholesterol—A steroid fat found in animal foods that is also produced in the body from saturated fat for several important functions. Excess cholesterol intake is linked to many diseases.

Complex carbohydrates—Carbohydrates that are broken down by the body into simple sugars for energy. They are found in grains, fruits, and vegetables. Complex carbohydrates are generally recommended by nutritionists over refined sugar and honey, because they are a better source of energy and often contain fiber and nutrients as well.

Legume—A group of plant foods that includes beans, peas, and lentils. Legumes are high in protein, fiber, and other nutrients.

Organic food—Food grown without the use of synthetic pesticides and fertilizers.

Saturated fat—A fat that is usually solid at room temperature. Saturated fats are found mainly in meat and dairy products but also in such vegetable sources as some nuts, seeds, and avocados.

Unsaturated fat—A type of fat found in plant foods that is typically liquid at room temperature. Unsaturated fats can be monounsaturated or polyunsaturated, depending on their chemical structure. They are the most frequently recommended dietary fats.

Getting enough vitamin B₁₂ is an issue for vegans because meat and dairy products are its main sources. Vegans are advised to take vitamin supplements containing B₁₂. Spirulina, a nutritional supplement made from algae, is used as a vegetarian source of this vitamin, as are fortified soy products and nutritional yeast. The symptoms of vitamin B₁₂ deficiency include muscle twitching and irreversible nerve damage; weakness; numbness and tingling in the extremities; and a sore tongue.

Riboflavin (vitamin B₂) is also generally found in high amounts in animal sources, so vegans should be aware of this fact and take a supplement if necessary. Vegetable sources of riboflavin include brewer’s yeast, almonds, mushrooms, whole grains, soybeans, and green leafy vegetables.

Vitamin D can be obtained from vitamin supplements, fortified foods, and sunshine. Calcium can be obtained from enriched tofu, seeds, nuts, legumes, and dark green vegetables, including broccoli, kale, spinach, and collard greens. Iron is found in raisins, figs, legumes, tofu, whole grains (particularly whole wheat), potatoes, and dark green leafy vegetables, and by cooking with iron skillet. Iron is absorbed more efficiently by the body when iron-containing foods are eaten with foods that contain **vitamin C**, such as fruits, tomatoes, and green vegetables. Zinc is abundant in nuts, pumpkin seeds, legumes, whole grains, and tofu. Getting enough omega-3 essential fatty acids may be an issue for vegans. These are found in walnuts, canola oil, and such supplements as flaxseed oil. Vegans should consider purchasing organically grown food when possible, to avoid exposure to pesticides and to contribute to sound agricultural practices.

Research and general acceptance

Scientists have analyzed **vegetarianism** more frequently, mainly because there are higher numbers of lacto-ovo vegetarians around the world than there are vegans. Studies have repeatedly shown many benefits of plant-based diets.

A significant study of veganism was published in 1985 in the *Journal of Asthma*, which used a vegan diet to treat asthma. After one year, 92% of patients exhibited significant improvement in asthma symptoms and in such measurements as lung capacity and cholesterol levels. People on the diet also experienced fewer episodes of colds and **influenza**. Researchers concluded that the vegan diet was helpful for asthma because it reduced food allergies, which are commonly caused by animal products. Scientists theorized that the animal-free diet also may have altered the patients' prostaglandin levels. Prostaglandins are hormone-like substances responsible for many body processes including allergic reactions. Finally, researchers proposed that the high quantity of antioxidants and plant nutrients in the vegan diet may have contributed to strengthened immune systems.

Resources

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Vegetarian Journal. Vegetarian Resource Group (VRG). PO Box 1463. Baltimore, MD 21203.

ORGANIZATIONS

Vegan Outreach. 211 Indian Drive. Pittsburgh, PA 15238. (412) 968-0268.

Douglas Dupler

Vegetarianism

Definition

Vegetarianism is the voluntary abstinence from eating meat. Vegetarians refrain from eating meat for various reasons, including religious, health, and ethical ones. Lacto-ovo vegetarians supplement their diet with dairy (lactose) products and eggs (ovo). Vegans (pronounced vee-guns) do not eat any animal-derived products at all.

Origins

The term vegetarian was coined in 1847 by the founders of the Vegetarian Society of Great Britain, but vegetarianism has been around as long as people have created diets. Some of the world's oldest cultures advocate a vegetarian diet for health and religious purposes. In India, millions of Hindus are vegetarians because of their religious beliefs. One of the ancient mythological works of Hinduism, the *Mahabharata*, states that, "Those who desire to possess good **memory**, beauty, long life with perfect health, and physical, moral and spiritual strength, should abstain from animal foods." The **yoga** system of living and health is vegetarian, because its dietary practices are based on the belief that healthy food contains *prana*. Prana is the universal life energy, which yoga experts believe is abundant in fresh fruits, grains, nuts and vegetables, but absent in meat because meat has been killed. Yogis also believe that spiritual health is influenced by the practice of *ahimsa*, or not harming living beings. The principle of *ahimsa* (non-violence) appears in the Upanishads (Vedic literature) from c. 600–300 B.C. Taking of animal life or human life under any circumstances is sinful and results in rebirth as a lower organism. It became a fundamental element of Jainism, another religion of India. Some Buddhists in Japan and China are also vegetarian because of spiritual beliefs. In the Christian tradition, the Trappist Monks of the Catholic Church are vegetarian, and some vegetarians argue that there is evidence that Jesus and his early followers were vegetarian. Other traditional cultures, such as those in the Middle East and the Mediterranean regions, have evolved diets that frequently consist of vegetarian foods. The Mediterranean diet, which a

Harvard study declared to be one of the world's healthiest, is primarily, although not strictly, vegetarian.

The list of famous vegetarians forms an illustrious group. The ancient Greek philosophers, including Socrates, Plato, and Pythagoras, advocated vegetarianism. In modern times, the word to describe someone who likes to feast on food and wine is "epicure," but it is little known that Epicurus, the ancient philosopher, was himself a diligent vegetarian. Other famous vegetarians include Leonardo da Vinci, Sir Isaac Newton, Leo Tolstoy, Ralph Waldo Emerson, and Henry Thoreau. This century's celebrated vegetarians include Gandhi, the physician Albert Schweitzer, writer George Bernard Shaw, musician Paul McCartney, and champion triathlete Dave Scott. Albert Einstein, although not a strict vegetarian himself, stated that a vegetarian diet would be an evolutionary step for the human race.

Vegetarianism in America received a lot of interest during the last half of the nineteenth century and the beginning of the twentieth century, during periods of experimentation with diets and health practices. Vegetarianism has also been a religious practice for some Americans, including the Seventh-day Adventists, whose lacto-ovo vegetarian diets have been studied for their health benefits. Vegetarianism has been steadily gaining acceptance as an alternative to the meat-and-potatoes bias of the traditional American diet. In 1992, *Vegetarian Times* magazine performed a poll that showed that 13 million Americans, or 5% of the population, identified themselves as vegetarians.

Several factors contribute to the interest in vegetarianism in America. Outbreaks of **food poisoning** from meat products, as well as increased concern over the additives in meat such as hormones and **antibiotics**, have led some people and professionals to question meat's safety. There is also an increased awareness of the questionable treatment of farm animals in factory farming. But the growing health consciousness of Americans is probably the major reason for the surge in interest in vegetarianism. **Nutrition** experts have built up convincing evidence that there are major problems with the conventional American diet, which is centered around meat products that are high in cholesterol and saturated fat and low in fiber. **Heart** disease, **cancer**, and diabetes, which cause 68% of all deaths in America, are all believed to be influenced by this diet. Nutritionists have repeatedly shown in studies that a healthy diet consists of plenty of fresh vegetables and fruits, complex **carbohydrates** such as whole grains, and foods that are high in fiber and low in cholesterol and saturated fat. Vegetarianism, a diet that fulfills all these criteria, has become part of many healthy lifestyles. In alternative medicine, vegetarianism is a cornerstone dietary therapy, used in Ayurvedic medicine,

detoxification treatments, macrobiotics, the Ornish diet for heart disease, and in therapies for many chronic conditions.

Benefits

Vegetarianism is recommended as a dietary therapy for a variety of conditions, including heart disease, high cholesterol, diabetes, and stroke. Vegetarianism is a major dietary therapy in the alternative treatment of cancer. Other conditions treated with a dietary therapy of vegetarianism include **obesity**, **osteoporosis**, arthritis, **allergies**, **asthma**, environmental illness, **hypertension**, **gout**, gallstones, hemorrhoids, **kidney stones**, ulcers, colitis, premenstrual syndrome, **anxiety**, and depression. Vegetarians often report higher energy levels, better digestion, and mental clarity. Vegetarianism is an economical and easily implemented preventative practice as well.

Preparations

Some people, particularly those with severe or chronic conditions such as heart disease or cancer, may be advised by a health practitioner to become vegetarian suddenly. For most people, nutritionists recommend that a vegetarian diet be adopted gradually, to allow people's bodies and lifestyles time to adjust to new eating habits and food intake.

Some nutritionists have designed transition diets to help people become vegetarian in stages. Many Americans eat meat products at nearly every meal, and the first stage of a transition diet is to substitute just a few meals a week with wholly vegetarian foods. Then, particular meat products can be slowly reduced and eliminated from the diet and replaced with vegetarian foods. Red meat can be reduced and then eliminated, followed by pork, poultry, and fish. For those wishing to become pure vegetarians or vegans, the final step would be to substitute eggs and dairy products with other nutrient-rich foods. Individuals should be willing to experiment with transition diets, and should have patience when learning how to combine vegetarianism with social activities such as dining out.

The transition to vegetarianism can be smoother for those who make informed choices with dietary practices. Sound nutritional guidelines include decreasing the intake of fat, increasing fiber, and emphasizing fresh fruits, vegetables, legumes, and whole grains in the diet while avoiding processed foods and sugar. Everyone can improve their health by becoming familiar with recommended dietary and nutritional practices, such as reading labels and understanding basic nutritional concepts such

as daily requirements for calories, protein, fat, and nutrients. Would-be vegetarians can experiment with meat substitutes, foods that are high in protein and essential nutrients. Thanks to the growing interest in vegetarianism, many meat substitutes are now readily available. Tofu and tempeh are products made from soybeans that are high in protein, **calcium**, and other nutrients. There are “veggie-burgers” that can be grilled like hamburgers, and vegetarian substitutes for turkey and sausage with surprisingly authentic textures and **taste**. There are many vegetarian cookbooks on the market as well.

Precautions

In general, a well-planned vegetarian diet is healthy and safe. However, vegetarians, and particularly vegans who eat no animal products, need to be aware of particular nutrients that may be lacking in non-animal diets. These are amino acids, **vitamin B₁₂**, **vitamin D**, calcium, **iron**, **zinc**, and essential fatty acids. Furthermore, pregnant women, growing children, and those with health conditions have higher requirements for these nutrients.

Vegetarians should be aware of getting *complete protein* in their diets. A complete protein contains all of the essential amino acids, which are the building blocks for protein essential to the diet because the body cannot make them. Meat and dairy products generally contain complete **proteins**, but most vegetarian foods such as grains and legumes contain incomplete proteins, lacking one or more of the essential amino acids. However, vegetarians can easily overcome this by combining particular foods in order to create complete proteins. For instance, beans are high in the amino acid lysine but low in tryptophan and methionine, but rice is low in lysine and high in tryptophan and methionine. Thus, combining rice and beans makes a complete protein. In general, combining legumes such as soy, lentils, beans, and peas with grains like rice, wheat, or oats forms complete proteins. Eating dairy products or nuts with grains also makes proteins complete. Oatmeal with milk on it is complete, as is peanut butter on whole wheat bread. Proteins do not necessarily need to be combined in the same meal, but generally within four hours.

Getting enough vitamin B₁₂ may be an issue for some vegetarians, particularly vegans, because meat and dairy products are the main sources. Vitamin supplements that contain vitamin B₁₂ are recommended. Spirulina, a nutritional supplement made from algae, is also a vegetarian source, as are fortified soy products and nutritional yeast.

Vitamin D can be obtained by **vitamins**, fortified foods, and sunshine. Calcium can be obtained in enriched tofu, seeds, nuts, legumes, dairy products, and dark green

vegetables including broccoli, kale, spinach, and collard greens. Iron is found in raisins, figs, legumes, tofu, whole grains (particularly whole wheat), potatoes, and dark green leafy vegetables. Iron is absorbed more efficiently by the body when iron-containing foods are eaten with foods that contain **vitamin C**, such as fruits, tomatoes, and green vegetables. Zinc is abundant in nuts, pumpkin seeds, legumes, whole grains, and tofu. For vegetarians who don't eat fish, getting enough omega-3 essential fatty acids may be an issue, and supplements such as flaxseed oil should be considered, as well as eating walnuts and canola oil.

Vegetarians do not necessarily have healthier diets. Some studies have shown that some vegetarians consume large amounts of cholesterol and saturated fat. Eggs and dairy products contain cholesterol and saturated fat, while nuts, oils, and avocados are vegetable sources of saturated fat. To reap the full benefits of a vegetarian diet, vegetarians should be conscious of cholesterol and saturated fat intake. Vegetarians may also consider buying organic foods, which are grown without the use of synthetic chemicals, as another health precaution.

Research and general acceptance

A vegetarian diet has many well-documented health benefits. It has been shown that vegetarians have a higher life expectancy, as much as several years, than those who eat a meat-centered diet. The U.S. Food and Drug Administration (FDA) has stated that data has shown vegetarians to have a strong or significant probability against contracting obesity, heart disease, **lung cancer**, colon cancer, **alcoholism**, hypertension, diabetes, gallstones, gout, kidney stones, and ulcers. However, the FDA also points out that vegetarians tend to have healthy lifestyle habits, so other factors may contribute to their increased health besides diet alone.

A vegetarian diet, as prescribed by Dr. Dean Ornish, has been shown to improve heart disease and reverse the effects of atherosclerosis, or hardening of the arteries. It should be noted that Dr. Ornish's diet was used in conjunction with **exercise**, **stress** reduction, and other holistic methods. The Ornish diet is lacto-ovo vegetarian, because it allows the use of egg whites and non-fat dairy products.

Vegetarians have a resource of statistics in their favor when it comes to presenting persuasive arguments in favor of their eating habits. Vegetarians claim that a vegetarian diet is a major step in improving the health of citizens and the environment. Americans eat over 200 lbs (91 kg) of meat per person per year. The incidence of heart disease, cancer diabetes, and other diseases has increased along with a dramatic increase in meat con-

sumption during the past century. Many statistics show significantly smaller risks for vegetarians contracting certain conditions. The risks of women getting **breast cancer** and men contracting prostate cancer are nearly four times as high for frequent meat eaters as for those who eat meat sparingly or not at all. For heart attacks, American men have a 50% risk of having one, but the risk drops down to 15% for lacto-ovo vegetarians and to only 4% for vegans. For cancer, studies of populations around the world have implied that plant-based diets have lower associated risks for certain types of cancer.

Vegetarians claim other reasons for adopting a meat-free diet. One major concern is the amount of pesticides and synthetic additives such as hormones that show up in meat products. Chemicals tend to accumulate in the tissue of animals that are higher in the food chain, a process called *bioaccumulation*. Vegetarians, by not eating meat, can avoid the exposure to these accumulated toxins, many of which are known to influence the development of cancer. One study showed that DDT, a cancer-causing pesticide, was present in significant levels in mother's milk for 99% of American women, but only 8% of vegetarian women had significant levels of the pesticide. Women who eat meat had 35 times higher levels of particular pesticides than vegetarian women. The synthetic hormones and antibiotics added to American cattle has led some European countries to ban American beef altogether. The widespread use of antibiotics in livestock has made many infectious agents more resistant to them, making some diseases harder to treat.

Vegetarians resort to ethical and environmental arguments as well when supporting their food choices. Much of U.S. agriculture is dedicated to producing meat, which is an expensive and resource-depleting practice. It has been estimated that 1.3 billion people could be fed with the grain that America uses to feed livestock, and starvation is a major problem in world health. Producing meat places a heavy burden on natural resources, as compared to growing grain and vegetables. One acre of land can grow approximately 40,000 lbs (18,000 kg) of potatoes or 250 lbs (113 kg) of beef, and it takes 50,000 gal (200,000 l) of water to produce 1 lb (0.45 kg) of California beef but only 25 gal (100 l) of water to produce 1 lb (0.45 kg) of wheat. Half of all water used in America is for livestock production. Vegetarians argue that the American consumption of beef may also be contributing to global warming, by the large amounts of fossil fuels used in its production. The South American rainforest is being cleared to support American's beef consumption, as the United States yearly imports 300 million lbs (136 million kg) of meat from Central and South America. The production of meat has been esti-

KEY TERMS

Cholesterol—A steroid fat found in animal foods that is also produced in the body from saturated fat for several important functions. Excess cholesterol intake is linked to many diseases.

Complex carbohydrates—Complex carbohydrates are broken down by the body into simple sugars for energy, are found in grains, fruits, and vegetables. They are generally recommended in the diet over refined sugar and honey, because they are a more steady source of energy and often contain fiber and nutrients as well.

Legume—Group of plant foods including beans, peas, and lentils, which are high in protein, fiber, and other nutrients.

Organic food—Food grown without the use of synthetic pesticides and fertilizers.

Saturated fat—Fat that is usually solid at room temperature, found mainly in meat and dairy products but also in vegetable sources such as some nuts, seeds, and avocados.

Unsaturated fat—Fat found in plant foods that is typically liquid (oil) at room temperature. They can be monounsaturated or polyunsaturated, depending on the chemical structure. Unsaturated fats are the most recommended dietary fats.

mated as causing up to 85% of the loss of topsoil of America's farmlands.

Despite the favorable statistics, vegetarianism does have its opponents. The meat industry in America is a powerful organization that has spent millions of dollars over decades advertising the benefits of eating meat. Vegetarians point out that life-long eating habits are difficult to change for many people, despite research showing that vegetarian diets can provide the same nutrients as meat-centered diets.

Resources

BOOKS

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PERIODICALS

Vegetarian Journal. Vegetarian Resource Group (VRG). PO Box 1463, Baltimore, MD 21203.

Vegetarian Nutrition and Health Letter. 1707 Nichol Hall, Loma Linda, CA 92350. (888) 558-8703.

Vegetarian Times. 4 High Ridge Park, Stamford, CT 06905. (877) 321-1796.

ORGANIZATIONS

North American Vegetarian Society (NAVS). PO Box 72, Dolgeville, NY 13329. (518) 568-7970.

Douglas Dupler

Venography see **Phlebography**

Ventilation assistance

Definition

Ventilation assistance includes a variety of methods designed to help restore or improve breathing function in patients who are unable to adequately breathe on their own. These methods range from at-home **oxygen therapy** for patients with chronic obstructive pulmonary disease (COPD) to mechanical ventilation for patients with acute **respiratory failure**. Ventilation assistance therapies usually include the following categories:

- oxygen therapy
- continuous positive airway pressure (CPAP)
- hyperbaric oxygen therapy
- mechanical ventilation
- newborn life support

Purpose

Ventilation assistance is used for disease or injury that causes progressive or sudden respiratory failure. It may also be used after surgery until patients recover enough to breathe adequately on their own. Physicians choose the therapy based on the type and stage of the disease process, as well as on the results of **blood** and pulmonary function tests that indicate the oxygenation status of the patient.

Oxygen therapy

Home oxygen therapy is commonly ordered for patients with COPD, and is usually started when a patient's pulse oximetry (amount of hemoglobin saturated with oxygen) is below 90% on room air. Oxygen ther-

apy is also used in the hospital to support a patient's respiratory status after illness, injury, or surgery.

Continuous positive airway pressure (CPAP)

One of the most common uses of CPAP is for patients with sleep apnea. It may also be used for both infants and adults with **respiratory distress syndrome**, collapse of lung tissue (atelectasis), or abnormalities of the lower airways.

Hyperbaric oxygen therapy

Hyperbaric oxygen therapy is used when there is an immediate need for greater blood oxygen saturation. Divers with **decompression sickness** (the bends), climbers with altitude sickness, patients suffering from severe **carbon monoxide poisoning**, and children or adults in acute respiratory distress may require hyperbaric oxygenation. In recent years, physicians have also used this therapy to assist in burn and wound healing, since the pressure under which the oxygen is delivered can reach areas that have an inadequate blood supply under normal conditions.

Mechanical ventilation

Mechanical ventilation is used for patients with acute respiratory distress, temporarily after surgery, or while sedated or pharmacologically paralyzed. Most patients can be weaned off of mechanical ventilation and resume breathing on their own. Some patients require long-term mechanical ventilation (i.e., quadriplegia) and, in some cases, mechanical ventilation is considered life-support for patients who would otherwise die.

Newborn life support

Newborn babies, particularly those who are born premature, may require ventilation assistance immediately after birth, since their **lungs** may not be fully developed. Some newborns may have serious respiratory problems or complications from birth, such as respiratory distress syndrome, neonatal wet lung syndrome, apnea of prematurity, or persistent fetal circulation (delayed closure of the ductus arteriosus and foramen ovale).

Precautions

Ventilation assistance can be beneficial during acute illness and it may provide a higher quality of life if the patient has end-stage COPD. However, oxygen is not a benign substance, and precautions must be used with any of these therapies.

Oxygen therapy

Oxygen is an extremely flammable gas, so patients who smoke should not have oxygen therapy prescribed. If there are family members who smoke, they must avoid smoking in the area of oxygen use.

Continuous positive airway pressure (CPAP)

Although CPAP can be very helpful in alleviating the symptoms of sleep apnea, it can also be uncomfortable because patients must wear a tight-fitting mask over their nose and the oxygen is pushed into their airway with considerable force. Patients who are unable or unwilling to comply with the physician's instructions regarding the use of CPAP are not likely to have it prescribed.

Hyperbaric oxygen therapy

Hyperbaric oxygen therapy involves administering 100% oxygen at three times the normal atmospheric pressure. This creates a high risk for fire and explosive decompression, as well as a risk for pulmonary and neurological toxicity. The benefits must be weighed against the potential complications. All patients, particularly children, must be carefully monitored while in the hyperbaric chamber.

Mechanical ventilation

The use of mechanical ventilation can cause pulmonary damage from high pressures. It is often frightening for patients because they are hooked up to an endotracheal or tracheostomy tube that prevents them from speaking and may make them feel like they are breathing through a straw. Usually, patients require sedation or even pharmacological **paralysis** to prevent accidental removal of the tube and to keep them from fighting against the ventilator.

Newborn life support

Not all infants with breathing problems require mechanical ventilation. The physician makes the determination based on the maturity and respiratory condition of the infant. Bronchopulmonary dysplasia is a chronic pulmonary disease that can develop in **premature infants** from high pressures and high oxygen levels delivered during mechanical ventilation.

Description

Oxygen therapy

Supplemental oxygen may be ordered for a patient who has pulse oximetry values below 90% on room air. The primary purpose of oxygen therapy is to prevent

damage to vital organs caused by inadequate oxygen supply. Since there is a risk of oxygen toxicity, the lowest possible level of oxygen (measured in liters/minute) is ordered to maintain the patient's pulse oximetry at an acceptable level. The oxygen is administered via nasal cannula, mask, or tracheostomy.

Patients with chronic hypoxemia often receive long-term oxygen therapy at home. A physician must prescribe home oxygen and the patients' pulse oximetry is monitored to ensure that they are receiving the correct amount of oxygen. Some patients require oxygen therapy only at night or when exercising.

The type of home oxygen system chosen varies depending on availability, cost, and the mobility of the patient. Patients who are ambulatory, especially those who work, need a system with a small portable tank. Frequent oxygen delivery and refilling of portable tanks is necessary.

In the case of respiratory distress in both newborns and adults, oxygen therapy may be attempted before mechanical ventilation since it is noninvasive and less expensive. Oxygen is also effective in treating patients with other diseases such as **cystic fibrosis**, chronic congestive **heart failure**, or other lung diseases.

Continuous positive airway pressure (CPAP)

Sleep apnea is caused by the collapse of the upper airway. CPAP administers a constant pressure during both inhalation and exhalation, which prevents a collapse. CPAP is usually administered through a tight-fitting mask as humidified oxygen. (When CPAP is administered through an endotracheal or tracheostomy tube, it is not used for sleep apnea). Patients receiving CPAP in a hospital setting must have continuous vital sign monitoring, along with periodic sampling of blood gas values.

Hyperbaric oxygen therapy

Hyperbaric oxygen therapy delivers pure oxygen under pressure that is three times that of normal atmospheric pressure. This treatment is especially effective for treating decompression sickness in scuba divers. The oxygen is delivered inside of a plastic cylinder-shaped chamber that is large enough for the patient to lie down in. The therapy usually lasts one hour, although it can take up to five hours. Before the patient exits the chamber, the pressure is gradually lowered back to normal atmospheric level.

Mechanical ventilation

In general, mechanical ventilation replaces or supports the normal ventilatory lung function of the patient.

Although mechanical ventilation is usually used for acute illness or injury in an intensive care setting, patients who require long-term mechanical ventilation can receive it at home under the supervision of a physician and home health agency. The patient must have a tracheostomy for long-term therapy.

There are several modes of mechanical ventilation, each offering different advantages and disadvantages. Many can be used in conjunction with one another.

CONTROL VENTILATION (CV). CV delivers the preset volume or pressure regardless of the patient's own inspiratory efforts. This mode is used for patients who are unable to initiate a breath. If it is used with spontaneously breathing patients, they must be sedated and/or pharmacologically paralyzed so they do not breathe out of synchrony with the ventilator.

ASSIST-CONTROL VENTILATION (A/C) OR CONTINUOUS MANDATORY VENTILATION (CMV). Both A/C and CMV deliver the preset volume or pressure in response to the patient's inspiratory effort, but will initiate the breath if the patient does not do so within the set amount of time. This mode is used for patients who can initiate a breath but who have weakened respiratory muscles. The patient may need to be sedated to limit the number of spontaneous breaths as hyperventilation can occur in patients with high respiratory rates.

SYNCHRONOUS INTERMITTENT MANDATORY VENTILATION (SIMV). SIMV delivers the preset volume or pressure and preset respiratory rate while allowing the patient to breathe spontaneously. The vent initiates each breath in synchrony with the patient's breaths. SIMV is used as a primary mode of ventilation as well as a weaning mode. (During weaning, the preset rate is gradually reduced, allowing patients to slowly regain breathing on their own.) The disadvantage of this mode is that it may increase the work of breathing and respiratory muscle fatigue. Breathing spontaneously through ventilator tubing has been compared to breathing through a straw.

POSITIVE-END EXPIRATORY PRESSURE (PEEP). PEEP is positive pressure that is applied by the ventilator at the end of expiration. This mode does not deliver breaths but is used as an adjunct to CV, A/C, and SIMV to improve oxygenation by opening collapsed alveoli at the end of expiration. Complications from the increased pressure can include decreased cardiac output, lung rupture, and increased intracranial pressure.

PRESSURE SUPPORT VENTILATION (PSV). PSV is preset pressure that augments the patient's spontaneous inspiration effort and decreases the work of breathing. The patient completely controls the respiratory rate and tidal volume. PSV is used for patients with a stable respiratory status and is often used with SIMV during weaning.

INTERMITTENT POSITIVE PRESSURE BREATHING (IPPB). IPPB is a form of assisted ventilation in which compressed oxygen is delivered under positive pressure into the patient's airway until a preset pressure is reached. Exhalation is passive. The cycle is repeated for the ordered number of breaths. IPPB is often used for a short time after a patient is weaned off of a ventilator to promote maximal lung expansion and to help clear secretions.

Newborn life support

Premature infants, particularly those born before the 28th week of gestation, have underdeveloped breathing muscles and immature lungs. These infants require respiratory support either by oxygen hood or through mechanical ventilation. The length of time that support is needed depends on the infant's gestational age and respiratory effort. CPAP can be delivered through a nasal or endotracheal tube by a ventilator that is specifically designed for neonates. As the infant's respiratory status improves, the ventilator can be weaned off.

Preparation

In an acute situation, preparation for any of these treatments includes gathering equipment and educating the patient and/or family about the treatment. At-home oxygen therapy or mechanical ventilation requires education and cooperation with a home health agency and respiratory therapist. Blood and pulmonary function tests are done to assist in individualizing the treatment for the patient.

Aftercare

Blood and pulmonary function tests are performed to verify that the treatment was successful or to monitor and adjust treatments if the therapy is long term. Mechanical ventilation requires frequent oral, nasal, or **tracheostomy care** for the area surrounding the insertion site of the breathing tube.

Complications

Ventilation assistance can be life saving, but these therapies also create their own set of complications and side effects.

Oxygen therapy

At-home oxygen therapy carries risk if patients or their families do not handle the oxygen in a safe manner. Patients and their families should not smoke near the oxygen supply and they should keep the tank and tubing

away from any source that could cause electrical spark, flames, or intense heat.

Continuous positive airway pressure (CPAP)

The effectiveness of CPAP for sleep apnea may be limited if patients do not apply the mask properly or if they do not wear it while sleeping. Possible complications of CPAP include skin abrasions from the mask, nasal congestion, nasal or oral dryness, and discomfort from the pressure of oxygen delivery.

Hyperbaric oxygen therapy

Hyperbaric oxygen therapy is painless; however, the high atmospheric pressure can lead to pulmonary and neurological oxygen toxicity. As with any oxygen therapy, there is the risk of flammability or explosion.

Mechanical ventilation

One complication of mechanical ventilation may be patients' dependence on the ventilator and the inability to wean them off. The physician should carefully select the mode of ventilation and monitor each patient's progress to prevent this complication. Intubation and mechanical ventilation are frightening and uncomfortable for many patients and they may fight the ventilator. If this occurs, the patient should be sedated, and pharmacologically paralyzed if needed, to promote optimal ventilation. However, prolonged sedation and paralysis can cause complications as well. Intubation may cause irritation to the trachea and larynx, and a tracheostomy can be associated with a risk of bleeding, pneumothorax (punctured lung), local **infection**, and increased incidence of aspiration.

Newborn life support

Mechanical ventilation in neonates can result in bronchopulmonary dysplasia from lung injury caused by high oxygen concentrations and high pressures. It also increases the risk of infection in premature babies. Complications of PEEP or CPAP can include pneumothorax and decreased cardiac output.

Results

Oxygen therapy

In the case of COPD, oxygen therapy does not treat the disease but can prolong life, increase quality of life, and delay the onset of more serious symptoms. Effective oxygen therapy for any patient should lead to improved or sustained levels of oxygen in arterial blood.

KEY TERMS

Aspiration—Accidental suction of fluids or vomit into the respiratory system.

Endotracheal tube—Tube inserted into the trachea via either the oral or nasal cavity for the purpose of providing a secure airway and delivery of mechanical ventilation.

Hypoventilation—Reduced gas exchange in the lungs resulting in low oxygen levels and high carbon dioxide levels.

Hypoxemia—Deficient oxygen supply in the blood.

Pharmacological paralysis—Paralysis induced by medication to promote optimal mechanical ventilation.

Pneumothorax—Air in the pleural space that can exert pressure on the heart and opposite lung, leading to decreased cardiac and pleural function.

Pulse oximetry—Measure of the percent of hemoglobin saturated with oxygen.

Tracheostomy—Surgically created opening in the trachea for the purpose of providing a secure airway and long term ventilation assistance.

Continuous positive airway pressure (CPAP)

Successful CPAP should result in a reduction in periods of apnea for patients with sleep apnea. Hospitalized patients on CPAP should show improvement in blood gas values and pulse oximetry.

Hyperbaric oxygen therapy

After one or two treatments, scuba divers undergoing emergency treatment in a hyperbaric chamber should exhibit immediate improvement in oxygen levels throughout the body, regardless of blood flow restrictions. Patients receiving oxygen chamber therapy for difficult **wounds** may receive treatments daily for several weeks before satisfactory results are reached. Patients with carbon monoxide **poisoning** should show improvement in neurologic function. Results of hyperbaric oxygen therapy depend largely on how quickly the patient was transported to the chamber, as well as on the severity of the initial condition.

Mechanical ventilation

Successful mechanical ventilation should result in a gradual decrease in dependence on the ventilator, with

eventual complete restoration of spontaneous respiration. A COPD exacerbation may be successfully treated with mechanical ventilation, and the patient may return to home oxygen therapy. Pediatric patients on long-term mechanical ventilation at home should demonstrate normal growth and development. Some patients in a hospital intensive care unit may be unable to breathe again without the ventilator; if the ventilator is the only thing keeping them alive, families and physicians may have to make hard decisions about continuing life support.

Newborn life support

Ventilation assistance is considered successful when the infant's respiratory rate is reduced by 30–40%, **chest x ray** and oxygen levels are improved, and the infant is able to breathe spontaneously.

Health care team roles

The nurse and respiratory therapist are responsible for carrying out the physician's orders for any type of ventilation assistance. The nurse monitors the patient's respiratory status and the level of effectiveness of the treatments. The respiratory therapist generally makes any ventilator changes ordered by the physician and sets up equipment required for treatment. Both the nurse and respiratory therapist are responsible for documenting their assessment of the patient's respiratory status. Both are also responsible for teaching the patient and family about the chosen treatment.

The nurse, respiratory therapist, or lab personnel may be responsible for drawing arterial **blood gases**, but the results are obtained by lab personnel. The nurse may need to inform the physician of the results, as changes in treatment may need to be made. The respiratory therapist often administers pulmonary function tests and reports the results to the physician.

Resources

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ORGANIZATIONS

American Lung Association. 800-LUNG-USA or 800-586-4872. <<http://www.lungusa.org>>.

Hyperbaric Research and Treatment Center. <<http://www.hyperbaricrx.com>>.

Abby Wojahn, R.N., B.S.N., C.C.R.N.

Ventilation management

Definition

Ventilation management involves providing optimal mechanical ventilation in order to promote the patient's recovery and to reestablish spontaneous breathing.

Purpose

Mechanical ventilation is used when a patient is unable to breathe adequately on their own. The purpose of ventilation management is to "breathe for them" until they are sufficiently recovered to initiate respiration. This process is usually a gradual one, and is referred to as weaning. During the ventilatory weaning process, the modes of mechanical ventilation are gradually changed to allow the patient to initiate more breaths while the ventilator provides less.

Precautions

Ventilatory weaning should not be attempted until the patient's respiratory status is stable and they are arousable and able to follow commands. If the patient is unstable or unarousable, attempting to wean may cause unnecessary physical **stress** and may delay recovery.

Description

The ventilatory weaning process is accomplished by decreasing the number of breaths supplied by the ventilator, as well as by changing the way in which those breaths are delivered to the patient. The process also depends on the reason why the patient requires mechanical ventilation. For example, post-operative cardiac bypass patients are generally weaned within a few hours after surgery. However, a patient with extensive lung disease may require days or weeks to wean.

There are three primary methods used to wean patients from the ventilator. These include T-piece, synchronized intermittent mandatory ventilation and pressure support ventilation. A short description of each of these is included here. The method chosen depends on the patient's respiratory status and on how long they have been on the ventilator.

T-piece trials consist of alternating intervals of time on the ventilator with intervals of spontaneous breathing. To facilitate spontaneous breathing, the patient is removed from the ventilator and a T-shaped tube is attached to the endotracheal tube or tracheostomy tube. One end of this tubing is attached to an oxygen flowmeter and the other end is open. The amount of oxygen to be

used is ordered by the physician. The patient on a T-piece doesn't have the ventilator as back-up if they can't breathe, so they must be monitored closely. If they tire out or their respiratory status becomes unstable, they should be reconnected to the ventilator. The goal of this method of weaning is to gradually increase the amount of time spent off the ventilator.

Synchronized intermittent mandatory ventilation (SIMV) is a ventilator mode that delivers a preset number of breaths to the patient but coordinates them with the patient's spontaneous breaths. Thus, the ventilator may be set to deliver 12 breaths per minute but the patient's respiratory rate may be 16 (12 ventilator-initiated breaths plus four patient-initiated breaths.) The goal of SIMV weaning is to gradually decrease the number of breaths delivered by the ventilator, which allows the patient to take more breaths of their own. The ventilator rate is usually decreased by one to three breaths at a time and an arterial **blood** gas (ABG) is obtained 30 minutes after the change to assess the patient's respiratory status. The benefits of SIMV weaning are that the patient has the ventilator for back-up if they fail to take a breath and the ventilator alarms will sound if they are not tolerating weaning. However, the patient should still be closely monitored for signs of respiratory fatigue.

Pressure support ventilation (PSV) augments the patient's spontaneous inspiration with a positive pressure "boost." This decreases the resistance created from breathing through ventilator tubing and is used with the SIMV mode to decrease the work of breathing.

If the patient tolerates SIMV weaning, the ventilator mode may be changed to constant positive airway pressure (CPAP) as a final trial of spontaneous breathing prior to removing the endotracheal tube. In this mode, patients will breathe on their own but have the benefit of the ventilator alarms if they have difficulty. CPAP maintains constant positive pressure in the airways, which facilitates **gas exchange** in the alveoli. PSV is often used with the CPAP mode to further decrease the work of breathing. If the patient tolerates CPAP, the endotracheal tube is removed and a face mask with humidified oxygen is applied for a short time. If the patient remains stable, a nasal cannula may be used to deliver oxygen.

If the patient has a tracheostomy, the weaning process is the same as with a endotracheal tube, with the exception that after the ventilator is disconnected, a tracheostomy collar may be used to deliver humidified oxygen instead of a face mask or nasal cannula. This is simply a mask-like device that fits loosely over the tracheostomy and is held in place by an elastic band around the neck.

Preparation

As discussed earlier, the patient's respiratory status must be stable and they must be arousable and able to follow commands prior to initiating weaning. Patients who require mechanical ventilation are often kept sedated or even paralyzed with drugs to facilitate optimal ventilation. These drugs must be tapered off prior to weaning.

Weaning criteria should be done to determine the patient's readiness to wean. The best indicators include a vital capacity of at least 10-15 cc/kg and a negative inspiratory fraction of greater than -30 cm H₂O, however, many other factors are also measured. The patient should be suctioned prior to any weaning attempt, both orally and via the endotracheal tube or tracheostomy. A **pulse oximeter** and **cardiac monitor** should be applied if they are not already present. Weaning should be done when there is adequate staffing so the patient can be closely monitored.

Aftercare

The patient's respiratory status should be assessed after any period of weaning. The ventilator should be securely reconnected and the patient made comfortable and reassured if necessary.

Complications

The greatest risk of ventilator weaning (especially premature weaning) is respiratory distress. The patient must be closely monitored and the weaning stopped before the respiratory distress becomes too great to control. Patients may also have **anxiety** or fear about weaning, which can complicate their respiratory distress.

Results

The goal of ventilation management is to wean the patient from mechanical support and to reestablish spontaneous respiration.

Health care team roles

The nurse and respiratory therapist share equal roles in ventilator management. Both are responsible for suctioning and monitoring the patient during weaning periods. Since the nurse is at the bedside the most, they have the primary monitoring role and are often able to predict the best time for a weaning trial. It is the nurse's responsibility to communicate with the respiratory therapist in planning when weaning trials will occur. The respiratory therapist is generally responsible for making the actual ventilator changes. Both the nurse and respiratory thera-

KEY TERMS

Alveoli—Saclike structures in the lungs where oxygen and carbon dioxide exchange takes place.

Endotracheal tube—Tube inserted into the trachea via either the oral or nasal cavity for the purpose of providing a secure airway.

Negative inspiratory fraction—The amount of force used to draw air into the lungs during maximal inspiration.

Pulse oximeter—Noninvasive machine that measures the amount of hemoglobin that is saturated with oxygen.

Tracheostomy—Surgically created opening in the trachea for the purpose of providing a secure airway. This is used when the patient requires long term ventilatory assistance.

Ventilator—Device used to provide assisted respiration and positive pressure breathing.

Vital capacity—Maximum volume of air that can be expelled from the lungs after a maximal inspiration.

pist document the ventilator change and their assessment of the patient's respiratory status before, during, and after the weaning period. Both are responsible for teaching and reassuring the patient and family regarding the weaning process.

Patients may be fearful about weaning because it is difficult for them to communicate around the endotracheal tube or tracheostomy. They may be afraid no one will know if they're having difficulty breathing. The nurse should explain all procedures before performing them, reassure the patient that they will be closely monitored, and ensure that the patient's call light is within reach. It is important that the patient actually see the nurse enter the room frequently, as this is the only way they will know they are being monitored.

Resources

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Ventilators

Definition

A ventilator is a device used to provide assisted respiration and positive-pressure breathing.

Purpose

Ventilators are used to provide mechanical ventilation for patients with **respiratory failure** who cannot breathe effectively on their own. They are also used to decrease myocardial gas consumption or intracranial pressure, provide stability of the chest wall after trauma or surgery, and when a patient is sedated or pharmacologically paralyzed.

Description

Different types of ventilators can be programmed to provide several modes of mechanical ventilation. A brief overview of each type and mode follows.

Negative-pressure ventilators

The original ventilators used negative pressure to remove and replace gas from the ventilator chamber. Examples of these include the iron lung, the Drinker respirator, and the chest shell. Rather than connecting to an artificial airway, these ventilators enclosed the body from the outside. As gas was pulled out of the ventilator chamber, the resulting negative pressure caused the chest wall to expand, which pulled air into the **lungs**. The cessation of the negative pressure caused the chest wall to fall and exhalation to occur. While an advantage of these ventilators was that they did not require insertion of an artificial airway, they were noisy, made nursing care difficult, and the patient was not able to ambulate.

Positive-pressure ventilators

Positive-pressure ventilators require an artificial airway (endotracheal or tracheostomy tube) and use positive pressure to force gas into a patient's lungs. Inspiration can be triggered either by the patient or the machine. There are four types of positive-pressure ventilators: volume-cycled, pressure-cycled, flow-cycled, and time-cycled.

VOLUME-CYCLED VENTILATORS. This type delivers a preset tidal volume then allows passive expiration. This is ideal for patients with acute **respiratory distress syndrome** (ARDS) or bronchospasm, since the same tidal volume is delivered regardless of the amount of airway

resistance. This type of ventilator is the most commonly used in critical care environments.

PRESSURE-CYCLED VENTILATORS. These ventilators deliver gases at a preset pressure, then allow passive expiration. The benefit of this type is a decreased risk of lung damage from high inspiratory pressures, which is particularly beneficial for neonates who have a small lung capacity. The disadvantage is that the tidal volume delivered can decrease if the patient has poor lung compliance and increased airway resistance. This type of ventilation is usually used for short-term therapy (less than 24 hours). Some ventilators have the capability to provide both volume-cycled and pressure-cycled ventilation. These combination ventilators are also commonly used in critical care environments.

FLOW-CYCLED VENTILATORS. Flow-cycled ventilators deliver oxygenation until a preset flow rate is achieved during inspiration.

TIME-CYCLED VENTILATORS. Time-cycled ventilators deliver oxygenation over a preset time period. These types of ventilators are not used as frequently as the volume-cycled and pressure-cycled ventilators.

Modes of ventilation

Mode refers to how the machine will ventilate the patient in relation to the patient's own respiratory efforts. There is a mode for nearly every patient situation; plus, many different types can be used in conjunction with each other.

CONTROL VENTILATION (CV). CV delivers the preset volume or pressure regardless of the patient's own inspiratory efforts. This mode is used for patients who are unable to initiate a breath. If it is used with spontaneously breathing patients, they must be sedated and/or pharmacologically paralyzed so they don't breathe out of synchrony with the ventilator.

ASSIST-CONTROL VENTILATION (A/C) OR CONTINUOUS MANDATORY VENTILATION (CMV). A/C or CMV delivers the preset volume or pressure in response to the patient's inspiratory effort, but will initiate the breath if the patient does not do so within a preset amount of time. This mode is used for patients who can initiate a breath but who have weakened respiratory muscles. The patient may need to be sedated to limit the number of spontaneous breaths, as hyperventilation can occur in patients with high respiratory rates.

SYNCHRONOUS INTERMITTENT MANDATORY VENTILATION (SIMV). SIMV delivers the preset volume or pressure and preset respiratory rate while allowing the patient to breathe spontaneously. The vent initiates each breath in synchrony with the patient's breaths. SIMV is

used as a primary mode of ventilation as well as a weaning mode. (During weaning, the preset rate is gradually reduced, allowing the patient to slowly regain breathing on their own.) The disadvantage of this mode is that it may increase the effort of breathing and cause respiratory muscle fatigue. (Breathing spontaneously through ventilator tubing has been compared to breathing through a straw.)

POSITIVE-END EXPIRATORY PRESSURE (PEEP). PEEP is positive pressure that is applied by the ventilator at the end of expiration. This mode does not deliver breaths but is used as an adjunct to CV, A/C, and SIMV to improve oxygenation by opening collapsed alveoli at the end of expiration. Complications from the increased pressure can include decreased cardiac output, lung rupture, and increased intracranial pressure.

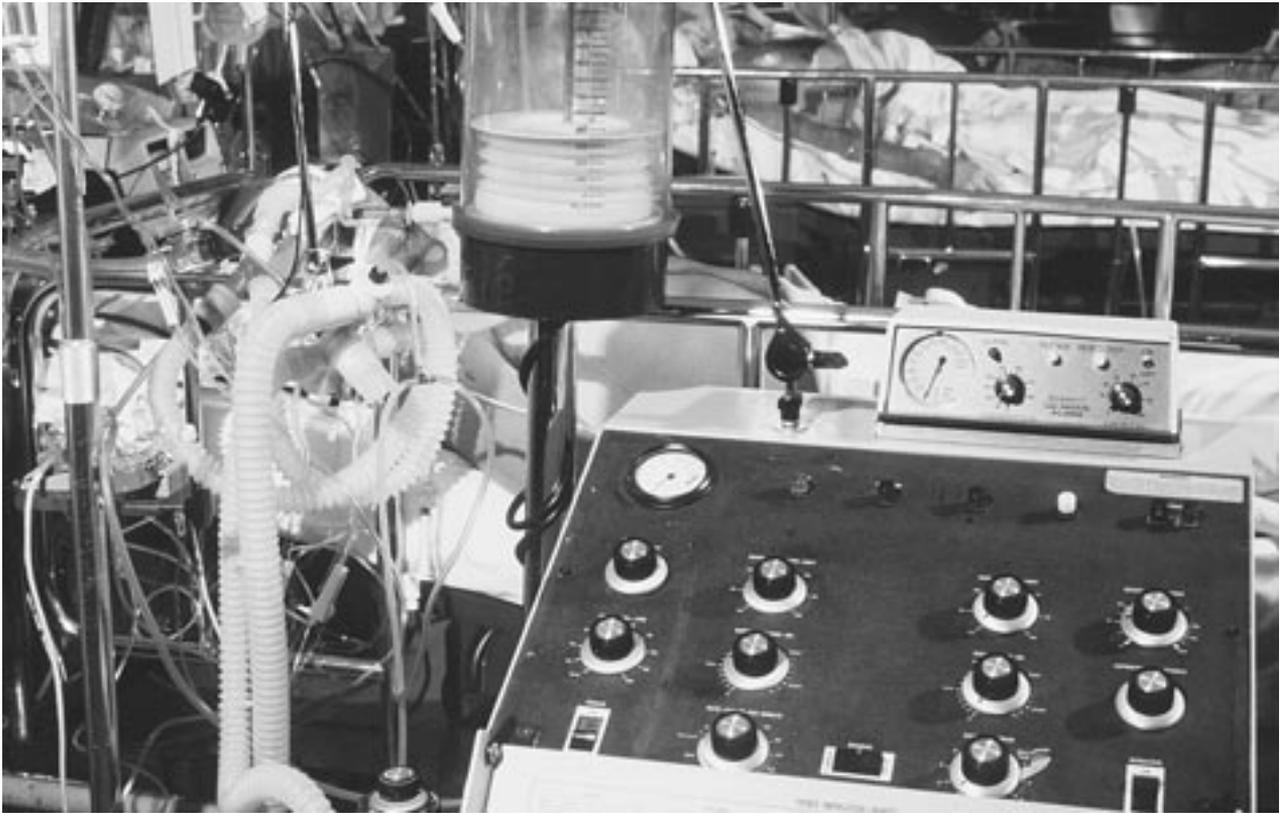
CONSTANT POSITIVE AIRWAY PRESSURE (CPAP). CPAP is similar to PEEP, except that it works only for patients who are breathing spontaneously. The effect of CPAP (and PEEP) is compared to inflating a balloon but not letting it completely deflate before inflating it again. The second inflation is easier to perform because resistance is decreased. CPAP can also be administered using a mask and CPAP machine for patients who do not require mechanical ventilation but who need respiratory support (for example, patients with sleep apnea).

PRESSURE SUPPORT VENTILATION (PSV). PS is preset pressure which augments the patient's spontaneous inspiration effort and decreases the work of breathing. The patient completely controls the respiratory rate and tidal volume. PS is used for patients with a stable respiratory status and is often used with SIMV during weaning.

INDEPENDENT LUNG VENTILATION (ILV). This method is used to ventilate each lung separately in patients with unilateral lung disease or a different disease process in each lung. It requires a double-lumen endotracheal tube and two ventilators. Sedation and pharmacologic **paralysis** are used to facilitate optimal ventilation and increase comfort for the patient on whom this method is used.

HIGH FREQUENCY VENTILATION (HFV). HFV delivers a small amount of gas at a rapid rate (as much as 60-100 breaths per minute). This is used when conventional mechanical ventilation would compromise hemodynamic stability, during short-term procedures, or for patients who are at high risk for lung rupture. Sedation and/or pharmacologic paralysis are required.

INVERSE RATIO VENTILATION (IRV). The normal inspiratory:expiratory ratio is 1:2, but this is reversed during IRV to 2:1 or greater (the maximum is 4:1). This method is used for patients who are still hypoxic, even with the use of PEEP. Longer inspiratory time increases



Ventilators assist with respiration for patients who cannot breathe on their own due to respiratory failure from trauma, paralysis, or other causes. (M. English, MD/Custom Medical Stock Photo. Reproduced by permission.)

the amount of air in the lungs at the end of expiration (the functional residual capacity) and improves oxygenation by reexpanding collapsed alveoli. The shorter expiratory time prevents the alveoli from collapsing again. This method requires sedation and therapeutic paralysis because it is very uncomfortable for the patient.

Ventilator settings

Ventilator settings are ordered by a physician and are individualized for the patient. Ventilators are designed to monitor most components of the patient's respiratory status. Various alarms and parameters can be set to warn healthcare providers that the patient is having difficulty with the settings.

RESPIRATORY RATE. The respiratory rate is the number of breaths the ventilator will deliver to the patient over a specific time period. The respiratory rate parameters are set above and below this number, and an alarm will sound if the patient's actual rate is outside the desired range.

TIDAL VOLUME. Tidal volume is the volume of gas the ventilator will deliver to the patient with each breath. The usual setting is 5-15 cc/kg. The tidal volume param-

eters are set above and below this number and an alarm sounds if the patient's actual tidal volume is outside the desired range. This is especially helpful if the patient is breathing spontaneously between ventilator-delivered breaths since the patient's own tidal volume can be compared with the desired tidal volume delivered by the ventilator.

OXYGEN CONCENTRATION (FIO₂). Oxygen concentration is the amount of oxygen delivered to the patient. It can range from 21% (room air) to 100%.

INSPIRATORY:EXPIRATORY (I:E) RATIO. As discussed above, the I:E ratio is normally 1:2 or 1:1.5, unless inverse ratio ventilation is desired.

PRESSURE LIMIT. Pressure limit regulates the amount of pressure the volume-cycled ventilator can generate to deliver the preset tidal volume. The usual setting is 10-20 cm H₂O above the patient's peak inspiratory pressure. If this limit is reached the ventilator stops the breath and alarms. This is often an indication that the patient's airway is obstructed with mucus and is usually resolved with suctioning. It can also be caused by the patient coughing, biting on the endotracheal tube, breathing against the ventilator, or by a kink in the ventilator tubing.

FLOW RATE. Flow rate is the speed with which the tidal volume is delivered. The usual setting is 40-100 liters per minute.

SENSITIVITY/TRIGGER. Sensitivity determines the amount of effort required by the patient to initiate inspiration. It can be set to be triggered by pressure or by flow.

SIGH. The ventilator can be programmed to deliver an occasional sigh with a larger tidal volume. This prevents collapse of the alveoli (atelectasis) which can result from the patient constantly inspiring the same volume of gas.

Operation

Many ventilators are now computerized and have a user-friendly control panel. To activate the various modes, settings, and alarms, the appropriate key need only be pressed. There are windows on the face panel which show settings and the alarm values. Some ventilators have dials instead of computerized keys, e.g., the smaller, portable ventilators used for transporting patients.

The ventilator tubing simply attaches to the ventilator on one end and to the patient's artificial airway on the other. Most ventilators have clamps that prevent the tubing from draping across the patient. However, there should be enough slack so that the artificial airway isn't accidentally pulled out if the patient turns.

Ventilators are electrical equipment so they must be plugged in. They do have battery back up, but this is not designed for long-term use. It should be ensured that they are plugged into an outlet that will receive generator power if there is an electrical power outage. Ventilators are a method of life-support. If the ventilator should stop working, the patient's life will be in jeopardy. There should be a bag-valve-mask device at the bedside of every patient receiving mechanical ventilation so they can be manually ventilated if needed.

Maintenance

When mechanical ventilation is initiated, the ventilator goes through a self-test to ensure it is working properly. The ventilator tubing should be changed every 24 hours and another self-test run afterwards. The **bacteria** filters should be checked for occlusions or tears and the water traps and filters should be checked for condensation or contaminants. These should be emptied and cleaned every 24 hours and as needed.

Health care team roles

The respiratory therapist is generally the person who sets up the ventilator, does the daily check described

KEY TERMS

Alveoli—Saclike structures in the lungs where oxygen and carbon dioxide exchange takes place.

Bag-valve-mask device—Device consisting of a manually compressible bag containing oxygen and a one-way valve and mask that fits over the mouth and nose of the patient.

Endotracheal tube—Tube inserted into the trachea via either the oral or nasal cavity for the purpose of providing a secure airway.

Hemodynamic stability—Stability of blood circulation, including cardiac function and peripheral vascular physiology.

Hypoxic—Abnormal deficiency of oxygen in the arterial blood.

Intracranial pressure—The amount of pressure exerted inside the skull by brain tissue, blood, and cerebral-spinal fluid.

Peak inspiratory pressure—The pressure in the lungs at the end of inspiration.

Pharmacologically paralyzed—Short-term paralysis induced by medications for a therapeutic purpose.

Tracheostomy tube—Surgically created opening in the trachea for the purpose of providing a secure airway. This is used when the patient requires long-term ventilatory assistance.

Weaning—The process of gradually tapering mechanical ventilation and allowing the patient to resume breathing on their own.

above, and changes the ventilator settings based on the physician's orders. The nurse is responsible for monitoring the alarms and the patient's respiratory status. The nurse is also responsible for notifying the respiratory therapist when mechanical problems occur with the ventilator and when there are new physician orders requiring changes in the settings or the alarm parameters. The physician is responsible for keeping track of the patient's status on the current ventilator settings and changing them when necessary.

Training

Training for using and maintaining ventilators is often done via hands-on methods. Critical care nurses usually have a small amount of class time during which

they learn the ventilator modes and settings. They then apply this knowledge while working with patients on the unit under the supervision of a nurse preceptor. This preceptorship usually lasts about six weeks (depending upon the nurse's prior experience) and includes all aspects of critical care. Nurses often learn the most from the respiratory therapists, since ventilator management is their specialty.

Respiratory therapists complete an educational program that specifically focuses on respiratory diseases, and equipment and treatments used to manage those diseases. During orientation to a new job, they work under the supervision of an experienced respiratory therapist to learn how to maintain and manage the ventilators used by that particular institution. Written resources from the company that produced the ventilators are usually kept in the **respiratory therapy** department for reference.

Physicians generally do not manage the equipment aspect of the ventilator. They do, however, manage the relation of the ventilator settings to the patient's condition. They gain this knowledge of physiology during medical school and residency.

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Ventilatory weaning process see **Ventilation management**

Vertebral column

Definition

The vertebral column is a flexible column, formed by a series of bones called vertebrae. It is part of the axial skeleton and consists of seven cervical, 12 thoracic, five lumbar, five sacral, and four coccygeal vertebrae. Its major function is to enclose and protect the **spinal cord** and provide structural support to the head and trunk.

Description

The vertebral column—or spinal column—is composed of a series of 33 separate bones known as vertebrae. It is located in the trunk of the body and extends from the base of the **skull** to the pelvis. It belongs to the axial skeleton, meaning that portion of the skeleton associated with the **central nervous system** that also includes the bones of the cranium, ribs, and breastbone. The vertebral column consists of seven cervical—or neck—vertebrae, twelve thoracic vertebrae, and five lumbar vertebrae, followed by the sacrum, composed of five fused vertebrae, and by four coccygeal vertebrae which are sometimes fused together and called the coccyx. The coccyx—or tailbone—is the last bone of the vertebral column.

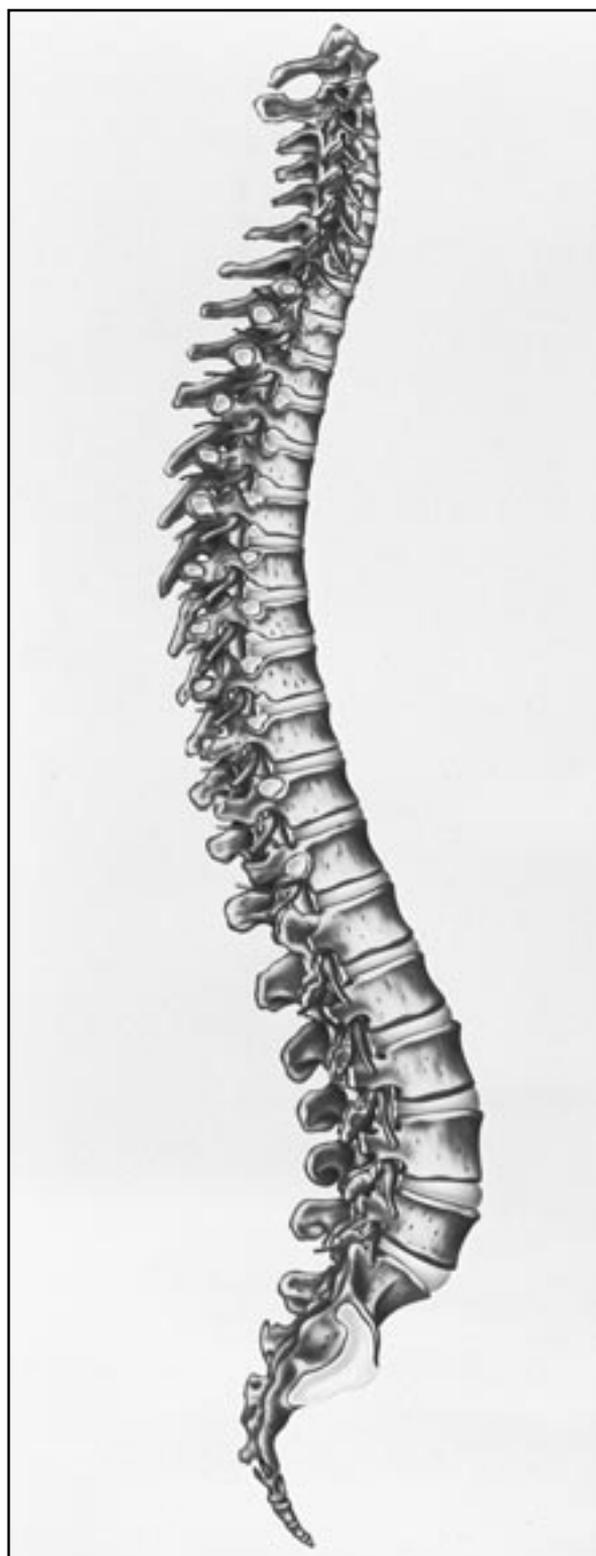
Vertebrae are stacked on top of one another from the first cervical vertebra, called C1 or the atlas, to the sacrum. Only the first 24 vertebrae are considered movable. Both the superior and inferior surfaces of each vertebra are covered by a thin layer of cartilage joined to disk-shaped pads of fibrous cartilage, called intervertebral disks, that cushion the vertebrae and stabilize the vertebral column while allowing it to move. Each disk has a jelly-like core, the nucleus pulposus surrounded by a ring of tough fibrous tissue, the annulus fibrosus. The vertebrae are also bound together by two strong ligaments running the entire length of the vertebral column and by smaller ligaments between each pair of connecting vertebrae. Several groups of muscles are also attached to the vertebrae, providing additional support as well as movement control. The length of the vertebral column depends on the height of the vertebrae and the thickness of the intervertebral disks.

There are four normal curvatures in the vertebral column of the adult that align the head with a straight line through the pelvis. In the region of the chest and sacrum, they curve inwards and each is known as a kyphosis. In the lower back and neck regions, they curve outward and each is known as a lordosis.

All vertebrae have common features. A typical vertebra consists of two parts: an arch that encloses an opening called a vertebral foramen; and a body. Since the vertebrae are all stacked on top of one another, the foramina form the vertebral canal that houses the spinal cord from which the spinal nerves emerge. The body of a vertebra is a round, stocky part on the surface of which the intervertebral disk lies and it has two projections, called pedicles, that connect around the foramen to similar bony projections on the arch called facets. Besides enclosing the foramen with its facets, an arch also has three bony spikes, a spinous process located directly opposite the body and two transverse processes on each side of the

foramen. These bony elements serve as important sites of attachment for deep back muscles. There are also differences between vertebrae, depending on their location in the column:

- The cervical vertebrae. The seven cervical vertebrae are numbered C1 to C7. Together, they make up the bony axis of the neck. Typical cervical vertebrae have large vertebral foramina, and oval-shaped vertebral bodies. They are the smallest vertebrae of the column, but their bone density is higher than that of all the other vertebrae. The transverse processes of the cervical vertebrae are special because they also contain transverse foramina, which are passageways for arteries leading to the **brain**. The two first cervical vertebrae are special, because they provide a seat for the head. C1 directly supports and balances the skull. It has practically no body and looks like a ring with two transverse processes. On its upper surface, C1 also has two kidney-shaped facets that link it to the skull. The other special cervical vertebra is C2. It forms an axis which bears a tooth-like odontoid process on its body. This bony spike projects upward and lies in the ring of C1. As the head is turned from side to side, C1 thus pivots around the odontoid process of C2.
- The thoracic vertebrae. The thoracic vertebrae are numbered T1 to T12 and are located in the chest area. They are larger than the cervical vertebrae. They have round foramina and long, pointed spinous processes that slope downward. Thoracic vertebrae have a unique feature, additional facets on the sides of their bodies that join them with the ribs. Starting with T3 and moving down, their bodies increase in size.
- The lumbar vertebrae. The lumbar vertebrae are numbered L1 to L5. They feature large, massive bodies, triangular foramina, and robust spinous and transverse processes. Their facets are oriented so as to favor a wide range of bending flexibility. Lumbar vertebrae also contain small extra bony processes on their bodies that serve as sites of attachment for back muscles.
- The sacrum. In the adult, the sacrum consists of five vertebrae that are fused together. It has a characteristically wide body curved upon itself and a triangular foramen. It is shorter and wider in the female than in the male. It links with L5 above and the coccyx below and it articulates on each side with the bones of the pelvis forming the sacroiliac joints with the iliac bones on either side. In addition to its characteristic shape, it contains two additional foramina through which spinal nerves pass.
- The coccyx. The tailbone is a small triangular bone consisting of four fused rudimentary vertebrae. The number of coccygeal vertebrae may be five or three.



The vertebral column consists of 33 vertebrae: seven cervical (at the top), twelve thoracic, five lumbar, five fused sacral, and four fused coccyx. (Photograph by John Bavosi. Science Source/Photo Researchers. Reproduced by permission.)

KEY TERMS

Annulus fibrosus—Peripheral ring of fibrous tissue in an intervertebral disk.

Atlas—The atlas is the first cervical vertebra, C1, the one upon which the base of the skull rests. Along with C2, it provides the pivot assembly around which the skull rotates.

Axial skeleton—The skeleton associated with the central nervous system and that consists of the cranium, all the bones of the vertebral column, the ribs, and the sternum. Those portions of the skeleton not associated with the central nervous system are associated with the appendicular skeleton or the skeleton of the extremities, such as the arms and legs.

Central nervous system (CNS)—One of two major divisions of the nervous system. The CNS consists of the brain, the cranial nerves and the spinal cord.

Cervical vertebrae—The seven vertebrae of the neck.

Coccyx—The last bone of the vertebral column just below the sacrum, also called the tailbone.

Condyle—A rounded enlargement that has an articulating surface.

Foramen—A hole in a bone usually for the passage of blood vessels and/or nerves.

Foramen magnum—Large opening at the base of the skull that allows passage of the spinal cord.

Ilium—The upper and largest part of the bony pelvic girdle, also called the iliac wing.

Intervertebral disk—Disk-shaped pads of fibrous cartilage interposed between the vertebrae of the vertebral column that provide cushioning and join the vertebrae together.

Nervous system—This is the entire system of nerve tissue in the body. It includes the brain, the brainstem, the spinal cord, the nerves and the ganglia and is divided into the peripheral nervous system (PNS) and the central nervous system (CNS).

Nucleus pulposus—Jelly-like core of an intervertebral disk.

Pelvis—The basin-shaped cavity that contains the bladder and reproductive organs of the body.

Process—A general term describing any marked projection or prominence on a bone.

Sacroiliac joints—Joints that allow the sacrum and the ilium to articulate.

Sacrum—The triangular-shaped bone found between the fifth lumbar vertebra and the coccyx. It consists of five fused vertebrae and it articulates on each side with the bones of the pelvis (ilium), forming the sacroiliac joints.

Skull—All of the bones of the head.

Spinal cord—Elongated part of the central nervous system (CNS) that lies in the vertebral canal of the vertebral column and from which the spinal nerves emerge.

Vertebra—Flat bones that make up the vertebral column. The spine has 33 vertebrae.

Vertebral canal—Hollow part of the vertebral column formed by the vertebral foramina of all vertebrae. It encloses the spinal cord.

Vertebral foramen—The opening formed in vertebrae that allows passage of the spinal cord.

They all lack pedicles and spinous processes, but a primitive body and transverse processes can be recognized in each of the first three vertebrae. The last vertebra is a mere small nodule of bone.

Function

The vertebral column has several major functions. It protects the sensitive spinal cord, which it encloses. It functions as a strong and flexible rod that allows movement of the trunk. It supports the head and acts as a pivot. It is also a point of structural attachment for the ribs.

Role in human health

The vertebral column plays a major protective role in human health because it encloses the spinal cord, that delicate bundle of nerve tissue which carries nerve impulses between the brain and the rest of the body. The vertebral column also plays another important role, not only in providing structural support for the chest, but also in maintaining the posture of the body and in locomotion.

Common diseases and disorders

Injuries to the vertebral column are common and are usually caused by one of three types of severe pressure:

longitudinal compression, hinging, or shearing. Longitudinal compression usually occurs as a result of a fall from a height, and it crushes one vertebra lengthwise against another. Hinging can occur in **whiplash** injuries: it subjects the vertebral column to sudden and violent acceleration and recoil motions. Shearing, which can occur when a person is knocked over with great force, combines both hinging and twisting forces. Any of these forces can dislocate the vertebrae, fracture them, or rupture the ligaments that bind them together. Damage to the vertebrae and ligaments usually causes severe **pain** and swelling in the injured area. In severe cases, the spinal cord may be affected as well, and thus sensory and/or motor nerve functions. Other common disorders and diseases of the vertebral column include:

- Degenerative disc disease (DDD). DDD affects the vertebral discs. As each disc is under constant pressure during flexion and extension of the vertebral column, the discs begin to wear and tear with age.
- Discitis. Discitis, or disc space **infection**, is an inflammation of the intervertebral disc that occurs in adults but more commonly in children. Its cause is believed to be infectious.
- Facet joint syndrome. The facet joints can get inflamed following injury or arthritis and cause pain and stiffness. It affects more commonly the facet joints of the cervical vertebrae and typically causes pain in this area as well headaches and difficulty rotating the head.
- Hyperlordosis. Hyperlordosis, also simply called lordosis, refers to an exaggerated lordosis of the lumbar vertebrae. It can be caused by **pregnancy** or obesity.
- Lumbar herniated disc. This condition represents a common cause of low back and leg pain. A herniated intervertebral disc is a ruptured disk. Symptoms may include dull or sharp pain, muscle spasm or cramping, and leg weakness or loss of leg function.
- **Osteoarthritis**. Osteoarthritis is a degenerative form of arthritis, it is a progressive joint disease associated with aging. In the vertebral column, osteoarthritis can affect the facet joints, which allow the body to bend and twist.
- Scheuermann's kyphosis. Scheuermann's kyphosis refers to an exaggerated kyphosis of the thoracic vertebrae. It can be caused by rickets or poor posture.
- Scoliosis. Abnormal sideways curvature of the vertebral column.
- Spondylolisthesis. A forward displacement of one vertebra on another, usually in the lower back region due to either a traumatic or a congenital defect.
- Vertebral osteomyelitis. Vertebral osteomyelitis is the infection of the bones of the vertebral column. It may

be caused by either a **bacteria** or a fungus. Bacterial or pyogenic vertebral osteomyelitis is the most common form.

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Vincent's infection see **Periodontitis**

Viral loading test see **AIDS tests**

Viral meningitis see **Meningitis**

Viruses

Definition

A virus is an infectious agent, often highly host-specific, consisting of genetic material surrounded by a protein coat.

Description

Viruses infect virtually every life form, including humans, animals, plants, **fungi**, and **bacteria**. So small that they cannot be seen by a light **microscope**, viruses range in size from about 30 nanometers (about 0.000001 in) to about 450 nanometers (about 0.000014 in) and are between 100 to 20 times smaller than bacteria. As of the seventh report of the International Committee on Taxonomy of Viruses (ICTV), published in September 2000, known viruses have been assigned to 1550 species in 53 different families. Hundreds of other viruses remain unclassified due to lack of information.

All standard viruses share a general structure of genetic material, or viral genome, and a protein coat, called a capsid. The viral genome is made of either deoxyribose nucleic acid (DNA), the genetic material found in plants and animals, or ribonucleic acid (RNA), a compound plant and animal cells use in protein synthesis. The protein capsid is made of repeating, often-identi-

cal subunits known as capsomeres. Viruses are not strictly free-living, as they cannot reproduce on their own. Instead, they use host cell machinery to make both the viral genome and capsids of the newly formed viruses, or virions.

The broad category of viruses also includes unusual infective agents that are missing one or more components of standard viruses. These unconventional viruses include viroids, which exist as circular RNA molecules that are not packaged, and prions, infective particles that contain protein and little or no nucleic acids.

Some viral infections can cause damage to the host cell, resulting in disease to the organism. Other viral infections appear to make the host cells divide uncontrollably, causing the development of **cancer**. However, many viral infections are asymptomatic and do not result in disease. There are no cures for viral infections, due in part to the difficulty of developing drugs that adversely affect only the virus and not the host. Accordingly, preventative measures such as vaccines play an important role in the treatment of viral diseases.

Function

The primary function of a virus is to infect host cells and create more viruses. The virus does this by taking over the host cell's protein and genetic material-making processes, forcing it to produce the new viruses. Exactly how viruses function in this manner is best understood by examining general viral structure, classification, and reproductive strategies.

Structure and classification

There are three basic structures for standard viral capsids: icosahedral, helical, and complex. Icosahedral capsids are 20-sided, made of triangular capsomere subunits. The points of the triangular subunits join at 12 vertices about the shape. Although exact structure varies from virus type to virus type, a common arrangement is five or six neighboring triangular subunits at each vertex. Some viruses show more than one capsomere arrangement within the capsid. An example of a virus having an icosahedral structure is adenovirus, the virus that can cause acute respiratory disease or viral **pneumonia** in humans.

The helical viruses have protein subunits that curve about a central axis running the length of the virus. The fanlike arrangement of protein forms a three-dimensional ribbon-shaped structure that covers the viral genome. Some of these capsid structures are stiff and rodlike, while other helical viruses are more flexible. The

influenza virus is an example of a virus with a helical capsid structure.

The third type of virus capsid structure is called complex. Although the structure is regular from virus to virus of the same type, the symmetry is not patterned enough to be fully understood. For example, poxvirus, the virus that causes smallpox in humans, has a complex capsid structure of over 100 **proteins**. Virologists are still trying to determine the exact arrangement of these proteins.

The combination of the capsid and the viral genome is known as a nucleocapsid. Some nucleocapsids are infective in this form and are known as naked viruses. Others require a surrounding lipid membrane derived from the host cell to be infective. The membrane envelope can encompass one or more nucleocapsids and usually contains on its surface at least one viral protein in addition to the host cell components. Viruses of this type are called enveloped or coated viruses.

Viruses are classified according to structural characteristics such as whether the virus genome is made of DNA or RNA. Both of these nucleic acids can form ladder-like structures where each side of the ladder is known as a strand. Viruses are differentiated by whether the DNA or RNA is single or doubled-stranded. The type of capsid structure and whether the virus is naked or enveloped are also considered. A few viral classifications take into account differences in replication strategy.

Replication

The generalized replication cycle for standard viruses begins with the absorption of the virus by the host cell. Absorption involves an interaction between the viral particle and the potential host cell. This is often mediated by a viral protein that is recognized by a binding protein located on the surface of the host cell. Whether the host cell recognizes the viral protein often determines whether a particular cell can or cannot function as a host for a particular virus. For example, the hemagglutinin protein of the influenza virus, a viral protein found within the lipid envelope of this coated virus, interacts with a receptor found on the surface of the epithelial cells that line the human respiratory tract.

The next step in the virus replication cycle is penetration and, if necessary, the uncoating of the virus in the host cell. With some coated viruses, the envelope membrane fuses directly with the host membrane, allowing movement of nucleocapsid into the cell's cytoplasm. Other coated viruses are brought into the cell using endosomes, small vesicles of cellular membrane that bud inwardly and are used to move materials into the cell. Due to the lower pH environment of the endosome, the

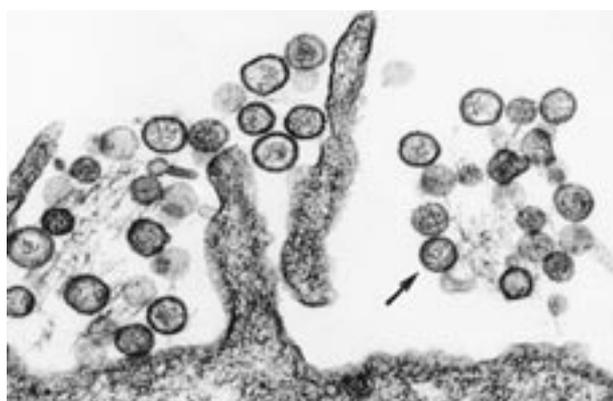
virus coat can fuse with the endosomal membrane to gain access to the cell cytoplasm. Naked viruses are sometimes small enough to move without help through the host cellular membrane, while others use the endosome system.

Once inside the cell, the virus takes over the host cell's protein and nucleic acid production, directing it to produce viral proteins and genomes. For many viruses having a DNA genome, the viral nucleic acid is inserted or integrated directly into the host cell's own DNA, that make up the cell's chromosomes. RNA viruses tend to keep the genome independent from the host cell's genetic material. In either case, the host cell is fooled into using the viral genetic material as the instructions for the production of new infectious virions. In order to ensure that new virions will be formed, viruses often have mechanisms that speed up the protein formation of the host cell. Sometimes the mechanism will be specific for increased production of viral proteins, while others speed up all protein formation.

A special method of producing new virions is employed by retroviruses, such as the human **immuno-deficiency** virus (HIV). These viruses carry their genomes as RNA, but upon entry into the host cell a viral enzyme known as reverse transcriptase converts the viral RNA into DNA, and that molecule is integrated into the host genome. The enzyme is called reverse transcriptase because generally genetic information moves from DNA to RNA copies rather than this reverse process. The integrated DNA is known as a provirus and will be replicated when the host cell divides, to be inherited by the two resulting daughter cells.

After production of the viral proteins and genomes by the host cellular machinery, the capsid is assembled around the genetic material and, for some viruses, a maturation step occurs that is necessary for infectivity. Finally, the new virions are released from the cell. Some coated viruses leave the cell by budding and do not cause the death of the host cell. The budding process is how the virus acquires its lipid membrane envelope. Other viruses lyse, or break down, the host cell membrane. Lysis kills the host cell.

Because of the ability of viruses to carry genetic material into and out of a cell during the reproduction cycle, viruses can function as vectors in **genetic engineering**. This is done by inserting foreign genetic material into viral genomes and allowing the material to be integrated and expressed in bacteria and animal cells. Viral vectors are often the basis for gene therapies that in their simplest form attempt to cure genetic defects by providing non-mutated copies of a damaged gene to an organism.



Electron micrograph of the hanta virus. (Photograph courtesy of the CDC.)

Role in human health

Viruses that infect humans cause damage to the infected cells, resulting in outward symptoms seen as human disease. Human viruses gain entry into the body using various routes. Some viruses are transmitted through skin-to-skin contact, such as herpes simplex 1, the virus that causes cold sores. Others are transmitted through exposure to infected **blood**, the mode of transmission of the hepatitis B virus. Some of the most easily caught viruses, such as varcella-zoster, the virus that causes chicken pox, are transmitted through water droplets suspended in the air. The virus is transmitted when the droplets are breathed in and come in contact with the respiratory tract of the new host.

Gastrointestinal viruses are transmitted through exposure to waste products containing virus particles that has contaminated water or food, and entry into the host's digestive tract through the mouth. Rotavirus, a cause of a diarrheal illness common in children, is transmitted in this manner. Sexually transmitted viruses move from host to host through sexual contact and enter the body by the genitourinary route. HIV and human papilloma virus (HPV) are examples of viruses that are sexually transmitted.

After gaining entry into the host, the response at a cellular level to the viral **infection** varies with the type of virus and the virulence of the strain. Thus, the response can vary from no apparent change, to detectable changes in the cell, known as cytopathic effects (CPE), to loss of growth control or malignancy. Virulence refers to the ability of a virus to cause disease in a host. Some viruses are highly virulent, causing disease with almost every infection. Measles, rabies, and influenza are virulent viruses. Other less virulent viruses, such as Epstein-Barr virus, which causes mononucleosis, only rarely results in disease symptoms.

Viral infections follow patterns that are specific to the virus. Some infections are localized, that is, restricted to a particular cell type or organ, while others are disseminated throughout the body. Disseminated infections are often propagated through the nervous system or the bloodstream. Infections can be acute, where the patient's **immune system** self-limits the disease and recovers, or chronic, where the infection continues for a long period of time.

Some viruses have the ability to cause an initial disease state upon infection and then establish a latent or dormant infective state. For example, herpes viruses cause blisters on the skin as a result of their lytic replication, but then establish a latent infection in nerve cells. Upon a stimulus such as exposure to the sun or **stress** the virus switches back to a lytic cycle, again producing blisters at the site of infection. In this way, the infection can persist for months or even years.

Several viruses, such as human papilloma viruses and Epstein-Barr virus, have been strongly associated with human cancers. The exact role of viruses in malignancy is not yet understood, as environmental and host genetic factors also seem to contribute to the development of tumors. However, it is highly probable that viruses are key triggers for a number of human cancers.

Another effect of viruses on human health is infection by zoonotic viruses, that is, viruses that can be transmitted from an animal host of another species to humans. Some of these viruses are transmitted through a blood-sucking insect intermediary, such as a mosquito, while others are transmitted directly from the infected animal to humans. Many of these viruses raise important **public health** concerns. An example of a mosquito-transmitted virus is flavivirus that causes West Nile encephalitis in humans. A strain of hantavirus was discovered in 1993 that infects rodents and transmits directly to humans, causing a respiratory illness.

Although most infect plants and animals, a few unconventional viruses cause human disease. The only known human viroid is the delta virus (hepatitis D) that requires co-infection with hepatitis B to be infective. The combined infection of hepatitis B and D causes more severe symptoms than B alone. An example of a human prion-mediated disease is Cruetzfeldt-Jakob disease (CJD), which causes neurological symptoms and is fatal. Of significant concern is a possible variant of CJD reported in Great Britain that affects younger individuals. Although cause and effect has not been conclusively shown, there is suspicion that this disease results from eating beef contaminated with the prion that causes bovine spongiform encephalopathy, or mad cow disease.

Immunological response

When challenged by a viral infection, the human body responds with both antibodies and cell-mediated responses to counteract the virus. Antibodies, produced by B lymphocytes, are specific for surface proteins of the virus. When acting as a target for antibodies, such viral proteins are known as antigens. The binding of the antibodies to the viruses can inactivate them or target them as foreign for destruction by other components of the immune system. Antibodies can also bind to viral proteins seen in the membrane of infected cells, directing their elimination by the immune system. Antibodies mediate the immunity to reinfection by the same virus. Unfortunately, many viruses have high rates of mutation that alter the surface antigens, rendering the host again susceptible to infection. This process is the reason that one cold does not make a person immune to all rhinoviruses, a virus with at least 95 different serotypes (a characteristic of a virus based on the antibodies that are produced against the surface antigens upon infection).

Non-specific cell-mediated responses are also important to the body's fight against viruses. The production of interferons and cytokines, in particular, is known to help control viral infections. However, the side effects of these molecules, including **fever**, malaise, fatigue and muscle pains, significantly contribute to the physical symptoms of viral infections.

Diagnosis

In general there are three methods of diagnosing viral disease in humans. Some viruses can be identified clinically, as the infection causes unmistakable outward signs. The blistery pox of the varicella-zoster or chicken pox virus is a good example of a clinically diagnosed viral disease. Viral diseases can also be diagnosed epidemiologically, through known exposure to certain viruses or virus-harboring hosts. However, many virus infections cannot be diagnosed definitively without diagnostic testing.

Diagnostic testing can involve direct detection, using electron microscopy, light microscopy of CPE seen in host cells, detection of viral antigen in patient samples, or detection of the viral genome using the polymerase chain reaction (PCR) test. Effective tests for some viral infections involve indirect detection, generally using cell culture systems to grow the virus *in vitro* (outside the organism). A final method of diagnosing viral illnesses is serological testing that involves the detection of antibodies against the virus antigen in samples taken at presentation and during convalescence. A serious drawback to traditional serological testing is the amount of time needed to obtain the results. New techniques are being devel-

oped, however, that may speed serological tests and make them more useful.

Treatment

Most viral diseases have no cure, so treatment involves easing symptoms and allowing the body's immune system to eliminate the virus. Viruses are not affected by **antibiotics**, which target bacteria. However, a handful of anti-viral drugs have been developed and many more are in the developmental and drug trial stage. In general, the development of anti-viral drugs has been hampered by the parasitic relationship between viruses and their hosts. It has been difficult to find pharmacological means to kill the virus without harming the host. The speed of viral infection has also been a problem, as viral numbers are so high by the time the infection has symptoms, the drugs have little effect.

Amantadine and rimantadine are two drugs that have been used successfully against influenza A. These drugs appear to inhibit the absorption of the influenza virus into the epithelial cells of the respiratory tract and, accordingly, are administered prior to infection as a prophylaxis.

Herpes simplex and varicella-zoster infections can be treated with acyclovir, valacyclovir, and famciclovir. Cytomegalovirus infection can be treated with ganciclovir, foscarnet, and cidofovir. All of these drugs are converted into a chemical that interferes with the production of the viral genome. As a viral enzyme produces the genome for these viruses, the chemical does not interfere with the production of genetic material for the host cell.

A number of drugs that inhibit reverse transcriptase have been developed for treatment of HIV. The best known of these is Zidovudine (AZT). The other major target for antiviral HIV drugs is the viral protease, an enzyme that cleaves both viral structural proteins and enzymes apart after formation by the host cell. Because the virus is noninfective if these cleavages do not occur, drugs inhibiting the protease action are effective antivirals. As advances in this field happen quickly, the International AIDS Society/USA Panel provides periodic recommendations as to what drugs given in what combinations have proven to be most effective in the treatment of AIDS.

Finally, genetically engineered interferon has been used with some success against hepatitis B and C and human papillomavirus. However, the severe side effects of this protein, in particular nausea and vomiting, have hampered its usefulness.

KEY TERMS

Capsid—The protein structure of a virus.

Capsomere—The protein subunits of the capsid.

Endosome—A membrane-mediated means of transporting materials from outside to inside the cell.

Genome—The genetic material encoding the genes of an organism.

Nucleocapsid—The combination of the capsid and viral genome.

Prion—An unconventional virus that is made almost entirely of protein.

Reverse transcriptase—A retroviral enzyme that produces DNA copies of genetic information encoded by RNA.

Virion—A single infectious virus particle.

Viroid—An unconventional virus that is made of uncoated RNA.

Zoonotic—A type of virus that primarily infects an insect or animal, but can be transmitted to humans.

Prevention

The most effective method of treatment of viral diseases is prevention of the infection. Vaccines, where the immune system is exposed to non-infective viral antigens to allow the development of protective antibodies, have proven effective in controlling many viral illnesses. Vaccines are made of inactivated (killed) virus, attenuated (weakened) virus, or isolated viral proteins, that are known as subunit vaccines. Vaccines are available for the viruses that cause measles, mumps, rubella, poliomyelitis, rabies, hepatitis A and B, influenza, varicella-zoster (chicken pox) and yellow fever. Many other vaccines are in the developmental or clinical trial stages.

The greatest drawback to vaccines is the inability of the protection to counter the same virus that has altered its antigens through mutation. Thus, viruses that undergo rapid mutation are difficult to control using **vaccination**. One solution used for influenza is to create a new vaccine every season against the viruses that are predicted to be responsible for upcoming flu outbreaks. Although this is an imperfect system, influenza vaccination is instrumental in shortening epidemics and protecting the populations most at risk for complications, including the chron-

ically ill, the elderly, and health care workers (primarily to prevent transmitting infection to those at risk).

A second preventative measure is the avoidance of infection by blocking transmission at the point of viral entry. This is done through the isolation of infected patients and avoiding contact with infected biological material such as lesions, blood, and airborne particles through the use of gloves, masks, and other barriers. Health care providers must practice careful hygiene of patients, including immediate removal of vomit or **diarrhea**, and thorough hand washing. These measures are taken equally to avoid patient-to-provider and provider-to-patient transmission of viruses. For zoonotic viruses, transmission can be reduced through pesticide control of the insect or animal reservoir of the disease.

Common diseases and disorders

Several hundred different viruses infect humans. The viruses that occur chiefly in humans can be categorized as respiratory, enteric, exanthematous, hepatitis, or persistent. The most common respiratory viruses include the rhinoviruses (the **common cold**) and the influenza viruses. Common enteric viruses include polioviruses (now rare because of vaccination), coxsackie viruses (herpangina), and epidemic gastroenteritis viruses such as rotaviruses. Rubeola (measles) and rubella (German measles) are two common exanthematous viruses.

Hepatitis viruses type A through E are known, with type A most often responsible for epidemics of the disease. Many of the persistent viruses are quite widespread and include cytomegalovirus (usually asymptomatic), Epstein-Barr virus (mononucleosis), Herpes simplex virus (cold sores and **genital herpes**), human herpes virus type 6 (roseola), human papilloma virus (warts), and varicella-zoster virus (chicken pox and shingles).

Zoonotic viruses, that chiefly infect insects or animals, with humans as minor or accidental host, are generally rarer. The diseases caused by these viruses are limited to areas that can support the insect or animal host as well as humans. Rabies is the most widespread of these diseases. Flaviviruses (yellow and dengue fever), bunyaviruses (California encephalitis and Hantavirus pulmonary syndrome), and filoviruses such as ebola (hemorrhagic fever) are other examples of zoonotic viruses that cause human disease.

Human disease caused by nonconventional viruses is very rare. The most common is CJD, a prion-mediated disease that occurs in one in a million individuals. Hepatitis D is the only known human viroid, and it requires co-infection with hepatitis B. Other diseases caused by nonconventional viruses are kuru and

Gerstmann-Sträussler-Scheinker syndrome (GSS), both caused by prions.

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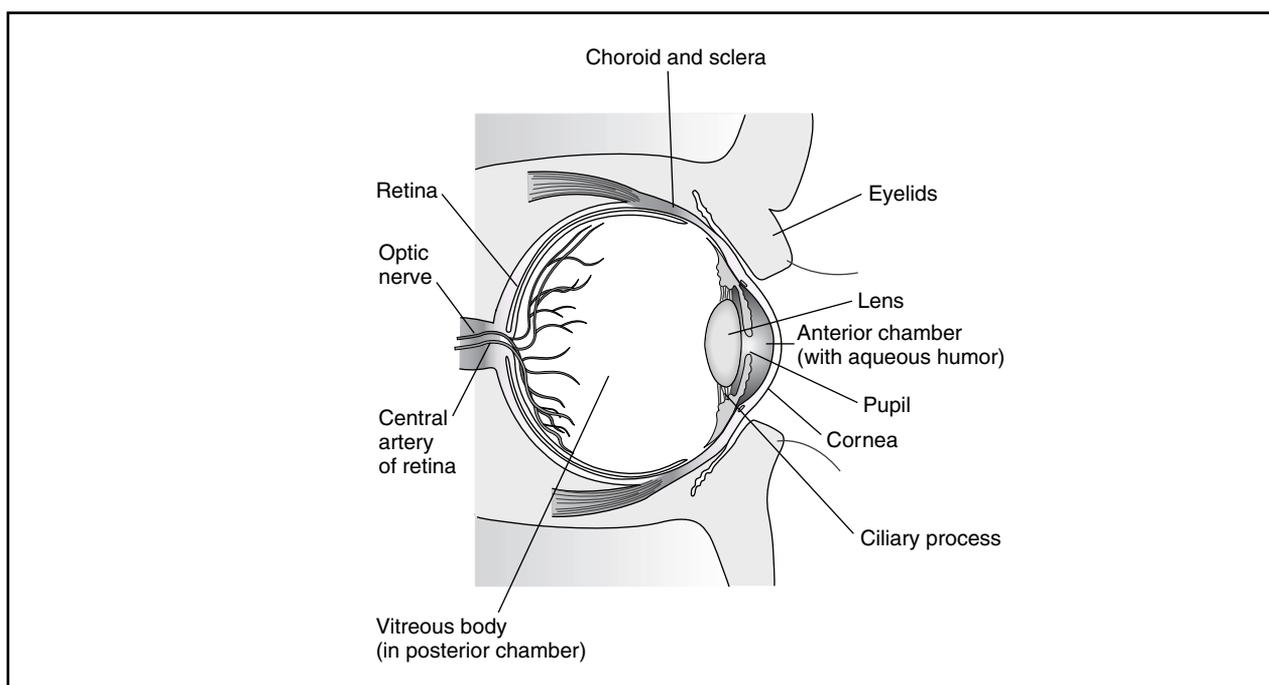
Vision

Definition

Vision is sight, the act of seeing with the eyes. Sight conveys more information to the **brain** than either **hearing**, touch, **taste**, or **smell**, and contributes enormously to **memory** and other requirements for normal, everyday human functioning.

Description

Because humans see objects with two eyes simultaneously, vision is binocular, and therefore stereoscopic. Vision begins when light enters the eye, stimulating photoreceptor cells in the retina called rods and cones. The retina forms the inner lining of each eye and functions in many ways like film in a camera. The photoreceptor cells produce electrical impulses which they transmit to adjoining nerve cells (**neurons**), which converge at the optic nerve at the back of the retina. The visual information coded as electrical impulses travels along nerve tracts to reach each visual cortex in the posterior of the brain's left and right hemispheres. Each eye conveys a slightly different, two-dimensional image to the brain,



Structures of the eye. (Delmar Publishers, Inc. Reproduced by permission.)

which decodes and interprets these images into a colorful, three-dimensional view of the world. The speed of the completion of this task is sensitive enough that it can be registered only on scientific equipment, rather than by human observation.

Function

Because human eyes are separated by about 6.5 cm (2.6 in), each eye has a slightly different horizontal view. This phenomenon is called binocular displacement. The visual images reaching each eye's retina are two-dimensional and flat. In normal binocular vision, the blending of these images into one single image is called stereopsis.

Monocular stereopsis, or depth perception, is also available. For example, even with one eye closed, a nearby car will appear much larger than the same sized car a mile away. The ability to unconsciously and instantaneously assess depth and distance allows humans to move without continually bumping into objects, also providing eye/hand coordination.

Ocular dominance

Studies strongly indicate there is a critical period during which normal development of the visual system takes place and environmental information is permanently encoded within the brain. Although the exact time frame is not clear, it is believed that by age six or seven

years, visual maturation is complete. Animal studies show that if one eye is covered during the critical period, neurons in the visual pathway and brain connected to the covered eye do not develop to optimal performance. When that eye is uncovered, only neurons relating to the unrestricted eye function in the visual process. This is an example of "ocular dominance," when cells activated by one eye dominate the cells of the other. It is not an abnormal development.

Memory

The same way in which vision plays an important role in memory, memory plays an important role in vision. The brain accurately stores visual data which it draws upon every time the eyes look at something.

Electrochemical messengers

The entire visual pathway—from the retina to the visual cortex—is paved with millions of neurons. From the time light enters the eye until the brain forms a visual image, vision relies upon the process of electrochemical communication between neurons. Each neuron has a cell body with branching fibers called dendrites and a single long, cylindrical fiber called an axon. When a neuron is stimulated it sends chemicals called neurotransmitters, which cause the release of electrical impulses along the axon. The point where information passes from one cell to the next is a gap called a synapse, and neuro-

transmitters affect the transmission of electrical impulses on to an adjacent cell. This synaptic transmission of impulses is repeated until the message reaches the appropriate location in the brain. In the retina, approximately 125 million rods and cones transmit information to approximately 1 million ganglion cells. As a result, that many rods and cones must converge onto one single ganglion cell. At the same time, however, information from each single rod and cone “diverges” on to more than one ganglion cell. This complicated phenomenon of convergence and divergence occurs along the entire optic pathway. The brain must transform all this stimulation into useful information and respond to it by sending messages back to the eye and other parts of the brain before we are able to see.

Although the pupil regulates to some degree the amount of light entering the eye, the rods and cones enable vision to adapt to extremes. Vision enabled by rods begins in dim light. Cones function in bright light and are responsible for color vision and visual activity.

When light hits the surface of an object, it is absorbed, reflected, or passes through it. The amount of light absorbed by an object is determined by the amount of pigment contained in that object. The more heavily pigmented the object, the darker it appears because it absorbs more light. A sparsely pigmented object, which absorbs little light and reflects a lot of back, appears lighter.

Color vision

Humans have three types of eye pigments: blue, green, and red. This combination, the primary colors, composes every impression of colors for humans. Human color vision extends 30 degrees from the macula, and after that distance, red and green are indistinguishable. That occurs due to the fact that in the periphery of the retina only a few cones are present that detect motion. Because rods are present, the periphery cannot determine colors. For example, a red object that is brought closer from the periphery will at first appear colorless. When the object is moved closer, the eyes will eventually pick up the red pigment.

Perception of color is dependent on three conditions. First, whether people have normal color vision; second, whether an object reflects or absorbs light; and third, whether the source of light transmits wavelengths within the visible spectrum. Rods contain only one pigment which is sensitive to very dim light, and which facilitates night vision but not color. Cones are activated by bright light and let us see colors and fine detail. There are three types of cones containing different pigments that absorb

wavelengths in the short (S), middle (M), or long (L) ranges. The peak wavelength absorption of the S (blue) cone is approximately 430 nm; the M (green) cone 530 nm; and the L (red) cone 560 nm.

The range of detectable wavelengths for all three types of cones overlap, and two of them—the L and M cones—respond to all wavelengths in the visible spectrum. Most of the light we see consists of a mixture of all visible wavelengths which results in “white” light, like that of sunshine. Cone overlap and the amount of stimulation they receive from varying wavelengths produces the vivid colors and gentle hues present in normal color vision.

Optic pathway

Only about 10% of the light which enters the eye reaches the photoreceptors in the retina. This is because light must pass first through the cornea aqueous, pupil, lens, and vitreous humors (the liquid and gel-like fluids inside the eye), the **blood vessels** of the lining of the eye, and then through two layers of nerve cells (ganglion and bipolar cells in the retina).

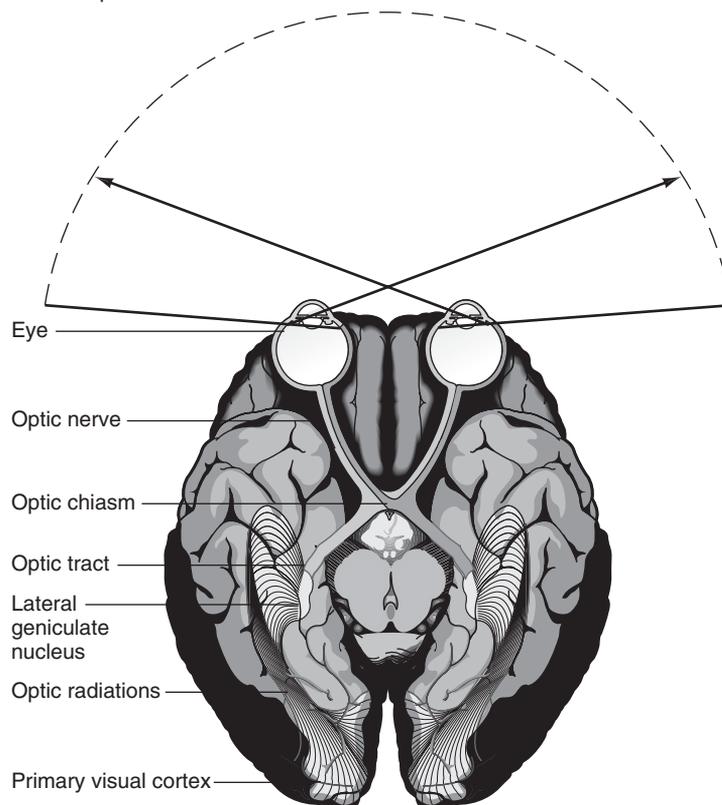
Visual discrimination

The retina has the ability to distinguish between visual stimuli, and the greater this ability, the greater the sensitivity in making such distinctions. The retina distinguishes visual stimuli in three ways: light discrimination (brightness sensitivity), spatial discrimination (ability to recognize shapes and patterns) and temporal (sensations) discrimination. Human temporal discrimination is limited. For example, this allows people to watch television without noticing the wavy lines that would distort the picture.

Optic chiasma

Vision functions in the brain are divided into two areas: the afferent (sensory) system and the efferent (motor) system. Synaptic transmission of impulses from retinal cells follows the optic nerve (an extension of the brain) to the optic chiasma, also referred to as the optic chiasm, an x-shaped junction in the brain where half the fibers from each eye cross to the other side of the brain. Consequently, visual information from the right half of each retina travels to the right visual cortex, and visual information from the left half of each retina travels to the left visual cortex. Information from the right half of our environment is processed in the left hemisphere of the brain, and vice versa. Damage to the optic pathway or visual cortex in the left brain—perhaps from a stroke—can cause loss of the right visual field. As a result, only

A human has a field of vision that covers almost 180°, although binocular vision is limited to the approximately 120° common to both eyes. The field extends upward about 60° and down about 75°.



Because the nerve fibers from the left half of the retina of the left eye go to the left side of the brain and fibers from the left half of the right eye cross the optic chiasm and go to the left side of the brain as well, all the information from the two left half-retinas ends up in the left half of the brain. And because the lens of the eye reverses the image it sees, it is information from the right half of the visual field that is going to the left visual cortex. Likewise, information from the left half of the visual field goes to the right visual cortex.

Aerial view showing the human field of vision. (Illustration by Hans & Cassidy. Courtesy of Gale Group.)

information entering the eye from the left side of our environment is processed, even though information still enters the eye from both visual fields.

Visual cortex

Each visual cortex is about 5 cm (2 in) square and contains about 200 million nerve cells which respond to elaborate stimuli. In primates, there are about 20 different visual areas in the visual cortex, the largest being the primary, or striate, cortex. The striate cortex sends information to an adjacent area which in turn transmits to at least three other areas about the size of postage stamps. Each of these areas then relays the information to several other remote areas called accessory optic nuclei.

Visual acuity

Visual acuity, keenness of sight and the ability to distinguish small objects, develops rapidly in infants between the age of three and six months, and decreases rapidly as people approach middle age. Optometrists and ophthalmologists test visual acuity during a routine examination, and poor acuity is often correctable with glasses, **contact lenses**, or refractive **laser surgery**. Visual acuity is highly complex and is influenced by many factors.

Retinal eccentricity

The area of the retina on which light is focused influences visual acuity, which is sharpest when the object is

KEY TERMS

Accommodation—The eye’s ability to focus clearly on both near and far objects.

Cones—Photoreceptors for daylight and color vision are found in three types, each type detecting visible wavelengths in either the short, medium, or long, (blue, green, or red) spectrum.

Ganglion cells—Neurons in the retina whose axons form the optic nerves.

Ocular dominance—When cells in the striate cortex respond more to input from one eye than from the other.

Optic pathway—The neuronal pathway leading from the eye to the visual cortex. It includes the eye, optic nerve, optic chiasm, optic tract, geniculate nucleus, optic radiations, and striate cortex.

Rods—Photoreceptors which allow vision in dim light but do not facilitate color.

Stereopsis—The blending of two different images into one single image, resulting in a three-dimensional image.

Suppression—A “blocking out” by the brain of unwanted images from one or both eyes. Prolonged, abnormal suppression will result in underdevelopment of neurons in the visual pathway.

Synapse—Junction between cells where the exchange of electrical or chemical information takes place.

Visual acuity—Keeness of sight and the ability to focus sharply on small objects.

Visual field—The entire image seen with both eyes, divided into the left and right visual fields.

projected directly onto the central fovea—a tiny indentation at the back of the retina comprised entirely of cones. Acuity decreases rapidly toward the retina’s periphery, as well as the number of cones. Studies have indicated recently that this may result from the decreasing density of ganglion cells toward the retina’s periphery.

Luminance

Luminance is the intensity of light reflecting off an object, and influences visual acuity. Dim light activates only rods, and visual acuity is poor. As luminance increases, more cones become active and acuity levels rise. Pupil size also affects acuity. When the pupil

expands, it allows more light into the eye. However, because light is then projected onto a wider area of the retina, optical irregularities can occur. Two issues are key regarding pupil size: light to the retina—more is better, up to a point; and, whether or not the light is hitting the rods or the the cones—for example, with bright illumination, the pupil naturally constricts because only cones are stimulated and thus increase visual acuity. A very narrow pupil can reduce acuity because it greatly reduces retinal luminance; but a small pupil (for example, a “pinhole”) will increase acuity in people with refractive errors. Optimal acuity seems to occur with an intermediate pupil size, but the optimum size varies depending on the degree of external luminance.

Accommodation

Accommodation is the eye’s ability to adjust its focus in order to bring about sharp images of both far and near objects. Accommodation begins to decline around age 20 and is so diminished by the mid-50s that sharp close-up vision is seldom possible without corrective lenses. This condition, called **presbyopia**, is the most common vision problem in the world.

Role in human health

Human memory and mental processes rely heavily on sight. There are more neurons in the nervous system dedicated to vision than to any other of the five senses, indicating vision’s importance. The almost immediate interaction between the eye and the brain in producing vision makes even the most intricate computer program pale in comparison. Although sighted individuals might seldom pause to imagine life without sight, vision is considered to be the most desirable of all human senses. Without it, a person’s relationship to the surrounding world and the ability to interact with the environment, is considered seriously diminished.

Common diseases and disorders

Color-blindness

Approximately 8% of all human males experience abnormal color vision, or color “blindness” or deficiency. Women who experience color-deficiency will pass the X-linked recessive gene to any son, and each will be color-blind. Color-blindness is caused when one of the pigments in a person’s photoreceptors is abnormal. Red deficient individuals are easier to categorize because that wavelength has minimal overlap with the other primary colors.

Various diseases and conditions can also cause color-blindness. These defects usually occur in one eye

and can be intermittent, while congenital defects are present in both eyes and remain constant.

Strabismus

Strabismus is the condition whereby visualization of two images occurs when viewing a single object. This results from a lack of parallelism of the visual axes of the eyes. In one form (known colloquially as cross-eyes) one or both eyes turn inward toward the nose. In another form, (known colloquially as wall-eyes), one or both eyes turn outward. A person with strabismus does not usually see a double image—particularly if onset was at a young age and remained untreated. This occurs due to the brain's suppression of the image from the weaker eye, causing neurons associated with the dominant eye (ocular dominance) take over.

Amblyopia (known colloquially as lazy eye) is the most common visual problem associated with strabismus. Amblyopia involves severely impaired visual acuity, and is the result of suppression and ocular dominance; it affects an estimated 4 million people in the United States and is a common cause of blindness in younger people.

Strabismus appears to be hereditary, and is often obvious soon after birth. In many cases, strabismus is correctable. The critical period extends until a child reaches the ages of six or seven. It is involved in normal neuronal development of vision thus rendering it crucial that the problem be detected and treated as early as possible.

Other common visual problems

Slight irregularities in the shape or structure of the eyeball, lens, or cornea cause imperfectly focused images on the retina. Resulting visual distortions include **hyperopia** (far-sightedness, or the inability to focus on close objects), **myopia** (near-sightedness, in which distant objects appear out of focus), and **astigmatism** (which causes distorted visual images) and presbyopia. These distortions can usually be rectified with corrective lenses or refractive surgery.

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ORGANIZATIONS

The Lighthouse National Center for Education. 111 E. 59th Street. New York, NY 10022. (800) 334-5497.
<<http://www.lighthouse.org>>.

National Eye Institute of the National Institute of Health. 9000 Rockville Pike, Bethesda, MD 20892. (301) 496-5248.
<<http://www.nei.nih.gov>>.

Mary Bekker

Visual disorders

Definition

Visual disorders are an impairment in **vision**, the ability to see. Total blindness is the inability to tell light from dark, or the total lack of vision. Visual impairment or low vision is a severe reduction in vision that cannot be corrected with standard glasses or **contact lenses**, and reduces a patient's ability to function at certain tasks. Legal blindness, defined as a severe visual impairment, refers to a best-corrected central vision of 20/200 or worse in the better eye, best corrected, or a visual acuity of better than 20/200 but with a visual field no greater than 20°—for example, side vision that is so reduced that it appears as if the person is looking through a tunnel.

Description

Vision is measured, as a rule, using a Snellen chart. A Snellen chart has letters of different sizes that are read, one eye at a time, from a distance of 20 ft. People with normal vision are able to read the 20 ft line at 20 ft—20/20 vision—or the 40 ft line at 40 ft, the 100 ft line at 100 ft, and so forth. If at 20 ft the smallest readable letter is larger, vision is designated as the distance from the chart over the size of the smallest letter that can be read.

Eye care professionals measure vision in many ways. Vision clarity indicates the strength of an individual's central visual status. The diopter is the unit of measure for refractive errors such as nearsightedness, far-sightedness, and **astigmatism**, and indicates the strength of corrective lenses needed. Patients do not just see straight ahead; the entire vision area is called the visual field. Some patients see clearly but have areas of reduced vision or blind spots in parts of their visual field. Others

have good vision in the center but poor vision around the edges (peripheral visual field). Patients with very poor vision may be unable to view any letters on the eye chart; they then will be asked to count fingers at a given distance from their eyes. This distance becomes the measure of their ability to see.

The World Health Organization (WHO) defines impaired vision in five categories:

- Low vision 1 is a best corrected visual acuity of 20/70.
- Low vision 2 starts at 20/200.
- Blindness 3 is below 20/400.
- Blindness 4 is worse than 5/300.
- Blindness 5 is no light perception at all.
- A visual field between 5° and 10° (compared with a normal visual field of about 120°) enters category 3; less than 5° into category 4, even if the tiny spot of central vision is perfect.

Color blindness represents the reduced ability to perceive certain colors, usually red and green. It is a hereditary defect and affects few tasks. Contrast sensitivity describes the ability to distinguish one object from another. Patients with reduced contrast sensitivity may have problems seeing things in the fog, for instance, due to decreased contrast between the object and the fog.

According to the WHO over 40 million people worldwide have vision that is category 3 or worse, 80% of whom live in developing countries. Half of the blind population in the United States is older than 65.

Causes and symptoms

The leading causes of blindness include:

- **macular degeneration**
- **glaucoma**
- **cataracts**
- diabetes mellitus

Other possible etiologies include infections, injury, or poor **nutrition**.

Infections

Most infectious eye diseases have been eliminated in the industrialized nations through sanitation, medication, and **public health** measures. Viral infections are the main exception to this statement. Some infections that may lead to visual impairment include:

- Herpes simplex keratitis. A viral **infection** of the cornea. Repeated occurrences may lead to corneal scarring.

- Trachoma. Trachoma is caused by an incomplete bacterium, *Chlamydia trachomatis*, that is easily treated with standard **antibiotics**. It is transmitted directly from eye to eye, mostly by flies. The chlamydia gradually destroy the cornea. This disease accounts worldwide for six to nine million of the third of a billion documented cases of blindness.
- Leprosy (Hansen's disease). This is bacterial disease that has a high affinity for the eyes. It can be effectively treated with medicines.
- River blindness. Much of the tropics of the Eastern Hemisphere are infested with *Onchocerca volvulus*, a worm that causes "river blindness." This worm is transmitted by fly bites and can be treated with a drug called ivermectin. Twenty-eight million people suffer from the disease, and 40% of those have incurred blindness as a result.

Other causes

When a pregnant woman is exposed to certain diseases, such as, rubella or toxoplasmosis, congenital eye problems can occur in her child. Also, eye injuries can result in blindness. **Brain** disease, or disease in the optic nerves accounts for a minimal amount of blindness. **Multiple sclerosis** and similar nervous system diseases, brain tumors, eye socket diseases, and head injuries are also rare causes of blindness.

Nutrition

Vitamin A deficiency is a widespread cause of corneal degeneration in children in developing nations. As many as five million children develop xerophthalmia from this deficiency each year. Five percent become blind.

Diagnosis

A low vision examination differs from a general examination. In many cases, the patient already has had a complete eye exam and is referred to a low vision specialist. These specialists can be either optometrists (O.D.s) or ophthalmologists (M.D.s). Case history, visual status, and eye health evaluation are common to both examinations, but other elements vary.

Because the low vision examination often results from a general examination, the specialists focus more intensely on the specific complaints detailing a patient's daily visual demands. Examiners must determine the exact source and outcome of the patient's visual challenges. Because many of these patients are elderly and may not want to complain about poor vision, it is crucial that the physician or ophthalmic assistant document the

patient's complaints by asking specific questions. For example, one question might be whether the patient is experiencing difficulty reading a phone book or street signs. Examiners might also give patients a "take-home test." Sometimes patients can see and read the charts easily in the physician's office. However, the difference between an acuity chart in the doctor's office and a newspaper read in poor lighting at someone's dining room table could be a key to understanding what problems the person is experiencing on a daily basis, and how best to address them.

Tests may include depth perception, color vision, and contrast sensitivity. Eye charts, with a larger range of letters than a Snellen eye chart, will be used. Testing distance will vary depending on the patient's ability to see. Refraction is facilitated with the use of a trial frame. Patients with poor vision may not be able to distinguish between lenses in the phoropter. The take-home test is more "real-life" in that it enables the patient to utilize his or her side vision as well.

Treatment

There are many options for patients with visual impairment. There are optical and nonoptical aids. Optical aids include:

- Telescopes. May be used to read street signs, watch television, and attend plays and sporting events.
- Hand magnifiers. May be used to read labels on items at the store, and menus.
- Stand magnifiers. May be used to read books, magazines, and other material.
- Prisms. Are utilized to move the image onto a healthy part of the retina, providing a helpful technique for vision only in eye diseases in which the healthy part of the retina exists.
- Closed circuit television (CCTV). For large magnification (for example, for reading fine print).

Nonoptical aids include special illumination, large print books and magazines, check-writing guides, large print dials on the telephone, and more. Special computer software is also used to provide low vision patients usable access—access which enable the individual to read what is being accessed—to computer programs.

Ophthalmic occupational therapists or rehabilitation specialists usually work in tandem with low vision specialists to help patients use these devices properly. Many times these professionals will make visits to the patient's home to ensure correct use of these aids and answer any



Optometrist administering glaucoma test to a female patient. (Custom Medical Stock Photo. Reproduced by permission.)

questions about low vision. Patients sometimes will be able to use the device correctly in the physician's office, but may be unable to do so at home. This inability can be due to forgetfulness; more often it is due to a low vision plan that has not been correctly adapted to the person's home environment. Home visits are crucial for effective treatment.

In some geographic areas as of 2001, **Medicare** has paid for part of the low vision therapy and rehabilitative services. However, low vision aids were not reimbursed by Medicare.

For those who are blind, extensive resources are available to improve the quality of life. For the legally blind, financial assistance for help may be possible from state and private organizations. Braille and audio books are increasingly available. Books-on-tape are provided free of charge from the Library of Congress to those who qualify as legally blind; and the service is usually arranged through the local public library. Guide dogs provide well-trained eyes and independence. Occupational therapists and rehabilitation specialists can provide orientation and mobility training. Special schools for blind children exist throughout the United States, as well as access to disability support through Social Security and private institutions.

Prognosis

The prognosis is often determined by the severity of the impairment and the ability of the aids to correct it. It also depends on the patient's ability and willingness to learn how to utilize the devices. The benefits of a thorough low vision examination include presentation of the most current low vision aids.

Health care team roles

Skilled ophthalmic nurses, technicians, and assistants help the O.D.s and M.D.s diagnose low vision by assisting with testing. These professionals log the patient history and perform many of the preliminary tests. Highly skilled technicians perform visual field tests and refractions.

Occupational therapists and rehabilitation specialists play an important role in treating low vision patients. They answer questions about low vision aids and instruct them on the devices' proper uses. They also help provide a sense of independence to these patients who may have previously been restricted in their activities by a total lack of, or limited vision.

These therapists and specialists also help totally blind patients adjust to daily life by providing orientation and mobility training. They evaluate home and job environments and make recommendations for adaptation. These professionals also consult with family members to ensure effective care methods. Especially with older adults, a total care plan that includes family and caretakers is essential to the success of offsetting the negative effects or trauma of decreased vision.

Patient education

Low vision specialists, the referring O.D.s and M.D.s, and ophthalmic staff need to make sure their patients fully understand their conditions. Many elderly patients are confused by the diagnosis and need to be carefully told what their condition means, what treatment options they can utilize. Some practitioners use a video explaining macular degeneration, for example, to further emphasize the disease's impact. Large-print brochures also are helpful. Occupational therapists and rehabilitation specialists need to make sure they emphasize the correct use of visual aids so patients can receive the maximum benefit from them.

Prevention

Regular eye exams are important to detect silent eye problems (for example, glaucoma). Left untreated, glaucoma can result in blindness.

Corneal infections can be treated with effective antibiotics. When a cornea has become opaque beyond recovery it must be transplanted.

Cataracts should be removed when they interfere with a person's quality of life.

Primary prevention addresses the causes before they begin to cause eye damage. In those climates and environments where it is an issue for eye diseases, fly control

can be accomplished by simple sanitation methods. Public health measures can reduce the incidence of many infectious diseases. Vitamin A supplementation, when appropriate, will eliminate xerophthalmia completely. Some studies show that protecting the eyes against ultraviolet (UV) light will reduce the incidence of cataracts, macular degeneration, and some other eye diseases. UV coatings can be placed on regular glasses, sunglasses, and ski goggles. Protective goggles should also be worn during certain activities for protection.

Secondary prevention addresses treating established diseases before they cause irreversible eye damage. Regular general physical examinations can also detect systemic diseases such as diabetes or high **blood pressure**. Diabetes control is a crucial factor in preserving sight in people affected by the disease.

Resources

BOOKS

"Neuro-ophthalmology." *Cecil Textbook of Medicine*, edited by J. Claude Bennett, and Fred Plum. Philadelphia, PA: W. B. Saunders, 1996.

ORGANIZATIONS

American Academy of Ophthalmology. P.O. Box 7242, San Francisco, CA 94120-7242. (415) 561-8500.

<<http://www.eyenet.org>>.

American Foundation for the Blind. 11 Penn Plaza, Suite 300, New York, NY 10001. (800) 232-5463.

<<http://www.afb.org>>.

Guide Dogs for the Blind. P.O. Box 1200, San Rafael, CA 94915. (415) 499-4000. <<http://www.guidedogs.org>>.

International Eye Foundation. 7801 Norfolk Avenue, Bethesda, MD 20814. (301) 986-1830.

The Lighthouse National Center for Education. 111 E. 59th Street. New York, NY 10022. (800) 334-5497.

<<http://www.lighthouse.org>>.

National Association for the Visually Handicapped. 22 West 21st Street, New York, NY 10010. (212) 889-3141.

National Center For Sight. (800) 221-3004.

National Children's Eye Care Foundation. One Clinic Center, A3-108, Cleveland, OH 44195. (216) 444-0488.

National Eye Institute of the NIH. 9000 Rockville Pike, Bethesda, MD 20892. (301) 496-5248.

<<http://www.nei.nih.gov>>.

Mary Bekker

Visual evoked potential study see **Evoked potential studies**

Vital capacity test see **Pulmonary function test**

Vital signs

Definition

Simply stated, vital signs are “signs of life.” Temperature, beat of the **heart** (pulse), respiratory rate, and **blood pressure** signal that a person is alive. All of these vital signs can be observed, measured, and monitored. This will enable the assessment of the level at which the individual is functioning. Normal ranges of measurements of vital signs change with a person’s age and medical condition.

Purpose

To establish a baseline on admission to a hospital or clinic, the nurse should take the patient’s vital signs. It is his or her responsibility to detect any abnormalities from the patient’s normal state, and to establish if current medication(s) is having the desired effect.

Precautions

As there may be no knowledge of the patient’s previous vital signs for comparison, it is important that the nurse be aware that there is a wide range of normal values that can apply to patients of different ages. The nurse should take as detailed a medical history from the patient as possible; any known medical or surgical history, prior measurements of vital signs, and details of current medication(s) should be recorded on the patient’s chart. Any physical exertion prior to measurement of vital signs, such as climbing stairs, may affect the measurements. Thirty minutes prior to the taking of one’s vital signs, the patient should not have consumed tobacco, caffeinated drinks, or alcohol.

Blood pressure is taken using a cuff that is the correct size for the patient; this will provide the most accurate reading. The reading can be 10 to 50 millimeters (mm) Hg too high with a cuff that is too small; a false reading of **hypertension** (high blood pressure) may result.

All types of sphygmomanometers—a cuff that can be filled with air, a hollow rubber bulb that pumps the air, and a glass tube that contains a column of mercury—should be calibrated annually by a trained technician. This will ensure that equipment remains accurate.

Description

Vital signs are recorded from once hourly to four times hourly, and as required by the patient’s condition.

Temperature is recorded to check for pyrexia (a febrile condition) or to monitor the degree of hypothermia. The body’s normal temperature, taken orally, is 98.6°F (37°C), with a range of 97.8 to 99.1°F (36.5–37.2°C). A **fever** is a temperature of 101°F (38.3°C) or higher in an infant younger than three months or above 102°F (38.9°C) for older children and adults. Hypothermia is recognized as a temperature below 96°F (35.5°C).

The pulse is checked for any abnormalities of the heart by measuring the rate, rhythm, and regularity of the beat, as well as the strength and tension of the beat against the arterial wall. The strength of the beat is raised during conditions such as fever and lowered by conditions such as **shock** and intracranial pressure. The average rate for older children (age 12 and up) and adults is 72 beats per minute (bpm). Tachycardia is a pulse rate over 100 bpm, while bradycardia is a pulse rate of under 60 bpm.

Respirations are quiet, slow, and shallow when the adult is asleep, and rapid, deeper, and noisier during and after activity.

Average respiration rates at rest are:

- infants, 34 to 40 per minute
- children five years of age, 25 per minute
- older children and adults, 16 to 20 per minute

Tachypnea is rapid respiration above 20 per minute.

Blood pressure is recorded for older children and adults. A normal blood pressure reading is 120/70.

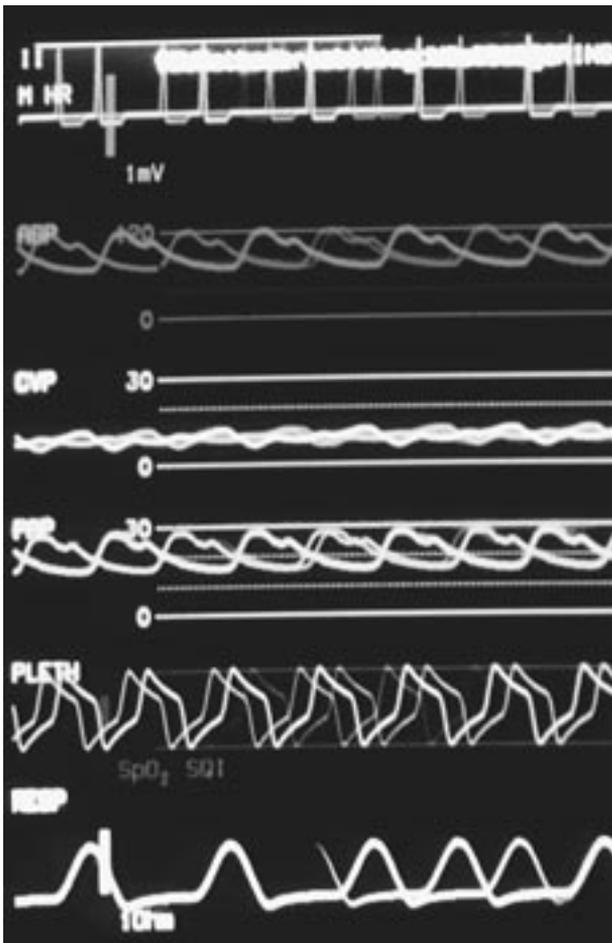
Preparation

The patient should be sitting down or lying comfortably to ensure that the readings are taken in a similar position each time. There should be little excitement, which can affect the results. The equipment required is a watch with a second hand, an electronic or mercury **thermometer**, an electronic or manual **sphygmomanometer** with an appropriate sized cuff, and a **stethoscope**.

Manufacturer’s guidelines should be followed when taking a temperature with an electronic thermometer. The result displayed on the LCD screen should be read, then recorded in the patient’s chart. Electronic temperature monitors do not have to be cleaned after use. They have protective guards that are disposed of after each use; these ensure that infections are not spread.

A mercury thermometer can be used to monitor a temperature by three methods:

- Axillary, under the armpit.



Normal vital signs, from the top: heart rate, arterial blood pressure (ABP), central venous pressure (CVP), pulmonary artery pressure (PAP), blood oxygen (PLETH), and respiration rate. (Photograph by James King-Holmes. Science Source/Photo Researchers. Reproduced by permission.)

- Oral, under the tongue. This method is never used with infants or very young children. Very young children might accidentally bite or break them. They also have difficulty holding oral thermometers under their tongues long enough for their temperatures to be accurately measured.
- Rectally, inserted into the rectum. This method is the gold standard for recording the temperature of infants. Although somewhat controversial because of potential discomfort and trauma to the baby, the investigators of a Harvard Medical School study, published in *Archives of Pediatrics and Adolescent Medicine* discovered that rectal thermometers were more accurate than ear thermometers in detecting high fevers. With the ability to detect low-grade fevers, rectal thermometers can be useful in discovering serious illnesses, such as **meningitis** and **pneumonia**. The tip of the thermometer is

usually blue tipped to distinguish it from the silver tip of an oral/axillary thermometer.

To record the temperature using a mercury thermometer, one should shake down the thermometer by holding it firmly at the clear end and flicking it quickly a few times, with the silver end pointing downward. The health care provider who is taking the temperature should confirm that the mercury is below a normal body temperature.

The silver tip of the thermometer should be placed under the patient's right armpit. The arm clamps the thermometer into place, against the chest. The thermometer should stay in place for three to four minutes. After the appropriate time has elapsed, the thermometer should be removed and held at eye level. During this waiting period, the body temperature will be measured. The mercury will have risen to a mark that indicates the temperature of the patient.

To record the oral temperature, the axillary procedure should be followed, except that the silver tip of the thermometer should be placed beneath the tongue for three to four minutes, then read as described previously.

In both cases, the thermometer is wiped clean with an antiseptic and stored in an appropriate container to prevent breakage.

The rectal thermometer, used to take accurate temperatures in infants, should be shaken down, as discussed previously. A small amount of water-based lubricant should be placed on the colored tip of the thermometer. With the infant lying on his or her back, the nurse must hold the child securely in place. The tip of the thermometer should then be inserted into the child's rectum carefully to avoid discomfort and possible injury—no more than one-half inch, or 2 cm—and held there for two to three minutes. After the thermometer is removed, it should be read (as described previously), and wiped clean with an antibacterial wipe. It should then be stored in an appropriate container to prevent breakage.

The pulse can be recorded anywhere that a surface artery runs over a bone, but the radial artery in the wrist is the more common point. To take the pulse, one should place his or her index, middle, and ring fingers over the radial artery. It is located above the wrist, on the anterior surface of the thumb side of the arm. Gentle pressure should be applied, taking care to avoid obstructing the patient's blood flow. The rate, rhythm, strength, and tension of the pulse should be noted. If there are no abnormalities detected, the pulsations can be counted for half a minute, and the result doubled. However, any irregularities discerned indicate that the pulse should be recorded for one minute. This will eliminate the possibility of error.

The fingers should be kept on the wrist, while the frequency of respirations in one minute is recorded. Every effort should be made to prevent patients from becoming aware that their breathing is being checked; if the patients were to realize this, they might consciously alter the rate at which they breathe. Both pulse and respiration results should be noted in the patient's chart.

Blood pressure is taken using a cuff that is the correct size for the patient. This will ensure the most accurate reading possible. With an electronic unit, the cuff is placed level with the heart and, if possible, wrapped around the upper left arm. Following the manufacturer's guidelines, the cuff is inflated and then deflated automatically, and the health care provider records the reading. If blood pressure is monitored manually, a cuff is placed level with the heart and wrapped around the upper arm. Placing a stethoscope over the brachial artery in front of the elbow with one hand and listening through the earpiece, the cuff should be inflated until the artery is occluded, and no sound is heard. The cuff should then be inflated a further 10 mm Hg above the last sound heard. Opening the valve in the pump slowly—no faster than 5mm Hg per second—pressure in the cuff is deflated until a sound is detected over the brachial artery. This point is noted as the systolic pressure. The pressure is further deflated until a soft muffled sound is heard. This allows the diastolic pressure to be taken. As in the case with in children, sounds will continue to be heard as the cuff deflates to zero.

The results are charted, with the systolic pressure being recorded first, and then the diastolic pressure. An entry in the patient's chart might appear as 120/70 (systolic/diastolic).

Aftercare

The patient should be made comfortable and reassured that recording vital signs is part of normal health checks, and that it is necessary to ensure that his or her health is being correctly monitored. Any abnormalities in the vital signs must be reported to the medical staff.

Complications

There is a nationwide initiative to ban the sale of mercury thermometers and promote mercury-free devices for monitoring blood pressure. Health activists are concerned about mercury contaminating the environment after it has been discarded. Several states have banned the use of products containing mercury and stores such as Wal-Mart, CVS, and Kmart have already stopped selling mercury thermometers. According to a study by the Mayo Clinic in March 2001, mercury-free devices

KEY TERMS

Blood pressure—The pressure of the blood on the walls of the arteries, depending on the energy of the heart action, elasticity of the arterial walls, and volume and viscosity (resistance of flow) of blood. The tension of the blood in the arteries measured in millimeters of mercury by a sphygmomanometer or by an electronic device.

Occlusion—Closed.

p.r.n.—pro re nata; as required.

Respiration—The gaseous exchange between the tissue cells and the atmosphere.

can monitor information without compromising accuracy. The Environmental Protection Agency's October 1999 report, "Reducing Mercury Use in Health Care," advises using alternative mercury products to avoid the future need for increased regulations and to protect human health and wildlife by reducing unnecessary exposure to mercury.

Results

The vital signs are recorded and compared with normal ranges for the patient's age and medical condition. Based on these results, it is decided whether any further action needs to be taken.

Health care team roles

Patients may ask questions about specific concerns they have regarding their vital signs, or even about a particular disease. The nurse can counsel on the prevention of illness, but can direct the patient to the physician for specific questions.

Resources

PERIODICALS

"Eleven of the Nation's Leading Retailers and Manufacturers Give Mercury Fever Thermometers the Heave-Ho."
PRNewswire via COMTEX/Health Care Without Harm.
Accessed September 27, 2000.

ORGANIZATIONS

American Nurses Association, 600 Maryland Avenue, SW, Suite 100 West, Washington, DC 20024. (202) 651-7000.

OTHER

"About Blood Pressure." American Heart Association, National Center, 7272 Greenville Avenue, Dallas, TX 75231. 800-AHA-USA1.

- Associated Press. "Best Way to Take Baby's Temperature? Bottoms Up!" Chicago. <http://www.abclocal.go.com/wtvd/health/031401_NH_thermometers.html>. Accessed June 29, 2001.
- Environmental Protection Agency. <<http://www.epa.gov/bns/merchealth>>.
- Franklin Institute Online. "Vital Signs." Accessed June 17, 2001. <<http://www.sln.fi.edu>>.
- "High Blood Pressure." <<http://www.Mayoclinic.com>> September 28 2000.
- "Home Monitoring of High Blood Pressure." American Heart Association, National Center, 7272 Greenville Avenue, Dallas, TX 752311. 800-AHA-USA1.
- Rathe, Richard. "Vital Signs." *University of Florida*. Accessed December 19, 2000. <<http://www.medinfo.ufl.edu/yea1/bcs/clist/vitals.html>>
- "Vital signs." *University of Maryland Medicine*. <<http://www.umm.drkoop.com>>. June 24, 2001.
- "What is High Blood Pressure?" American Heart Association, National Center, 7272 Greenville Avenue, Dallas, TX 752311. 800-AHA-USA1.

Margaret A Stockley, RGN

Vital signs in the aging

Definition

Vital signs are basic health status indicators. They include temperature, pulse, rate of respiration, and **blood pressure**. Several physiologic changes occur in the elderly which may impact the measurement of vital signs by the health care practitioner.

Purpose

Vital signs are measured to obtain basic indicators of a patient's health status. If outside of a normal range of values, they may point to dysfunction or a disease state.

Precautions

There are no significant contraindications to the measurement of vital signs in the aging patient.

Description

Some normal vital sign values may change as a person ages because of normal physiologic processes. The health care practitioner should be aware of these normal changes when assessing vital signs.

Normal body temperature does not significantly change as a person grows older. However, heat regulation may be altered due to physiologic changes that occur as a result of normal aging and from diseases that frequently occur in the elderly. For example, the elderly have a more difficult time maintaining body heat because of a loss of subcutaneous fat and may frequently complain of being too cold. Conversely, an older person, especially one who is obese, may have a harder time keeping cool in warmer weather. The overall ability to perceive temperature decreases, contributing to the problem. The elderly patient may not always be able to mount a **fever** during an **infection**.

Changes in the **heart** may cause the resting heart rate to slow down as a person ages. The pulse may take longer to quicken when exercising and longer to return to normal afterwards. The elderly person who exercises attains a lower maximum heart rate. When assessing heart rate, the pulse should be measured in both arms for a period of 30 seconds and any irregularities noted.

The range of values for normal **blood** pressure does not change with aging. However, arterial stiffness tends to increase, causing blood pressure measurements to sometimes be falsely high. In addition, many older people, especially women, are nervous in the doctor's office, sometimes elevating the blood pressure above the individual's typical values. Proper measurement technique is important. Because occlusive atherosclerotic disease often decreases the systolic pressure in one arm, blood pressure measurements should be taken in both arms. In addition, **blood vessels** tend to respond more slowly to changes in body position as a person ages. For this reason, measurements should be made while the patient is in a sitting or supine (lying down on back) position, then immediately after the patient stands, so that orthostatic hypotension can be detected.

The normal respiratory rate in the older patient may be as high as 16 to 25 breaths per minute. Breathing may appear somewhat shallower than in the younger population. However, even a very elderly person should be able to breathe without effort in the absence of disease. A rate higher than 25 breaths per minute may indicate congestive **heart failure** or a lower respiratory tract infection.

Preparation

Instruct the patient regarding the rationale for vital sign measurement. The patient should be sitting or lying in a comfortable, relaxed position.

KEY TERMS

Orthostatic hypotension—Hypotension occurring immediately after a person gets up from a sitting or reclining position.

Results

A normal temperature range is 97.5°F to 99.5°F (36°C to 38°C). The resting heart rate may be lower than the normal 60-100 beats per minute in a younger person. Normal blood pressure is the same as for a younger adult: less than 140 mm Hg (systolic) over less than 90 mm Hg (diastolic). The normal respiratory rate of an older person ranges from 16 to 25 breaths per minute.

Health care team roles

Vital sign readings may be obtained by the physician, the nurse or nursing assistant, and the physical therapist.

Resources

BOOKS

Beers, Mark H. and Robert Berkow, eds. *The Merck Manual of Geriatrics*. Whitehouse Station, NJ: Merck & Co., Inc., 2000.

PERIODICALS

Currey, Chuck. "Biology and Physiology of Aging" *University of Florida PA Program Introduction to Medicine II* (Spring 2001).

ORGANIZATIONS

Administration on Aging 330 Independence Avenue SW, Washington DC, 20201. (202) 619-7501.

Deanna M. Swartout-Corbeil, R.N.

Vital signs in children

Definition

Vital signs are the observation of temperature, pulse, respiration, and **blood pressure**. Vital signs may be different in children those of adults or the elderly.

Purpose

The goal of obtaining a child's vital signs is to establish a baseline on admission and detect any abnormalities from the normal state.

Precautions

As there may be no prior knowledge of the patient's previous vital signs for comparison, it is important that the nurse be aware of the wide range of normal values that apply to children of different ages.

Description

Vital signs are recorded hourly to every four hours and as needed based on the patient's condition.

Temperature is recorded to check for pyrexia or monitor the degree of hypothermia. The body's normal temperature is 98.6°F (37°C). A **fever** is a body temperature two standard deviations greater than 98.6°F (37°C) taken orally, or 100.4°F (38°) taken rectally or above 102°F (38.9°C) for older children. Hypothermia is recognized by a temperature below 96°F (35.5°C).

The rate and rhythm of the pulse is checked to detect any abnormalities of the **heart**; the beat of the pulse is reflects the strength and tension of the beat against the arterial wall. The strength of the beat increases, for example, with fever; it is lowered by conditions such as **shock** and inter-cranial pressure.

Respirations are quiet, slow, and shallow when the child is asleep; the rapid, deeper and noisier respirations are heard during and after activity. Average rates of respiration:

- infants, 34 to 40 per minute
- children aged 1-5, 25 per minute
- children older than 5, 16 to 20 per minute

Preparation

Have the child sitting or lying comfortably and ensure a calm environment. Ensure that the readings are taken in similar positions each time, as a change in either can affect the results. The equipment required is a watch with a second hand, an electronic **thermometer**, an electronic or manual **sphygmomanometer**, and a **stethoscope**.

Follow the manufacturer's guidelines for taking a temperature with an electronic thermometer. Read the result displayed on the LCD screen and then record it in the patient's chart.

KEY TERMS

Blood pressure—The tension of the blood in the arteries measured in millimeters of mercury by a sphygmomanometer or by an electronic device.

Occlusion—Closed, or blocked.

p.r.n.—pro re nata, when required.

Respiration—The gaseous exchange between the tissue cells and the atmosphere.

The pulse can be recorded in many areas where a surface artery runs over a bone, but the radial artery in the wrist is the more common option. To take the pulse, place the index, middle, and ring fingers over the radial artery that is located above the wrist on the anterior surface of the thumb side of the arm. Apply gentle pressure to avoid obstructing the patient's **blood** flow. The rate, rhythm, strength and tension of the pulse should be noted. If there are no abnormalities detected, the pulsations can be counted for half a minute, and the result doubled. If, however, any irregularities are present, the pulse should be recorded for one full minute to avoid any discrepancies.

Keeping the fingers on the wrist, the frequency of respirations in one minute should be noted. The patient should not be made aware that breathing is being monitored; he or she may consciously modify his or her breathing, thereby affecting the respiratory rate. The pulse and respiration results are noted in the patient's chart.

If the child is old enough, the blood pressure is taken using a cuff that is the correct size. This will provide a more accurate reading.

With an electronic unit, the cuff is placed level with the heart and wrapped around the upper arm. Following the manufacturer's guidelines, the cuff is inflated and then deflated automatically; the nurse records the reading.

If blood pressure is monitored manually, a cuff is placed level with the heart and wrapped around the upper arm. Placing a stethoscope over the brachial artery in front of the elbow with one hand and listening through the earpiece, the cuff is inflated until the artery is occluded and no sound is heard. The cuff is then inflated a further 10 mmHg above the last audible sound. The valve in the pump is slowly opened no faster than 5 mm Hg per second to deflate the pressure in the cuff until a sound is heard over the brachial artery. This point is noted as the systolic pressure. The pressure is further deflated until a soft, muffled sound is heard. That point is noted as the diastolic pressure.

The results are charted: first, the systolic is noted, then the diastolic pressure. It is done in the following manner: xxx/xx (e.g., 120/70).

Aftercare

The child should be made comfortable and give assurance that recording vital signs is part of normal health checks, and that it is necessary to ensure that health is being correctly checked. Electronic temperature monitors have disposable protective guards for hygiene to prevent the spread of infections. Any abnormalities in the vital signs must be reported to the medical staff.

Complications

There is a nationwide initiative to ban the sale of mercury thermometers and mercury devices for monitoring blood pressure. There are concerns among health activists regarding mercury contaminating the environment after its disposal. In fact, several states have banned the use of products containing mercury. Mercury thermometers are not longer sold by many large, commercial retailers. The Environmental Protection Agency recommendation is to use alternatives to mercury products, to avoid the need for increased regulations in the future and to protect human health and wildlife.

Results

The vital signs are recorded and compared with normal ranges for the patient's age and medical condition. With the interpretation of the results, a decision is made regarding the need for any further action.

Health care team roles

The nurse can provide counseling on the normal development of children and the prevention of illness and injuries. Alternatively, the nurse can guide the child's caregiver to the patient's doctor.

Resources

PERIODICALS

Board, Michele. "Comparison of disposable and glass mercury thermometers." *Nursing Times* Vol. 91, no. 33, pp 36-37.

ORGANIZATIONS

American Association of Critical Care Nurses, 101 Columbia, Aliso Viejo, CA, 92656.

American Nurses Association, 600 Maryland Avenue, SW, Suite 100 West, Washington, DC 20024. (202) 651-7000.

National Association of Neonatal Nurses, 4700 W Lake Avenue, Glenview, IL 60025. (847) 375-3660 or (800) 451-3795.

National Association of Pediatric Nurse Associates and Practitioners, NAPNAP, 1101 Kings Highway, N, Suite 206, Cherry Hill, NJ 08034. (856) 667-1773.

OTHER

Environmental Protection Agency.
<<http://www.epa.gov/bns/merchealth>>.

Margaret A Stockley, RGN

Vitamin A

Description

Vitamin A is one of the four fat-soluble **vitamins** necessary for good health. It serves an important role as an antioxidant by helping to prevent free radicals from causing cellular damage. Adequate levels are important for good eyesight, and poor night **vision** may be one of the first symptoms of a deficiency. It is also necessary for proper function of the immune, skeletal, respiratory, reproductive, and integumentary (skin) systems.

General use

An adequate level of vitamin A unquestionably contributes to good health. It is essential for the proper function of the retina, where it can act to prevent night blindness, as well as lower the odds of getting age-related **macular degeneration** (AMD), which is the most common cause of blindness in the elderly. There is also evidence that good levels of vitamin A in the form of carotenoids may decrease the risk of certain cancers, **heart** attacks, and strokes. The **immune system** is also strengthened. It is unclear, however, that supplemental forms have the same benefit as consuming them in natural foods in the case of a person without deficiency. Taking high levels of vitamin A in any supplemental form is not advisable without the counsel of a healthcare professional.

Preparations

Natural sources

There are two basic forms of vitamin A. Retinoids, the active types, are contained in animal sources, including meat, whole milk, and eggs. Liver is particularly rich in vitamin A, since it is one of the storage sites for excess. Precursor forms of the vitamin (carotenoids) are found in orange and leafy green produce such as sweet potatoes, carrots, collard greens, spinach, winter squash, kale, and turnip greens. Very fresh foods have the highest levels,

followed by frozen foods. Typically, canned produce has little vitamin A. Preparing vegetables by steaming, baking, or grilling helps them to release the carotenes they contain. Alpha and beta carotene, as well as some of the other lesser-known carotenoids, can be converted to vitamin A in the **small intestine**. This is done by the body on an as-needed basis, so there is no risk of **overdose** as there is with the active form.

Supplemental sources

Supplements may contain either the active or precursor forms of vitamin A. The active form may be more desirable for those who may have some difficulty in converting the carotenoids into the active vitamin. This is more often true in those over age 55 or who have a condition that impairs absorption of fat. There is a water-soluble form of the vitamin, retinyl palmitate, which may be better utilized in the latter case. Carotenes are also available either as oil-based or natural water-based formulas. Be sure to store both away from light and heat, which will destroy them.

Units

There are several units that can express the amount of vitamin A activity in a product. Many supplements are still labeled with the old International Unit (IU), although the more current and most accurate unit is the Retinol Equivalent (RE). The new measurement distinguishes between the differences in absorption of retinol and beta carotene. One RE is equal to one microgram (μg) of retinol, or six μg of beta carotene.

Dose limits

Adults should take no more than 25,000 IU (5000 RE) per day of vitamin A in its active form, except in the case of women who are pregnant or may become pregnant. The latter group should not exceed 10,000 IU (2000 RE) per day in order to avoid potential toxic effects to the fetus. The best way to get vitamins is in the natural food form, as the complexities are not always either known or reproducible in a supplement. A diet rich in foods containing carotenoids is optimal, but in the event of nutritional deficiencies, supplements may be needed. Mixed carotenoids are preferable to either large doses of vitamin A or pure beta carotene supplements to avoid toxicity and maximize healthful benefits. Some of the minor carotenoids appear to have beneficial effects that are still being explored. A good mixture will contain alpha and beta carotene, as well as lycopene and xanthophylls. Eating foods high in many carotenoids may confer some benefits—such as lower risk of **cancer**, heart attacks, and strokes—which a supplement may not.

KEY TERMS

Antioxidant—Substance, such as vitamin A, which blocks the destructive action of free radicals.

Carotenoids—Any of a group of over 600 orange or red substances which are found primarily in vegetables, many of which are vitamin A precursors.

Free radical—Highly reactive atoms which are very reactive as a result of having one or more unpaired electrons. They form through exposure to smoke and other environmental pollutants, as well as radiation and other sources. They have great potential to cause cellular damage, and may even be a factor in aging.

Retinoids—Any of the group of substances which comprise active vitamin A, including retinaldehyde, retinol, and retinoic acid.

Deficiency

Low enough levels of vitamin A to cause symptomatic deficiency are uncommon in people of normal health in industrialized nations. Symptoms of deficiency may include, but are not limited to, loss of appetite, poor immune function causing frequent infections (especially respiratory), hair loss, rashes, dry skin and eyes, visual difficulties including night blindness, poor growth, and fatigue. Generally symptoms are not manifested unless the deficiency has existed for a period of months. Deficiencies are more likely in people who are malnourished, including the chronically ill and those with impaired fat absorption. Those with normal health and nutritional status have a considerable vitamin A reserve.

In countries where nutritional status tends to be poor and deficiency is more common, vitamin A has been found to reduce the mortality rate of children suffering from a number of different viral infections.

Risk factors for deficiency

Taking the RDA level of a nutrient will prevent a deficiency in most people, but under certain circumstances, an individual may require higher doses of vitamin A. Those who consume alcoholic beverages may be more prone to vitamin A deficiency. People taking some medications, including birth control pills, methotrexate, cholestyramine, colestipol, and drugs that act to sequester bile will also need larger amounts. Those who are malnourished, chronically ill, or recovering from surgery or other injuries

may also benefit from a higher dose than average. Patients undergoing treatments for cancer, including radiation and **chemotherapy**, typically have compromised immune systems that may be boosted by judicious supplementation with vitamin A. Other conditions that may impair vitamin A balance include chronic **diarrhea**, **cystic fibrosis**, and kidney or liver disease. Diabetics are often deficient in vitamin A, but may also be more susceptible to toxicity. Any supplementation for these conditions should be discussed with a healthcare provider. Supplements are best taken in the form of carotenoids to avoid any potential for toxicity. There is not an established RDA for beta carotene. Recommendations for how much to take vary between six and 30 milligrams a day, but the middle range—around 15mg—is a reasonable average.

Precautions

Overdose can occur when taking megadoses of the active form of this vitamin. Amounts above what is being utilized by the body accumulate in the liver and fatty tissues. Symptoms may include dry lips and skin, bone and joint **pain**, liver and spleen enlargement, diarrhea, vomiting, headaches, blurry or double vision, confusion, irritability, fatigue, and bulging fontanel (soft spot on the head) in infants; these are most often reversible, but a doctor should be contacted if a known overdose occurs. Very high levels of vitamin A may also create deficiencies of vitamins C, E, and K. Symptoms will generally appear within six hours following an acute overdose, and take a few weeks to resolve after ceasing the supplement. Children are more sensitive to high levels of vitamin A than adults are, so instructions on products designed for children should be followed with particular care. Vitamin supplements should always be kept out of reach of children.

It is especially important to avoid overdoses in **pregnancy**, as it may cause **miscarriage** or fetal malformations. Using supplements that provide carotenoids will avoid the potential of overdose. Those with kidney disease are also at higher risk for toxicity due to either vitamin A or beta carotene, and should not take these supplements without professional healthcare advice.

There is some evidence that taking beta carotene supplements puts smokers at higher risk of lung cancers. The CARET (Beta Carotene and Retinol Efficacy Trial) study is one that demonstrated this effect. Clarification through more study is needed, as evidence also exists showing that beta carotene, along with other antioxidants, can be a factor in cancer prevention. Some of the lesser-known carotenoids may be key factors. Whole sources are better obtained from foods than from supplements. Smokers should consult with a healthcare provider before taking supplemental beta carotene.

Side effects

Very high levels of carotenoids (carotenemia) may cause an orange discoloration of the skin, which is harmless and transient.

Interactions

Vitamin A supplements should not be taken in conjunction with any retinoid medications, including isotretinoin (Accutane), a drug used to treat acne. There is a higher risk of toxicity.

A very low fat diet or use of fat substitutes impairs absorption of all the fat-soluble vitamins, including A. Mineral oil and aluminum-containing **antacids** may also inhibit absorption, as do the cholesterol-lowering drugs cholestyramine and colestipol. Vitamin A reserves of the body are depleted by a number of substances, including alcohol, barbiturates, **caffeine**, cortisone, tobacco, and very high levels of **vitamin E**. Overuse of alcohol and vitamin A together may increase the possibility of liver damage.

Taking appropriate doses of **vitamin C**, vitamin E, **zinc**, and selenium optimizes absorption and use of vitamin A and carotenoids. As vitamin A is fat-soluble, a small amount of dietary fat is also helpful.

Studies of both children and pregnant women with **iron deficiency anemia** show that this condition is better treated with a combination of **iron** supplements and vitamin A than with iron alone.

Resources

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Vitamin B₁ see **Thiamine**

Vitamin B₂ see **Riboflavin**

Vitamin B₃ see **Niacin**

Vitamin B₇ see **Biotin**

Vitamin B₁₂

Description

Cobalamin, also known as B₁₂, is a member of the water-soluble family of **B vitamins**. It is a key factor in the body's proper use of **iron** and formation of red **blood** cells. The nervous system also relies on an adequate supply of cobalamin to function appropriately, as it is an essential component in the creation and maintenance of the myelin sheath that lines nerve cells. Other roles of cobalamin include working with pyridoxine (vitamin B₆) and **folic acid** to reduce harmful homocysteine levels, participating in the metabolism of food, and keeping the **immune system** operating smoothly.

General use

Very small amounts of cobalamin are needed to maintain good health. The RDA value is 0.3 micrograms (mcg) for infants under six months, 0.5 mcg for those six months to one year old, 0.7 mcg for children one to three years old, 1.0 mcg for children four to six years old, 1.4 mcg for children seven to 10 years old, and 2 mcg for those 11 years of age and older. Requirements are slightly higher for pregnant (2.2 mcg) and lactating (2.6 mcg) women.

The primary conditions that benefit from supplementation with cobalamin are megaloblastic and pernicious anemia. Megaloblastic anemia is a state resulting from an inadequate intake of cobalamin, to which vegans are particularly susceptible because of the lack of animal food sources. Vegans, who do not consume any animal products including meat, dairy, or eggs, should take at least 2 mcg of cobalamin per day in order to prevent this condition. In the case of pernicious anemia, intake may be appropriate but absorption is poor due to a lack of normal **stomach** substance, called intrinsic factor, that facilitates absorption of vitamin B₁₂. Large doses are required to treat pernicious anemia, which occurs most commonly in the elderly population as a result of decreased production of intrinsic factor by the stomach. Supplements are generally effective when taken orally in very large amounts (300-1000 mcg/day) even if no intrinsic factor is produced. These supplements require a prescription, and should be administered with the guidance of a health care provider. Injections, instead of the supplements, are often used.

Those who have infections, **burns**, some types of **cancer**, recent surgery, illnesses that cause decay or loss of strength, or high amounts of **stress** may need more than the RDA amount of B₁₂ and other B vitamins. A balanced supplement is the best approach.

KEY TERMS

Homocysteine—An amino acid produced from the metabolization of other amino acids. High levels are an independent risk factor for heart disease.

Megaloblastic anemia—A condition caused by cobalamin deficiency, which is characterized by red blood cells which are too few, too fragile, and abnormally large. Also known as macrocytic anemia.

Pernicious anemia—Megaloblastic anemia resulting from a cobalamin deficiency that is the result of poor absorption due to inadequate production of intrinsic factor in the stomach.

Vegan—A person who doesn't eat any animal products, including dairy and eggs.

Male **infertility** can sometimes be resolved through use of cobalamin supplements. Other conditions that may be improved by cobalamin supplementation include: **asthma**, atherosclerosis (hardening of the arteries caused by plaque formation in the arteries), **bursitis** (inflammation of a bodily pouch, especially the shoulder or elbow), **Crohn's disease** (chronic recurrent inflammation of the intestines), depression, diabetes, high cholesterol, **osteoporosis**, and vitiligo (milky-white patches on the skin). There is not enough evidence to judge whether supplementation for these diseases is effective.

Preparations

Natural sources

Usable cobalamin is only found naturally in animal source foods. Fresh food is best, as freezing and exposure to light may destroy some of the vitamin content. Clams and beef liver have very high cobalamin levels. Other good sources include chicken liver, beef, lamb, tuna, flounder, liverwurst, eggs, and dairy products. Some plant foods may contain cobalamin, but it is not in a form that is usable by the body.

Supplemental sources

Cobalamin supplements are available in both oral and injectable formulations. A nasal gel is also made. Generally a balanced B-complex vitamin is preferable to taking high doses of cobalamin unless there is a specific indication for it, such as megaloblastic anemia. Strict vegetarians will need to incorporate a supplemental source of B₁₂ in the diet. Cyanocobalamin is the form

most commonly available in supplements. Two other, possibly more effective, types are hydrocobalamin and methyl-cobalamin. As with all supplements, cobalamin should be stored in a cool, dry, dark place and out of the reach of children.

Deficiency

Cobalamin deficiency may be manifested as a variety of symptoms since cobalamin is so widely used in the body. Severe fatigue may occur initially. Effects on the nervous system can be wide-ranging, and include weakness, numbness and tingling of the limbs, **memory** loss, confusion, delusion, poor balance and **reflexes**, **hearing** difficulties, and even **dementia**. Severe deficiency may appear similar to **multiple sclerosis**. Nausea and **diarrhea** are possible gastrointestinal signs. The anemia that results from prolonged deficiency may also be seen as a pallor, especially in mucous membranes such as the gums and the lining of the inner surface of the eye.

Megaloblastic anemia is a common result of inadequate cobalamin. This condition can also result if a person stops secreting enough intrinsic factor in the stomach, a substance essential for the absorption of cobalamin. Inadequate intrinsic factor leads to pernicious anemia, so called because it persists despite iron supplementation. Long-term deficiencies of cobalamin also allow homocysteine levels to build up. Negative effects of large amounts of circulating homocysteine include **heart** disease, and possibly **brain** toxicity. Taking high levels of folic acid supplements can mask cobalamin deficiency and prevent the development of megaloblastic anemia, but neurological damage can still occur. This damage may become permanent if the cobalamin deficiency persists for a long period of time.

Risk factors for deficiency

The primary groups at risk for cobalamin deficiency are vegans who are not taking supplements, and the elderly. Older adults are more likely to have both insufficient intrinsic factor secreted by the stomach and low levels of stomach acid, causing cobalamin to be poorly absorbed. Malabsorptive diseases and stomach surgery can also predispose to a deficiency.

Precautions

People who are sensitive to cobalamin or cobalt should not take cobalamin supplements. Symptoms of hypersensitivity may include swelling, itching, and **shock**. Adverse effects resulting from B₁₂ supplementation are rare. Cobalamin should also be avoided by those

who have a type of hereditary optic nerve atrophy known as Leber's disease.

Side effects

Very high doses of cobalamin may sometimes cause acne.

Interactions

Large amounts of **vitamin C** taken within an hour of vitamin B supplements will destroy the cobalamin component. Absorption of cobalamin is also impaired by deficiencies of folic acid, iron, or **vitamin E**. Improved absorption occurs when it is taken with other B vitamins or **calcium**. Some medications may also cause an increased use or decreased absorption of this vitamin. Those on colchicine, **corticosteroids**, methotrexate, metformin, phenformin, oral contraceptives, cholestyramine, colestipol, clofibrate, epoetin, neomycin, or supplemental potassium may need extra cobalamin. Use of nicotine products or excessive alcohol can deplete B₁₂.

Resources

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both names and corresponding numbers. They are B₁ (thiamin), B₂ (**riboflavin**), B₃ (**niacin**), B₅ (pantothenic acid), B₆ (pyridoxine), B₇ (**biotin**), B₉ (**folic acid**), and B₁₂ (cobalamin). Biotin in particular is not always included in B complex supplements. The numbers that appear to have been skipped were found to be duplicate substances or non-vitamins. The four unnumbered components of B complex that can be synthesized by the body are choline, inositol, PABA, and lipoic acid. As a group, the B vitamins have a broad range of functions. These include maintenance of myelin, which is the covering of nerve cells. A breakdown of myelin can cause a large and devastating variety of neurologic symptoms. B vitamins are also key to producing energy from the nutrients that are consumed. Three members of this group—folic acid, pyridoxine, and cobalamin—work together to keep homocysteine levels low. This is quite important, since high homocysteine levels are associated with **heart** disease. Some B vitamins prevent certain birth defects (like neural tube defects), maintain healthy red **blood** cells, support immune function, regulate cell growth, aid in production of hormones, and may have a role in preventing some types of **cancer**. They also function in maintenance of healthy skin, hair, and nails.

General use

There are many claims for usefulness of various B vitamins. **Thiamine** is thought to be supportive for people with **Alzheimer's disease**. Niacin at very high doses is useful to lower cholesterol, and balance high-density (HDL) and low-density (LDL) lipoproteins. This should be done under medical supervision only. Some evidence shows that niacin may prevent juvenile diabetes (type I insulin dependent) in children at risk. It may also maintain pancreatic excretion of some insulin for a longer time than would occur normally. Niacin has also been used to relieve intermittent claudication and **osteoarthritis**, although the dose used for the latter risks **liver** problems. The frequency of migraines may be significantly reduced, and the severity decreased, by the use of supplemental riboflavin. Pyridoxine is used therapeutically to lower the risk of heart disease, and to relieve nausea associated with morning sickness and to treat premenstrual syndrome (PMS). In conjunction with magnesium, pyridoxine may have some beneficial effects on the behavior of children with autism. Cobalamin supplementation has been shown to improve male fertility. Folic acid may reduce the odds of cervical or colon cancer in certain at risk groups.

Vitamin B complex

Description

Vitamin B complex is a set of 12 related water-soluble substances. Eight are considered **vitamins**, by virtue of needing to be included in the diet, and four are not, as the body can synthesize them. Since they are water-soluble, most are not stored to any great extent and must be replenished on a daily basis. The eight vitamins have

KEY TERMS

Homocysteine—An amino acid produced from the metabolization of other amino acids. High levels are an independent risk factor for heart disease.

Macrocytic anemia—A condition caused by cobalamin deficiency, which is characterized by red blood cells that are too few, too fragile, and abnormally large.

Neural tube defect—Incomplete development of the brain, spinal cord, or vertebrae of a fetus, which is sometimes caused by a folic acid deficiency.

Vasodilatory—Causing the veins in the body to dilate, or enlarge.

Vegan—A person who doesn't eat any animal products, including dairy and eggs.

Deficiency

Vitamin B complex is most often used to treat deficiencies that are caused by poor vitamin intake, difficulties with vitamin absorption, or conditions causing increased metabolic rate such as hyperthyroidism that deplete vitamin levels at a higher than normal rate.

Biotin and pantothenic acid are rarely deficient since they are broadly available in food, but often those lacking in one type of B vitamin are lacking in other B components as well. An individual may be symptomatic due to an inadequate level of one vitamin but be suffering from an undetected underlying deficiency as well. One possibility of particular concern is that taking folic acid supplements can cover up symptoms of cobalamin deficiency. This scenario could result in permanent neurologic damage if the cobalamin shortage remains untreated.

Some of the B vitamins have unique functions within the body that allow a particular deficiency to be readily identified. Often, however, they work in concert so symptoms due to various inadequate components may overlap. In general, poor B vitamin levels will cause profound fatigue and an assortment of neurologic manifestations, which may include weakness, poor balance, confusion, irritability, **memory** loss, nervousness, tingling of the limbs, and loss of coordination. Depression may be an early sign of significantly low levels of pyridoxine and possibly other B vitamins. Additional symptoms of vitamin B deficiency are sleep disturbances, nausea, poor appetite, frequent infections, and skin lesions.

A certain type of anemia (megaloblastic) is an effect of inadequate cobalamin. This anemia can also result if a person stops secreting enough intrinsic factor in the **stomach**. Intrinsic factor is essential for the absorption of cobalamin. The result of a lack of intrinsic factor is pernicious anemia, so called because it persists despite **iron** supplementation. Neurologic symptoms often precede anemia when cobalamin is deficient.

A severe and prolonged lack of niacin causes a condition called pellagra. The classic signs of pellagra are dermatitis, **dementia**, and **diarrhea**. It is very rare now, except in alcoholics, strict vegans, and people in areas of the world with very poor **nutrition**.

Thiamine deficiency is similarly rare, save in the severely malnourished and alcoholics. A significant depletion causes a condition known as beriberi, and it can cause weakness, leg spasms, poor appetite, and loss of coordination. Wernicke-Korsakoff syndrome is the most severe form of deficiency, and occurs in conjunction with **alcoholism**. Early stages of neurologic symptoms are reversible, but psychosis and death may occur if the course is not reversed.

Risk factors for deficiency

People are at higher risk for deficiency if they have poor nutritional sources of B vitamins, take medications or have conditions that impair absorption, or are affected by circumstances that increase the need for vitamin B components above the normal level. Since the B vitamins often work in harmony, a deficiency in one type may have broad implications. Poor intake of B vitamins is most often a problem in strict vegetarians and the elderly. People who frequently fast or diet may also benefit from taking B vitamins. Vegans will need to use brewer's yeast or other sources of supplemental cobalamin, since the only natural sources are meats.

Risk factors that may decrease absorption of some B vitamins include smoking, excessive use of alcohol, surgical removal of portions of the digestive tract, and advanced age. Absorption is also impaired by some medications. Some of the drugs that may cause this are **corticosteroids**, colchicine, metformin, phenformin, omeprazol, colestipol, cholestyramine, methotrexate, tricyclic antidepressants, and slow-release potassium.

Need for vitamin B complex may be increased by conditions such as **pregnancy**, breastfeeding, emotional **stress**, and physical stress due to surgery or injury. People who are very physically active require extra riboflavin. Use of birth control pills also increases the need for certain B vitamins.

Preparations

Natural sources

Fresh meats and dairy products are the best sources for most of the B vitamins, although they are prevalent in many foods. Cobalamin is only found naturally in animal source foods. Freezing of food and exposure to light of food or supplements may destroy some of the vitamin content. Dark-green leafy vegetables are an excellent source of folic acid. To make the most of the B vitamins contained in foods, don't overcook them. It is also best to steam rather than boil or simmer vegetables.

Supplemental sources

B vitamins are generally best taken in balanced complement, unless there is a specific deficiency or need of an individual vitamin. An excess of one component may lead to depletion of the others. Injectable and oral forms of supplements are available. The injectable types may be more useful for those with deficiencies due to problems with absorption. B complex products vary as to which components are included, and at what dose level.

Individual components are also available as supplements. These are best used with the advice of a health care professional. Some are valuable when addressing specific problems such as pernicious anemia. Strict vegetarians will need to incorporate a supplemental source of B₁₂ in the diet.

Precautions

In many cases, large doses of water-soluble vitamins can be taken with no ill effects since excessive amounts are readily excreted. However, when niacin is taken at daily doses of over 500 mg (and more often at doses six times as high), liver inflammation may occur. It is generally reversible once the supplementation is stopped. Niacin may also cause difficulty in controlling blood sugar in diabetics. It can increase uric acid levels that will aggravate **gout**. Those with ulcers could be adversely affected as niacin increases the production of stomach acid. Niacin also lowers **blood pressure** due to its vasodilatory effect, so should not be taken in conjunction with medications that are used to treat high blood pressure. If the form of niacin known as inositol hexaniacinate is taken instead, problems with flushing, gout, and ulcers, and liver inflammation do not occur but beneficial effects on cholesterol are maintained.

High doses of pyridoxine may also cause liver inflammation or permanent nerve damage. Megadoses of this vitamin are not necessary or advisable.

Those on medication for seizures, high blood pressure, and **Parkinson's disease** are at increased risk for interactions. Any person with a chronic health condition, or taking other medications should seek the advice of a health professional before beginning any program of supplementation.

Side effects

Niacin in large amounts commonly causes flushing and headache, although this can be circumvented by taking it in the form of inositol hexaniacinate. Large doses of riboflavin make the urine turn very bright yellow.

Interactions

Some medications may be affected by B vitamin supplementation, including those for high blood pressure, Parkinson's disease (such as levodopa, which is inactivated by pantothenic acid) and epileptiform conditions. Folic acid interacts with Dilantin as well as other anticonvulsants. Large amounts of **vitamin C** taken within an hour of vitamin B supplements will destroy the cobalamin component. Niacin may interfere with control of blood sugar in people on **antidiabetic drugs**. Isoniazid, a medication to treat **tuberculosis**, can impair the proper production and utilization of niacin. **Antibiotics** potentially decrease the level of some B vitamins by killing the **bacteria** in the digestive tract that produce them.

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Vitamin C

Description

Vitamin C, or ascorbic acid, is naturally produced in fruits and vegetables. The vitamin, which can be taken in dietary or supplementary form, is absorbed by the intestines. That which the body cannot absorb is excreted in the urine. The body stores a small amount, but daily intake, preferably in dietary form, is recommended for optimum health.

Certain health conditions may cause vitamin C depletion, including diabetes and high **blood pressure**. Individuals who smoke and women who take estrogen may also have lower vitamin C levels. In addition, men are more likely to be vitamin C depleted, as are the elderly. High **stress** levels have also been linked to vitamin C deficiency.

Severe vitamin C deficiency leads to scurvy, a disease common on ships prior to the sixteenth century, due to the lack of fresh fruits and other dietary vitamin C sources. Symptoms of scurvy include weakness, bleeding, tooth loss, bleeding gums, bruising, and joint **pain**. Less serious vitamin C depletion can have more subtle effects such as weight loss, fatigue, weakened **immune system** (as demonstrated by repeated infections and colds), bruises that occur with minor trauma and are slow to heal, and slow healing of other **wounds**.

Low vitamin C levels have also been associated with high **blood pressure**, increased **heart** attack risk, increased risk for developing **cataracts**, and a higher risk for certain types of **cancer** (i.e., prostate, **stomach**, colon, oral, and lung).

General use

Vitamin C is a critical component to both disease prevention and to basic body building processes. The therapeutic effects of vitamin C include:

- Allergy and **asthma** relief. Vitamin C is present in the lung's airway surfaces, and insufficient vitamin C levels have been associated with bronchial constriction and reduced lung function. Some studies have associated vitamin C supplementation with asthmatic symptom relief, but results have been inconclusive and further studies are needed.
- Cancer prevention. Vitamin C is a known antioxidant and has been associated with reduced risk of stomach, lung, colon, oral, and prostate cancer.
- Cataract prevention. Long-term studies on vitamin C supplementation and cataract development have shown

that supplementation significantly reduces the risk for cataracts, particularly among women.

- Collagen production. Vitamin C assists the body in the manufacture of collagen, a protein that binds cells together and is the building block of connective tissues throughout the body. Collagen is critical to the formation and ongoing health of the skin, cartilage, ligaments, corneas, and other bodily tissues and structures. Vitamin C is also thought to promote faster healing of wounds and injuries because of its role in collagen production.
- Diabetes control. Vitamin C supplementation may assist diabetics in controlling blood sugar levels and improving **metabolism**.
- **Gallbladder** disease prevention. A study of over 13,000 subjects published in the *Archives in Internal Medicine* found that women who took daily vitamin C supplements were 34% less likely to contract gallbladder disease and gallstones, and that women deficient in ascorbic acid had an increased prevalence of gallbladder disease.
- Immune system booster. Vitamin C increases white blood cell production and is important to immune system balance. Studies have related low vitamin C levels to increased risk for **infection**. Vitamin C is frequently prescribed for HIV-positive individuals to protect their immune system.
- Neurotransmitter and hormone building. Vitamin C is critical to the conversion of certain substances into neurotransmitters, **brain** chemicals that facilitate the transmission of nerve impulses across a synapse (the space between **neurons**, or nerve cells). Neurotransmitters such as serotonin, dopamine, and norepinephrine are responsible for the proper functioning of the **central nervous system**, and a deficiency of neurotransmitters can result in psychiatric illness. Vitamin C also helps the body manufacture adrenal hormones.

Other benefits of vitamin C are less clear cut and have been called into question with conflicting study results. These include vitamin C's role in treating the **common cold**, preventing heart disease, and treating cancer.

Treating the common cold

Doses of vitamin C may reduce the duration and severity of cold symptoms, particularly in those individuals who are vitamin C deficient. The effectiveness of vitamin C therapy on colds seems to be related to the dietary vitamin C intake of the individual and the individual's general health and lifestyle.

Heart disease prevention

Some studies have indicated that vitamin C may prevent heart disease by lowering total blood cholesterol and LDL cholesterol and raising HDL, or good cholesterol, levels. The antioxidant properties of vitamin C have also been associated with protection of the arterial lining in patients with **coronary artery disease**.

However, the results of a recent study conducted at the University of Southern California and released in early 2000 have cast doubt on the heart protective benefits of vitamin C. The study found that daily doses of 500 mg of vitamin C resulted in a thickening of the arteries in study subjects at a rate 2.5 times faster than normal. Thicker arterial walls can cause narrow **blood vessels** and actually increase the risk for heart disease. Study researchers have postulated that the collagen producing effects of vitamin C could be the cause behind the arterial thickening. Further studies will be needed to determine the actual risks and benefits of vitamin C in relation to heart disease and to establish what a beneficial dosage might be, if one exists. For the time being, it is wise for most individuals, particularly those with a history of heart disease, to avoid megadoses over 200 mg because of the risk of arterial thickening.

Blood pressure control

A 1999 study found that daily doses of 500 mg of vitamin C reduced blood pressure in a group of 39 hypertensive individuals. Scientists have hypothesized that vitamin C may improve high blood pressure by aiding the function of nitric oxide, a gas produced by the body that allows blood vessels to dilate and facilitates blood flow. Again, recent findings that vitamin C may promote arterial wall thickening seem to contradict these findings, and further long-term studies are needed to assess the full benefits and risks of vitamin C in relation to blood pressure control.

Cancer treatment

Researchers disagree on the therapeutic use of vitamin C in cancer treatment. On one hand, studies have shown that tumors and cancer cells absorb vitamin C at a faster rate than normal cells because they have lost the ability to transport the vitamin. In addition, radiation and **chemotherapy** work in part by stimulating oxidation and the growth of free radicals in order to stop cancer cell growth. Because vitamin C is an antioxidant, which absorbs free radicals and counteracts the oxidation process, some scientists believe it could be counterproductive to cancer treatments. The exact impact vitamin C has on patients undergoing chemotherapy and other cancer treatments is not fully understood, and for this reason

many scientists believe that vitamin C should be avoided by patients undergoing cancer treatment.

On the other side of the debate are researchers who believe that high doses of vitamin C can protect normal cells and inhibit the growth of cancerous ones. In lab-based, *in vitro* studies, cancer cells were killed and/or stopped growing when large doses of vitamin C were administered. Researchers postulate that unlike normal healthy cells, which will take what they need of a vitamin and then discard the rest, cancer cells continue to absorb antioxidant **vitamins** at excessive rates until the cell structure is effected, the cell is killed, or cell growth simply stops. However, it is important to note that there have been no *in vivo* controlled clinical studies to prove this theory.

Based on the currently available controlled clinical data, cancer patients should avoid taking vitamin C supplementation beyond their recommended daily allowance.

Preparations

The U.S. recommended dietary allowance (RDA) of vitamin C is as follows:

- men: 60 mg
- women: 60 mg
- pregnant women: 70 mg
- lactating women: 95 mg

In April 2000, the National Academy of Sciences recommended changing the RDA for vitamin C to 75 mg for women and 90 mg for men, with an upper limit (UL), or maximum daily dose, of 2,000 mg. Daily values for the vitamin as recommended by the U.S. Food and Drug Administration, the values listed on food and beverage labeling, remain at 60 mg for both men and women age four and older.

Many fruits and vegetables, including citrus fruits and berries, are rich in vitamin C. Foods rich in vitamin C include raw red peppers (174 mg/cup), guava (165 mg/fruit), orange juice (124 mg/cup), and black currants (202 mg/cup). Rose hips, broccoli, tomatoes, strawberries, papaya, lemons, kiwis, and brussels sprouts are also good sources of vitamin C. Eating at least five to nine servings of fruits and vegetables daily should provide adequate vitamin C intake for most people. Fresh, raw fruits and vegetables contain the highest levels of the vitamin. Both heat and light can reduce vitamin C potency in fresh foods, so overcooking and improper storage should be avoided. Sliced and chopped foods have more of their surface exposed to light, so keeping vegetables

KEY TERMS

Adrenal hormone—The adrenocortical hormones are cortisol and cortisone. They are anti-inflammatory substances that aid in the function of a number of body systems, including the central nervous system, the cardiovascular system, the musculoskeletal system, and the gastrointestinal system.

Antioxidants—Enzymes that bind with free radicals to neutralize their harmful effects.

Bioflavonoids—Plant-derived substances that help to maintain the small blood vessels of the circulatory system.

Free radicals—Reactive molecules created during cell metabolism that can cause tissue and cell damage like that which occurs in aging and with disease processes such as cancer.

In vitro testing—A test performed in a lab setting rather than in a human or animal organism. The test may involve living tissue or cells, but takes place out of the body.

In vivo testing—A test performed on a living organism, such as a controlled clinical study involving human test subjects. In vivo is Latin for “in the living body.”

and fruits whole may also help to maintain full vitamin potency.

Vitamin C supplements are another common source of the vitamin. Individuals at risk for vitamin C depletion such as smokers, women who take birth control pills, and those with unhealthy dietary habits may benefit from a daily supplement. Supplements are available in a variety of different forms including pills, capsules, powders, and liquids. Vitamin C formulas also vary. Common compounds include ascorbic acid, **calcium** ascorbate, sodium ascorbate, and C complex. The C complex compound contains a substance called bioflavonoids, which may enhance the benefits of vitamin C. Vitamin C is also available commercially as one ingredient of a multivitamin formula.

The recommended daily dosage of vitamin C varies by individual need, but an average daily dose might be 200 mg. Some healthcare providers recommend megadoses (up to 40 g) of vitamin C to combat infections. However, the efficacy of these megadoses has not been proven, and in fact, some studies have shown that doses

above 200 mg are not absorbed by the body and are instead excreted.

Precautions

Overdoses of vitamin C can cause nausea, **diarrhea**, stomach cramps, skin rashes, and excessive urination.

Because of an increased risk of kidney damage, individuals with a history of kidney disease or **kidney stones** should never take dosages above 200 mg daily, and should consult with their healthcare provider before starting vitamin C supplementation.

A 1998 study linked overdoses (above 500 mg) of vitamin C to cell and DNA damage. However, other studies have contradicted these findings, and further research is needed to establish whether high doses of vitamin C can cause cell damage.

Side effects

Vitamin C can cause diarrhea and nausea. In some cases, side effects may be decreased or eliminated by adjusting the dosage of vitamin C.

Interactions

Vitamin C increases **iron** absorption, and is frequently prescribed with or added to commercial iron supplements for this reason.

Individuals taking anticoagulant, or blood thinning, medications should speak with their doctor before taking vitamin C supplements, as large doses of vitamin C may impact their efficacy.

Large amounts of vitamin C may increase estrogen levels in women taking hormone supplements or birth control medications, especially if both the supplement and the medication are taken simultaneously. Women should speak with their doctor before taking vitamin C if they are taking estrogen-containing medications. Estrogen actually decreases absorption of vitamin C, so larger doses of vitamin C may be necessary. A healthcare provider can recommend proper dosages and the correct administration of medication and supplement.

Individuals who take aspirin, **antibiotics**, and/or steroids should consult with their healthcare provider about adequate dosages of vitamin C. These medications can increase the need for higher vitamin C doses.

Large dosages of vitamin C can cause a false-positive result in tests for diabetes.

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ORGANIZATIONS

United States Department of Agriculture. Center for Nutrition Policy and Promotion. 1120 20th Street NW, Suite 200, North Lobby, Washington, D.C. 20036. (202) 418-2312. <<http://www.usda.gov/cnpp/>>. john.webster@usda.gov.

Paula Ford-Martin

Vitamin D

Description

Vitamin D, also known as calciferol, is essential for strong teeth and bones. There are two major forms of vitamin D: D₂ or ergocalciferol and D₃ or cholecalciferol. Vitamin D can be synthesized by the body in the presence of sunlight, as opposed to being required in the diet. It is the only vitamin whose biologically active formula is a hormone. It is fat-soluble, and regulates the body's absorption and use of the **minerals calcium** and **phosphorus**. Vitamin D is important not only to the maintenance of proper bone density, but to the many calcium-driven neurologic and cellular functions, as well as normal growth and development. It also assists the **immune system** by playing a part in the production of a type of white **blood** cell called the monocyte. White blood cells are **infection** fighters. There are many chemical forms of vitamin D, which have varying amounts of biological activity.

General use

The needed amount of vitamin D is expressed as an Adequate Intake (AI) rather than an Required Daily Amount (RDA). This is due to a difficulty in quantifying the amount of the vitamin that is produced by the body with exposure to sunlight. Instead, the AI estimates the

amount needed to be eaten in order to maintain normal function. It is measured in International Units (IU) and there are 40 IU in a microgram (mcg). The AI for vitamin D in the form of cholecalciferol or ergocalciferol for everyone under 50 years of age, including pregnant and lactating women, is 200 IU. It goes up to 400 IU for people 51-70 years old, and to 600 IU for those over age 70. A slightly higher dose of vitamin D, even as little as a total of 700 IU for those over age 65, can significantly reduce age-related **fractures** when taken with 500 mg of calcium per day.

One of the major uses of vitamin D is to prevent and treat **osteoporosis**. This disease is essentially the result of depleted calcium, but calcium supplements alone will not prevent it since vitamin D is required to properly absorb and utilize calcium. Taking vitamin D without the calcium is also ineffective. Taking both together may actually increase bone density in postmenopausal women, who are most susceptible to bone loss and complications such as fractures.

Osteomalacia and rickets are also effectively prevented and treated through adequate vitamin D supplementation. Osteomalacia refers to the softening of the bones that occurs in adults that are vitamin D deficient. Rickets is the syndrome that affect deficient children, causing bowed legs, joint deformities, and poor growth and development.

Vitamin D also has a part in **cancer** prevention, at least for colon cancer. A deficiency increases the risk of this type of cancer, but there is no advantage to taking more than the AI level. There may also be a protective effect against breast and **prostate cancer**, but this is not as well established. Studies are in progress to see if it can help to treat leukemia and lymphoma. The action of at least one chemotherapeutic drug, tamoxifen, appears to be improved with small added doses of vitamin D. Tamoxifen is commonly used to treat ovarian, uterine, and breast cancers.

Many older adults are deficient in vitamin D. This can affect **hearing** by causing poor function of the small bones in the ear that transmit sound. If this is the cause of the **hearing loss**, it is possible that supplementation of vitamin D can act to reverse the situation.

Some metabolic diseases are responsive to treatment with specific doses and forms of vitamin D. These include Fanconi syndrome and familial hypophosphatemia, both of which result in low levels of phosphate. For these conditions, the vitamin is given in conjunction with a phosphate supplement to aid in absorption.

A topical form of vitamin D is available, and can be helpful in the treatment of plaque-type psoriasis. It may

KEY TERMS

Osteomalacia—Literally soft bones, a condition seen in adults deficient in vitamin D. The bones are painful and fracture easily.

Scleroderma—A condition causing thickened, hardened skin.

Tetany—Painful muscles spasms and tremors caused by very low calcium levels.

Vegan—A person who doesn't eat any animal products, including dairy and eggs.

Vitiligo—Patchy loss of skin pigmentation, resulting in lighter areas of skin.

also be beneficial for those with vitiligo or scleroderma. This cream, in the form of calcitriol, is not thought to affect internal calcium and phosphorus levels. Oral supplements of vitamin D are not effective for psoriasis. The cream is obtainable by prescription only.

Evidence does not support the use of vitamin D to treat **alcoholism**, acne, arthritis, **cystic fibrosis**, or herpes.

Preparations

Natural sources

Exposure to sunlight is the primary method of obtaining vitamin D. In clear summer weather, approximately ten minutes per day in the sun will produce adequate amounts, even when only the face is exposed. In the winter, it may require as much as two hours. Many people don't get that amount of winter exposure, but are able to utilize the vitamin that was stored during extra time in the sun over the summer. Sunscreen blocks the ability of the sun to produce vitamin D, but should be applied as soon as the minimum exposure requirement has passed, in order to reduce the risk of skin cancer. The chemical 7-dehydrocholesterol in the skin is converted to vitamin D₃ by sunlight. Further processing by first the **liver**, and then the **kidneys**, makes D₃ more biologically active. Since it is fat-soluble, extra can be stored in the liver and fatty tissues for future use. Vitamin D is naturally found in fish liver oils, butter, eggs, and fortified milk and cereals in the form of vitamin D₂. Milk products are the main dietary source for most people. Other dairy products are not a good supply of vitamin D, as they are made from unfortified milk. Plant foods are also poor sources of vitamin D.

Supplemental sources

Most oral supplements of vitamin D are in the form of ergocalciferol. It is also available in topical (calcitriol or calcipotriene), intravenous (calcitriol), or intramuscular (ergocalciferol) formulations. Products designed to be given by other than oral routes are by prescription only. As with all supplements, vitamin D should be stored in a cool, dry place, away from direct light, and out of the reach of children.

Deficiency

In adults, a mild deficiency of vitamin D may be manifested as loss of appetite and weight, difficulty sleeping, and **diarrhea**. A more major deficiency causes osteomalacia and muscle spasm. The bones become soft, fragile, and painful as a result of the calcium depletion. This is due to an inability to properly absorb and utilize calcium in the absence of vitamin D. In children, a severe lack of vitamin D causes rickets.

Risk factors for deficiency

The most likely cause of vitamin D deficiency is inadequate exposure to sunlight. This can occur with people who don't go outside much, those in areas of the world where pollution blocks ultraviolet (UV) light or where the weather prohibits spending much time outdoors. Glass filters out the rays necessary for vitamin formation, as does sunscreen. Those with dark skin may also absorb smaller amounts of the UV light necessary to effect conversion of the vitamin. In climates far to the north, the angle of the sun in winter may not allow adequate UV penetration of the atmosphere to create D₃. Getting enough sun in the summer, and a good dietary source, should supply enough vitamin D to last through the winter. Vegans, or anyone who doesn't consume dairy products in combination with not getting much sun is also at higher risk, as are the elderly, who have a decreased ability to synthesize vitamin D.

Babies are usually born with about a nine-month supply of the vitamin, but breast milk is a poor source. Those born prematurely are at an increased risk for deficiency of vitamin D and calcium, and may be prone to tetany. Infants past around nine months old who are not getting vitamin D fortified milk or adequate sun exposure are at risk of deficiency.

People with certain intestinal, liver and kidney diseases may not be able to convert vitamin D₃ to active forms, and may need an activated type of supplemental vitamin D.

Those taking certain medications may require supplements, including anticonvulsants, **corticosteroids**, or the

cholesterol-lowering medications cholestyramine or colestipol. This means that people who are on medication for arthritis, **asthma**, **allergies**, autoimmune conditions, high cholesterol, epilepsy, or other seizure problems should consult with a healthcare practitioner about the advisability of taking supplemental vitamin D. As with some other **vitamins**, the abuse of alcohol also has a negative effect. In the case of vitamin D, the ability to absorb and store it is diminished by chronic overuse of alcohol products.

Populations with poor nutritional status may tend to be low on vitamin D, as well as other vitamins. This can be an effect of poor sun exposure, poor intake, or poor absorption. A decreased ability to absorb oral forms of vitamin D may result from cystic fibrosis or removal of portions of the digestive tract. Other groups who may need higher than average amounts of vitamin D include those who have recently had surgery, major injuries, or **burns**. High levels of **stress** and chronic wasting illnesses also tend to increase vitamin requirements.

Precautions

The body will not make too much vitamin D from overexposure to sun, but since vitamin D is stored in fat, toxicity from supplemental **overdose** is a possibility. Symptoms are largely those of hypercalcemia, and may include high **blood pressure**, headache, weakness, fatigue, **heart** arrhythmia, loss of appetite, nausea, vomiting, diarrhea, constipation, dizziness, irritability, seizures, kidney damage, poor growth, premature hardening of the arteries, and **pain** in the abdomen, muscles, and bones. If the toxicity progresses, itching and symptoms referable to renal disease may develop, such as thirst, frequent urination, proteinuria, and inability to concentrate urine. Overdoses during **pregnancy** may cause fetal abnormalities. Problems in the infant can include tetany, seizures, heart valve malformation, retinal damage, growth suppression, and mental retardation. Pregnant women should not exceed the AI, and all others over one year of age should not exceed a daily dose of 2000 IU. Infants should not exceed 1000 IU. These upper level doses should not be used except under the advice and supervision of a healthcare provider due to the potential for toxicity.

Individuals with hypercalcemia, sarcoidosis, or hypoparathyroidism should not use supplemental calciferol. Those with kidney disease, arteriosclerosis, or heart disease should use ergocalciferol only with extreme caution and medical guidance.

Side effects

Minor side effects may include poor appetite, constipation, dry mouth, increased thirst, metallic **taste**, or

fatigue. Other reactions, which should prompt a call to a healthcare provider, can include headache, nausea, vomiting, diarrhea, or confusion.

Interactions

The absorption of vitamin D is improved by calcium, choline, **fats**, phosphorus, and vitamins A and C. Supplements should be taken with a meal to optimize absorption.

There are a number of medications that can interfere with vitamin D levels, absorption, and **metabolism**. Rifampin, H₂ blockers, barbiturates, heparin, isoniazid, colestipol, cholestyramine, carbamazepine, phenytoin, fosphenytoin, and phenobarbital reduce serum levels of vitamin D and increase metabolism of it. Anyone who is on medication for epilepsy or another **seizure disorder** should check with a healthcare provider to see whether it is advisable to take supplements of vitamin D. Overuse of mineral oil, Olestra, and stimulant **laxatives** may also deplete vitamin D. Osteoporosis and hypocalcemia can result from long-term use of corticosteroids. It may be necessary to take supplements of calcium and vitamin D together with this medication. The use of thiazide diuretics in conjunction with vitamin D can cause hypercalcemia in individuals with hypoparathyroidism. Concomitant use of digoxin or other cardiac glycosides with vitamin D supplements may lead to hypercalcemia and heart irregularities. The same caution should be used with herbs containing cardiac glycosides, including black hellebore, Canadian hemp, digitalis, hedge mustard, figwort, lily of the valley, motherwort, oleander, pheasant's eye, pleurisy, squill, and strophanthus.

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Judith Turner

Vitamin E

Description

Vitamin E is an antioxidant responsible for proper functioning of the **immune system** and for maintaining healthy eyes and skin. It is actually a group of fat soluble compounds known as tocopherols (i.e., alpha tocopherol and gamma tocopherol). Gamma tocopherol accounts for approximately 75% of dietary vitamin E. Vitamin E rich foods include nuts, cereals, beans, eggs, cold-pressed oils, and assorted fruits and vegetables. Because vitamin E is a fat soluble vitamin, it requires the presence of fat for proper absorption. Daily dietary intake of the recommended daily allowance (RDA) of vitamin E is recommended for optimum health.

Vitamin E is absorbed by the gastrointestinal system and stored in tissues and organs throughout the body. Certain health conditions may cause vitamin E depletion, including **liver** disease, celiac disease, and **cystic fibrosis**. Patients with end-stage renal disease (kidney failure) who are undergoing chronic dialysis treatment may be at risk for vitamin E deficiency. These patients frequently receive intravenous infusions of **iron** supplements which can act against vitamin E.

Vitamin E deficiency can cause fatigue, concentration problems, weakened immune system, anemia, and low thyroid levels. It may also cause **vision** problems and irritability. Low serum (or **blood**) levels of vitamin E have also been linked to major depression.

General use

Vitamin E is necessary for optimal immune system functioning, healthy eyes, and cell protection throughout the body. It has also been linked to the prevention of a number of diseases. The therapeutic benefits of vitamin E include:

- **Cancer** prevention. Vitamin E is a known antioxidant, and has been associated with a reduced risk of gastrointestinal, cervical, prostate, lung, and possibly **breast cancer**.
- Immune system protection. Various studies have shown that vitamin E supplementation, particularly in elderly patients, boosts immune system function. Older patients have demonstrated improved **immune response**, increased resistance to infections, and higher antibody production. Vitamin E has also been used with some success to slow disease progression in HIV-positive patients.
- Eye disease prevention. Clinical studies on vitamin E have shown that supplementation significantly reduces

the risk for **cataracts** and for **macular degeneration**, particularly among women.

- **Memory** loss prevention. Vitamin E deficiency has been linked to poor performance on memory tests in some elderly individuals.
- **Alzheimer's disease** treatment. In a study performed at Columbia University, researchers found that Alzheimer's patients who took daily supplements of vitamin E maintained normal functioning longer than patients who took a placebo.
- Liver disease treatment. Vitamin E may protect the liver against disease.
- Diabetes treatment. Vitamin E may help diabetic patients process insulin more effectively.
- **Pain** relief. Vitamin E acts as both an anti-inflammatory and analgesic (or pain reliever). Studies have indicated it may be useful for treatment of arthritis pain in some individuals.
- **Parkinson's disease** prevention. High doses of vitamin E intake was associated with a lowered risk of developing Parkinson's disease in one 1997 Dutch study.
- Tardive dyskinesia treatment. Individuals who take neuroleptic drugs for **schizophrenia** or other disorders may suffer from a side effect known as tardive dyskinesia, in which they experience involuntary muscle contractions or twitches. Vitamin E supplementation may lessen or eliminate this side effect in some individuals.

Other benefits of vitamin E are less clear cut, and have been called into question with conflicting study results or because of a lack of controlled studies to support them. These include:

- **Heart** disease prevention. A number of epidemiological studies have indicated that vitamin E may prevent heart disease by lowering total blood cholesterol levels and preventing oxidation of LDL cholesterol. However, a large, controlled study known as the Heart Outcomes Prevention Evaluation (HOPE) published in early 2000 indicates that vitamin E does not have any preventative effects against heart disease. The study followed 9,500 individuals who were considered to be at a high risk for heart disease. Half the individuals were randomly chosen to receive vitamin E supplementation, and the other half of the study population received a placebo. After five years, there was no measurable difference in heart attacks and heart disease between the two patient populations. Still, vitamin E may still hold some hope for heart disease prevention. It is possible that a longer-term study beyond the five years of the HOPE study may demonstrate some heart protective benefits of vitamin E consumption. It is also possible that while the

high-risk patient population that was used for the HOPE study did not benefit from vitamin E, an average-risk patient population might still benefit from supplementation. It is also possible that vitamin E needs the presence of another vitamin or nutrient substance to protect against heart disease. Further large, controlled, and long-term clinical studies are necessary to answer these questions.

- **Skin care.** Vitamin E is thought to increase an individual's tolerance to UV rays when taken as a supplement in conjunction with **vitamin C**. Vitamin E has also been touted as a treatment to promote faster healing of flesh **wounds**. While its anti-inflammatory and analgesic properties may have some benefits in reducing swelling and relieving discomfort in a wound, some dermatologists dispute the claims of faster healing, and there are no large controlled studies to support this claim.
- **Hot flashes.** In a small study conducted at the Mayo Clinic, researchers found that breast cancer survivors who suffered from hot flashes experienced a decrease in those hot flashes after taking vitamin E supplementation.
- **Muscle maintenance and repair.** Recent research has demonstrated that the antioxidative properties of vitamin E may prevent damage to tissues caused by heavy endurance exercises. In addition, vitamin E supplementation given prior to surgical procedures on muscle and joint tissues has been shown to limit reperfusion injury (muscle damage which occurs when blood flow is stopped, and then started again to tissues or organs).
- **Fertility.** Vitamin E has been shown to improve sperm function in animal studies, and may have a similar effect in human males. Further studies are needed to establish the efficacy of vitamin E as a treatment for male infertility.

Preparations

The U.S. recommended dietary allowance (RDA) of the alpha-tocopherol formulation of vitamin E is as follows:

- men: 10 mg or 15 IU
- women: 8 mg or 12 IU
- pregnant women: 10 mg or 15 IU
- lactating women: 12 mg or 18 IU

In April 2000, the National Academy of Sciences recommended changing the RDA for vitamin E to 22 international units (IUs), with an upper limit (UL), or maximum daily dose, of 1500 IUs. Daily values for the vitamin as recommended by the U.S. Food and Drug Administration, the values listed on food and beverage



Vitamin E capsules, which are transparent yellow-orange.
(Photograph by David Doody. FPG International Corp.
Reproduced by permission.)

labeling, remain at 30 IUs for both men and women age four and older.

Many nuts, vegetable-based oils, fruits, and vegetables contain vitamin E. Foods rich in vitamin E include wheat germ oil (26.2 mg/tbsp), wheat germ cereal (19.5 mg/cup), peanuts (6.32 mg/half cup), soy beans (3.19 mg/cup), corn oil (2.87/tbsp), avocado (2.69 mg), and olive oil (1.68 mg/tbsp). Grapes, peaches, broccoli, Brussels sprouts, eggs, tomatoes, and blackberries are also good sources of vitamin E. Fresh, raw foods contain the highest levels of the vitamin. Both heat and light can reduce vitamin and mineral potency in fresh foods, so overcooking and improper storage should be avoided. Sliced and chopped foods have more of their surface exposed to light, therefore keeping vegetables and fruits whole may also help to maintain full vitamin potency.

For individuals considered at risk for vitamin E deficiency, or those with an inadequate dietary intake, vitamin E supplements are available in a variety of different forms, including pills, capsules, powders, and liquids for oral ingestion. For topical use, vitamin E is available in ointments, creams, lotions, and oils. Vitamin E is also available commercially as one ingredient of a multivitamin formula.

The recommended daily dosage of vitamin E varies by individual need and by the amount of polyunsaturated **fats** an individual consumes. The more polyunsaturated fats in the diet, the higher the recommended dose of vitamin E, because vitamin E helps to prevent the oxidizing

KEY TERMS

Antioxidants—Enzymes which bind with free radicals to neutralize their harmful effects.

Contact dermatitis—Inflammation, redness, and irritation of the skin caused by an irritating substance.

Epidemiological study—A study which analyzes health events and trends in particular patient populations.

Free radicals—Reactive molecules created during cell metabolism that can cause tissue and cell damage like that which occurs in aging and with disease processes such as cancer.

Macular degeneration—Degeneration, or breakdown, of the retina that can lead to partial or total blindness.

Non-heme iron—Dietary or supplemental iron that is less efficiently absorbed by the body than heme iron (ferrous iron).

Reperfusion—The reintroduction of blood flow to organs or tissues after blood flow has been stopped for surgical procedures.

Vitamin A—An essential vitamin found in liver, orange and yellow vegetables, milk, and eggs that is critical for proper growth and development.

Vitamin K—A fat-soluble vitamin responsible for blood clotting, bone metabolism, and proper kidney function.

effects of these fats. Because vitamin E is fat soluble, supplements should always be taken with food.

Supplements are also available in either natural or synthetic formulations. Natural forms are extracted from wheat germ oil and other vitamin E food sources, and synthetic forms are extracted from petroleum oils. Natural formulas can be identified by a d prefix on the name of the vitamin (i.e., d-alpha-tocopherol).

Precautions

Overdoses of vitamin E (over 536 mg) can cause nausea, **diarrhea**, headache, abdominal pain, bleeding, high **blood pressure**, fatigue, and weakened immune system function.

Patients with rheumatic heart disease, **iron deficiency anemia**, **hypertension**, or thyroid dysfunction should consult their healthcare provider before starting

vitamin E supplementation, as vitamin E may have a negative impact on these conditions.

Side effects

Vitamin E is well-tolerated, and side effects are rare. However, in some individuals who are **vitamin K** deficient, vitamin E may increase the risk for hemorrhage or bleeding. In some cases, side effects may be decreased or eliminated by adjusting the dosage of vitamin E and vitamin K.

Vitamin E ointments, oils, or creams may trigger an allergic reaction known as contact dermatitis. Individuals who are considering using topical vitamin E preparations for the first time, or who are switching the type of vitamin E product they use, should perform a skin patch test to check for skin sensitivity to the substance. A small, dime sized drop of the product should be applied to a small patch of skin inside the elbow or wrist. The skin patch should be monitored for 24 hours to ensure no excessive redness, irritation, or rash occurs. If a reaction does occur, it may be in response to other ingredients in the topical preparation, and the test can be repeated with a different vitamin E formulation. Individuals who experience a severe reaction to a skin patch test of vitamin E are advised not to use the product topically. A dermatologist or other healthcare professional may be able to recommend a suitable alternative.

Interactions

Individuals who take anticoagulant (blood thinning) or anticonvulsant medications should consult their healthcare provider before starting vitamin E supplementation. Vitamin E can alter the efficacy of these drugs.

Non-heme, inorganic iron supplements destroy vitamin E, so individuals taking iron supplements should space out their doses (e.g., iron in the morning and vitamin E in the evening).

Large doses of **vitamin A** can decrease the absorption of vitamin E, so dosage adjustments may be necessary in individuals supplementing with both **vitamins**.

Alcohol and mineral oil can also reduce vitamin E absorption, and these substances should be avoided if possible in vitamin E deficient individuals.

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United States Department of Agriculture. Center for Nutrition Policy and Promotion. 1120 20th Street NW, Suite 200, North Lobby, Washington, D.C. 20036. (202) 418-2312. <<http://www.usda.gov/cnpp/>>.

Paula Ford-Martin

Vitamin H see **Biotin**

Vitamin K

Description

Vitamin K originates from the German term *koajulation*. It is also known as antihemorrhagic factor, is one of the four fat-soluble **vitamins** necessary for good health. The others are vitamins A, D, and E. The primary and best-known purpose of vitamin K is support of the process of **blood** clotting. Prothrombin and other clotting factors are dependent on vitamin K for production. It also plays a role in bone health, and may help to prevent **osteoporosis**. Appropriate growth and development are supported by adequate vitamin K.

There are several forms of the vitamin:

- K₁ or phyloquinone also known as phytonadione
- K₂, a family of substances called menaquinones
- K₃ or menadione, a synthetic substance

General use

The Required Daily Amount (RDA) of vitamin K is 5 micrograms (mcg) for infants less than six months old, 10 mcg for babies six months to one year old, 15 mcg for children aged one to three years, 20 mcg for those aged four to six years, and 30 mcg for those seven to ten years old. Males require 45 mcg from 11-14 years, 65 mcg from 15-18 years, 70 mcg from 19-24 years, and 80 mcg after the age of 24 years. Females need 45 mcg from 11-14 years, 55 mcg from 15-18 years, 60 mcg from 19-24 years, and 65 mcg after the age of 24, and for pregnant or lactating women. These values are based on an estimate of 1 mcg of vitamin K per kilogram of body weight.

The most common use of vitamin K is to supplement babies at birth, thus preventing hemorrhagic disease of

the newborn. Others who may benefit from supplemental vitamin K include those taking medications that interact with it or deplete the supply. It also appears to have some effectiveness in preventing osteoporosis, but the studies done involved patients using a high dietary intake rather than supplements. People taking warfarin, a vitamin K antagonist, are able to use the vitamin as an antidote if the serum level of warfarin is too high, increasing the risk of hemorrhage.

Topical formulations of vitamin K are sometimes touted as being able to reduce spider veins on the face and legs. The creams are quite expensive and the efficacy is questionable at best.

Preparations

Natural sources

Dark green leafy vegetables are among the best food sources of vitamin K in the form of K₁. Seaweed is packed with it, and beef liver, cauliflower, eggs, and strawberries are rich sources as well. Vitamin K is fairly heat stable, but gentle cooking preserves the content of other nutrients that are prone to breaking down when heated. Some of the supply for the body is synthesized as vitamin K₂ by the good **bacteria** in the intestines.

Supplemental sources

Vitamin K is not normally included in daily multivitamins, as deficiency is rare. Oral, topical, and injectable forms are available, but should not be used except under the supervision of a health care provider. Injectable forms are by prescription only. Supplements are generally given in the form of phytonadione since it is the most effective form and has lower risk of toxicity than other types. Synthetic forms of vitamin K are also available for supplemental use.

Deficiency

Deficiency of vitamin K is uncommon in the general population but is of particular concern in neonates, who are born with low levels of vitamin K. Hemorrhagic disease of the newborn can affect infants who do not receive some form of vitamin K at birth. Affected babies tend to have prolonged and excessive bleeding following circumcision or blood draws. In the most serious cases, bleeding into the **brain** may occur. Most commonly an injection of vitamin K is given in the nursery following birth, but a series of oral doses is also occasionally used. The primary sign of a deficiency at any age is bleeding, and poor growth may also be observed in children.

KEY TERMS

Anticoagulant—Substance which inhibits clotting, used therapeutically for such things as stroke prevention in susceptible people.

Bilirubin—When gathered in large amounts, this water insoluble pigment occurs in bile and blood.

Hemolytic anemia—Destruction of red blood cells.

Hemorrhage—Excessive bleeding.

Prothrombin—One protein component of the cascade reaction which results in clot formation.

Chronically low levels of vitamin K are correlated with higher risk of hip fracture in women.

Risk factors for deficiency

Deficiency is unusual, but may occur in certain populations, including those on the medications mentioned in interactions, alcoholics, and people with diseases of the gastrointestinal tract that impair absorption. Conditions that may be problematic include **Crohn's disease**, chronic **diarrhea**, sprue, and ulcerative colitis. Anything that impairs fat absorption also risks decreasing the absorption of the fat-soluble vitamins. Long term use of broad spectrum **antibiotics** destroys the bacteria in the intestinal tract that are necessary for the body's production of vitamin K.

Precautions

Allergic reactions to vitamin K supplements can occur, although they are rare. Symptoms may include flushed skin, nausea, rash, and itching. Medical attention should be sought if any of these symptoms occur. Infants receiving vitamin K injections occasionally suffer hemolytic anemia or high bilirubin levels, noticeable from the yellow cast of the skin. Emergency medical treatment is needed for these babies. Liver and brain impairment are possible in severe cases.

Certain types of liver problems necessitate very cautious use of some forms of vitamin K. Menadiol sodium diphosphate, a synthetic form also known as vitamin K₄, may cause problems in people with biliary fistula or obstructive **jaundice**. A particular metabolic disease called G6-PD deficiency also calls for careful use of vitamin K₄. The expertise of a health care professional is called for under these circumstances. Sheldon Saul

Hendler, MD, PhD, advises there is no reason to supplement with more than 100mcg daily except in cases of frank vitamin K deficiency.

Side effects

Vitamin K₄ may occasionally irritate the gastrointestinal tract. High doses greater than 500 mcg daily have been reported to cause some allergic-type reactions, such as skin rashes, itching, and flushing.

Interactions

There are numerous medications that can interfere with the proper absorption or function of vitamin K. Long term use of **antacids** may decrease the efficacy of the vitamin, as can certain anticoagulants. Warfarin is an anticoagulant that antagonizes vitamin K. Efficacy of the vitamin is also decreased by dactinomycin and sucralbate. Absorption is decreased by cholestyramine and colestipol, which are drugs used to lower cholesterol. Other drugs that may cause a deficiency include long-term use of mineral oil, quinidine, and sulfa drugs. Primaquine increases the risk of side effects from taking supplements.

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Judith Turner

Vitamin poisoning see **Vitamin toxicity**

Vitamin tests

Definition

Vitamins are small organic molecules that are necessary for many biochemical reactions in the body. For example, many vitamins participate as cofactors in

enzyme reactions within the cells. They must be obtained through diet, microorganisms in the gut or sunlight since humans cannot synthesize them. Vitamin tests measure the levels of certain vitamins in an individual's **blood** which can be correlated to the levels of vitamin in their tissues. They are generally used to aid in the diagnosis of vitamin deficiencies or in detecting toxic amounts of a vitamin in a patient's system.

Purpose

Vitamins are components of food that are needed for growth, reproduction, wound healing, digestion of food, blood clotting, bone **metabolism** and maintaining good health. They can be isolated from plants and organisms or they can be synthesized in the laboratory. The vitamins include **vitamin D**, **vitamin E**, **vitamin A**, and **vitamin K**, which are the fat-soluble vitamins, and folate, **vitamin B₁₂**, **biotin** (vitamin H), vitamin B₆, **niacin**, thiamin, **riboflavin**, pantothenic acid, and ascorbic acid (**vitamin C**), which are the water-soluble vitamins. Fat soluble vitamins are absorbed and transported differently from the water soluble vitamins. They can remain in the body longer since they can be stored in fat so they are more toxic in high doses.

Vitamins are required in the diet in only tiny amounts, in contrast to sugars, starches, **proteins** and **fats**. However, vitamin requirements can rise after surgery, with **cancer** and other illnesses, and during **infection** and **pregnancy**. Not receiving sufficient quantities of a certain vitamin can be devastating, resulting in vitamin deficiency diseases such as scurvy (vitamin C deficiency), pellagra (niacin deficiency), megaloblastic anemia (vitamin B₁₂ or folate deficiency) or rickets (vitamin D deficiency). Less extreme deficiencies can cause a delay in wound healing. Conversely, consuming too much of a certain vitamin, especially the fat soluble ones, can be toxic to a person's system. While most vitamin deficiencies are rare in our society, they can be caused by certain diseases, especially those that affect absorption of food, or can be caused by inborn errors of metabolism, **fad diets**, anorexia, blood loss, **parenteral nutrition** and dialysis. The vitamins that are most commonly measured by doctors are folate, vitamin B₁₂, vitamin K, vitamin D, and vitamin A.

Precautions

Most vitamin tests are performed on blood samples collected from a vein in the crease of the arm. The nurse or phlebotomist performing the procedure should observe **universal precautions** for the prevention of transmission of bloodborne pathogens. Some drugs are known to increase or decrease the level of specific vitamins. The

physician should obtain a thorough list of the patient's medications when requesting vitamin measurements.

Description

Many of the vitamin tests done today are vitamin status panels, such as megaloblastic anemia panels that measure the concentration of both vitamin B₁₂ and folate. A deficiency of either of these vitamins results in anemia associated with enlarged (macrocytic) red blood cells. The actual testing methods take advantage of the compound's chemical composition. Fat soluble vitamins are measured differently from water soluble vitamins. In general, the tests are performed on plasma, although some tests for metabolites of vitamins can be done on urine, as is the case with many of the water soluble vitamins. Each vitamin occurs at extremely small concentrations in the blood and urine when compared to levels of most other molecules. For this reason, a procedure that separates the vitamin from the rest of the compounds in the sample is usually performed immediately prior to conducting the actual test. This isolation is done using filters that allow the vitamin to pass through and leave the bigger molecules behind. Vitamin B₁₂ and folate are routinely measured by immunoassay methods, but the most common method to measure other vitamins is high-performance liquid chromatography (HPLC). In HPLC, the vitamin to be measured is extracted from the sample and injected into a stream of solvent that is pumped at high pressure through a column packed with particles to which an organic liquid has been bonded. The molecules separate at different rates depending upon their affinity for the bonded particles. The time at which they elute (i.e., come out of the column) is used to identify the molecules. As the vitamins elute, they flow through a detection cell where they are measured by ultraviolet or infrared light absorption or by fluorescence. In these reactions, the amount of light absorbance or amount of fluorescence is proportional to the amount of vitamin in the sample.

While HPLC and immunoassay are the testing methods used most often, other types of tests exist including biochemical (photometric) tests and microbiological assays. Some tests, such as those for riboflavin, are conducted by giving the patient a riboflavin "load" and looking at metabolites in the urine. Vitamin K deficiency, a vitamin crucial in blood clotting, is often evaluated by a surrogate test, the prothrombin time. The prothrombin time is measured routinely on patients before they undergo a surgical procedure since long clotting times can complicate surgeries. The test measures how long it takes for a fibrin clot to form in a plasma sample to which **calcium** and tissue thromboplastin (a clot activator) have

KEY TERMS

Antioxidant—A compound that protects against oxidation, usually by being oxidized itself. Antioxidant vitamins include C and E.

Carotenoids—Pigments found in vegetables and fruits, similar in structure to vitamin A. These compounds act as antioxidants.

Megaloblastic anemia—A disorder caused by a deficiency in vitamin B₁₂ and folate. The blood contains immature red blood cells causing a decrease in oxygen carrying capacity and symptoms of fatigue and peripheral neuropathies.

Parenteral nutrition—Also called total parenteral nutrition or TPN. A slang term is “tube feeds.” Parenteral nutrition is the taking in of nutrients through any way other than by the gastrointestinal system. TPN can be administered by intravenous, subcutaneous, intramuscular or intramedullary injection. TPN formulations need to be prescribed based on the patient’s illness and how long they will be on the feeding regimen.

Pellagra—A disorder caused by a deficiency in niacin. The patient will have dementia, diarrhea and dermatitis.

Peripheral neuropathy—A disorder characterized by tingling and numbness in extremities. This can cause difficulties with walking and using your hands.

RDA—Recommended dietary allowance. The amount of vitamin needed to maintain a healthy level in tissues by a healthy person.

Rickets—A disorder caused by a deficiency in vitamin D. The symptoms are muscle hypotonia (weak muscles) and skeletal deformity. Seen mainly in children.

Scurvy—A disorder caused by a deficiency in ascorbic acid, or vitamin C. The patient will have swollen and bleeding gums, loss of teeth, skin lesions and pain and weakness in lower extremities.

Vitamins—Small compounds required for metabolism that must be supplied by diet, microorganisms in the gut (vitamin K) or sunlight (UV light converts pre-vitamin D to vitamin D).

been added. Clotting factors II, VII, XI, and X are made from vitamin K. The prothrombin time is prolonged when there is a deficiency of fibrinogen or factors II, V, VII, or X. Therefore, a prolonged prothrombin time can result from an inherited or acquired deficiency of one of these factors or a deficiency of vitamin K.

Other vitamins can be measured by taking advantage of their functions. One example is the measurement of oxidation/reduction reactions to measure vitamins E and C, two major antioxidants. In addition, many of the water soluble vitamins such as vitamin B₆ are measured using microbiological tests. Samples, usually filtered urine, are applied to a culture medium. The medium is inoculated with a standardized concentration of the **bacteria** or yeast that requires the vitamin for growth. The plate is incubated for several days to see if the organism grows. Lack of growth indicates a low concentration of the vitamin and correlates well with vitamin deficiency.

Preparation

Most vitamin tests require no preparation; however, some may require that the patient fast for at least eight hours before giving a blood sample, or stop using some medications.

Results

Levels of vitamins in the body must be interpreted carefully. Many times low levels do not correlate with disease and the patient is asymptomatic. Other times the levels may seem fine, but the patient displays symptoms of a deficiency. Physicians must take into account the patient’s dietary history (ie, is the patient a vegetarian), medications, and also do a thorough physical exam.

Representative normal ranges for certain vitamins are listed below. Normal ranges vary depending upon the patient’s age and method of analysis. Levels of some vitamins will be different in pregnancy. Please note that, by convention, the units used for reporting one vitamin may differ from another. The units picogram/milliliter (pg/mL), nanogram/milliliter (ng/mL), and micrograms per deciliter (micrograms/dL) refer to the weight of vitamin in the specified volume. The units nanomoles/liter (nmol/L) and micromoles/liter (umol/L) refer to the concentration of vitamin in the specified volume.

- Folate (**follic acid**): 3.0-20.0 ng/mL in serum, 140-628 ng/ml in red blood cells.
- Vitamin B₁₂: 200-835 pg/mL.
- Thiamine: 9-44 nmol/L.
- Riboflavin: 4-24 micrograms/dL.
- Vitamin B₆: 5-30 ng/mL.

- Vitamin C (ascorbic acid): 0.4-1.5 mg/dL.
- Vitamin A: 30-80 micrograms/dL.
- Vitamin D (25-hydroxy-vitamin D): 14-60 ng/mL.
- Vitamin K: 13-1190 pg/mL.
- Vitamin E: 0.5-1.8 mg/dL.

Health care team roles

Tests for specific vitamins are requested by a physician. Vitamin deficiencies may be suspected by physicians and nurses, and patients who are deficient should be referred to a dietician who can advise them on food choices. In addition, health care providers should be vigilant for hidden deficiencies in those who are pregnant, have malabsorption disorders or chronic illnesses such as **cystic fibrosis**. Blood samples are collected by a nurse or phlebotomist. Vitamin assays are performed by clinical laboratory scientists/medical technologists.

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Jane E. Phillips, PhD

Vitamin toxicity

Definition

Vitamin toxicity is a condition in which a person develops symptoms as side effects from taking massive doses of **vitamins**. Vitamins vary in the amounts that are required to cause toxicity and in the specific symptoms that result. Vitamin toxicity, which is also called hypervitaminosis or vitamin **poisoning**, is becoming more common in developed countries because of the popularity of vitamin supplements.

Description

Overview

Vitamins are organic molecules in food that are needed in small amounts for growth, reproduction, and the maintenance of good health. Some vitamins can be

dissolved in oil or melted fat. These fat-soluble vitamins include **vitamin D**, **vitamin E**, **vitamin A** (retinol), and **vitamin K**. Other vitamins can be dissolved in water. The water-soluble vitamins include folate (**folic acid**), **vitamin B₁₂**, **biotin**, vitamin B₆, **niacin**, thiamin, **riboflavin**, pantothenic acid, and **vitamin C** (ascorbic acid). Taking too much of any vitamin can produce a toxic effect. However, megadoses with the fat-soluble vitamins are more likely to become toxic than with water-soluble vitamins because fat-soluble vitamins are often stored in the body while excess water-soluble vitamins are usually excreted in the urine. Vitamins A and D are the most likely to produce hypervitaminosis in large doses, while riboflavin, pantothenic acid, biotin, and vitamin C appear to be the least likely to cause problems.

Vitamins in medical treatment

Vitamin supplements are used for the treatment of various diseases or for reducing the risk of certain diseases. For example, moderate supplements of folic acid appear to reduce the risk for certain birth defects such as neural tube defects, and possibly reduce the risk of **cancer**. Therapy for diseases brings with it the risk for irreversible vitamin toxicity only in the case of vitamin D. This vitamin is toxic at levels that are only moderately greater than the recommended dietary allowance (RDA). Niacin is commonly used as a drug for the treatment of **heart** disease, but niacin is far less toxic than vitamin D. Vitamin toxicity is not a risk with medically supervised therapy using any of the other vitamins.

Vitamin megadoses

With the exception of folic acid supplements, the practice of taking vitamin supplements by healthy individuals has little or no relation to good health. Most adults in the United States can obtain enough vitamins by eating a well-balanced diet. It has, however, become increasingly common for people to take vitamins at levels far greater than the RDA. These high levels are sometimes called vitamin megadoses. Megadoses are harmless for most vitamins. But in the cases of a few of the vitamins—specifically, vitamins D, A, and B₆—megadoses can be harmful or fatal. Researchers have also started to look more closely at megadoses of vitamins C and E, since indirect evidence suggests that these two vitamins may reduce the risks of cancer, heart disease, and aging. It is not yet clear whether taking megadoses of either vitamin C or vitamin E has any influence on health. Some experts think that megadoses of vitamin C may protect people from cancer. On the other hand, other researchers have gathered indirect evidence that vitamin C megadoses may cause cancer when combined with smoking.

Causes and symptoms

Fat-soluble vitamins

VITAMIN D. Vitamins D and A are the most toxic of the fat-soluble vitamins. The symptoms of vitamin D toxicity are nausea, vomiting, **pain** in the joints, and loss of appetite. The patient may experience constipation alternating with **diarrhea**, or have tingling sensations in the mouth. The toxic dose of vitamin D depends on its frequency. In infants, a single dose of 15 milligrams (mg) or greater may be toxic, but it is also the case that daily doses of 1.0 mg over a prolonged period may be toxic. In adults, a daily dose of 1.0 to 2.0 mg of vitamin D is toxic when consumed for a prolonged period. A single dose of about 50 mg or greater is toxic for adults. The immediate effect of an **overdose** of vitamin D is abdominal cramps, nausea, and vomiting. Toxic doses of vitamin D taken over a prolonged period of time can result in irreversible deposits of **calcium** crystals in the soft tissues of the body that may damage the heart, **lungs**, and **kidneys**. The dietary reference intake (DRI) suggests an upper tolerable limit of 25 micrograms (mcg) per day for children and 50 mcg per day for adults. The DRI is between 5–15 mcg from childhood to adulthood in the absence of adequate sunlight. Older adults have a requirement on the higher end of the scale due to generally reduced sun exposure.

VITAMIN A. Vitamin A toxicity can occur with long-term consumption of 20 mg of retinol or more per day. The symptoms of vitamin A overdosing include accumulation of water in the **brain** (hydrocephalus), vomiting, tiredness, constipation, bone pain, and severe headaches. The skin may acquire a rough and dry appearance, with hair loss and brittle nails. Vitamin A toxicity is a special issue during **pregnancy**. Expectant mothers who take 10 mg vitamin A or more on a daily basis may have an infant with birth defects. These birth defects include abnormalities of the face, nervous system, heart, and thymus gland. It is possible to take in toxic levels of vitamin A by eating large quantities of certain foods. For example, about 30 grams of beef liver, 500 grams of eggs, or 2,500 grams of mackerel would supply 10 mg of retinol.

VITAMIN E. Megadoses of vitamin E may produce headaches, tiredness, double **vision**, and diarrhea in humans. Studies with animals fed large doses of vitamin E have revealed that this vitamin may interfere with the absorption of other fat-soluble vitamins. The term absorption means the transfer of the vitamin from the gut into the bloodstream. Thus, large doses of vitamin E consumed over many weeks or months might result in deficiencies of vitamin D, vitamin A, and vitamin K. The DRI suggests an upper tolerable limit between 200–800 mg per day for children and teenagers, depending on age (younger children have requirements on the lower end of

the scale), and 1000 mg per day for adults. The DRI is 15 mg per day for adults and pregnant women.

VITAMIN K. Prolonged consumption of megadoses of vitamin K (menadione) results in anemia, which is a reduced level of red **blood** cells in the bloodstream. When large doses of menadione are given to infants, they result in the deposit of pigments in the brain, nerve damage, the destruction of red blood cells (hemolysis), and death. A daily injection of 10 mg of menadione into an infant for three days can kill the child. This tragic fact was discovered during the early days of vitamin research, when newborn infants were injected with menadione to prevent a disease known as hemorrhagic disease of the newborn. Today, a different form of vitamin K is used to protect infants against this disease.

Water-soluble vitamins

FOLATE. Folate occurs in various forms in food. There are more than a dozen related forms of folate. The folate in oral vitamin supplements occurs in only one form, however—folic acid. Large doses of folic acid (20 grams/day) can eventually result in kidney damage. Folate is considered, however, to be relatively nontoxic, except in cases where folate supplementation can lead to pernicious anemia. The DRI suggests an upper tolerable limit between 300–800 mcg per day for children and teenagers, depending on age (younger children have requirements on the lower end of the scale), and 1000 mcg per day for adults. The DRI is 400 mcg per day for adults and slightly lower in children; 600 mcg during pregnancy and 500 mcg while lactating.

VITAMIN B₁₂. Vitamin B₁₂ is important in the treatment of pernicious anemia. Pernicious anemia is more common among middle-aged and older adults; it is usually detected in patients between the ages of 40 and 80. The disease affects about 0.1% of all persons in the general population in the United States, and about 3% of the elderly population. Pernicious anemia is treated with large doses of vitamin B₁₂. Typically, 0.1 mg of the vitamin is injected each week until the symptoms of pernicious anemia disappear. Patients then take oral doses of vitamin B₁₂ for the rest of their life. Although vitamin B₁₂ toxicity is not an issue for patients being treated for pernicious anemia, treatment of these patients with folic acid may cause problems. Specifically, pernicious anemia is often first detected because the patient feels weak or tired. If the anemia is not treated, the patient may suffer irreversible nerve damage. The problem with folic acid supplements is that the folic acid treatment prevents the anemia from developing, but allows the eventual nerve damage to occur.

VITAMIN B₆. Vitamin B₆ is clearly toxic at doses about 1000 times the RDA. Daily doses of 2–5 grams of

one specific form of this vitamin can produce difficulty in walking and tingling sensations in the legs and soles of the feet. Continued megadoses of vitamin B₆ result in further unsteadiness, difficulty in handling small objects, and numbness in the hands. When the high doses are stopped, recovery begins after two months. Complete recovery may take two to three years. The DRI suggests an upper tolerable limit between 30–80 mg per day for children and teenagers, depending on age (younger children have requirements on the lower end of the scale), and 100 mg per day for adults. The DRI is between 1.3–1.7 mg per day for adults, slightly higher during pregnancy, and lower in children.

VITAMIN C. Large doses of vitamin C are considered to be toxic in persons with a family history of or tendency to form **kidney stones** or **gallbladder stones**. Kidney and gallbladder stones usually consist of calcium oxalate. Oxalate occurs in high concentrations in foods such as cocoa, chocolate, rhubarb, and spinach. A fraction of the vitamin C in the body is normally broken down to produce oxalate. A daily supplement of 3.0 grams of vitamin C has been found to double the level of oxalate that passes through the kidneys and is excreted into the urine. The DRI suggests an upper tolerable limit between 400–1200 mg per day for children and teenagers, depending on age (younger children have requirements on the lower end of the scale), and 2000 mg per day for adults.

NIACIN. The DRI for niacin is 14–16 mg per day in adults. Niacin comes in two forms, nicotinic acid and nicotinamide. Either form can satisfy the adult requirement for this vitamin. Nicotinic acid, however, is toxic at levels of 100 times the RDA. It can cause flushing of the skin, nausea, diarrhea, and liver damage. Flushing is an increase in blood passing through the veins in the skin, due to the dilation of arteries passing through deeper parts of the face or other parts of the body. In spite of the side effects, however, large doses of nicotinic acid are often used to lower blood cholesterol in order to prevent heart disease. Nicotinic acid results in a lowering of LDL-cholesterol (so-called bad cholesterol), an increase in HDL-cholesterol (so-called good cholesterol), and a decrease in plasma triglycerides. Treatment involves daily doses of 1.5–4.0 grams of nicotinic acid per day. Flushing of the skin occurs as a side effect when nicotinic acid therapy is started, but may disappear with continued therapy. The DRI suggests an upper tolerable limit between 10–30 mg per day for children and teenagers, depending on age (younger children have requirements on the lower end of the scale), and 35 mg per day for adults. The DRI for vitamin C in adults is between 75–90 mg per day, slightly more during pregnancy.

Diagnosis

The diagnosis of vitamin toxicity is usually made on the basis of the patient's dietary or medical history. Questioning the patient about the use of vitamin supplements may shed light on some physical symptoms. The doctor can confirm the diagnosis by ordering blood or urine tests for specific vitamins. When large amounts of the water-soluble vitamins are consumed, a large fraction of the vitamin is absorbed into the bloodstream and promptly excreted into the urine. The fat-soluble vitamins are more likely to be absorbed into the bloodstream and deposited in the fat and other tissues. In the cases of both water-soluble and fat-soluble vitamins, any vitamin not absorbed by the intestines is excreted in the feces. Megadoses of many of the vitamins produce diarrhea, because the non-absorbed nutrient draws water out of the body and into the gut, resulting in the loss of this water from the body.

Treatment

In all cases, treatment of vitamin toxicity requires discontinuing vitamin supplements. Vitamin D toxicity needs additional action to reduce the calcium levels in the bloodstream because it can cause abnormally high levels of plasma calcium (hypercalcemia). Severe hypercalcemia is a medical emergency and is treated by infusing a solution of 0.9% sodium chloride into the patient's bloodstream. The infusion consists of 2–3 qt (liters) of salt water given over a period of one to two days.

Prognosis

The prognosis for reversing vitamin toxicity is excellent for most patients. Side effects usually go away as soon as overdoses are stopped. The exceptions are severe vitamin D toxicity, severe vitamin A toxicity, and severe vitamin B₆ toxicity. Too much vitamin D leads to deposits of calcium salts in the soft tissue of the body, which cannot be reversed. Birth defects due to vitamin A toxicity cannot be reversed. Damage to the nervous system caused by megadoses of vitamin B₆ can be reversed, but complete reversal may require a recovery period of more than a year.

Health care team roles

Health care professionals should familiarize themselves with the symptoms of vitamin toxicities in order to successfully diagnose toxic levels.

Patient education

Health care professionals can direct patients in learning about the recommended requirements for each vitamin so that toxicities do not pose a risk. The DRI can be

KEY TERMS

Absorption—The transfer of a vitamin from the digestive tract to the bloodstream.

Ascorbic acid—Another name for vitamin C.

Dietary reference intakes (DRI)—These standards explain the daily amounts of energy, protein, minerals, and fat-soluble and water-soluble vitamins needed by healthy males and females, from infancy to old age.

Hypercalcemia—A condition marked by abnormally high levels of calcium in the blood.

Hypervitaminosis—Another name for vitamin toxicity.

Megadose—A very large dose of a vitamin, taken by some people as a form of self-medication.

Menadiol—A synthetic form of vitamin K, sometimes called vitamin K₃.

Pernicious anemia—A rare disorder in which the body does not absorb enough vitamin B₁₂ from the digestive tract, resulting in an inadequate amount of red blood cells produced.

Recommended dietary allowance (RDA)—The quantities of nutrients in the diet that are needed for good health.

Retinol—Another name for vitamin A.

referred to for information regarding recommended intakes for individuals, estimated average requirements, and upper tolerable limits. The healthiest way to acquire vitamins is through good **nutrition** via food. Following the Dietary Guidelines for Americans, published by the U.S. Department of Agriculture and Health and Human Services, can provide a broad overall view of good nutrition. The Food Guide Pyramid was created by the U.S. Department of Agriculture to help Americans choose foods from each food grouping. The food pyramid, developed by nutritionists, provides a visual guide to healthy eating.

Prevention

Vitamin toxicity can be prevented by minimizing the use of vitamin supplements or by only taking a dose within recommended levels of the DRI or RDA. If vitamin D supplements are being used on a doctor's orders, monitoring the levels of plasma calcium help prevent toxicity. The

development of hypercalcemia with vitamin D treatment indicates that the patient is at risk for vitamin D toxicity.

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OTHER

- Food and Nutrition Professionals Network. <<http://nutrition.cos.com/>>.

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Vitamins

Definition

Vitamins are organic components in food that are needed for growth and for maintaining good health. They include the fat-soluble vitamins, such as **vitamin D**, **vitamin E**, **vitamin A**, and **vitamin K**; and the water-soluble vitamins, such as folate (**folic acid**), **vitamin B₁₂**, **biotin**, vitamin B₆, **niacin**, thiamin, **riboflavin**, pantothenic acid, and **vitamin C** (ascorbic acid). Vitamins are required in the diet in only tiny amounts, in contrast to the energy components (sugars, starches, **fats**, and oils).

Purpose

All of the vitamins serve several important functions in the body and provide many health benefits. Therefore, a lack of a particular vitamin in the diet can cause a corresponding vitamin-deficiency disease.

Vitamin D, which helps to fight **infection**, is available from butter, cream, salmon, egg yolks, and adequate sun exposure. Vitamin D deficiency in children is called rickets, which is a disease of the bones. Symptoms include knocked knees, bowed legs, and protruding chests. Osteomalacia is the adult form of vitamin D deficiency; it is a result of low **calcium** intakes or lack of sun exposure during childhood and the adult years. Vitamin E acts as an antioxidant in the body for cells that are highly exposed to oxygen, and it resists hemolysis of red **blood** cells. Vitamin E is very widespread in food, so a deficiency is rare. However, when vitamin E deficiency does occur, it can cause serious nerve damage. Hemolytic anemia results if there is a vitamin E deficiency. A deficiency in vitamin E usually occurs only in premature babies due to the fact that they are born before the vitamin can be transferred to the developing baby during the last few weeks of **pregnancy**.

Vitamin A functions in maintaining **vision**, immune defense, bone development, cell growth, and reproduction. Food sources of vitamin A include fortified milk, spinach, carrots, and sweet potatoes. Vitamin A deficiency is common throughout the poorer parts of the world, and causes night blindness (nyctalopia). Severe vitamin A deficiency can result in xerophthalmia, a disease that, if left untreated, results in total blindness. Dry, scaly skin (hyperkeratosis) also results from vitamin A deficiency. Vitamin K is a nutrient that is essential for blood clotting; it can be obtained from intestinal **bacteria**. It is also present in dark-green leafy vegetables, cabbage, liver, eggs, cereals, and fruit. Vitamin K deficiency results in sponta-

neous bleeding. It can be affected by mineral oil, **antibiotics**, and anticoagulants.

Folate, also known as folic acid, is required for the synthesis of new cells in the body. Mild or moderate folate deficiency is common throughout the world, and can result from the failure to eat green leafy vegetables or fruits and fruit juices. Folate deficiency causes megaloblastic anemia, which is characterized by the presence of large abnormal cells, called megaloblasts, in the circulating blood. The symptoms of megaloblastic anemia are tiredness and weakness. Folic-acid deficiency is also associated with neural-tube birth defects such as spina bifida and anencephaly. These serious congenital malformations are the result of inadequate folate intake during pregnancy. Neural-tube defects occur early in pregnancy before most women even know they are pregnant, so it is essential that women of childbearing age receive adequate amounts of folate before they become pregnant, as well as during pregnancy. For this reason, folate fortification of enriched flour, breads, rice, and other grain products was approved by the U.S. Food and Drug Administration (FDA) in 1996. Vitamin B₁₂ helps make red blood cells in the body and protect nerve fibers. A deficiency occurs with the failure to consume sufficient meat or milk or other dairy products. Vitamin B₁₂ deficiency causes pernicious anemia, which is the result of a lack of the intrinsic factor needed for the absorption of vitamin B₁₂. A deficiency of vitamin B₁₂ can be masked by folate deficiency.

The B vitamins niacin, thiamine, and riboflavin each play a role in the energy **metabolism** of cells. Niacin can be found in such foods as tuna, chicken, mushrooms, and baked potatoes. A deficiency of niacin results in the disease known as pellagra, which involves skin rashes, scabs, **diarrhea**, and mental depression. Thiamin is found in pork, ham, green leafy vegetables, legumes, and whole-grain cereals. Thiamine deficiency results in beriberi, a disease resulting in atrophy, weakness of the legs, nerve damage, and **heart failure**. Vitamin C helps protect against infection and enhances the absorption of **iron**. Orange juice, grapefruit, broccoli, green peppers, and brussels sprouts are significant sources of vitamin C. A deficiency results in scurvy, a disease that contributes to the breakdown of collagen, which causes loose teeth, bleeding gums, and swollen wrists and ankles. Specific diseases uniquely associated with deficiencies in vitamin B₆, riboflavin, or pantothenic acid have not been found in humans, though people who have been starving, or consuming poor diets for several months, might be expected to be deficient in most of the nutrients, including vitamin B₆, riboflavin, and pantothenic acid. Homocystinurias, a group of autosomal recessive disorders, are associated with low levels of folate and vitamins B₆ and B₁₂.

ESSENTIAL VITAMINS	
<i>Vitamin</i>	<i>What It Does For The Body</i>
Vitamin A (Beta Carotene)	Promotes growth and repair of body tissues; reduces susceptibility to infections; aids in bone and teeth formation; maintains smooth skin
Vitamin B-1 (Thiamin)	Promotes growth and muscle tone; aids in the proper functioning of the muscles, heart, and nervous system; assists in digestion of carbohydrates
Vitamin B-2 (Riboflavin)	Maintains good vision and healthy skin, hair, and nails; assists in formation of antibodies and red blood cells; aids in carbohydrate, fat, and protein metabolism
Vitamin B-3 (Niacinamide)	Reduces cholesterol levels in the blood; maintains healthy skin, tongue, and digestive system; improves blood circulation; increases energy
Vitamin B-5	Fortifies white blood cells; helps the body's resistance to stress; builds cells
Vitamin B-6 (Pyridoxine)	Aids in the synthesis and breakdown of amino acids and the metabolism of fats and carbohydrates; supports the central nervous system; maintains healthy skin
Vitamin B-12 (Cobalamin)	Promotes growth in children; prevents anemia by regenerating red blood cells; aids in the metabolism of carbohydrates, fats, and proteins; maintains healthy nervous system
Biotin	Aids in the metabolism of proteins and fats; promotes healthy skin
Choline	Helps the liver eliminate toxins
Folic Acid (Folate, Folacin)	Promotes the growth and reproduction of body cells; aids in the formation of red blood cells and bone marrow
Vitamin C (Ascorbic Acid)	One of the major antioxidants; essential for healthy teeth, gums, and bones; helps to heal wounds, fractures, and scar tissue; builds resistance to infections; assists in the prevention and treatment of the common cold; prevents scurvy
Vitamin D	Improves the absorption of calcium and phosphorous (essential in the formation of healthy bones and teeth) maintains nervous system
Vitamin E	A major antioxidant; supplies oxygen to blood; provides nourishment to cells; prevents blood clots; slows cellular aging
Vitamin K (Menadione)	Prevents internal bleeding; reduces heavy menstrual flow

(Illustration by Standley Publishing. Courtesy of Gale Group.)

Some of the vitamins serve only one function in the body, while other vitamins serve a variety of unrelated functions. Hence, some vitamin deficiencies tend to result in one type of defect, while other deficiencies result in a variety of problems.

Purpose

People are treated with vitamins for three reasons. The primary reason is to relieve a vitamin deficiency when one has been detected. Chemical tests suitable for

the detection of all vitamin deficiencies are available. The diagnosis of vitamin deficiency is often aided by visual tests, such as the examination of blood cells with a **microscope**, the x-ray examination of bones, or a visual examination of the eyes or skin.

A second reason for vitamin treatment is to prevent the development of an expected deficiency. In this case, vitamins are administered even with no test for possible deficiency. One example is vitamin K treatment of newborn infants to prevent bleeding. Food supplementation

is another form of vitamin treatment. The vitamin D added to foods serves the purpose of preventing the deficiency from occurring in people who may not be exposed much to sunlight and who fail to consume foods that are fortified with vitamin D, such as milk. Niacin supplementation prevents pellagra among people who rely on corn as the main source of food and who do not eat much meat or milk. In general, the U.S. food supply is fortified with niacin.

A third reason for vitamin treatment is to reduce the risk for diseases that may occur even when vitamin deficiency cannot be detected by chemical tests. One example is folate deficiency. The risk for cardiovascular disease can be slightly reduced for a large fraction of the population by folic-acid supplements. These supplements can also sharply reduce the risk for certain birth defects.

Vitamin treatment is important during specific diseases where the body's normal processing of a vitamin is impaired. In these cases, high doses of the needed vitamin can force the body to process or utilize it in the normal manner. One example is pernicious anemia, a disease that tends to occur in middle age or old age; it impairs the absorption of vitamin B₁₂. Surveys have revealed that about 0.1% of the general population, and 2% to 3% of the elderly, may have the disease. If left untreated, pernicious anemia leads to nervous-system damage. The disease can easily be treated with large daily oral doses of vitamin B₁₂ (hydroxocobalamin) or with monthly injections of the vitamin.

Vitamin supplements are widely available as over-the-counter products. But whether they work to prevent or curtail certain illnesses, particularly in people with a balanced diet, is a matter of debate and ongoing research. For example, vitamin C is not proven to prevent the **common cold**, yet millions of people take it for that reason.

Precautions

Vitamin A and vitamin D can be toxic in high doses; side effects range from dizziness to kidney failure. High doses of niacin can be toxic to the liver, while excessive intake may occur with vitamin C, especially among the elder. Doses of vitamin K can have toxic effects in infants. A physician or pharmacist should be consulted about the correct use of a multivitamin supplement that contains these vitamins.

Description

Vitamin treatment is usually done in three ways: by replacing a poor diet with one that supplies the recommended dietary allowance (RDA), by consuming oral supplements, or by injections. Injections are useful for

KEY TERMS

Anencephaly—A neural-tube defect that causes lack of brain formation and results in death shortly after birth.

Antioxidant—A compound that prevents other compounds from being damaged by oxygen by reacting with oxygen itself.

Genetic disease—A disease that is passed from one generation to the next but does not necessarily appear in each generation. An example of genetic disease is Down syndrome.

Neural tube defects—A group of birth defects that affect the brain and spinal cord.

Recommended dietary allowance (RDA)—The recommended dietary allowances (RDAs) are quantities of nutrients of the diet that are required to maintain human health. RDAs are established by the Food and Nutrition Board of the National Academy of Sciences and may be revised every few years. A separate RDA value exists for each nutrient. The RDA values refer to the amount of nutrient expected to maintain health in the greatest number of people.

Vitamin status—The state of vitamin sufficiency or deficiency of any person. For example, a test may reveal that a patient's folate status is sufficient, borderline, or severely inadequate.

persons with diseases that prevent absorption of fat-soluble vitamins. Oral vitamin supplements are especially useful for people who otherwise cannot or will not consume food that is a good vitamin source, such as meat and dairy products. For example, a vegetarian who will not consume meat may be encouraged to consume oral supplements of vitamin B₁₂.

Treatment of genetic diseases that impair the absorption or utilization of specific vitamins may require megadoses of the vitamin throughout one's lifetime. Megadose means a level of about 10 to 1,000 times greater than the RDA for a particular vitamin. Pernicious anemia, homocystinuria, and biotinidase deficiency are three examples of genetic diseases that are treated with megadoses of vitamins.

Preparation

The diagnosis of a vitamin deficiency usually involves a blood test. An overnight fast is usually recom-

mended as preparation prior to the blood test so that vitamin-fortified foods do not affect the test results.

Aftercare

The response to vitamin treatment can be monitored by chemical tests, by an examination of red or white blood cells, or by physiological tests, depending on the exact vitamin deficiency.

Complications

Although there are few complications associated with vitamin treatment, possible risks depend on the vitamin and the reason why it was prescribed. In general, the higher the dose that is taken, the higher the risk of toxicity. It is also important to remember that vitamins are better absorbed from food rather than in concentrated pill form. Physicians or pharmacists should be consulted about how and when to take vitamin supplements, particularly those that have not been prescribed by a physician.

Health care team roles

Dietitians can provide a wide range of information concerning the well-balanced diet that is necessary to receive adequate amounts of all the vitamins. Dietitians also play an important role in educating people about the dangers of consuming too much or too little of a particular vitamin. When a particular vitamin deficiency is present, consulting a dietitian, pharmacist, or physician about how and when to take vitamin supplements is advised.

Resources

BOOKS

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Lisa Gourley

Voice disorders

Definition

A voice disorder is an abnormality of one or more of the three characteristics of voice: pitch, intensity (loudness), and quality (resonance).

Description

The National Institute on Deafness and Other Communication Disorders estimates that approximately 7.5 million persons in the United States suffer from some sort of voice disorder. The negative impact of a voice disorder is often social, psychological, professional, and economic (as in the case of a singer or actor).

Voice is typically described in terms of three characteristics: pitch, intensity, and quality. Pitch may be described as the relative tone of a person's voice—how high or low it is, how monotonous, or how it demonstrates repeated inappropriate pitch patterns. A disorder may result from pitch being inappropriate for an individual's age and gender. An inability to perceive pitch and pitch patterns may result in a monotonous voice, a high-pitched voice, or inappropriate use of repeated pitch patterns.

Loudness describes the volume or intensity of a person's voice. A person who spends a great deal of time in a noisy location or who is suffering from **hearing loss** may speak with high intensity, or louder than normal. A soft or inaudible voice may be associated with a psychological condition such as shyness or with a structural defect of the vocal cords.

Some disorders of voice quality are related to how the vocal cords function: breathiness is caused by vocal cord vibration that does not have a closed phase, while hoarseness is caused by vocal cords that are closed too tightly, so they cannot vibrate properly. Other disorders are related to how the voice resonates in the oral (mouth), nasal (nose), and pharyngeal (throat) cavities. If the nasal passage becomes blocked such as with a cold, then air is unable to reach the nasal cavity and a voice sounds hyponasal. Hypernasality results when too much air passes through the nasal cavities during phonation or when there is an obstruction in the anterior nasal cavities (pinching the nostrils).

Causes and symptoms

Normal voice production

The larynx is an organ found in the neck that helps to control the flow of air during breathing and to produce

sound during speech. The vocal folds, also called the vocal cords, are two folds of muscle covered by a thin membrane that lie inside a framework of cartilage and soft tissue. The tension, position, and shape of the vocal folds are controlled by a number of muscles called intrinsic muscles.

Prior to the production of sound, the vocal folds are brought together by the intrinsic muscles. During exhalation, air pressure builds up beneath the closed vocal folds, causing them to separate. They are brought back together, only to separate again when pressure increases. This cycle repeats itself approximately 200 times per second in order to produce sound.

Abnormal voice production

Some of the most common causes of voice disorders in adults include **infection**, inflammation, vocal misuse or abuse, **cancer**, neuromuscular disorders, and psychological problems. In children, vocal misuse or abuse is the most common cause of voice disorder of quality.

INFECTION. A viral or bacterial infection may directly or indirectly result in voice problems. Upper respiratory infections may cause inflammation of the vocal fold membranes, resulting in changes in voice pitch and/or quality; this condition is called acute viral laryngitis. Recurrent respiratory papillomas (RRP) are wart-like growths caused by infection by the human papilloma virus (HPV); papillomas may grow on the larynx or in the throat, nose, or trachea and cause hoarseness and/or shortness of breath.

INFLAMMATION. A condition called laryngopharyngeal reflux disease (LPRD) has been associated with approximately 55% of voice disorder cases. LPRD is caused by the backflow (reflux) of acidic **stomach** contents into the larynx, causing inflammation. Hoarseness, difficulty swallowing, **pain**, and coughing are some symptoms of LPRD.

Exposure to cigarette smoke has been shown to cause inflammation of the larynx, leading to a negative change in voice quality. Long-term tobacco use has also been associated with the development of LPRD. Reinke's **edema**, a term used to describe very swollen vocal cords, is another condition common in long-term smokers; fluid accumulates under the outer covering of the vocal folds and causes the voice to become low pitched.

VOCAL MISUSE OR ABUSE. Examples of vocal misuse are singing or speaking out of range and producing harsh vocal sounds. Extended screaming and yelling are other examples of vocal abuse. The result of vocal misuse or abuse may be swelling of the vocal folds (edema), followed by the formation of vocal fold nodules (callus-

es). Consequences may range from vocal fatigue or hoarseness to vocal fold hemorrhage (bleeding).

LARYNGEAL CANCER. Laryngeal cancer accounts for 2–5% of cancers diagnosed in the United States. Chronic tobacco and alcohol use are major risk factors for developing laryngeal cancer. Symptoms include chronic hoarseness, coughing, **sore throat**, difficulty swallowing or breathing, and/or pain that radiates to the neck.

NEUROMUSCULAR DISORDERS. Vocal fold **paralysis** and paresis (partial paralysis) are examples of neuromuscular voice disorders. The cause of vocal fold paralysis is usually due to trauma or to cancer. It may also occur as a result of tumor involvement of the laryngeal nerves. Spasmodic dysphonia (SD) is another neuromuscular disorder and is caused by abnormal contractions of the muscles that control the vocal folds, resulting in a hoarse, shaky, and/or strained or strangled voice. Finally, the causes of neuromuscular disorders include degenerative conditions both of the nervous system and muscle.

PSYCHOLOGICAL CONDITIONS. Voice is often affected by one's emotions; psychological **stress** may cause changes to loudness or pitch. More rarely, voice disorders may be caused by psychological trauma or extreme stress. Aphonia, or a complete loss of voice, may be a result. Often, such voice disorders may be successfully treated with psychological therapy.

Diagnosis

A variety of technologies are available to examine the larynx for abnormalities, including:

- **Laryngoscopy:** The indirect examination involves holding a small mirror at the back of the throat in order to visualize the larynx. In a direct examination, a flexible (inserted through the nose to the back of the throat) or rigid (held at the back of the mouth) tube-like instrument is used to more clearly visualize the interior of the larynx.
- **Video stroboscopy:** A strobe light is used in this test to help visualize the rapidly vibrating vocal folds as if they were in slow motion, potentially revealing changes in the vocal folds not readily seen using other methods.
- **Electromyography (EMG):** A laryngeal EMG is used to examine the electrical activity of the muscles of the larynx as they contract; this may reveal injury to nerves that are important in voice production.
- **Double-probe pH monitoring:** Special probes are placed in the esophagus and larynx to measure the extent of laryngopharyngeal reflux (LPR) over a 24-

KEY TERMS

Botox—A toxin produced by the bacteria *Clostridium botulinum* that can provide temporary relief to people suffering from spasmodic dysphoria.

Neuromuscular—Relating to the muscles and nerves.

Otolaryngologist—A specialist who treats disorders of the ear, nose, and throat.

Trachea—The windpipe.

hour period. This test is therefore useful in diagnosing LPRD.

Treatment

How a voice disorder is treated depends largely on how it was caused. Often, voice therapy with a certified speech-language pathologist can dramatically improve a person's voice. Voice therapy may include vocal and listening exercises, information on vocal hygiene (appropriate uses of voice), and education regarding proper voice technique. Treatment may also be the medical management of contributing health factors such as **allergies** and, in some cases, surgery. Other than medical treatment, therapy may include modification of the environment and psychological counseling.

A promising treatment for SD is injection with small amounts of a bacterial toxin called botox into the muscles of the larynx. The toxin temporarily weakens the laryngeal muscles, resulting in several months of improved voice quality.

Occasionally, surgery may be required to repair damaged vocal folds or remove cancerous tumors. **Laser surgery** has been used successfully in laryngeal surgery due to its precise cutting beam. Treatment of laryngeal cancer may include **chemotherapy**, radiation therapy, and/or partial or total laryngectomy, in which part, or all, of the larynx is removed. Voice therapy before and after surgery is recommended to provide the patient with a new mode of speech, if necessary.

Health care team roles

Common health care professionals involved with the care of a patient with a voice disorder may include:

- speech-language pathologists

- otolaryngologist, specialists who treat disorders of the ears, nose, and throat
- respiratory therapists
- psychiatrist or psychologist
- oncologists, cancer specialists
- audiologists, **hearing specialists**

Prevention

In order to prevent the development or deterioration of a voice disorder, patients are recommended to:

- Drink six to eight glasses of water a day and minimize intake of alcoholic and caffeinated beverages.
- Decrease exposure to cigarette smoke.
- Avoid unnecessarily coughing or clearing the throat, or speaking or singing out of range.
- Seek medical care if hoarseness or other voice changes persist for longer than 10 days.

Resources

ORGANIZATIONS

American Speech-Language-Hearing Association (ASHA). 10801 Rockville Pike, Rockville, MD 20852. (888) 321-ASHA. <<http://www.asha.org>>.

National Institute on Deafness and Other Communication Disorders (NIDCD) Information Clearinghouse. 1 Communication Avenue, Bethesda, MD 20892-3456. (800) 241-1044. <<http://www.nidcd.nih.gov>>.

The Voice Foundation. 1721 Pine Street, Philadelphia, PA 19103. (215) 735-7999. <<http://www.voicefoundation.org>>.

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Walking pneumonia *see* **Pneumonia**

Water and nutrition

Definition

Water is essential to life and nutritional health. Humans can live for several weeks without food, but we can survive only a few days without water. Water makes up a large percentage of the body, in muscles, fat cells, **blood** and even bones.

Purpose

Every cell, tissue and organ requires water to function properly. Water transports nutrients and oxygen to the cells, provides a medium for chemical reactions to take place, helps to flush out waste products, aids in maintaining a constant body temperature, and keeps the tissues in the skin, mouth, eyes, and nose moist.

Precautions

The body does not store excess water, unlike it does with other nutrients. With physical exertion, water requirements increase; therefore, fluid replacement during **exercise** is critical. The longer the duration and the more physical exertion athletes put into their exercise, the more fluid they lose during workouts. To keep the body working at its best, it is essential to replenish lost fluid after workouts, and to stay well hydrated during exercise.

The body can accommodate extreme changes in water intake when the **brain** and **kidneys** are functioning normally. It is usually possible for a person to consume enough water to maintain blood volume and **electrolyte balance** in the blood. However, if a person is unable to

consume enough water to equal excessive water loss, **dehydration** may result.

Description

Water for sustaining life

The body works to maintain water balance through mechanisms such as the thirst sensation. When the body requires more water, the brain stimulates nerve centers in the brain to encourage a person to drink in order to replenish the water stores.

The kidneys are responsible for maintaining homeostasis of the body water (i.e. water balance) through the elimination of waste products and excess water. Water is primarily absorbed through the gastrointestinal tract and excreted by the kidneys as urine. Water intake can vary widely on a daily basis, influenced by such factors as: access to water, thirst, habit, and cultural factors. The variation in water volume ingested is dependent on the ability of kidneys to dilute and concentrate the urine as needed. There is a reservoir of water outside of the bloodstream that can replace or absorb excess water in the blood when necessary.

For a normal adult, a minimum daily intake between 700-800 ml (0.74-0.84 US quarts) is required to meet water losses and maintain the body's water balance. To protect against dehydration and developing **kidney stones**, greater water consumption (between 1.4-2 L/day or 1.5-2 US quarts/day) is advised. Water losses occur through evaporation in expired air and through the skin. Sweat losses are usually minimal but can be significant in warmer climates or with accompanying **fever**.

The following conditions increase water consumption needs. However, the amount of water necessary depends on body size, age, climate, and exertion level.

Water needs are increased by:

- Exercise. Water is lost through perspiration.
- Hot and humid climates.

- High altitudes. The breathing rate is twice as fast as at sea level. At high altitudes, most water loss is due to respiration rather than perspiration.
- Prescription drugs. If adequate water is not available for proper blood flow, medication can become concentrated in the bloodstream and become less effective.
- Dieting. A reduced carbohydrate intake may have a diuretic effect because **carbohydrates** store water.
- Airplane, bus, or train travel. The re-circulated air causes water to evaporate from skin faster.
- Illness. Fever, **diarrhea** and vomiting lead to increased water losses.

Individuals should not wait until they are thirsty to replenish water stores. By the time the thirst mechanism signals the brain to encourage a person to drink water, already 1–3% of the body fluids are lost and an individual is mildly dehydrated.

Nutrition for optimal health

Not only is water necessary to sustain life, but proper **nutrition** is also required to ensure optimal health. Consumption of wide variety of foods, with adequate vitamin and mineral intake is the basis of a healthy diet. **Vitamins** are compounds that are essential in small amounts for proper body function and growth. Vitamins are either fat soluble: A, D, E, and K; or water soluble: vitamin B and C. The B vitamins include vitamins B₁ (**thiamine**), B₂ (**riboflavin**), and B₆ (pyridoxine), pantothenic acid, **niacin**, **biotin**, **folic acid** (folate), and **vitamin B₁₂** (cobalamin).

Researchers state that no single nutrient is the key to good health, but that optimum nutrition is derived from eating a diverse diet including a variety of fruits and vegetables. Because there are many more nutrients available in foods such as fruits and vegetables than vitamin supplements, food is the best source for acquiring needed vitamins and **minerals**. The mineral nutrients are defined as all the inorganic elements or inorganic molecules that are required for life. As far as human nutrition is concerned, the inorganic nutrients include water, sodium, potassium, chloride, **calcium**, phosphate, sulfate, magnesium, **iron**, **copper**, **zinc**, manganese, iodine, selenium, and molybdenum. Other inorganic nutrients include phosphate, sulfate, and selenium. Inorganic nutrients have a great variety of functions in the body. The electrolytes are affected by **fluid balance** in particular (sodium, potassium, calcium, phosphate, and magnesium etc.). Water, sodium, and potassium deficiencies are most closely associated with abnormal nerve action and cardiac arrhythmias.

Laboratory studies with animals have revealed that severe deficiencies in any one of the inorganic nutrients can result in very specific symptoms, and finally in death, due to the failure of functions associated with that nutrient. In humans, deficiency in one nutrient may occur less often than deficiency in several nutrients. A patient suffering from malnutrition is deficient in a variety of nutrients.

Complications

Sodium deficiency (hyponatremia) and water imbalances (dehydration) are the most serious and widespread deficiencies in the world. These electrolyte deficiencies tend to arise from excessive losses from the body, such as during prolonged and severe diarrhea or vomiting. Diarrheal diseases are a major world health problem, and are responsible for about a quarter of the 10 million infant deaths that occur each year. Nearly all of these deaths occur in impoverished parts of Africa and Asia, where they result from contamination of the water supply by animal and human feces.

Dehydration is a deficit of body water that results when the output of water exceeds intake. Dehydration stimulates the thirst mechanism, instigating water consumption. Sweating and the output of urine both decrease. If water intake continues to fall short of water loss, dehydration worsens.

Causes of dehydration may include:

- vomiting
- diarrhea
- diuretics
- excessive heat
- excessive sweating
- fever
- decreased water intake

Dehydration induces water to move from the reservoir inside cells into the blood. If dehydration progresses, body tissues begin to dry out and the cells start to shrivel and malfunction. The most susceptible cells to dehydration are the brain cells. Mental confusion, one of the most common signs of severe dehydration may result, possibly leading to **coma**. Dehydration can occur when excessive water is lost with diseases such as **diabetes mellitus**, diabetes insipidus, and Addison's disease.

Dehydration is often accompanied by a deficiency of electrolytes, sodium and potassium in particular. Water does not move as rapidly from the reservoir inside of the cells into the blood when electrolyte concentration is decreased. **Blood pressure** can decline due to a lower

volume of water circulating in the bloodstream. A drop in blood pressure can cause light-headedness, or a feeling of impending blackout, especially upon standing (orthostatic hypotension). Continued fluid and electrolyte imbalance may further reduce blood pressure, causing **shock** and damage to many internal organs including the brain, kidneys, and **liver**.

Consumption of *plain water* is usually sufficient for mild dehydration. However, when both water and electrolyte losses have occurred after vigorous exercise, electrolytes must be replaced, sodium and potassium in particular. Adding a little salt to drinking water or consuming drinks such as Gatorade during or following exercise can replace lost fluids. Individuals with **heart** or **kidneys** problems should consult a physician regarding the replacement of fluids after exercise.

Overhydration is an excess of body water that results when water intake exceeds output. Drinking large amounts of water does not typically lead to overhydration if the kidneys, heart, and **pituitary gland** are functioning properly. An adult would have to drink more than 7.6 L per day (2 US gallons/day) to exceed the body's ability to excrete water. Excessive body water causes electrolytes in the blood, including sodium to become overly diluted. Overhydration occurs in individuals whose kidneys do not function normally, primarily in kidney, heart, or liver disease. People with these conditions may have to limit their water and dietary salt intake. Similar to dehydration, the brain is the most sensitive organ to overhydration. The brain cells can adapt to increased fluid volume when overhydration increases slowly, however, when it occurs rapidly, mental confusion, seizures, and coma can result.

Results

Consuming adequate food and fluid before, during, and after exercise can help maintain blood glucose during exercise and also maximize exercise performance. Athletes should be well-hydrated before exercise commencement and should drink enough fluid during and after exercise to maintain homeostasis. The same rules apply to non-athletes who are participating in physical activity or are in conditions that increase dehydration. Careful attention to water intake and urine output should provide the best results.

Avoiding some beverages such as coffee, tea, alcohol and caffeinated soft drinks may reduce the risk of dehydration. These beverages are all diuretics (substances that increase fluid loss). Water in foods, especially fruits and vegetables, is a great source of fluid. Fruits and vegetables can contain up to 95 percent water, so a well-balanced diet is a good way to stay hydrated.

KEY TERMS

Dehydration—A deficit of body water that results when the output of water exceeds intake.

Diuretic—An agent or drug that eliminates excessive water in the body by increasing the flow of urine.

Electrolyte—A substance such as an acid, bases, or salt. An electrolyte's water solution will conduct an electric current and ionizes. Acids, bases, and salts are electrolytes.

Homeostasis—An organism's regulation of body processes to maintain internal equilibrium in temperature and fluid content.

Overhydration—An excess of body water that results when water intake exceeds output.

Health care team roles

All health care professionals should recognize the importance of promoting proper nutrition and hydration. Encouraging patients to follow nutrition guidelines for adequate vitamin and mineral intakes is critical.

Patient education

Patients and individuals can be educated regarding the importance of hydration by nutrition experts and physicians as well as the need for good nutrition. Individuals themselves can become familiar with concepts for healthy eating using a number of resources such as the Food Pyramid, which provides a visual guide to healthy eating. In addition, the U.S. Department of Agriculture and the U.S. Department of Health and Human Services have developed official dietary guidelines that include ten basic recommendations for healthy eating:

- Aim for a healthy weight.
- Be physically active each day.
- Let the Food Pyramid guide your food choices.
- Choose a variety of grains daily, especially whole grains.
- Choose a variety of fruits and vegetables daily.
- Keep food safe to eat.
- Choose a diet low in saturated fat and cholesterol, and moderate in total fat.
- Choose beverages and foods to moderate intake of sugars.
- Choose and prepare foods with less salt.

- If you drink alcoholic beverages, do so in moderation.

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Water fluoridation

Definition

Water fluoridation is the **public health** practice of altering municipal water supplies to reflect an optimal range of fluoride in drinking water in order to combat **dental caries** (tooth decay).

Description

At the beginning of the 20th century, dental caries were widespread and lead to serious tooth loss. In fact,

having sound teeth was so important and such a rarity in the general population that the U.S. military made having a minimum of six opposing teeth a requirement during recruitment for WW I and II.

The first glimmer of an association between fluoride and oral health was observed by Dr. Frederick S. McKay in 1901. Noticing a brown stain on the teeth of his patients, Dr. McKay found that those who had these stains seemed to have less fewer caries. In 1909, Dr. F.L. Robertson noticed mottling on the enamel (the hard outer surface) of children's teeth after the digging of a new well—source of the local drinking water. It wasn't until 1930 that the well water was analyzed, and high concentrations of fluoride were found. Fluoride, a naturally occurring fluorine ion, is found in soil, foods, and water.

The brown staining and mottling were characteristic of **fluorosis**, an abnormal condition caused by excessive exposure to fluoride while a child's teeth are forming under the gums. It affects the formation of tooth enamel and can vary from very mild to severe. Very mild fluorosis is manifested as tiny, white spots on 25% of a tooth's surface. Mild fluorosis covers 26% to 50%, and moderate fluorosis compromises all of a tooth's surface. It is most often characterized by brown discoloration of the tooth. Severe fluorosis involves pitting of the enamel and more serious brown staining. Approximately 94% of dental fluorosis today ranges from very mild to mild.

Extensive studies of national water supplies have been conducted. It has been found that dental caries were fewer in cities with more fluoride in the community water supply. A 1945 field study was conducted in four pairs of cities to determine whether a low level of fluoride (between 1.0 ppm and 1.2 ppm) could prevent dental caries. The result was a 50% to 70% reduction in the number of dental caries in communities with fluoridated water; only 10% of the people had mild fluorosis.

In 1962, another study found an optimal fluoride level of 0.7 parts per million (ppm) to 1.2 ppm (warm climates, where water consumption is higher, vs. cooler climates, respectively). This fluoride level range was determined to combat dental caries and pose only a slight risk of mild fluorosis.

Water fluoridation was rapidly adopted in major U.S. cities. About 46% of all public water supplies, however, remain non-fluoridated. Still, there has been a drastic reduction in the incidence of dental caries among children, in 2000 about half of all American children aged five to 17 years have never had a cavity in their permanent teeth. Adults also have experienced a 20% to 40% reduction in dental caries on enamel surfaces, as well as on exposed root caries—a condition peculiar to persons with gingival recession. Some of the earlier studies from

the 1980s showed little difference in the reduction rates of dental caries between fluoridated communities and non-fluoridated communities. This may be due to improved **dental hygiene**, and the use of other fluoride products like fluoridated toothpaste and mouth rinses.

Viewpoints

Adding fluoride to drinking water has always been controversial. Though fluoride appears naturally in many water supplies, its purposeful introduction into community water supplies has brought claims of causing **cancer**, **heart disease**, **Down syndrome**, **osteoporosis**, acquired **immunodeficiency syndrome (AIDS)**, low intelligence, **Alzheimer's disease**, nephritis, cirrhosis, intracranial lesions, allergic reactions, and hip **fractures**. There has been no credible evidence to link fluoride to these diseases.

Early geographic studies in the 1980s reported a correlation between water fluoridation and bone fractures. However, an October 2000 study of women in four U.S. communities who had a continuous 20-year exposure to fluoride in drinking water found that fluoride was not a factor in increased spinal and hip fractures. In fact, these women exhibited greater bone density in the large bones like the femur, the hip, and the lumbar spine, with a slight decrease in hip and spine fractures. There was, however, a slight increase in the incidence of wrist fractures.

Though claims of increased medical risk when drinking fluoridated water still exist, opponents are finding other issues with platforms from which to fight fluoridation (for example, the fact the individuals do not get to decide whether to fluoridate their own personal drinking water) and whether dental caries are a serious public health problem anymore. These opponents cite studies from the mid-1980s that showed only an 18% difference in dental caries among children living in communities with and without fluoridated water. They claim, and rightly so, that this difference is due to widespread use of fluoridated toothpaste. However, increased use of bottled water, and processed foods that may contain fluoridated water, may also be contributing factors.

Water fluoridation provides inexpensive prevention for at-risk populations in every community. Despite **Medicaid** benefits that cover dental treatment, poor children often have less access than higher income families to dentists and fluoridated dental hygiene products. Children in non-fluoridated communities seek dental treatment in hospital emergency rooms more often than children in fluoridated communities; this increases costs for their dental treatment. The consumption of fluoridated water can reduce these expenses.

Adding fluoride to drinking water is the most cost-effective method for preventing dental caries. The average costs of fluoridation is around \$0.50 per person annually, with some communities paying out only \$0.12 per person. Smaller areas with fewer than 10,000 people, however, have costs that can run between \$3 and \$5 a year per person. Still, the cost of fluoridation for a single person over his or her lifetime can be less than the cost of one filling.

Fluoridation has been found to be effective for all citizens within a community regardless of socioeconomic status, and it has been proven safe for every person to use. Fluoridated water has a topical benefit. It provides ambient fluoride, which promotes remineralization of teeth to all ages and populations who consume the treated water. The latest concern, however, centers on over-fluoridation. There are many more ways to ingest fluoride than just in drinking water. Fluoride is added to prepared foods and bottled drinks. Carbonated drinks, juices, and some bottled waters have fluoride in varying amounts. Often, the fluoride in these products is not revealed on the label. Foods high in fluoride are fish with bones, tea, poultry products, cereals, or infant formula, which is made with fluoridated water. Dental products such as mouth rinses, toothpaste, and fluoride supplements) all have added fluoride. Some pediatricians prescribe fluoride supplements without determining the fluoride content of the water a child drinks or assessing the amount of fluoride exposure the child has in his or her environment. Parents need to take a proactive role in learning the contents of their children's prescriptions.

It is of most concern when children ingest large amounts of fluoride, not because of known health risks related to fluoride, but because of the added potential of having fluorosis in children's permanent teeth. Young children under six years of age often use too much fluoride toothpaste and consistently swallow it. This alone has been the biggest cause of excess fluoride ingestion. For that reason, fluoride products should be kept out of the reach of children. Parents should supervise children who are under six years of age as they brush their teeth, ensuring that only a pea-sized drop of toothpaste is used, and directing them not to swallow toothpaste. Children under six should not use fluoridated mouth rinses.

Professional implications

Water fluoridation has been recognized by over 90 professional health organizations in the world as the most effective dental caries preventive in the 20th century. Dentists, dental hygienists, pediatricians, nurses, dietitians, and professionals from the United States Centers for Disease Control have endorsed the benefits of fluoridated

KEY TERMS

Dental caries—Tooth decay.

Enamel—The hard, calcified outer surface of a tooth; the hardest known substance in the human body.

Fluoride—A fluorine ion used to treat water or apply directly to tooth surfaces to prevent dental caries.

Fluorosis—Fluorosis is an abnormal condition caused by excessive exposure to fluoride while a child's teeth are forming under the gums. It affects the formation of tooth enamel and can be very mild (a few white spots on a tooth) to severe (etching, pitting, and brown discoloration).

water. Unfortunately, about half of the population of the United States lives in areas that do not have fluoridated water. Health care professionals need to be aggressive in their efforts to bring fluoride to these areas. Careful monitoring of fluoride present in all environments, and an assessment of the client's fluoride history, need to be carried out by local pediatricians and dentists before fluoride supplements are prescribed. Nurses and other professionals need to take a role in educating parents about fluoride dental products and foods containing fluoride, as well as proper fluoride consumption by children under the age of six.

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American Academy of Pediatrics. 141 Northwest Point Boulevard, Elk Grove Village, IL 60007-1098. (847) 434-4000. <<http://www.aap.org>>.

American Dental Association. 211 East Chicago Ave., Chicago, IL 60611. (800)947-4746, (312)440-2500. <<http://www.ada.org>>.

Centers for Disease Control and Prevention. 4770 Buford Highway, NE, Atlanta, GA 30341. (770) 488-6054. <<http://www.cdc.gov/nohss>>.

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Janie F. Franz

Water therapy see **Hydrotherapy**

Weber test see **Rinne and Weber tests**

Wernicke-Korsakoff disease see **Alcoholic paralysis**

Wheelchair prescription

Definition

A wheelchair is a mobile chair used by individuals who have impairments that limit their ability to walk. A wheelchair prescription defines the specifications of a chair according to an individual's particular needs.

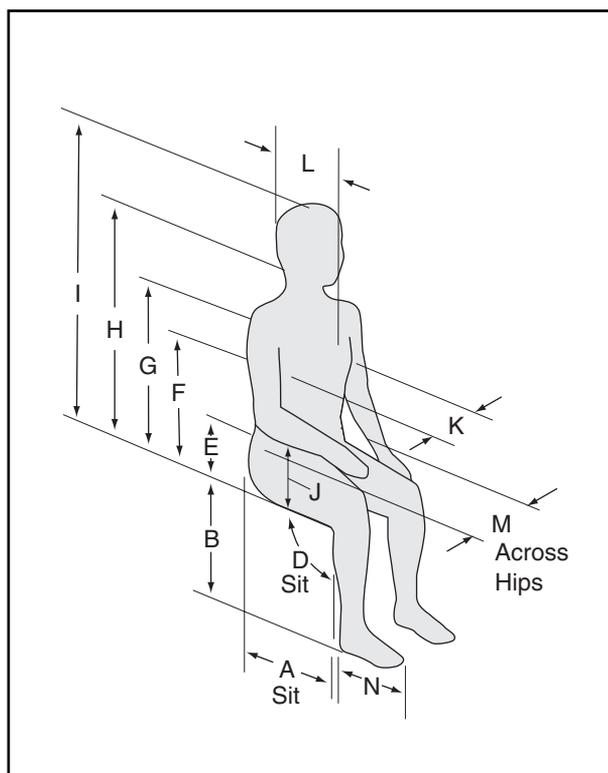
Purpose

Wheelchairs are used either as primary or secondary means of mobility, depending upon the extent of an individual's functional limitations. When using a wheelchair as a primary means of mobility, an individual may spend the majority of his or her day in the chair and use it for movement within his or her home, work, school or community setting. As a secondary means of mobility, a chair may be used just for longer distances by an individual who has low endurance or tolerance for walking. The wheelchair prescription is used to define the type of wheelchair required, seating needs, and details about components.

Description

Selection of a wheelchair, its fit, and components depends largely on the following factors:

- What are the patient's disability, medical, and management issues? These can include considerations such as level of independence, pressure relief, orthoses, etc.
- What is the patient's size, weight, and posture? Does the patient need a heavy-duty chair? Is there a fixed **scoliosis** or kyphosis that needs to be accommodated?
- What is the individual's functional ability? Sitting balance, ability to transfer oneself and provide pressure relief, upper extremity strength and dexterity, and cognitive level are just a few of the things that must be considered.
- What are the patient and family goals for using the chair? What has been tried already? Will the chair be used as a primary or secondary means of positioning and mobility? Will it be used around the house, at school/work, outside, for sports participation?
- What are the environmental concerns? Access to public and private settings, including work, school, libraries,



Measurements necessary for a wheelchair prescription.
(Illustration by Argosy. Courtesy of Gale Group.)

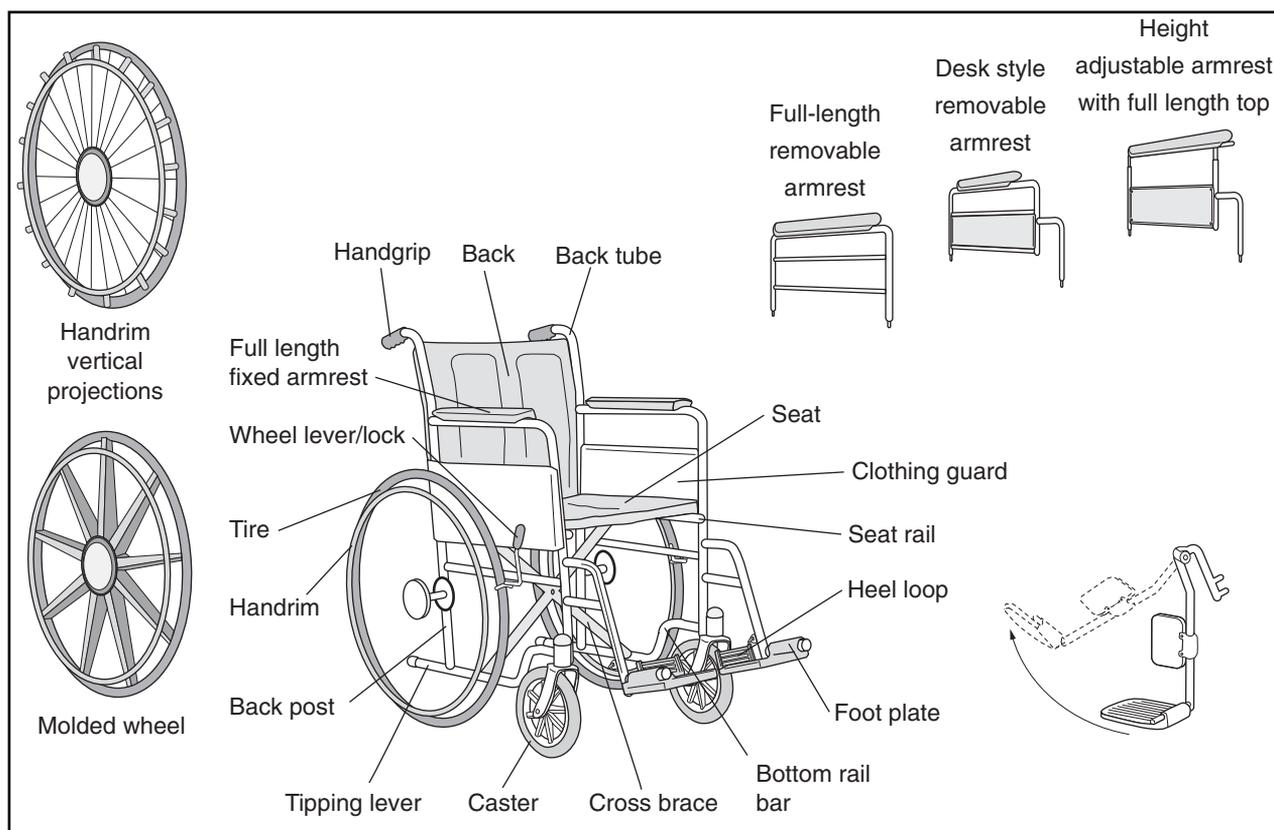
and transportation, must be considered. Is the individual's own home wheelchair-accessible?

- What are the funding issues? The cost of basic and special features, sources of funding, rental/leasing options, future maintenance, and upgrade costs should all be considered.

The prescription should include the following categories of specifications:

Type of wheelchair

There are standard and heavy-duty adult chairs, in addition to junior, youth, and "growing" frames. In a user assessment study in 2000, ultra lightweight chairs with a high degree of adjustability were shown to be preferred over lightweight chairs for ride comfort and ergonomics in long-term wheelchair use. Chairs for people with hemiplegia include a seat that is lower to accommodate for propulsion with a lower extremity. One-hand drive chairs allow a chair to be propelled with one handrim controlling both wheels. Chairs for people with lower-extremity amputations are designed to widen the base of support, compensating for the loss of anterior weight. Sports wheelchairs are lighter and easier to maneuver, for active individuals. They include a lower back, canted



Components of a wheelchair. (Illustration by Argosy. Courtesy of Gale Group.)

wheels for more efficient propulsion, and small handrims. Reclining and tilt wheelchairs offer individuals the opportunity to either recline, opening up the angle at the hips, or tilt their entire position back. Reclining chairs tend to be used for relief from orthostatic hypotension, while tilt chairs address pressure relief and gravity-assisted positioning. Power wheelchairs may be used by individuals who would have difficulty with operating a manual wheelchair. Dependent bases, which allow only for a caregiver to push the chair, also exist; however, great care must be taken in choosing this option because it does not allow for the user to self-propel the chair in any capacity.

Standard measurements

Measurements should be taken with the individual seated on a firm surface in an erect posture. The individual may require physical support to maintain this position while being measured. If an additional seat cushion or back will be used with the chair, those measurements also must be figured in to the individual measurements.

Specific formulas exist and should be used to determine: seat height, depth and width; back height and armrest height. The size of a standard adult wheelchair is:

- Seat width = 18 in (45 cm).
- Seat depth = 16 in (40 cm).
- Seat height = 20 in (50 cm).

Standard sizes exist for smaller adults and children as well; custom fabrication also is available but can be costly.

Components

Wheel locks are used to prevent movement of the chair while the user is moving into or out of it. The wheels of the chair may have solid rubber, pneumatic or semi-pneumatic tires. Pneumatic tires provide a smoother ride and are easier to maneuver on rough and soft surfaces, but they also create more friction, increasing the energy expenditure required. The caster wheels are the front, smaller wheels that allow turns to occur. The rear wheels are large and include an outer handrim that is used to propel the chair.

Lap and chest belts are used to prevent the user from falling out of the chair. Several types of armrests exist, including fixed, removable, reversible, desk-length, and adjustable. The front rigging supports the lower leg and foot. The leg rest may be swing-away, removable, or ele-

vating. The footplates may be fixed or adjustable, and may include strapping for proper foot positioning. Antitipping devices often are attached to the lower rear support bar to prevent backward tipping of the chair.

All of these components may be included on the chair with various options that must be specified on the wheelchair prescription according to the patient's needs.

Seating

Seating is an important consideration, especially for users who will spend most of their waking day in the chair or for those with pressure relief concerns. Several cushion types exist: planar, contoured, and molded. A planar surface offers the least support and pressure relief, but may be the least expensive and simplest to maintain. A contoured surface may either assume contour with pressure through the use of foam, air, or gel within the cushion, or it may be preformed. It provides more support than the planar surface, but is more adjustable than the molded surface. A molded seat is created from liquid foam that follows the direct contours of the specific user. It offers the most support for an individual with low trunk control and may be formed to accommodate fixed deformities; however, it also is costly and room for growth is limited.

Operation

Operation of a wheelchair varies depending on the type. A user who is going to be active in self-propelling a manual wheelchair must learn the following techniques, if applicable to his or her individual needs:

- Locking brakes, swinging away or removing front riggings, and adjusting or removing armrests.
- Transferring into and out of the chair, which may include transfers to standing, to the floor, to an automobile seat, to various sitting surfaces, or to bed.
- Wheeling the chair, using the handrims, over various types of terrain including smooth tile, carpeting, gravel, sand, asphalt, and/or grass.
- Maneuvering the chair over curbs and ramps.
- Folding or disassembling the chair for transport in a car or for storage.

The user also should be able to educate another individual on how to assist with or perform any of the above activities, in case the user requires assistance at any time. A caregiver should be able to assist with reclining or tilt-in-space functions as well.

A user of a power wheelchair must learn to maneuver the chair using the control interface selected for his or her individual needs. This may be a joystick, sip-and-

puff, tongue touch pad, eye gaze, or chin or head control, depending upon the level of disability. Research has found that in individuals with severe disabilities resulting from high-level **spinal cord injury**, nervous system diseases, cognitive impairment or blindness, 10% find it extremely difficult to perform activities of daily living with power wheelchairs, and up to 40% find many steering and maneuvering situations difficult or impossible. New technology using microprocessors and sensors to assist navigation may help to alleviate this problem in the future.

Maintenance

Maintenance, just like operation, depends on the type of wheelchair used. A solidly built manual chair may require minimal maintenance, while a power chair often requires nightly battery charges. Proper function of wheel locks and other components should be monitored frequently and adjusted as necessary by the wheelchair supplier or with his or her explicit instruction.

Health care team roles

A physician, physical therapist, occupational therapist, seating specialist, and assistive technology specialist all may be involved in making recommendations for the wheelchair type and specification of components.

Training

Training is required in order for an individual to successfully operate a wheelchair, regardless of the type. A physical therapist often is the health care team member who works with a patient to learn transferring, propulsion, and maneuvering techniques. The occupational therapist and assistive technology practitioner (who may also be an OT or PT) play key roles as well in training the patient for optimum use of hand, head, mouth, or other controls.

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Whiplash

Definition

Whiplash is the mechanism that causes the neck injury often suffered in a rear-end automobile collision. People also use the same term, whiplash, to mean the resultant neck injury itself. Whiplash produces a wide range of symptoms, but almost all victims experience **pain**. About 1,000,000 whiplash injuries occur in the United States every year.

Description

An occupant of a car struck suddenly from the rear undergoes rapid acceleration and deceleration. The head and neck swing freely while the body remains supported by the seat and seatbelts. The rapid movement of the head causes variable amounts of hyperextension, hyperflexion, stretching, and twisting of neck structures, in a fashion similar to the snapping of a whip.

The structures often affected include muscles, ligaments, nerves, intervertebral disks, and spinal joints. Specific damage may range from minimal strains to complicated tears, hemorrhage, and joint injury, as shown by animal studies and autopsies of accident victims.

Causes and symptoms

Besides motor vehicle accidents, causes of whiplash include sports and other recreational activities, **falls**, and fights. Women tend to have more persistent symptoms

than men do, perhaps because women's smaller neck muscles are more vulnerable.

Symptoms following a whiplash injury may begin immediately or any time up to a few days later. Symptoms include variable combinations of:

- pain or stiffness in the neck, jaw, shoulders, arms, or back
- dizziness
- headache
- loss of feeling in the upper extremities
- problems with **vision** or hearing
- problems with concentration
- depression, **anxiety**, or other changes in mood

Symptoms may last for no more than a day or two, or may persist for months or years.

Diagnosis

Many patients with whiplash receive evaluation by **emergency medical technicians** (EMTs) at the scene of an accident, always starting with the ABCs of resuscitation: airway, breathing, and circulation. At the same time, in head or neck trauma, initial care providers always worry about the possibility of dangerous injury to the spine bones or **spinal cord**. Often, the EMTs will immobilize the neck in a stiff brace and strap the patient flat on a board, until a physician determines that it is safe for the neck to move. This minimizes the risk that any serious injury could progress and cause irreversible nerve damage. Unfortunately, this immobilization is usually very uncomfortable for the patient.

When such a patient arrives at the emergency department (ED), the nurse will further assess the patient for stable **vital signs**, proper alertness, and good ability to move and feel the extremities. A patient strapped to a spine immobilization board often demands to remove the neck brace and get up, but the nurse must ensure that the patient remains still until cleared by the physician. The nurse quickly asks the doctor to examine the patient.

Another danger is that a patient may vomit while immobilized. This presents a risk for aspiration of **stomach** contents, which can threaten breathing. The nurse must be alert to quickly turn the patient on the side, while still immobilized and with the neck brace still in place, to prevent this complication.

The physician obtains the patient's description of the event, then looks for injury to other organs, especially in the head, chest, abdomen, and back. The doctor will check for bony tenderness or limitation of movement, and examine the functions of deep tendon **reflexes** plus

motor and sensory nerves. When the physician is confident that no injury threatens the spinal cord the patient is “cleared.” The physician will remove the brace and free the patient from the rigid board.

The physician may order x-ray studies to exclude fracture or displacement of bone, but in typical whiplash these tests rarely show any abnormality. When there is severe or persistent pain or numbness, **magnetic resonance imaging (MRI)** may detect more subtle damage.

Treatment

Patients should apply ice in the first 24-48 hours. Physicians prescribe medicines such as ibuprofen (Motrin, Advil) or aspirin, acetaminophen, **muscle relaxants**, or narcotics (codeine, hydrocodone, Vicodin).

Use of soft cervical collars is controversial. Many doctors prescribe them, but some studies have shown that these devices prolong the return to normal activities. **Physical therapy** or exercises may reduce pain or limitation of movement.

Many patients use balms or salves, and seek alternative treatments such as chiropractic manipulation, biofeedback, acupuncture, or **acupressure**. In cases of protracted symptoms, patients may benefit from traction, ultrasound treatments, local injections of cortisone, or use of a nerve stimulator.

Prognosis

The course of an individual whiplash injury is unpredictable. Most people improve within a month, but 20% or more have symptoms that last longer than a year. The risk of greater symptoms increases for an unrestrained victim of a rear-end collision, or for one whose head is turned or tilted at the time of injury.

Controversy surrounds the role that accident-related litigation plays in delaying recovery from whiplash. An April 2000, article in *The New England Journal of Medicine* examined this issue. The authors showed a decreased incidence and improved prognosis of whiplash injury when the province of Saskatchewan changed to a new insurance claim system that eliminated payments for pain and suffering. However, other authors downplay the effect of psychosocial factors on recovery from whiplash.

Health care team roles

The EMT performs rescue, assessment, and initial treatment at the scene of an accident. A nurse in the ED or medical office also assesses the patient with whiplash. The nurse carries out physician orders for medication and treatments, monitors the patient throughout the stay, and

KEY TERMS

Aspiration—The inhaling of stomach contents or other unwanted material, potentially leading to a form of pneumonia.

Hyperextension—Overstretching toward the back.

Hyperflexion—Overstretching toward the front.

Intervertebral disk—A cushioning structure between two adjacent spine bones.

instructs the patient and caregivers before discharge. The aide assists the nurse.

A radiology technician performs the x-ray or MRI studies. A physical therapist helps with **exercise**, massage, ultrasound, and other treatments. A social worker may coordinate later care.

Prevention

Proper adjustment of the automobile headrest is important to reduce the severity of a whiplash injury, because a headrest that does not come up behind the head offers no protection. Driving habits that reduce the frequency of abrupt stops make it less likely that a driver will suffer a rear-end collision.

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American Academy of Orthopaedic Surgeons. 6300 North River Road, Rosemont, IL 60018-4262. (800) 346-AAOS. <<http://www.aaos.org>>.

Kenneth J. Berniker, M.D.

Whipple’s disease see **Malabsorption syndrome**

White blood cell count and differential

Definition

A white **blood** cell (WBC) count determines the concentration of white blood cells in the patient's blood. A differential determines the percentage of each of the five types of mature white blood cells.

Purpose

This test is included in general health examinations and to help investigate a variety of illnesses. An elevated WBC count occurs in **infection**, allergy, systemic illness, inflammation, tissue injury, and leukemia. A low WBC count may occur in some viral infections, **immunodeficiency** states, and bone marrow failure. The WBC count provides clues about certain illnesses, and helps physicians monitor a patient's recovery from others. Abnormal counts which return to normal indicate that the condition is improving, while counts that become more abnormal indicate that the condition is worsening. The differential will reveal which WBC types are affected most. For example, an elevated WBC count with an absolute increase in lymphocytes having an atypical appearance is most often caused by infectious mononucleosis. The differential will also identify early WBCs which may be reactive (e.g. a response to acute infection) or the result of a leukemia.

Precautions

Many medications affect the WBC count. Both prescription and non-prescription drugs including herbal supplements should be noted. Normal values for both the WBC count and differential are age related.

Sources of error in manual WBC counting are largely due to variance in the dilution of the sample and the distribution of cells in the chamber, and the small number of WBCs that are counted. For electronic WBC counts and differentials, interference may be caused by small fibrin clots, nucleated RBCs, platelet clumping, and unlysed RBCs. Immature WBCs and nucleated RBCs may cause interference with the automated differential count. Automated cell counters may not be acceptable for counting white blood cells in other body fluids especially when the number of WBCs is less than 1000/ μ L or when other nucleated cell types are present.

Description

White cell counts are usually performed using an automated instrument, but may be done manually using a **microscope** and a counting chamber especially when counts are very low, or the person has a condition known to interfere with an automated WBC count. An electronic WBC count is based upon the principle of impedance. The red blood cells are lysed using a detergent in the counting diluent. As the cells move one at a time through a counting aperture, they displace electrolyte in the diluent causing a voltage pulse. The magnitude of the voltage pulse is dependent upon size which allows the instrument to discriminate between different types of WBCs.

An automated differential may be performed by an electronic cell counter or by an image analysis instrument. The automated electronic cell counter uses a combination of impedance measurement and other means such as radio frequency conductance and angular light scattering to differentiate between closely related WBCs. Image analysis systems use morphometric and densitometric programs to distinguish the cells which are photographed from a stained slide by a digital color camera. When the electronic WBC count is abnormal or a cell population is flagged, meaning that one or more of the results is atypical, a manual differential is performed. The WBC differential is performed manually by microscopic examination of a blood sample that is spread in a thin film on a glass slide. The film is air-dried and stained with Wright stain, a polychromatic stain consisting of buffered solutions of methylene blue and eosin. Acidic structures such as DNA take up the basic methylene blue dye, while basic **proteins**, such as hemoglobin, take up the acidic eosin dye. White blood cells are identified by their size, the shape and texture of the nuclear chromatin, cytoplasmic and nuclear staining, and the presence and color of granules in the cytoplasm.

The manual WBC differential involves a thorough evaluation of a stained blood film. In addition to determining the percentage of each mature white blood cell, the following tests are performed as part of the differential:

- Evaluation of RBC morphology is performed. This includes grading of the variation in RBC size (anisocytosis) and shape (poikilocytosis); reporting the type and number of any abnormal RBCs such as target cells, sickle cells, stippled cells, etc.; reporting the presence of immature RBCs (polychromasia); and counting the number of nucleated RBCs per 100 WBCs.
- An estimate of the WBC count is made and compared to the automated or chamber WBC count. An estimate of the platelet count is made and compared to the automated or chamber platelet count. Abnormal platelets

Causes for abnormalities in the white blood cell (WBC) differential count

Type of WBC and normal differential count	Elevated	Decreased
Neutrophils 55–70%	Neutrophilia Physical or emotional stress Acute suppurative infection Myelocytic leukemia Trauma Cushing's syndrome Inflammatory disorders Metabolic disorder	Neutropenia Aplastic anemia Dietary deficiency Overwhelming bacterial infection Viral infections Radiation therapy Addison's disease Drug therapy: myelotoxic drugs (as in chemotherapy)
Lymphocytes 20–40%	Lymphocytosis Chronic bacterial infection Viral infection Lymphocytic leukemia Multiple myeloma Infectious mononucleosis Radiation Infectious hepatitis	Lymphocytopenia Leukemia Sepsis Immunodeficiency diseases Lupus erythematosus Later stages of HIV infection Drug therapy: adrenocorticosteroids, antineoplastics Radiation therapy
Monocytes 2–8%	Monocytosis Chronic inflammatory disorders Viral infections Tuberculosis Chronic ulcerative colitis Parasites	Monocytopenia Drug therapy: prednisone
Eosinophils 1–4%	Eosinophilia Parasitic infections Allergic reactions Eczema Leukemia Autoimmune diseases	Eosinopenia Increased adrenosteroid production
Basophils 0.5–1.0%	Basophilia Myeloproliferative disease (e.g., myelofibrosis, polycythemia rubra vera) Leukemia	Basopenia Acute allergic reactions Hyperthyroidism Stress reactions

SOURCE: Pagana, K.D. and T.J. Pagana. *Mosby's Diagnostic and Laboratory Test Reference*. 3rd ed. St. Louis: Mosby, 1997.

such as clumped platelets or excessively large platelets are noted on the report.

- Any immature white blood cells are included in the differential count of 100 cells, and any inclusions or abnormalities of the WBCs are reported.

WBCs consist of two main subpopulations, the mononuclear cells and the granulocytic cells. Mononuclear cells include lymphocytes and monocytes. Granulocytes include neutrophils (also called polymorphonuclear leukocytes or segmented neutrophils), eosinophils, and basophils. Each cell type is described below:

- Neutrophils are normally the most abundant WBCs. They measure 12–16 μm in diameter. The nucleus stains dark purple-blue, and is divided into several lobes (usually three to four) consisting of dense chromatin. A neutrophil just before the final stage of maturation will have an unsegmented nucleus in the shape of a band. These band neutrophils may be counted along with mature neutrophils or as a separate category. The cytoplasm of a neutrophil contains both primary

(azurophilic) and secondary (specific) granules. The secondary granules are lilac in color and are more abundant almost covering the pink cytoplasm. Neutrophils are phagocytic cells and facilitate removal of **bacteria** and antibody-coated antigens. The neutrophilic granules are rich in peroxidase, and aid the cell in destroying bacteria and other ingested cells.

- Eosinophils are 14–16 μm in diameter and contain a blue nucleus that is segmented into two distinct lobes. The cytoplasm is filled with large refractile orange-red granules. The granules contain peroxidase, hydrolases, and basic proteins which aid in the destruction of phagocytized cells. Eosinophils are increased in allergic reactions and parasitic infections.
- Basophils, like eosinophils, are 14–16 μm in diameter and have a blue nucleus that is bilobed. The cytoplasm of the basophil is filled with large dark blue-black granules that may obscure the nucleus. These contain large amounts of histamine, heparin, and acid mucopolysaccharides. Basophils mediate the allergic response by releasing histamine.

KEY TERMS

Band cell—An immature neutrophil at the stage just preceding a mature cell. The nucleus of a band cell is unsegmented.

Basophil—Segmented white blood cell with large dark blue-black granules that releases histamine in allergic reactions.

Differential—Blood test that determines the percentage of each type of white blood cell in a person's blood.

Eosinophil—Segmented white blood cell with large orange-red granules that increases in response to parasitic infections and allergic reactions.

Lymphocyte—Mononuclear white blood cell that is responsible for humoral (antibody mediated) and cell mediated immunity.

Monocyte—Mononuclear phagocytic white blood cell that removes debris and microorganisms by phagocytosis and processes antigens for recognition by immune lymphocytes.

Neutrophil—Segmented white blood cell normally comprising 50-70% of the total. The cytoplasm contains both primary and secondary granules that take up both acidic and basic dyes of the Wright stain. Neutrophils remove and kill bacteria by phagocytosis.

Phagocytosis—A process by which a white blood cell envelopes and digests debris and microorganisms to remove them from the blood.

- Lymphocytes are the second most abundant WBCs. They may be small (7-9 μm in diameter) or large (12-16 μm in diameter). The nucleus is dark blue and is nearly round or slightly indented and the chromatin is clumped and very dense. The cytoplasm is medium blue and usually agranular. An occasional lymphocyte will have a few azurophilic granules in the cytoplasm. Lymphocytes originate in the lymphoid tissues and are not phagocytic. They are responsible for initiating and regulating the **immune response** by the production of antibodies and cytokines.
- Monocytes are the largest WBCs measuring 14-20 μm in diameter. They have a large irregularly shaped and folded blue nucleus with chromatin that is less dense than other WBCs. The cytoplasm is grey-blue, and is filled with fine dust-like lilac colored granules.

Monocytes are phagocytic cells that process and present antigens to lymphocytes, an event required for lymphocyte activation.

Preparation

This test requires a 3.5 mL sample of blood. Venipuncture is usually performed by a nurse or phlebotomist following standard precautions for the prevention of transmission of bloodborne pathogens. There is no restriction on diet or physical activity.

Aftercare

Discomfort or bruising may occur at the puncture site. Pressure to the puncture site until the bleeding stops reduces bruising; warm packs relieve discomfort. Some people feel dizzy or faint after blood has been drawn and should be treated accordingly.

Complications

Other than potential bruising at the puncture site, and/or dizziness, there are no complications associated with this test.

Results

Normal values vary with age. White counts are highest in children under one year of age and then decrease somewhat until adulthood. The increase is largely in the lymphocyte population. Adult normal values are shown below.

- WBC count: 4,500-11,000/ μL
- polymorphonuclear neutrophils: 1800-7800/ μL ; (50-70%)
- band neutrophils: 0-700/ μL ; (0-10%)
- lymphocytes: 1000-4800/ μL ; (15-45%)
- monocytes: 0-800/ μL ; (0-10%)
- eosinophils: 0-450/ μL ; (0-6%)
- basophils: 0-200/ μL ; (0-2%)

Health care team roles

The WBC count and differential are ordered and interpreted by physicians. The samples may be collected by a nurse, physician assistant, phlebotomist, or technician. Testing is performed by a clinical laboratory scientist, CLS (NCA)/medical technologist, MT (ASCP) or by a clinical laboratory technician, CLT (NCA)/medical laboratory technician, MLT (ASCP).

Resources

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Work activities evaluation and treatment
see **Ergonomic assessment**

Wound care

Definition

A wound is a disruption in the continuity of cells—anything that causes cells that would normally be connected to become separated. Wound healing is the restoration of that continuity. Several effects may result with the occurrence of a wound: immediate loss of all or part of organ functioning, sympathetic **stress** response, hemorrhage and **blood** clotting, bacterial contamination, and death of cells. The most important factor in minimizing these effects and promoting successful care is careful asepsis.

Description

A biological process, wound healing begins with trauma and ends with scar formation. There are two types of tissue injury: full and partial thickness. Partial thickness injury is limited to the epidermis and superficial dermis with no damage to the dermal **blood vessels**. Healing occurs by regeneration of epithelial tissue. Full thickness injury involves loss of the dermis and extends to deeper tissue layers and disrupts dermal blood vessels. Wound healing involves the synthesis of several types of tissue and scar formation.

The three phases of repair are lag, proliferative, and remodeling. Directly after injury, hemostasis is achieved with clot formation. The fibrin clot acts like a highway for the migration of cells into the wound site. Within the first four hours of injury, neutrophils begin to appear. These inflammatory cells kill microbes, and prevent the colonization of the wound. Next the monocyte, or macrophage, appears. Functions of these cells include the killing of microbes, the breakdown of wound debris, and the secretion of cytokines that initiate the proliferative

phase of repair. Synthetic cells, or fibroblasts, proliferate and synthesize new connective tissue, replacing the transitional fibrin matrix. At this time, an efficient nutrient supply develops through the arborization (terminal branching) of adjacent blood vessels. This ingrowth of new blood vessels is called angiogenesis. This new very vascularized connective tissue is referred to as granulation tissue.

The first phase of repair is called the lag or inflammatory phase. The inflammatory response is dependent upon the depth and volume of tissue loss from the injury. Characteristics of the lag phase include acute inflammation and the initial appearance and infiltration of neutrophils. Neutrophils protect the host from microorganisms and **infection**. If inflammation is delayed or stopped, the wound becomes susceptible to infection and closure is delayed.

The proliferative phase is the second phase of repair and is anabolic in nature. The lag and remodeling phase are both catabolic processes. The proliferative phase generates granulation tissue. In this process, acute inflammation releases cytokines, promoting fibroblast infiltration of the wound site, then creating a high density of cells. Collagen is the major connective tissue protein produced and released by fibroblasts. The connective tissue physically supports the new blood vessels that form and endothelial cells promote ingrowth of new vessels. These new blood vessels are necessary to meet the nutritional needs of the wound healing process. The mark of wound closure is when a new epidermal cover seals the defect. The process of wound healing continues underneath the new surface. This is the remodeling or maturation phase and is the third phase in healing.

The first principle of wound care is the removal of non-viable tissue including necrotic (dead) tissue, slough, foreign debris, and residual material from dressings. Removal of non-viable tissue is referred to as debridement; removal of foreign matter is referred to as cleansing. Chronic **wounds** are colonized with **bacteria**, but not necessarily infected. A wound is colonized when a limited number of bacteria are present in the wound and are of no consequence in the healing process. A wound is infected when the bacterial burden overwhelms the **immune response** of the host and bacteria grow unchecked. Clinical signs of infection are redness of the skin around the wound, purulent (pus-containing) drainage, foul odor, and **edema**.

The second principle is providing a moist environment. This has been shown to promote re-epithelialization and healing. Exposing wounds to air dries the surface and may impede the healing process. Gauze dressings provide a moist environment as long as they are kept moist

KEY TERMS

Anabolic—Metabolic processes characterized by the conversion of simple substances into more complex compounds.

Catabolic—Metabolic processes characterized by the release of energy through the conversion of complex compounds into simple substances.

Cytokine—A protein that regulates the duration and intensity of the body's immune response.

Dermis—The thick layer of skin below the epidermis.

Epidermis—The outermost layer of the skin.

Exudate—Fluid, cells, or other substances that are slowly discharged by tissue, especially due to injury or inflammation.

Fibrin—The fibrous protein of blood clots.

Fibroblast—An undifferentiated connective tissue cell that is capable of forming collagen fibers.

Neutrophil—A type of white blood cell.

Scar—Scar tissue is the fibrous tissue that replaces normal tissue destroyed by injury or disease.

in the wound. These are referred to as wet to dry dressings. Generally a saline soaked gauze dressing is loosely placed into the wound and covered with a dry gauze dressing to prevent drying and contamination. It also supports autolytic debridement (the body's own capacity to lyse and dissolve necrotic tissue), absorbs exudate, and traps bacteria in the gauze, which are removed when the dressing is changed.

Preventing further injury is the third principle of wound care. This involves elimination or reduction of the condition that allowed the wound to develop. Factors that contribute to the development of chronic wounds include losses in mobility, mental status changes, deficits of sensation, and circulatory deficits. Patients must be properly positioned to eliminate continued pressure to the chronic wound. Pressure reducing devices, such as mattresses, cushions, supportive boots, foam wedges, and fitted shoes can be used to keep pressure off wounds.

Providing **nutrition**, specifically protein for healing, is the fourth principle of healing. Protein is essential for wound repair and regeneration. Without essential amino acids, angiogenesis, fibroblast proliferation, collagen synthesis, and scar remodeling will not occur. Amino acids also support the immune response. Adequate

amounts of **carbohydrates** and **fats** are needed to prevent the amino acids from being oxidized for caloric needs. Glucose is also needed to meet the energy requirements of the cells involved in wound repair. Albumin is the most important indicator of malnutrition because it is sacrificed to provide essential amino acids if there is inadequate protein intake.

Preparation

Effective wound care begins with an assessment of the entire patient. This includes obtaining a complete **health history** and a physical assessment. Assessing the patient assists in identifying causes and contributing factors of the wound. When examining the wound, it is important to document its size, location, appearance, and the surrounding skin. The health care professional also examines the wound for exudate, necrotic tissue, signs of infection, and drainage, and documents how long the patient has had the wound. It is also important to know what treatment, if any, the patient has previously received for the wound.

Actual components of wound care include cleaning, dressing, determining frequency of dressing changes, and reevaluation. Removing dead tissue and debris that impedes healing, is the goal of cleaning the wound. When cleaning the wound, protective goggles should be worn and sterile saline solution should be used. Providone iodine, sodium hypochlorite, and hydrogen peroxide should never be used, as they are toxic to cells.

Gentle pressure should be used to clean the wound if there is no necrotic tissue. This can be accomplished by utilizing a 60 cc catheter tip syringe to apply the cleaning solution. If the wound has necrotic tissue, more pressure may be needed. Whirlpools can also be used for wounds having a thick layer of exudate. At times, chemical or surgical debridement may be needed to remove debris.

Dressings are applied to wounds for the following reasons: to provide the proper environment for healing, to absorb drainage, to immobilize the wound, to protect the wound and new tissue growth from mechanical injury and bacterial contamination, to promote hemostasis, and to provide mental/physical patient comfort. There are several types of dressings and most are designed to maintain a moist wound bed:

- **Alginate**: made of non-woven fibers derived from seaweed, alginate forms a gel as it absorbs exudate. It is used for wounds with moderate to heavy exudate or drainage, and is changed every 12 hours to three days, depending on when the exudate comes through the secondary dressing.

- Composite dressings: combining physically distinct components into a single dressing, composite dressings provide bacterial protection, absorption, and adhesion. The frequency of dressing changes vary.
- Foam: made from polyurethane, foam comes in various thicknesses having different absorption rates. It is used for wounds with moderate to heavy exudate or drainage. Dressing change is every three to seven days.
- Gauze: available a number of forms including sponges, pads, ropes, strips and rolls, gauze can be impregnated with petroleum, antimicrobials, and saline. Frequent changes are needed because gauze has limited moisture retention properties, and there is little protection from contamination. With removal of a dried dressing, there is a risk of wound damage to the healing skin surrounding the wound. Gauze dressings are changed two to three times a day.
- Hydrocolloid: made of gelatin or pectin, hydrocolloid is available as a wafer, paste, or powder. While absorbing exudate, the dressing forms a gel. Hydrocolloid dressings are used for light to moderate exudate or drainage. This type of dressing is not used for wounds with exposed tendon or bone, or third-degree **burns**, and not in the presence of bacterial, fungal, or viral infection, active cellulitis or vasculitis, because it is almost totally occlusive. Dressings are changed every three to seven days.
- Hydrogel: composed primarily of water, hydrogel dressings are used for wounds with minimal exudate. Some are impregnated in gauze or non-woven sponge. Dressings are changed one or two times a day.
- Transparent film: an adhesive waterproof membrane that keeps contaminants out while allowing oxygen and water vapor to cross through, it is used primarily for wounds with minimal exudate. It is also used as a secondary material to secure non-adhesive gauzes. Dressings are changed every three to five days, if the film is used as a primary dressing.

Complications

- Hematoma: dressings should be inspected for hemorrhage at intervals during the first 24 hours after surgery. A large amount of bleeding is to be reported immediately. Concealed bleeding sometimes occurs in the wound, beneath the skin. If the clot formed is small, it will be absorbed by the body, but if large, the wound bulges and the clot must be removed for healing to continue.
- Infection: the second most frequent nosocomial (hospital acquired) infection in hospitals is surgical wound infections with *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. Prevention is accomplished with meticulous wound management. Cellulitis is a bacterial infection that spreads into tissue planes. Systemic **antibiotics** are usually prescribed. If the infection is in an arm or leg, elevation of the limb reduces dependent edema and heat application promotes blood circulation. **Abscess** is a bacterial infection that is localized and characterized by pus. Treatment consists of surgical drainage or excision with the concurrent administration of antibiotics.
- Dehiscence (disruption of surgical wound) and evisceration (protrusion of wound contents): this condition results from sutures giving way, infection, distention, or cough. **Pain** results and the surgeon is called immediately. Prophylactically, an abdominal binder may be utilized.
- Keloid: refers to excessive growth of scar tissue. Careful wound closure, hemostasis, and pressure support are used to ward off this complication.

Results

The goals of wound care include reducing risks that inhibit wound healing, enhancing the healing process, and lowering the incidence of wound infections.

Health care team roles

Members of the health care team actively work to reduce patients' exposure to infections, as well as to administer prescribed treatments and **patient education**, which includes teaching home wound care.

Resources

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Wound culture

Definition

A wound culture is a diagnostic laboratory test in which microorganisms from an infected wound are grown in the laboratory on media and identified. Wound cultures always include aerobic culture, but direct smear evaluation (**Gram stain**) and anaerobic culture are not performed on every wound. These tests are performed when indicated or requested by the physician.

Purpose

The purpose of a wound culture is to isolate and identify microorganisms causing an **infection** of the wound, and to identify **antibiotics** that will be effective in destroying the organism.

Preparation

A biopsy sample is usually preferred by clinicians, but this is a moderately invasive procedure and may not always be feasible. The patient is prepped by cleansing the area with a sterile solution such as saline. **Antiseptics** such as ethyl alcohol are not recommended since they will kill **bacteria** and results will be negative. The patient is given a local anesthetic and the tissue is removed using a cutting sheath. Pressure is applied to the wound to control bleeding. Needle aspiration is less invasive and is a good technique to use in **wounds** where there is little loss of skin such as puncture wounds. Skin around the wound is cleaned with an antiseptic to kill bacteria on the skin's surface and a small 22 gauge needle is inserted. The clinician should pull back on the plunger and then change the angle of the needle two or three times to remove fluid from different areas of the wound. This procedure may be painful for the patient, so many initial cultures are done with the swab technique. The nurse should clean the wound area with sterile saline and moisten a sterile swab with sterile saline. The tip is inserted into the wound and rotated with pressure applied. The pressure will give a better yield of the fluid that is deeper in the wound. The swab used for anaerobic culture should be oxygen-free. After all three procedures, the wound should be cleaned thoroughly and bandaged.

Tissue specimens collected by biopsy should be placed in a screw capped vial containing a small amount of sterile saline to keep the tissue moist. The anaerobic sample should be placed in a gassed out vial that may contain prerduced medium or a gassed out bag and sealed. Syringes should be tightly capped immediately

following aspiration. A common practice for anaerobic culture is to inoculate an anaerobic **blood culture** bottle at the point of care to insure the sample is not exposed to air. Several swabs (at least three) should be collected. One swab is placed in Stuart, Cary-Blair, or Amies transport medium for aerobic culture and another in PRAS transport medium for anaerobic culture. One swab is placed in a clean dry envelope or tube for direct smear examination.

Description

Wounds are injuries to body tissues caused by physical trauma or disease processes including surgery, diabetes, **burns**, punctures, gunshots, lacerations, bites, bed sores and broken bones. Types of wounds include:

- **Abraded:** Caused by abrasion such as falling on concrete.
- **Contused:** A bruise or contusion.
- **Incised:** Caused by a clean cut, as by a sharp instrument.
- **Lacerated:** Caused by a laceration, tearing of the skin or tissues.
- **Nonpenetrating:** Injury caused without disruption of the surface of the body. These wounds are usually in the thorax or abdomen and can also be termed blunt trauma wounds.
- **Open:** A wound in which tissues are exposed to the air.
- **Penetrating:** Disruption of the body surface and extension into the underlying tissue.
- **Perforating:** A wound with an exit and an entry, such as a gunshot wound.
- **Puncture:** A wound formed when something goes through the skin and into the body tissues. This wound has a very small opening but can be very deep.

The chance of a wound becoming infected is dependent upon the nature, size, and depth of the wound; its proximity to and involvement of nonsterile areas such as the skin and gastrointestinal tract; the opportunity for organisms from the environment to enter the wound; and the immunological and general health status of the person. Skin and body compartmentalization prevent many infections. In general, acute wounds are more prone to infection than chronic wounds. Wounds with a large loss of body surface such as abrasions are also easily infected. Puncture wounds may permit the growth of microorganisms since there is a break in the skin with minimal bleeding and they are hard to clean. Deep wounds, closed-off from oxygen, are an ideal environment for an anaerobic infection to develop. Foul-smelling odor, gas,

or **gangrene** at the infection site are signs of an infection caused by an anaerobic bacteria. Surgical wounds can cause infection by introducing bacteria from one body compartment into another.

Diagnosing infection in a wound may be difficult. One of the cardinal signs the clinician looks for is slow healing. Within hours of injury, most wounds will display a release of fluid called an exudate. This fluid contains compounds that aid in healing and is normal. It should not be present 48-72 hours after injury. Exudate indicative of infection may be thicker than the initial exudate and may also be purulent (containing pus) and foul smelling. Clinicians will look at color, consistency and the amount of exudate to monitor early infection. In addition, infected wounds may display skin discoloration, swelling, warmth to touch and an increase in **pain**.

Wound infection prevents healing, and the microorganisms can spread from wounds to other body parts, including the **blood**. Infection in the blood is termed septicemia and can be fatal. Symptoms of a systemic infection include a **fever** and rise in white blood cells, along with confusion and mental status changes in the elderly. It is important to treat the infected wound early with a regimen of antibiotics to prevent further complications.

Wound infections often contain multiple organisms including both aerobic and anaerobic gram-positive cocci and gram-negative bacilli and yeast. The most common pathogens isolated from wounds are: *Streptococcus* Group A, *Staphylococcus aureus*, *Escherichia coli*, *Proteus*, *Klebsiella*, *Pseudomonas*, *Enterobacter*, Enterococci, *Bacterioides*, *Clostridium*, *Candida*, *Peptostreptococcus*, *Fusobacterium*, and *Aeromonas*.

A Gram stain is prepared by rolling the smear across the center of a glass slide or dropping a liquid specimen onto the center and allowing it to air dry. The initial Gram stain is used to evaluate the adequacy of the specimen; estimate the amount of any bacteria, yeast, or fungus present; and determine whether a specialized culture medium is required based upon the appearance of the organisms found. For example, the Gram stain may reveal gram positive filamentous bacteria suggestive of *Nocardia* that requires special growth medium.

The tissue used for the tests is obtained by three different methods, tissue biopsy, needle aspiration or the swab technique. The biopsy method involves the removal of tissue from the wound using a cutting sheath. The piece of tissue is transported to the laboratory where it must be liquified. This is done by adding approximately 1 mL of liquid medium and grinding the tissue in a blender or grinder until it forms a thick homogenized liquid. This is vortexed and dispensed onto solid media and into broth with a sterile pipet. Samples aspirated by

syringe can be injected directly into broth and dispensed onto solid media. The swab technique is most commonly used but contains the least amount of specimen, and therefore, recovery is lower than with biopsied tissues or aspirates. The swab is pressed against the transport tube and the suspension of transport media is transferred to broth and solid media with a sterile pipet.

Wound specimens are cultured on both nonselective enriched and selective media. Cultures for anaerobes should include anaerobic sheep blood agar supplemented with **vitamin K** and hemin for general isolation; kanomycin-vancomycin laked blood agar for *Bacterioides* spp.; phenylethyl alcohol (PEA) or colistin-nalidixic acid (CNA) anaerobic sheep blood agar to suppress gram-negative bacilli; and thioglycolate broth with hemin and vitamin K for slow growing organisms, especially if tissues or aspirates are being cultured. Anaerobic media are inoculated inside a glove box or in an anaerobic (degassed) holding jar and incubated at 36°C in the absence of oxygen for five to seven days. Aerobic culture should include inoculation of sheep blood agar for general growth; chocolate agar for isolation of *Haemophilus*; MacConkey agar for isolation of enteric gram negative bacilli; CNA or PEA blood agar for gram-positive cocci; and potato dextrose agar with antibiotics for isolation of yeast. Cultures are incubated in humid air at 36°C for 48 hours (except for chocolate agar which is incubated in 5-10% carbon dioxide). Cultures are examined each day for growth and any colonies are Gram stained and subcultured (i.e., transferred) to appropriate media. The subcultured isolates are tested via appropriate biochemical identification panels to identify the species present. Organisms are also tested for antibiotic susceptibility by the microtube broth dilution or Kirby Bauer method. The selection of antibiotics for testing depends upon the organism isolated (i.e., gram-negative versus gram-positive, aerobe versus anaerobe).

Results

The initial Gram stain result is available the same day, or in less than an hour if requested by the physician. An early report, known as a preliminary report, is usually available after one day. After that, preliminary reports will be posted whenever an organism is identified. Cultures showing no growth are signed out after two to three days unless a slow growing mycobacterium or fungus is found. These organisms take several weeks to grow and are held for four to six weeks. The final report includes complete identification, an estimate of the quan-

KEY TERMS

Aerobe—Bacteria that require oxygen to live.

Agar—A gelatinous material extracted from red algae that is not digested by bacteria. It is used as a support for growth in plates.

Anaerobe—Bacteria that live only where there is no oxygen.

Antibiotic—A medicine that can be used topically or taken orally, intramuscularly or intravenously to limit the growth of bacteria.

Antimicrobial—A compound that prevents the growth of microbes which may include bacteria, fungi and viruses.

Antimycotic—A medicine that can be used to kill yeast and fungus.

Antiseptic—A compound that kills all bacteria, also known as a bactericide.

Broth—A growth mixture for bacteria. Different compounds such as sugars or amino acids may be added to increase the growth of certain organisms. Also known as media.

Exudate—Any fluid that has been released by tissue or its capillaries due to injury or inflammation.

Gram stain—A staining technique used in microbiology to identify and classify bacteria. The organisms will stay purple if gram-positive or counterstain pink if gram-negative. The Gram stain result depends upon the chemical composition of the bacterial cell wall.

Normal flora—The mixture of bacteria normally found at specific body sites.

Purulent—Containing, consisting of or forming pus.

Pus—A fluid that is the product of inflammation and infection containing white blood cells and debris of dead cells and tissue.

tity of the microorganisms, and a list of the antibiotics to which each organism is sensitive and resistant.

Complications

The physician may choose to start the person on an antibiotic before the specimen is collected for culture. This may alter results, since antibiotics in the person's system may prevent microorganisms present in the

wound from growing in culture. In some cases, the patient may begin antibiotic treatment after the specimen is collected based upon Gram stain results or clinical findings. The antibiotic chosen may or may not be appropriate for one or more organisms recovered by culture.

Nurses must be very careful when finishing a wound culture collection to make sure the wound has been cleaned thoroughly and is bandaged properly. It is important to watch for bleeding and further infection from the procedure. In addition, patients may be in pain from the manipulation so pain killing drugs such as acetaminophen may be advised.

Health care team roles

Wound culture requires the expertise of many clinicians including nurses, doctors and microbiologists. A physician requests the wound culture and is responsible for specimen collection and antibiotic selection. The physician may be assisted by a nurse, nurse practitioner, or physician assistant. Nurses should inform the patient about the testing procedure and what pain to expect. They should clean the wound thoroughly afterwards, bandage it correctly and watch for signs and symptoms of further infection. Doctors should monitor the patient closely for signs of systemic infection and be prepared to repeat the procedure if the patient does not respond to a course of antibiotics. Cultures are performed by clinical laboratory scientists/medical technologists who specialize in clinical microbiology.

Resources

BOOKS

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ORGANIZATIONS

The Wound Healing Society. 1550 South Coast Highway, Suite 201, Laguna Beach, CA 92651. (888)434-4234. <<http://www.woundhealsoc.org/>>.

Jane E. Phillips, PhD

Wounds

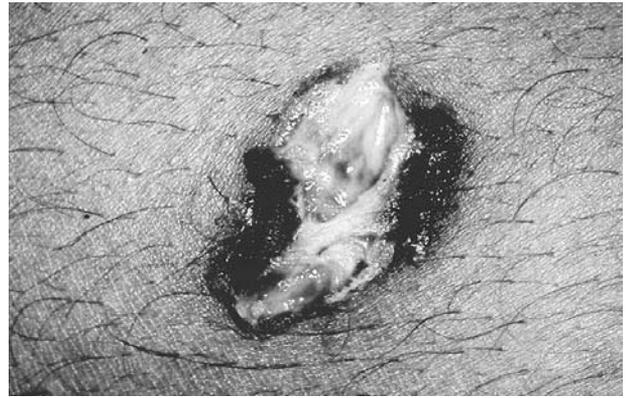
Definition

A wound occurs when the integrity of skin is compromised (e.g., skin breaks, **burns**, or bone **fractures**). A wound may be caused by an act, such as a gunshot, fall, or surgical procedure; by an infectious disease; or by an underlying condition.

Description

Types and causes of wounds are wide ranging. They may be chronic, as are pressure ulcers (which are common in persons with diabetes as a result of skin breakdown)—or they may be acute, as in gunshot wounds or animal bites. Wounds may also be referred to as open, in which the skin has been compromised and underlying tissues are exposed. Alternatively, they may be closed. Here, the skin has not been compromised, but trauma to underlying tissue has occurred (e.g., a bruised rib or cerebral contusion). Emergency personnel generally place acute wounds in one of eight categories:

- **Abrasions.** Also called scrapes, they occur when the skin is rubbed away by friction against a rough surface (e.g., rope burns and skinned knees).
- **Avulsions.** Occur when an entire structure or part of it is forcibly pulled away, such as in the loss of a permanent tooth or an ear lobe. Explosions, gunshots, and animal bites may cause avulsions.
- **Contusions.** Also called bruises, these are the result of a forceful trauma that injures an internal structure without breaking the skin. Blows to the chest, abdomen, or head with a blunt instrument (e.g., a football or a fist) can cause contusions.
- **Crush wounds.** Occur when a heavy object falls onto a person, splitting the skin and shattering or tearing underlying structures.
- **Cuts.** These are slicing wounds made with a sharp instrument, leaving even edges, or those made with a dull cutting instrument, which leaves uneven edges. Cuts may be as minimal as those caused by paper (i.e., paper cuts), or as significant as surgical incisions.
- **Lacerations.** Also called tears, these are separating wounds that produce ragged edges. They are produced by a tremendous force against the body, either from an internal source, as in **childbirth**, or from an external source, like a punch.
- **Missile wounds.** Also called velocity wounds, they are caused by an object entering the body at a high speed, typically a bullet.



A close-up of a hard-contact gun shot wound with accompanying burn marks on the left and right sides of the wound. (Custom Medical Stock Photo. Reproduced by permission.)

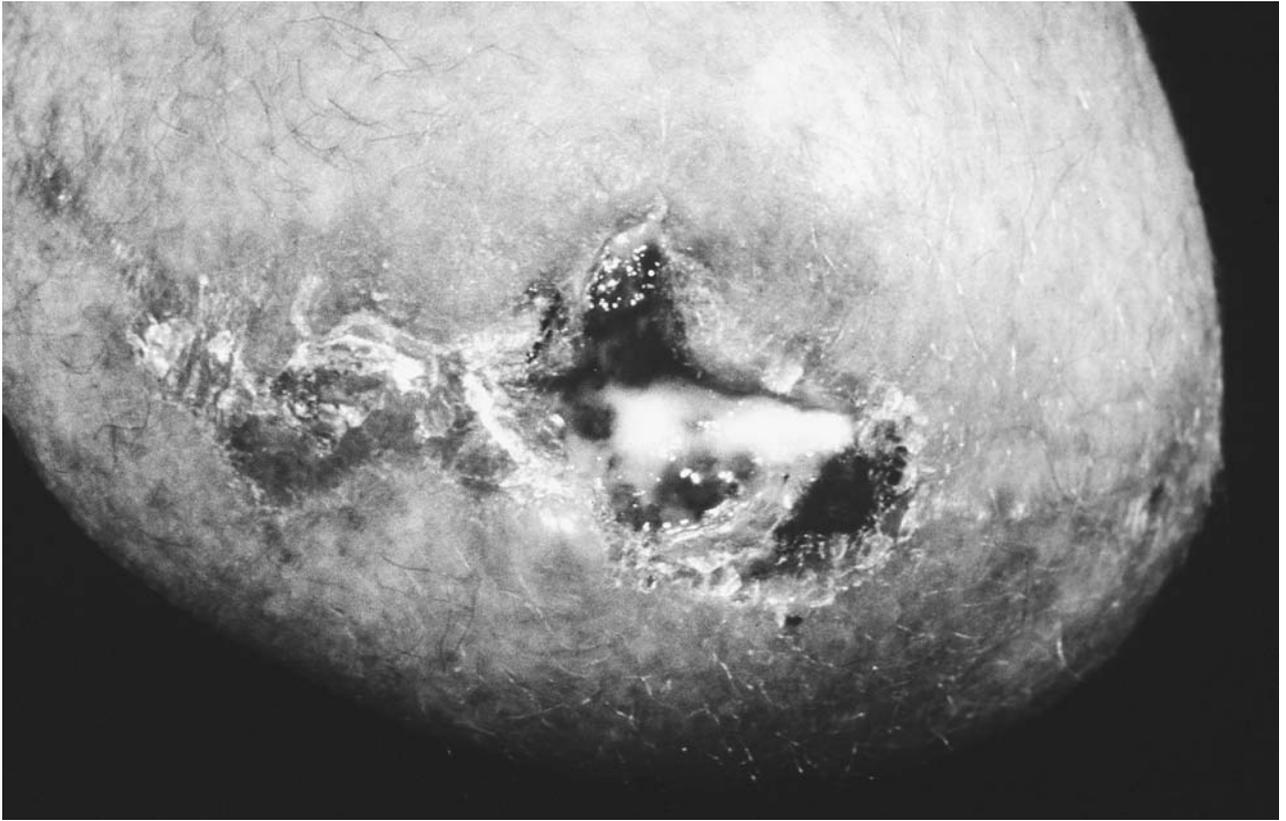
- **Punctures.** Deep, narrow wounds produced by sharp objects such as nails, knives, and broken glass.

Causes and symptoms

Acute wounds have a wide range of causes. Often, they are the unintentional results of motor vehicle accidents, falls, mishandling of sharp objects, or sports-related injuries. Wounds may also be the intentional results of violence involving assault with weapons, including fists, knives, and guns.

The general symptoms of a wound are localized **pain** and bleeding. Descriptions of the appearance of different kinds of wounds are as follows:

- An abrasion usually appears as lines of scraped skin with tiny spots of bleeding.
- An avulsion has heavy, rapid bleeding and a noticeable absence of tissue.
- A contusion may appear as a bruise beneath the skin or may appear only on imaging tests; an internal wound may also generate symptoms such as weakness, perspiration, and pain.
- A crush wound may have irregular margins like a laceration; however, the wound will be deeper, and trauma to muscle and bone may be apparent.
- A cut may have little or profuse bleeding depending on its depth, length, and anatomical site. Its even edges readily line up.
- A laceration, too, may have little or profuse bleeding; the tissue damage is generally greater, and the wound's ragged edges do not readily line up.



Ulcerated wound on a limb stump. (Custom Medical Stock Photo. Reproduced by permission.)

- A missile entry wound may be accompanied by an exit wound, and bleeding may be profuse, depending on the nature of the injury.
- A puncture wound will be greater in its length; therefore, there is usually little bleeding around the outside of the wound and more bleeding inside, causing discoloration.

Diagnosis

A diagnosis is made by visual examination and may be confirmed by a report of the causal events. Health care personnel will also assess the extent of the wound and what effect it has had on the patient's well-being (e.g., profound **blood** loss, damage to the nervous system or **skeletal system**).

Treatment

Treatment of wounds involves stopping any bleeding, then cleaning and dressing the wound to prevent **infection**. Additional medical attention may be required if the effects of the wound have compromised the body's ability to function effectively.

Stopping the bleeding

Most bleeding may be stopped by direct pressure. Direct pressure is applied by placing a clean cloth or dressing over the wound and pressing the palm of the hand over the entire area. This limits local bleeding without disrupting a significant portion of the circulation. The cloth absorbs blood and allows clot formation. The clot should not be disturbed. Therefore, if blood soaks through the original cloth, another one should be placed directly on top of it. The new cloth should not be replace the original one.

If the wound is on an arm or a leg that does not appear to have a broken bone, the injured limb should be elevated to a height above the person's **heart**, while direct pressure is applied. Elevating the wound allows gravity to slow the flow of blood to that area.

If severe bleeding cannot be stopped by direct pressure or with elevation, the next step is to apply pressure to the major artery supplying blood to the area of the wound. In the arm, pressure would be applied to the brachial artery by pressing the inside of the upper arm against the bone. In the leg, pressure would be applied to

the femoral artery by pressing on the inner crease of the groin, against the pelvic bone.

If the bleeding from an arm or leg is so extreme as to be life threatening, and if it cannot be stopped by any other means, a tourniquet may be required. However, in the process of limiting further blood loss, the tourniquet also drastically deprives the limb tissues of oxygen. As a result, the patient may live, but the limb may die.

Dressing the wound

Once the bleeding has been stopped, cleaning and dressing the wound is important for preventing infection. Although the flowing blood flushes debris from the wound, running water should also be used to rinse away dirt. Embedded particles, such as wood splinters and glass splinters—if not too deep—may be removed with a needle or pair of tweezers that has been sterilized in rubbing alcohol or in the heat of a flame. Once the wound has been cleared of foreign material and washed, it should be blotted dry gently, with care not to disturb the blood clot. An antibiotic ointment may be applied. The wound should then be covered with a clean dressing and a bandage to hold the dressing in place. Depending on the wound type, dressings can be designed to retain (or absorb) moisture, or to rehydrate desiccated wounds. Dressing materials may include polyurethane films or foams, hydrogels, hydrofibre, **calcium** alginates, and hydrocolloids.

Getting medical assistance

A person who has become impaled on a fixed object, such as a fence post or a stake in the ground, should only be moved by emergency medical personnel. Foreign objects embedded in the eye should only be removed by a physician. Larger penetrating objects, such as a fishhook or an arrow, should only be removed by a doctor, who can prevent further damage as the object is extracted.

In several instances, additional medical attention will be necessary. Wounds that penetrate the muscle beneath the skin should be cleaned and treated by a doctor, and may require stitches to stay closed during healing. Some deep wounds that do not extend to the underlying muscle may only require butterfly bandages. Wounds to the face and neck, even small ones, should always be examined by a physician so that scarring can be minimized and sensory function can be preserved. Deep wounds to the hands and wrists should be examined for nerve and tendon damage. Puncture wounds may require a tetanus shot to prevent serious infection. Animal bites should always be examined and the possibility of rabies infection considered.

KEY TERMS

Abrasion—Also called a scrape. The rubbing away of the skin surface by friction against another rough surface.

Avulsion—The forcible separation of a piece from the entire structure.

Butterfly bandage—A narrow strip of adhesive with wider flaring ends (shaped like butterfly wings) used to hold the edges of a wound together while it heals.

Cut—Separation of skin or other tissue made by a sharp edge, producing regular edges.

Laceration—Also called a tear. Separation of skin or other tissue by a tremendous force, producing irregular edges.

Plasma—The straw-colored fluid component of blood, without the other blood cells.

Puncture—An injury caused by a sharp, narrow object deeply penetrating the skin.

Tourniquet—A device used to control bleeding, consisting of a constricting band applied tightly around a limb above the wound. It should only be used if the bleeding is life-threatening and cannot be controlled by other means.

Traumatic shock—A condition of depressed body functions as a reaction to injury with loss of body fluids or lack of oxygen. Signs of traumatic shock include weak and rapid pulse, shallow and rapid breathing, and pale, cool, clammy skin.

Whole blood—Blood which contains red blood cells, white blood cells, and platelets in plasma.

Infection

Wounds that develop signs of infection should also be brought to a doctor's attention. Signs of infection are swelling, redness, tenderness, throbbing pain, localized warmth, **fever**, swollen lymph glands, the presence of pus either in the wound or draining from it, and red streaks spreading away from the wound.

Emergency treatment

With as little as one quart of blood lost, a person may lose consciousness and go into traumatic **shock**. If the person stops breathing, artificial respiration should be administered. In the absence of a pulse, **cardiopulmonary resuscitation (CPR)** must be performed. Once

the person is breathing unassisted, one can attend to the bleeding.

In cases of severe blood loss, treatment may include the intravenous replacement of body fluids. This may be infusion with saline or plasma, or with a whole-blood transfusion.

Some alternative therapies may help to support the injured person. Homeopathic remedies include: *Ledum* (*Ledum palustre*) taken internally for puncture wounds, calendula (*Calendula officinalis*) or tea tree oil (*Melaleuca* spp.) used topically as an antiseptic, aloe (*Aloe barbadensis*) applied topically to soothe skin during healing, and St. John's wort (*Hypericum perforatum*) used internally or topically when wounds affect the nerves, especially in the arms and legs. Acupuncture is thought to support the healing process by restoring energy flow in the meridians affected by the wound. In some cases, **vitamin E**, taken orally or applied topically, may speed healing and prevent scarring.

Prognosis

Without the complication of infection, most wounds heal well with time. Depending on the depth and size of the wound, it may or may not leave a visible scar.

Health care team roles

Nurses are extensively involved in the assessment and treatment of wounds. Typical responsibilities include daily cleaning of the wound with disinfectant soap, removal of crusting and loose, non-viable tissue, dressing the wound, and ensuring that a physician is notified of any changes in the wound, especially signs of infection. Other issues to be addressed by nursing staff may include **pain management**, appropriate **nutrition** to promote healing, psychosocial effects of serious or disfiguring wounds, and administration of tetanus toxoid to prevent

a systemic infection. It can be very important to determine the cause of wounds, especially those that are chronic—such as leg ulcers.

Prevention

Most actions that result in wounds are preventable. Injuries from motor vehicle accidents may be reduced by advising patients to wear seatbelts and to place children in size-appropriate car seats in the back seat. Sharp, jagged, or pointed objects or machinery parts should be used according to the manufacturer's instructions and only for their intended purpose. Firearms and explosives should be used only by adults with explicit training; they should also be kept locked and away from children. Persons engaging in sports, games, and recreational activities should wear all proper protective equipment and follow safety rules.

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David Helwig

Writing therapy see **Journal therapy**

X

X-ray technology see **Radiologic technology**

X-ray unit

Definition

An x-ray unit is the equipment used to produce x rays. Because of the risk of over-exposure to x rays, the x-ray unit includes both the machine used for collecting x rays and the protective room within which the x rays are taken and developed.

Purpose

Film radiographs, or x rays, are the most widely used means of medical imaging. Radiographs are used to examine bones for **fractures**, growth abnormalities, and joint dysfunctions. X rays are also used to find abnormal growths in the breasts (**mammography**), other organs and soft tissues; problems in the gastrointestinal tract; circulatory problems such as clogged arteries and **blood** clots; and a variety of other ailments. Additionally, radiation therapy to treat **cancer** is generally performed with x rays.

Description

The production of an x-ray image (radiograph) involves three distinct steps: the generation of an x-ray beam, the interaction of that beam with the structures of the patient to be imaged, and the development of the image.

Generation of an x-ray beam

Visible light is electromagnetic energy that has characteristics that allow it to be seen by humans. There are many other familiar forms of electromagnetic energy that

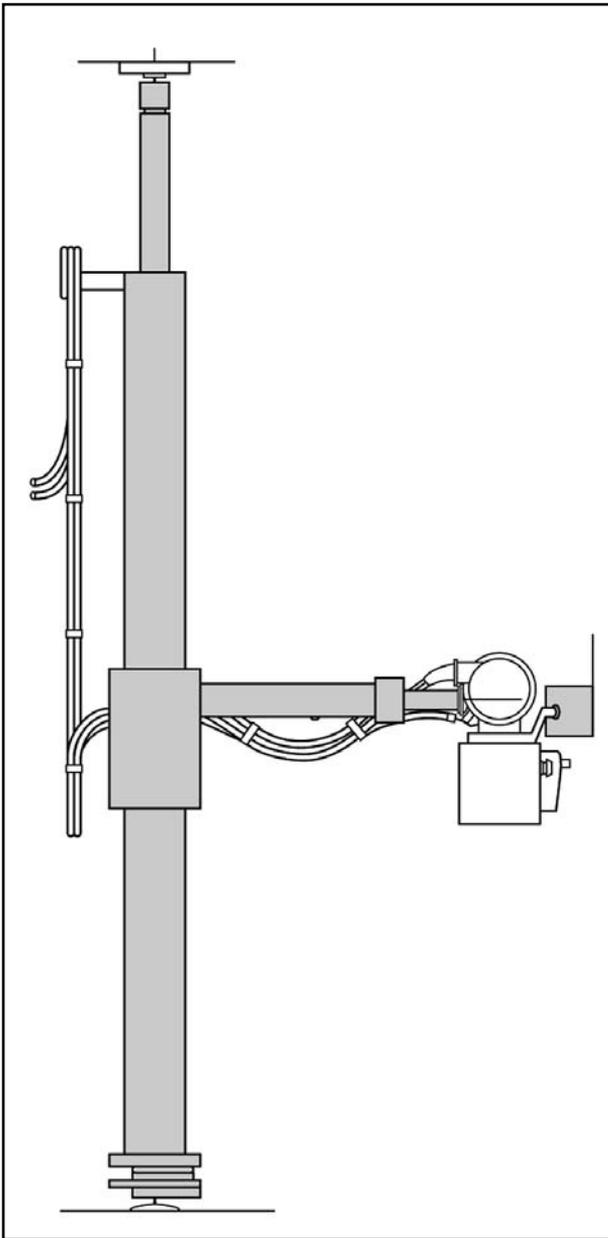
are not visible to humans. These include radio waves, which permit the transmission of radio signals and the operation of cellular phones; microwaves, which are often used to heat food; and x rays. Each of these forms of light has a characteristic size (wavelength) and speed (frequency) range that defines it. An x-ray beam is an invisible form of light that has a wavelength that is much smaller than visible light and a frequency that is much faster than visible light.

Because an x-ray beam is a beam of light, just like visible light, it is generated in a type of light bulb that resembles a camera flash bulb. A flash bulb is used to increase the amount of visible light available for a photograph during the brief time that the camera is actually taking the picture (creating the visual image). An x-ray bulb is used to provide x-ray light during the brief time while the radiograph is being imaged.

The major differences between an x-ray light bulb and a visible flash bulb are the amount of energy required to produce the light and the energy characteristics (wavelength and frequency) of the light produced. Also, a flash bulb is not “tunable”: a visible light bulb produces light anywhere within the visible light range. An x-ray bulb is “tunable” in that only x rays with the exact wavelength and frequency characteristics desired for the production of the radiograph are allowed to contact the patient. An x-ray bulb uses a filter system to produce light only in a specified x-ray range determined either by the filter system being used, or, in more advanced settings, by the x-ray unit operator through a variable control system.

Interaction of the x-ray beam with the patient

When visible light from a flash bulb strikes the skin of a human arm, that light is reflected back to the lens of the camera to which the flash bulb is attached, producing an image of a human arm on the film within the camera. The camera lens and film are designed to be able to image visible light. They generally cannot create an image from light outside the visible range.



Floor-to-ceiling tube suspension system. (Delmar Publishers, Inc. Reproduced by permission.)

Because x rays travel much faster than visible light, and because they have a much smaller wavelength, they have more “penetrating power” than visible light. This means that when x rays strike the same human arm, they are not stopped (reflected) by the skin and soft tissues, which are composed primarily of liquids. Instead, these x rays continue to travel through the skin and soft tissues until they meet a relatively dense material, such as bone. It is the “penetrating power” of light in the x-ray range that allows an x-ray image to “see inside” the human body.

An x-ray beam passes through sparse materials and only interacts with (becomes reflected by) dense materials. For this reason, x rays are most often thought of as being useful for the observance of dense tissues, such as bone. But, because an x-ray bulb is tunable, what is “sparse” and what is “dense” can often be defined by the particular type of x ray used. For instance, x-ray imaging of the breast (mammography) does not rely on a very large discrepancy in densities between the tissues being imaged and the tissues being ignored. The breast is largely composed of fat tissue and vessels of the circulatory and lymphatic systems, which are relatively dense when compared to skin and other non-fatty tissues. It is possible to tune an x ray to image the fatty tissues, **blood vessels** and lymphatic vessels of the breast in preference to the non-fatty tissues of the breast. Also, because abnormal growths (tumors) in the breast are denser than the typical breast tissue, radiographic mammography is an excellent diagnostic tool for the discovery of such breast abnormalities.

Often it is desirable to selectively image certain structures that are not sufficiently more dense than their surrounding tissue. This may often be accomplished through the use of a tracer, or dye, material that is dense that is administered to the type of tissue that is to be imaged. Examples of this type of x-raying include the use of barium to coat the lower gastrointestinal tract (**barium enema**) and the use of iodine compounds to coat the linings of blood vessels (angiograms). The introduction of barium or iodine tracers makes the gastrointestinal tract or the blood vessels appear to be more dense than the surrounding tissues.

Development of the x-ray image

Only about 1% of the x rays that strike a patient’s body emerge from the body to produce the final image. The radiographic image is formed on a radiographic plate that is similar to the film of a camera. The other 99% of the x rays are either absorbed by the body or scattered by the tissues of the body.

Those x rays that are scattered (reflected) by the tissues of the body are generally scattered in a random pattern. If these x rays reach the radiographic plate, they tend to obscure the radiographic image. Therefore, an anti-scatter grid, which is similar to a set of partially closed window blinds, is used to prevent these scattered x rays from reaching the plate. X rays that have passed through the body without being scattered will reach this grid traveling perpendicular to the grid. X rays that have been scattered will reach this grid traveling, for the most part, in directions other than perpendicular. Any x rays that are traveling perpendicular to the grid will pass



X-ray unit. (Photograph by Guy Marche. FPG International Corp. Reproduced by permission.)

through and strike the radiographic plate, helping to create the final radiographic image. Those x rays that are not traveling perpendicular to the grid will strike the grid and be absorbed, such that they do not contribute to the final radiographic image.

After passing through the anti-scatter grid, x rays strike a radiographic plate that works almost identically to a photographic plate, or film in a camera. In recent years, modifications in the development process of radiographic plates have been achieved that allow the necessary clarity of the radiograph with much lower x-ray exposures to the patient.

Those x rays that are absorbed by the body do not reach the radiographic plate. Therefore, they present no difficulty in the production of a clear radiographic image. However, these absorbed x rays have been shown to be a cause of cancer in those individuals who are overexposed to them, either over time or during periods of intense radiation.

Components of the x-ray unit

To prevent exposure to the operator and to prevent the unnecessary leakage of x-ray radiation to the rest of the facility where x rays are performed, the x-ray unit is generally enclosed in a room that has walls made of, or reinforced with, a dense material (usually lead) that will absorb any x rays that are scattered during the x-ray process.

Additionally, the operator of an x-ray unit generally turns the x-ray equipment on and off from behind a protective wall that is lined with lead. Lead is extremely dense to x rays and even a one-quarter inch thickness of lead will prevent all x rays emitted from current x-ray machines from being able to pass.

A lead-impregnated smock or apron is also provided to patients while they are being x-rayed to prevent unwanted exposure of their bodies to x rays.

KEY TERMS

Anti-scatter grid—A grid that is placed between the patient and the radiographic plate to prevent x rays that have been reflected from reaching the plate. Without the use of this grid, the resulting x-ray image (radiograph) would be unreadable, or would appear severely “out-of-focus.”

Radiograph—An image formed on a radiographic plate (similar to the film in a camera) by x rays. This is the final image produced by an x-ray unit.

Tracer—A chemical that is relatively dense to x rays that is added to the body to make that part of the body imaggable with x rays. Examples include barium, used to image the gastrointestinal tract, and iodine, used to image blood vessels. Without the use of a tracer, these structures would be difficult, or impossible, to differentiate from surrounding tissues.

X ray—An invisible form of light that has a wavelength that is much smaller than visible light and a frequency that is much faster than visible light. Because of these properties of x rays, they can be used to image dense structures within the human body.

Operation

Modern x-ray equipment is automated. An x-ray technician, or other licensed radiographer, properly positions the patient between the x-ray source and the radiographic plate. Then the technician goes into a separate room and pushes a button to turn on the x-ray beam. The reason for leaving the room while x rays are being taken is to prevent harmful effects in the technician that could occur after repeated x-ray exposure. The length of time that the x-ray beam remains on and the intensity level of the beam are based on the part of the body being imaged. In the newest equipment, these times and intensities are controlled by a computer, but may be manually adjusted, within certain safety limits, by the x-ray technician. After exposure, the technician removes the radiographic plate and places it in a fully automated development chamber where the final image is produced.

The skill and training of the technician comes in the proper positioning of the patient and in the examination of the resulting image. The image is ultimately examined for clinical findings by a radiologist and/or by the physician who ordered the x rays. It is the job of the x-ray technician to exam the radiograph to ensure that a clinically

useful image has been produced. When an unsuitable image is produced, the x-ray technician will have to retake the x ray. Unsuitable images may be produced when the patient failed to remain still during the x ray exposure, the positioning of the patient was incorrect, there was an alignment or other problem with either the radiographic plate or the x-ray beam, or the exposure time and/or intensity was incorrect for the part of the body being imaged.

Maintenance

X-ray units are large and expensive pieces of equipment. They are generally covered by maintenance contracts provided by their manufacturers. Medical personnel should not attempt to maintain this equipment. Maintenance contracts generally call for routine maintenance every four months to inspect the equipment, replace any aging or wearing parts, to check for radiation leakage, and to ensure proper operation.

Health care team roles

X rays are generally ordered by primary care, emergency, or other specialized physicians. Most x rays are taken by registered x-ray technologists under the supervision of radiologists. A radiologist is a physician who has completed a minimum of a four-year residency program in radiology after medical school. A registered x-ray technologist is a person who has received a one year certificate, a two year associate degree, or a four year bachelor degree from a training program that is accredited by the Joint Review Committee on Education in **Radiologic Technology** and, if required, has received a license from the state in which he or she practices, to perform radiologic measurements or therapies on the general public.

Training

All people who take x rays of patients or perform radiation therapies in the United States are required to be licensed and/or registered under the Consumer-Patient Radiation Health and Safety Act of 1981. This act was designed to protect the general public from unnecessary exposure to medical and dental radiation by ensuring that operators of radiologic equipment are properly trained in the use of such equipment.

Education and training programs in x-ray technology are offered by hospitals, colleges and universities, the armed forces, and vocational-technical institutes. Formal training is offered in radiography, radiation therapy, mammographic imaging, and diagnostic medical imaging (e.g. ultrasound, CT, and MRI). Programs range in

length from 1 to 4 years and lead to a certificate, an associate degree, or a bachelor degree. Associate degrees that require 2 years of training are the most common. One year certificate programs are generally pursued by individuals already trained in another health occupation, such as medical or dental technology, or registered nursing, who want to change fields or expand their skill set within the setting in which they are presently employed; or, by experienced radiographers who want to specialize in radiation therapy or medical imaging.

All x-ray technology programs offer classroom and clinical instruction in anatomy and physiology, **medical terminology**, **medical ethics**, patient care procedures, positioning of patients for appropriate radiologic imaging, radiation physics, radiation protection (of both the patient and the x-ray technician), and radiobiology. In order to retain his or her licensure or registration as an x-ray technician or radiation therapist, a person licensed or registered as such must complete and provide documentation to the licensing or registration board of his or her state of 24 hours of continuing education every two years.

With additional training, available at most major cancer centers, radiation therapy technicians can specialize as medical radiation dosimetrists. A medical radiation dosimetrist works with oncologists (physicians specializing in cancer causes and treatments) and health physicists to develop effective treatment plans for patients who require radiation therapy in the treatment of cancerous tumors.

X-ray technologists who are also able to perform medical imaging are projected to have the best job opportunities, at least through 2006. This is because many hospitals, the main employers of x-ray technologists, are attempting to cut costs by merging their radiologic and nuclear medical imaging (MRI) facilities. The need for independent diagnostic imaging centers that specialize in providing radiographic and other medical imaging techniques to medical clinics and private physician practices is also expected to grow extremely rapidly. Advances in technology that lead to lower cost equipment permit more and more radiographic and medical imaging procedures to be performed outside a hospital environment.

Resources

BOOKS

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ORGANIZATIONS

American Healthcare Radiology Administrators (AHRA). 111 Boston Post Road, Suite 105, Sudbury, MA 01776. 1-

800-334-2472 or 978-443-7591. <<http://www.ahraonline.org/contact.htm>>.

American Society of Radiologic Technologists (ASRT). 15000 Central Avenue, SE, Albuquerque, NM 87213-3917. 505-298-4500. <<http://www.asrt.org>>.

Radiological Society of North America, Inc. 820 Jorie Boulevard, Oak Brook, IL 60523-2251. 630-571-2670. <<http://www.rsna.org/index.html>>.

Paul A. Johnson

X rays of the eye's orbit see **X rays of the orbit**

X rays of the orbit

Definition

Orbital x rays are a radiographic study of the area and structures containing the eyes. The orbits are bony cone-shaped cavities that contain and protect the eyes. Each orbit is lined with fatty tissue to cushion the eyeballs. The orbits are thin and easily subjected to **fractures**, particularly blow-out fractures of the orbital floor.

Purpose

Orbital x ray, or orbital radiography, is used to detect problems resulting from injury or trauma to the eye. Seventy percent of all facial fractures involve the orbits in some way. An x ray of the orbits may also be ordered for patients complaining of **pain**, **vision** trouble, or excessive tearing of the eyes. An ophthalmologist may also order orbital x rays when a foreign body cannot be detected with an ophthalmoscope.

Orbital x ray is also used as a screening tool before an MRI is performed, since intraorbital metallic **foreign bodies** are a contraindication for MRI (the magnetic field in the MRI could move the metallic object causing eye injury). Patients scheduled for MRIs are screened for the possible presence of metallic foreign bodies by a questionnaire or interview with the MRI technologist. If there is a suspicion that a metallic foreign body may be present, the patient will have x rays taken of the orbit to ensure that no foreign body is present.

Precautions

Pregnant women and women who could possibly be pregnant should only receive orbital x rays when absolutely necessary. The x-ray technologist will use pro-

KEY TERMS

Blowout fracture—A fracture or break in the orbit that is caused by a sudden and violent impact to the area.

Malignancy—A malignancy is a tumor that is cancerous and growing.

Medial wall—The mid-line bone, or wall, of the eye's orbit. It is generally thicker than the roof and floor walls.

Ophthalmologist—A physician who specializes in the workings, structures, and care of the eyes.

Ophthalmoscope—An instrument routinely used by ophthalmologists to examine the interior of the eye. It consists of a small light, a mirror, and lenses of differing powers that magnify.

Periorbital—The area surrounding the eye.

Radiography—Examination of any part of the body through the use of x rays. The process produces an image of shadows and contrasts on film.

Water's view—A radiographic view of the facial bones invented by Dr. S. Water to see all of the facial bones clearly. The patient is prone with the head straight and the chin extended forward 37°.

X ray—A form of electromagnetic radiation with shorter wavelengths than visible light.

tective shielding on all women of child-bearing age as well as on children.

Description

Each orbit is formed by the frontal, ethmoid, and sphenoid bones of the **skull** and the lacrimal, palatine, maxillary, and zygomatic bones of the face. Each orbit consists of a medial and lateral wall as well as a roof and floor, therefore a series of views is necessary to see all of the structures well. Both orbits are always imaged so that a comparison can be made of the two sides. A typical routine for the orbits consists of a Water's view, Caldwell and lateral of the affected side. In some cases a basal view may be requested if the patient is able to extend the head backwards. Projections of the optic canals or Rhese views will be included in some cases.

X rays of the orbits may be done with the patient sitting or lying down. The patient is placed prone (lying horizontally face down) with no rotation of the head. The tube is angled 15° caudad (towards the feet) for the

Caldwell position, where the petrous ridges will be in the lower third of the orbits. In the Water's position (occipito-mental) the chin is extended forward at least 37°, centering on the acanthion (the small indentation in the center of the upper lip). This is the best view to see the orbits completely clear of any other structures. The maxillary sinuses are well visualized with the Water's view, so any fluid levels are easily detected. In the lateral position the patient's head is turned onto the affected side if possible, with the interpupillary line perpendicular to the table.

When x rays for a foreign body are requested, a Water's view is done with the patient looking straight ahead. Sometimes two views in the lateral position are done—one with the patient looking up and one with the patient looking down. A soft tissue technique should be used when looking for a foreign body. An ultrasound exam of the eye also will detect any foreign body in the eye.

X rays of the orbits should normally be completed in 15 minutes if the patient is cooperative. The patient must wait until the x rays are developed to ensure that all required structures are well demonstrated with no rotation or movement.

Preparation

There are no special dietary preparations needed prior to an orbital x ray. As with any radiography procedure, the patient should remove dentures, jewelry, or metal objects, which may interfere with obtaining a detailed image.

Aftercare

No aftercare is required following this diagnostic test.

Complications

Radiation exposure is low for this procedure and all certified radiology facilities follow strict personnel and equipment guidelines for radiation protection. Women of child-bearing age and children will be given a protective shielding (lead apron) to cover the genital and/or abdominal areas. Patients who are unable to lie prone can be tested in a supine position (lying horizontally on the back). The lateral view can be done by turning the x-ray tube 90° and placing the film against the affected side. Severe trauma patients will have a CT scan done instead of orbital or facial x rays.

Results

Normal findings show the bones of the orbits are intact, with no fractures, tumors, or cysts that could erode the surrounding bone.

Positive findings from an orbital x ray may show that there has been some injury to the eye. Radiologists look for asymmetry in the facial bones, periorbital or intracranial air as well as fluid in the paranasal sinuses. Tiny fractures in the orbital bones can usually be detected on the radiograph. In a blowout fracture (one involving the orbital floor), radiographic findings may include overlapping of bone fragments on the orbital floor and opacification of the sinuses (due to hemorrhage).

Indications of differences in size and shape of the various structures in the orbit may be apparent. The orbit may be enlarged, indicating irritation from an injury or foreign body. A number of growing tumors within the eye or **brain** area may also cause orbital enlargement. Destruction of the walls of the orbit may indicate a near-by **infection** or malignancy. Changes in density may also be a sign of bone disease or a **cancer** that has spread to the bone.

Children's orbits are more likely to be enlarged by a fast growing lesion, since their orbital bones have not fully developed, but are less likely to have facial fractures due to the resiliency of their facial skeleton.

Health care team roles

The x-ray technologist works as part of the treatment team to make sure that the patients are radiographed and then returned to the emergency department as soon as

possible. If portable (mobile radiography) orbital x rays are ordered the radiography technologist must make sure that all staff members remaining in the room wear proper shielding (lead aprons).

Patient education

Patients are instructed to remain still during the x rays and to allow the x-ray technologist to position the head. Certain positions may be uncomfortable but are necessary to visualize all areas of the orbits. All radiologic technologists must be certified and registered with the American Society of Radiologic Technologists.

Resources

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ORGANIZATIONS

American Academy of Ophthalmology. P.O. Box 7424, San Francisco, CA 94120-7424. (415) 561-8500.

National Eye Institute. Building 31, Room 6A32, Bethesda, MD 20892. (301) 496-5248. <<http://www.nei.nih.gov>>.

Radiological Society of North America. 2021 Spring Rd., Suite 600, Oak Brook, IL 60521-1860. (708) 571-2670. <<http://www.rsna.org>>.

OTHER

Eye Institute. University of Pennsylvania Health System. <<http://www.med.upenn.edu/opth/patinfo>>.

Lorraine K. Ehresman

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Y

Yeast culture see **Fungal culture**

Yoga

Definition

The term *yoga* comes from a Sanskrit word which means yoke or union. Traditionally, yoga is a method joining the individual self with the Divine, Universal Spirit, or Cosmic Consciousness. Physical and mental exercises are designed to help achieve this goal, also called self-transcendence or enlightenment. On the physical level, yoga postures, called *asanas*, are designed to tone, strengthen, and align the body. These postures are performed to make the spine supple and healthy and to promote **blood** flow to all the organs, glands, and tissues, keeping all the bodily systems healthy. On the mental level, yoga uses breathing techniques (*pranayama*) and **meditation** (*dyana*) to quiet, clarify, and discipline the mind. However, experts are quick to point out that yoga is not a religion, but a way of living with health and peace of mind as its aims.

Origins

Yoga originated in ancient India and is one of the longest surviving philosophical systems in the world. Some scholars have estimated that yoga is as old as 5,000 years; artifacts detailing yoga postures have been found in India from over 3000 B.C. Yoga masters (*yogis*) claim that it is a highly developed science of healthy living that has been tested and perfected for all these years. Yoga was first brought to America in the late 1800s when Swami Vivekananda, an Indian teacher and yogi, presented a lecture on meditation in Chicago. Yoga slowly began gaining followers, and flourished during the 1960s when there was a surge of interest in Eastern philosophy. There has since been a vast exchange of yoga knowledge

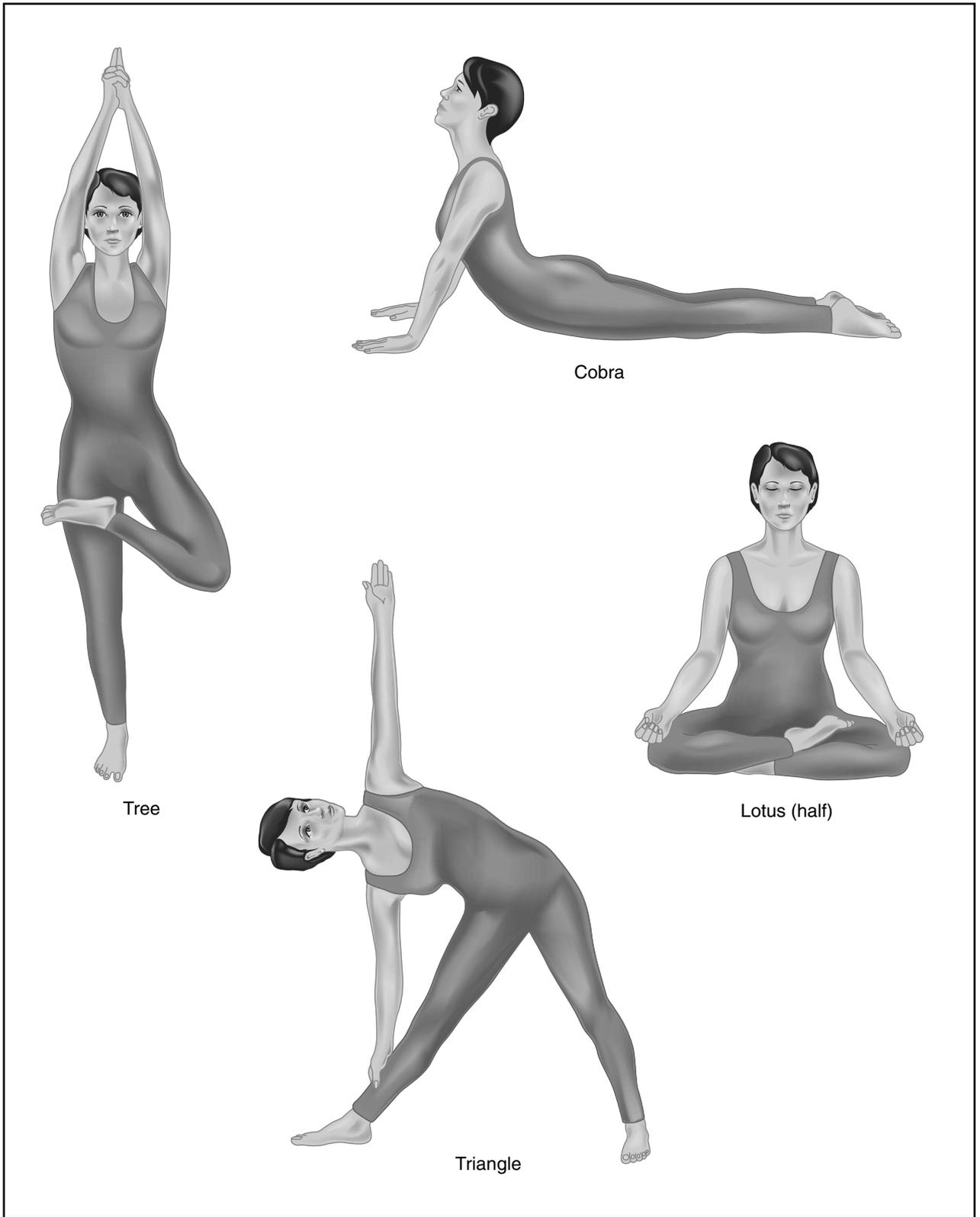
in America, with many students going to India to study and many Indian experts coming here to teach, resulting in the establishment of a wide variety of schools. Today, yoga is thriving, and it has become easy to find teachers and practitioners throughout America. A recent Roper poll, commissioned by *Yoga Journal*, found that 11 million Americans do yoga at least occasionally and 6 million perform it regularly. Yoga stretches are used by physical therapists and professional sports teams, and the benefits of yoga are being touted by movie stars and Fortune 500 executives. Many prestigious schools of medicine have studied and introduced yoga techniques as proven therapies for illness and **stress**. Some medical schools, like UCLA, even offer yoga classes as part of their physician training program.

Benefits

Yoga has been used to alleviate problems associated with high **blood pressure**, high cholesterol, migraine headaches, **asthma**, shallow breathing, backaches, constipation, diabetes, **menopause**, **multiple sclerosis**, **varicose veins**, **carpal tunnel syndrome** and many chronic illnesses. It also has been studied and approved for its ability to promote **relaxation** and reduce stress.

Yoga can also provide the same benefits as any well-designed **exercise** program, increasing general health and stamina, reducing stress, and improving those conditions brought about by sedentary lifestyles. Yoga has the added advantage of being a low-impact activity that uses only gravity as resistance, which makes it an excellent **physical therapy** routine; certain yoga postures can be safely used to strengthen and balance all parts of the body.

Meditation has been much studied and approved for its benefits in reducing stress-related conditions. The landmark book, *The Relaxation Response*, by Harvard cardiologist Herbert Benson, showed that meditation and breathing techniques for relaxation could have the opposite effect of stress, reducing blood pressure and other



Tree

Cobra

Lotus (half)

Triangle

Demonstrations of the tree, triangle, cobra, and lotus poses. The tree and triangle are good for balance and coordination. Cobra stretches the pelvic and strengthens the back. Lotus is a meditative pose. (Illustration by Electronic Illustrators Group.)

indicators. Since then, much research has reiterated the benefits of meditation for stress reduction and general health. Currently, the American Medical Association recommends meditation techniques as a first step before medication for borderline **hypertension** cases.

Modern psychological studies have shown that even slight facial expressions can cause changes in the involuntary nervous system; yoga utilizes the mind/body connection. That is, yoga practice contains the central ideas that physical posture and alignment can influence a person's mood and self-esteem, and also that the mind can be used to shape and heal the body. Yoga practitioners claim that the strengthening of mind/body awareness can bring eventual improvements in all facets of a person's life.

Description

Classical yoga is separated into eight limbs, each a part of the complete system for mental, physical and spiritual well-being. Four of the limbs deal with mental and physical exercises designed to bring the mind in tune with the body. The other four deal with different stages of meditation. There are six major types of yoga, all with the same goals of health and harmony but with varying techniques: hatha, raja, karma, bhakti, jnana, and tantra yoga. Hatha yoga is the most commonly practiced branch of yoga in America, and it is a highly developed system of nearly 200 physical postures, movements and breathing techniques designed to tune the body to its optimal health. The yoga philosophy believes the breath to be the most important facet of health, as the breath is the largest source of *prana*, or life force, and hatha yoga utilizes *spranayama*, which literally means the science or control of breathing. Hatha yoga was originally developed as a system to make the body strong and healthy enough to enable mental awareness and spiritual enlightenment.

There are several different schools of hatha yoga in America; the two most prevalent ones are Iyengar and ashtanga yoga. Iyengar yoga was founded by B.K.S. Iyengar, who is widely considered as one of the great living innovators of yoga. Iyengar yoga puts strict emphasis on form and alignment, and uses traditional hatha yoga techniques in new manners and sequences. Iyengar yoga can be good for physical therapy because it allows the use of props like straps and blocks to make it easier for some people to get into the yoga postures. Ashtanga yoga can be a more vigorous routine, using a flowing and dance-like sequence of hatha postures to generate body heat, which purifies the body through sweating and deep breathing.

The other types of yoga show some of the remaining ideas which permeate yoga. Raja yoga strives to bring

about mental clarity and discipline through meditation, simplicity, and non-attachment to worldly things and desires. Karma yoga emphasizes charity, service to others, non-aggression and non-harming as means to awareness and peace. Bhakti yoga is the path of devotion and love of God, or Universal Spirit. Jnana yoga is the practice and development of knowledge and wisdom. Finally, tantra yoga is the path of self-awareness through religious rituals, including awareness of sexuality as sacred and vital.

A typical hatha yoga routine consists of a sequence of physical poses, or asanas, and the sequence is designed to work all parts of the body, with particular emphasis on making the spine supple and healthy and increasing circulation. Hatha yoga asanas utilize three basic movements: forward bends, backward bends, and twisting motions. Each asana is named for a common thing it resembles, like the sun salutation, cobra, locust, plough, bow, eagle, tree, and the head to knee pose, to name a few. Each pose has steps for entering and exiting it, and each posture requires proper form and alignment. A pose is held for some time, depending on its level of difficulty and one's strength and stamina, and the practitioner is also usually aware of when to inhale and exhale at certain points in each posture, as breathing properly is another fundamental aspect of yoga. Breathing should be deep and through the nose. Mental concentration in each position is also very important, which improves awareness, poise and posture. During a yoga routine there is often a position in which to perform meditation, if deep relaxation is one of the goals of the sequence.

Yoga routines can take anywhere from 20 minutes to two or more hours, with one hour being a good time investment to perform a sequence of postures and a meditation. Some yoga routines, depending on the teacher and school, can be as strenuous as the most difficult workout, and some routines merely stretch and align the body while the breath and **heart** rate are kept slow and steady. Yoga achieves its best results when it is practiced as a daily discipline, and yoga can be a life-long exercise routine, offering deeper and more challenging positions as a practitioner becomes more adept. The basic positions can increase a person's strength, flexibility and sense of well-being almost immediately, but it can take years to perfect and deepen them, which is an appealing and stimulating aspect of yoga for many.

Yoga is usually best learned from a yoga teacher or physical therapist, but yoga is simple enough that one can learn the basics from good books on the subject, which are plentiful. Yoga classes are generally inexpensive, averaging around 10 dollars per class, and students can learn basic postures in just a few classes. Many YMCAs, colleges, and community health organizations offer

KEY TERMS

Asana—A position or stance in yoga.

Dyana—The yoga term for meditation.

Hatha yoga—Form of yoga using postures, breathing methods and meditation.

Meditation—Technique of concentration for relaxing the mind and body.

Pranayama—Yoga breathing techniques.

Yogi—A trained yoga expert.

beginning yoga classes as well, often for nominal fees. If yoga is part of a physical therapy program, it can be reimbursed by insurance.

Preparations

Yoga can be performed by those of any age and condition, although not all poses should be attempted by everyone. Yoga is also a very accessible form of exercise; all that is needed is a flat floor surface large enough to stretch out on, a mat or towel, and enough overhead space to fully raise the arms. It is a good activity for those who can't go to gyms, who don't like other forms of exercise, or have very busy schedules. Yoga should be done on an empty **stomach**, and teachers recommend waiting three or more hours after meals. Loose and comfortable clothing should be worn.

Precautions

People with injuries, medical conditions, or spinal problems should consult a doctor before beginning yoga. Those with medical conditions should find a yoga teacher who is familiar with their type of problem and who is willing to give them individual attention. Pregnant women can benefit from yoga, but should always be guided by an experienced teacher. Certain yoga positions should not be performed with a **fever**, or during menstruation.

Beginners should exercise care and concentration when performing yoga postures, and not try to stretch too much too quickly, as injury could result. Some advanced yoga postures, like the headstand and full lotus position, can be difficult and require strength, flexibility, and gradual preparation, so beginners should get the help of a teacher before attempting them.

Yoga is not a competitive sport; it does not matter how a person does in comparison with others, but how aware

and disciplined one becomes with one's own body and limitations. Proper form and alignment should always be maintained during a stretch or posture, and the stretch or posture should be stopped when there is **pain**, dizziness, or fatigue. The mental component of yoga is just as important as the physical postures. Concentration and awareness of breath should not be neglected. Yoga should be done with an open, gentle, and non-critical mind; when one stretches into a yoga position, it can be thought of accepting and working on one's limits. Impatience, self-criticism and comparing oneself to others will not help in this process of self-knowledge. While performing the yoga of breathing (pranayama) and meditation (dyana), it is best to have an experienced teacher, as these powerful techniques can cause dizziness and discomfort when done improperly.

Side effects

Some people have reported injuries by performing yoga postures without proper form or concentration, or by attempting difficult positions without working up to them gradually or having appropriate supervision. Beginners sometimes report muscle soreness and fatigue after performing yoga, but these side effects diminish with practice.

Research and general acceptance

Although yoga originated in a culture very different from modern America, it has been accepted and its practice has spread relatively quickly. Many yogis are amazed at how rapidly yoga's popularity has spread in America, considering the legend that it was passed down secretly by handfuls of adherents for many centuries.

There can still be found some resistance to yoga, for active and busy Americans sometimes find it hard to believe that an exercise program that requires them to slow down, concentrate, and breathe deeply can be more effective than lifting weights or running. However, ongoing research in top medical schools is showing yoga's effectiveness for overall health and for specific problems, making it an increasingly acceptable health practice.

Training and certification

Many different schools of yoga have developed in America, and beginners should experiment with them to find the best-suited routine. Hatha yoga schools emphasize classical yoga postures, and raja yoga schools concentrate on mental discipline and meditation techniques. In America, there are no generally accepted standards for the certification of yoga teachers. Some schools certify teachers in a few intensive days and some require years

of study before certifying teachers. Beginners should search for teachers who show respect and are careful in their teaching, and should beware of instructors who push them into poses before they are ready.

Resources

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- Carrico, Mara. *Yoga Journal's Yoga Basics*. New York: Henry Holt, 1997.
- Iyengar, B.K.S. *Light on Yoga*. New York: Schocken, 1975.

PERIODICALS

- Yoga International Magazine*. R.R. 1 Box 407, Honesdale, PA 18431. <<http://www.yimag.com>>.
- Yoga Journal*. P.O. Box 469088, Escondido, CA 92046. <<http://www.yogajournal.com>>.

ORGANIZATIONS

- International Association of Yoga Therapists (IAYT). 4150 Tivoli Ave., Los Angeles, CA 90066.

OTHER

- Yoga Directory. <<http://www.yogadirectory.com>>.
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Douglas Dupler

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Z

Z-track injection

Definition

Z-track injection is a method of injecting medication into a large muscle using a needle and syringe. This method seals the medication deeply within the muscle and allows no exit path back into the subcutaneous tissue and skin. This is accomplished by displacing the skin and subcutaneous tissue 1–1.5 inches (2.5–3.75 cm), laterally, prior to injection and releasing the tissue immediately after the injection.

Purpose

The Z-track method of intra-muscular (I.M.) injection is used primarily when giving dark-colored medication solutions, such as **iron** solutions, that can stain the subcutaneous tissue or skin. It is also the method of choice when giving I.M. medications that are very irritating to the tissue, such as haloperidol or vistaryl.

Precautions

Precautions taken when giving Z-track injections are all aimed at preventing the medication from leaking into the subcutaneous tissue or skin. These precautions include:

- Do not give a Z-track injection into skin that is lumpy, reddened, irritated, bruised, stained, or hardened.
- Add 0.3–0.5 ml of air into the syringe after drawing up the correct dosage of medication.
- Change the needle after drawing the medication into the syringe.
- Select a long needle (2–3 inches; 5–7.5 cm), depending upon the size of the patient, with a 21- or 22-gauge needle to place the medication deeply within the muscle.
- Give Z-track injections into a large muscle in the buttock (the gluteus medius or gluteus minimus).

- Aspirate on the syringe before injecting the medication to be sure not to hit a **blood** vessel. If blood appears in the syringe, a vein may have been hit. Remove and discard the syringe and medication. Start over with a new syringe, fresh medication, and a new site.
- Caution the patient not to wear restrictive clothing that could put constant pressure on the injection site.
- Rotate the injection sites from one buttock to the other and from site to site.
- Do not place injections into a disabled limb. If there is decreased circulation, the medication absorption will be affected and **abscess** formation can occur.
- Never inject more than 5ml of medication at a time when using the Z-track method. If a larger dose is ordered, divide it and inject it into two separate sites.

Description

To give a Z-track injection, use the non-dominant hand to move and hold the skin and subcutaneous tissue about 1–1.5 in (2.5–3.75 cm) laterally from the injection site. Alert patients when the medication is about to be injected. Ask them to breathe through their mouth and to try to relax the muscle to avoid muscle resistance. Continue holding the displaced skin and tissue until after the needle is removed. Dart the syringe rapidly into the site at a 90° angle. Aspirate on the syringe to be sure that a blood vessel has not been penetrated. Inject the medication slowly into the muscle. Be sure that the syringe is completely empty, including the air, before withdrawing the syringe. Withdraw the syringe and immediately release the skin and subcutaneous tissue.

Preparation

Wash both hands and put on gloves. Check the medication label before giving the medicine to avoid medication errors. Be sure it is the right medicine, the right dose (strength), the right time, the right person, and the right

KEY TERMS

Gluteus medius—One of the large muscles of the buttock, located above the gluteus maximus that allows the thigh to abduct, rotate, and extend.

Gluteus minimus—One of the large muscles of the buttock, located above the gluteus maximus that allows the thigh to abduct, rotate, and extend.

Laterally—Toward the side.

Subcutaneous tissue—The tissue found immediately below the skin.

method. Note the expiration date on the label. Do not use outdated medicine. Draw the correct dosage into the syringe including 0.3–0.5 ml of air. Discard the uncapped needle in a needle-box and attach a new sterile needle. Provide privacy and position the patient on the side with the knee slightly bent to relax the buttock muscles. Expose the buttock only, using the patient's clothing or a drape. Use the landmarks defined in the I.M. injection section to identify the desired injection site along the gluteus medius or gluteus minimus muscle. Prepare the site with an alcohol swab by rubbing the swab firmly in a 3-inch (7.5 cm) circle from the center of the site outward to remove **bacteria** from the skin. Allow the skin to air dry.

Aftercare

Apply gentle pressure to the site, using a dry gauze pad, if necessary. Do not rub the site. Continue pressure if bleeding occurs, and apply a bandage, if necessary. Replace the patient's clothing and allow the patient a 5-minute rest period. Then encourage the patient to walk about to enhance absorption of the medication. Discard the used syringe and uncapped needle in a needle-box. Place gloves and used swabs in a plastic trash bag that can be sealed and discarded. Wash both hands when the procedure is complete.

Complications

The complications of a Z-track injection are not common, but include tissue staining, bruising, abscess formation at the injection site, and severe **pain** at the injection site. Notify the physician if any of these conditions are noted.

Results

Medication administered by Z-track injection is absorbed rapidly from the muscle into the bloodstream.

The effects are seen over hours to days, depending upon the medication given.

Health care team roles

Medication given intramuscularly, using the Z-track method, is done by an R.N., L.P.N., or a physician in the health care setting. Rarely, a physician will ask the nurse to teach a family member or caretaker this injection technique so that Z-track injections can be given correctly in the home. If family members are giving medication in this manner, set up regular follow-up visits with the physician or a **home care** nurse to examine and assess the injection sites.

Resources

BOOKS

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Mary Elizabeth Martelli, R.N., B.S.

ZIFT *see* **Fertility treatments**

Zinc

Description

Zinc is a mineral that is essential for a healthy **immune system**, production of certain hormones, wound healing, bone formation, and clear skin. It is required in very small amounts, and is thus known as a

trace mineral. Despite the low requirement, zinc is found in nearly every cell of the body and is a key to the proper function of over 300 enzymes, including superoxide dismutase. Normal growth and development cannot occur without it.

General use

The U.S. Recommended Dietary Allowance (RDA) for zinc is 5 milligrams (mg) for children under one year of age, 10 mg for children aged one to 10 years old, 15 mg for males 11 years or older, 12 mg for females 11 years or older, 15 mg for women who are pregnant, and 16-19 mg for women who are lactating.

Zinc has become a popular remedy for the **common cold**. Evidence shows that it is unlikely to prevent upper respiratory infections, but beginning a supplement promptly when symptoms occur can significantly shorten the duration of the illness. The only form of zinc proven effective for this purpose is the zinc gluconate or zinc acetate lozenge. Formulations of 13-23 mg or more appear to be most effective, and need to be dissolved in the mouth in order to exert antiviral properties. Swallowing or sucking on oral zinc tablets will not work. The lozenges can be used every two hours for up to a week or two at most.

People who are deficient in zinc are prone to getting more frequent and longer lasting infections of various types. Zinc acts as an immune booster, in part due to stimulation of the thymus gland. This gland tends to shrink with age, and consequently produces less of the hormones that boost the production of infection-fighting white **blood** cells. Supplemental zinc, at one to two times RDA amounts, can reverse this tendency and improve immune function.

In another immune stimulant capacity, zinc can offer some relief from chronic infections with *Candida albicans*, or yeast. Most women will experience a vaginal yeast **infection** at some time, and are particularly prone to them during the childbearing years. Some individuals appear to be more susceptible than others. One study showed yeast-fighting benefits for zinc even for those who were not deficient in the mineral to begin with. Other supplements that will complement zinc in combating yeast problems are **vitamin A**, **vitamin C**, and **vitamin E**. Another measure that can help to limit problems with *Candida* is eating yogurt, which is an excellent source of *Lactobacillus*, a friendly **bacteria** that competes with yeast. Limiting sweets in the diet and eating garlic or odor-free garlic supplements may also prove helpful.

People who are going to have surgery are well advised to make sure they are getting the RDA of zinc, vitamin A, and vitamin C in order to optimize wound healing. A deficiency of any of these nutrients can significantly lengthen the time it takes to heal. Adequate levels of these **vitamins** and **minerals** for at least a few weeks before and after surgery can speed healing. The same nutrients are important to minimize the healing time of bedsores, **burns**, and other skin lesions too.

There are two male health problems that can potentially benefit from zinc supplementation. Testosterone is one of the hormones that requires zinc in order to be produced. Men with **infertility** as a result of low testosterone levels may experience improvement from taking a zinc supplement. Another common condition that zinc can be helpful for is benign prostatic hypertrophy, a common cause of abnormally frequent urination in older men. Taking an extra 50 mg a day for three to six months offers symptomatic relief for some men.

Teenagers are often low in zinc, and also tend to experience more acne than the general population. The doses used in studies have been in the high range, requiring medical supervision, but increasing dietary zinc or taking a modest supplement in order to get the RDA amount is low risk and may prove helpful for those suffering from acne. Consult a knowledgeable health care provider before taking large doses of any supplement.

There is some evidence that zinc supplementation may slightly relieve the symptoms of rheumatoid arthritis, but the studies are not yet conclusive. It's possible that those who initially had low zinc levels benefited the most.

Zinc is sometimes promoted as an aid for **memory**. This may be true to the extent that vitamin B₆ and neurotransmitters are not properly utilized without it. However, in the case of people with **Alzheimer's disease**, zinc can cause more harm than good. Some experiments indicate that zinc actually decreases intellectual function of people with this disease. Under these circumstances, it is probably best to stick to the RDA of 15 mg as a maximum daily amount of zinc.

The frequency of sickle-cell crisis in patients with sickle-cell anemia may be decreased by zinc supplementation. The decrease was significant in one study, although the severity of the attacks that occurred was not affected. Use of zinc supplementation or other treatment for sickle-cell anemia, a serious condition, should not be undertaken without the supervision of a health care provider.

Both the retina of the eye, and the cochlea in the inner ear contain large amounts of zinc, which they appear to need in order to function properly. Dr. George

KEY TERMS

Acrodermatitis enteropathica—Hereditary metabolic problem characterized by dermatitis, diarrhea, and poor immune status. Oral treatment with zinc is curative.

Benign prostatic hypertrophy—Enlargement of the prostate gland, which surrounds the male urethra, causing frequent urination. This condition is very common in older men.

Hemochromatosis—A hereditary condition which results in excessive storage of iron in various tissues of the body.

Macular degeneration—Deterioration of part of the retina, causing progressive loss of vision. This is the most common cause of blindness in the elderly.

Sickle-cell anemia—A genetic malformation of red blood cells that can cause periodic crises in sufferers.

Tinnitus—Perceived ringing, buzzing, whistling, or other noise heard in one or both ears that has no external source. There are a number of conditions that may cause this.

E. Shambaugh, Jr., M.D., is a professor emeritus of otolaryngology and head and neck surgery at Northwestern University Medical School in Chicago. In *Prevention's Healing with Vitamins*, he “estimates that about 25% of the people he sees with severe tinnitus are zinc-deficient.” He adds that they sometimes have other symptoms of zinc deficiency. Large doses may be used in order to provide relief for this problem. Medical supervision and monitoring are necessary to undertake this course of treatment.

Topical zinc can be useful for some conditions, including cold sores. It is also available in a combination formula with the antibiotic erythromycin for the treatment of acne. Zinc oxide is a commonly used ingredient in the strongest sun block preparations and some creams for the treatment of diaper rash and superficial skin injuries. Men can use topical zinc oxide to speed the healing of **genital herpes** lesions, but it is too drying for women to use in the vaginal area.

There is still not enough information on some of the claims that are made for zinc. A few that may have merit are the prevention or slowing of **macular degeneration**, and relieving psoriasis. Consult a health care provider for these uses.

Deficiency

It is not uncommon to have a mild to moderately low levels of zinc, although serious deficiency is rare. Symptoms can include an increased susceptibility to infection, rashes, hair loss, poor growth in children, delayed healing of **wounds**, rashes, acne, male infertility, poor appetite, decreased sense of **taste** and **smell**, and possibly swelling of the mouth, tongue, and eyelids.

A more serious, chronic deficiency can cause severe growth problems, including dwarfism and poor bone maturation. The spleen and **liver** may become enlarged. Testicular size and function both tend to decrease. **Cataracts** may form in the eyes, the optic nerve can become swollen, and color **vision** is sometimes affected by a profound lack of zinc. **Hearing** is sometimes affected as well.

Since meats are the best sources of zinc, strict vegetarians and vegans are among the groups more likely to be deficient. The absorption of zinc is inhibited by high fiber foods, so people who have diets that are very high in whole grain and fiber need to take supplements separately from the fiber. Zinc is needed in larger amounts for women who are pregnant or breastfeeding. Deficiency during **pregnancy** may lower fetal birthweight, as well as increase maternal risk of toxemia. A good prenatal vitamin is likely to contain an adequate amount. People over age 50 don't absorb zinc as well, nor do they generally have adequate intake, and may require a supplement. Alcoholics generally have poor nutritional status to begin with, and alcohol also depletes stored zinc.

There is an increased need for most vitamins and minerals for people who are chronically under high **stress**. Those who have had surgery, severe burns, wasting illnesses, or poor **nutrition** may require larger amounts of zinc than average.

Some diseases increase the risk of zinc deficiency. Sickle-cell anemia, diabetes, and kidney disease can all affect zinc **metabolism**. People with **Crohn's disease**, sprue, chronic **diarrhea**, or babies with acrodermatitis enteropathica also have an increased need for zinc. Consult a health care provider for appropriate supplementation instructions.

Preparations

Natural sources

Oysters are tremendously high in zinc. Some sources, such as whole grains, beans, and nuts, have good zinc content but the fiber in these foods prevents it from being absorbed well. Foods with zinc that is better utilized include beef, chicken, turkey, milk, cheese, and yogurt. Pure maple syrup also is a good dose of zinc.

Supplemental sources

Zinc supplements are available as oral tablets in various forms, as well as lozenges. Zinc gluconate is the type most commonly used in lozenge form to kill upper respiratory **viruses**. Select brands that do not use citric acid or tartaric acid for flavoring, as these appear to impair the effectiveness. The best-absorbed oral types of zinc may include zinc citrate, zinc acetate, or zinc picolinate. Zinc sulfate is the most likely to cause **stomach irritation**. Topical formulations are used for acne and skin injuries. Oral zinc should not be taken with foods that will reduce its absorption, such as coffee, bran, protein, phytates, **calcium**, or **phosphorus**. Supplements should be stored in a cool, dry location, away from direct light, and out of the reach of children.

Precautions

Toxicity can occur with excessively large doses of zinc supplements, and produce symptoms, including **fever**, cough, abdominal **pain**, nausea, vomiting, diarrhea, drowsiness, restlessness, and gait abnormalities. If doses greater than 100 mg per day are taken chronically, it can result in anemia, immune insufficiency, **heart problems**, and **copper** deficiency. High doses of zinc can also cause a decrease in high density lipoprotein (HDL), or good, cholesterol.

People who have hemochromatosis, are allergic to zinc, or are infected with HIV should not take supplemental zinc. Ulcers in the stomach or duodenum may be aggravated by supplements as well. Those with **glaucoma** should use caution if using eye drops containing zinc. Overuse of supplemental zinc during pregnancy can increase the risk of premature birth and stillbirth, particularly if the supplement is taken in the third trimester. This increase in adverse outcomes has been documented with zinc dosages of 100 mg taken three times daily.

Side effects

Zinc may cause irritation of the stomach, and is best taken with food in order to avoid nausea. The lozenge form used to treat colds has a strong taste, and can alter the sense of taste and smell for up to a few days.

Interactions

The absorption of vitamin A is improved by zinc supplements, but they may interfere with the absorption of other minerals taken at the same time, including calcium, magnesium, **iron**, and copper. Supplements of calcium, magnesium, and copper should be taken at different times than the zinc. Iron should only be taken if a known deficiency exists. Thiazide and loop diuretic medications, sometimes used for people with high **blood pressure**, congestive **heart failure**, or liver disease, increase the loss of zinc. Levels are also lowered by oral contraceptives. Zinc can decrease the absorption of tetracycline and quinolone class **antibiotics**, **antacids**, soy, or manganese, and should not be taken at the same time of day. Drinking coffee at the same time as taking zinc can reduce the absorption by as much as half. Even moderate amounts of alcohol impair zinc metabolism and increase its excretion. Chelation with EDTA can deplete zinc, so patients undergoing chelation need to supplement with zinc, according to the instructions of the health care provider.

Resources

BOOKS

- Bratman, Steven and David Kroll. *Natural Health Bible*. California: Prima Publishing, 1999.
- Feinstein, Alice. *Prevention's Healing with Vitamins*. Pennsylvania: Rodale Press, 1996.
- Griffith, H. Winter. *Vitamins, Herbs, Minerals & supplements: the complete guide*. Arizona: Fisher Books, 1998.
- Jellin, Jeff, Forrest Batz, and Kathy Hitchens. *Pharmacist's letter/Prescriber's Letter Natural Medicines Comprehensive Database*. California: Therapeutic Research Faculty, 1999.
- Pressman, Alan H. and Sheila Buff. *The Complete Idiot's Guide to Vitamins and Minerals*. New York: alpha books, 1997.

Judith Turner

Zinc deficiency see **Mineral deficiency**

Zinc protophophyrin test see **Trace metal tests**

Zygote intrafallopian transfer see **Fertility treatments**

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APPENDIX OF NURSING AND ALLIED HEALTH ORGANIZATIONS

The list of organizations is arranged in alphabetical order by topic. Although the list is comprehensive, it is by no means exhaustive. It is a starting point for further information that can be used in conjunction with the Resources section of each entry, as well as other online and print sources. Gale Group is not responsible for the accuracy of the addresses or the contents of the websites.

Biomedical Equipment Technology

Association for the Advancement of Medical Instrumentation

1110 North Glebe Road, Ste. 220
Arlington, VA 22201-4795
Tel: (703) 525-4890 or (800) 332-2264
Fax: (703) 276-0793
Web: <<http://www.aami.org>>

North Central Biomedical Association

P.O. Box 719
Keewatin, MN 55753
Web: <<http://www.ncbiomed.org>>

Dental Hygiene

American Dental Association

211 E. Chicago Avenue
Chicago, IL 60611
Tel: (312) 440-2500
Fax: (312) 440-2800
Web: <<http://www.ada.org>>

American Dental Hygienists' Association

444 N. Michigan Avenue, Ste. 3400
Chicago, IL 60611
Tel: (312) 440-8900
E-mail: mail@adha.net
Web: <<http://www.adha.org>>

Dietetics

American College of Nutrition

3005 Duncan Avenue, Ste. 225
Clearwater, FL 33755
Tel: (727) 446-6086
Fax: (727) 446-6202

E-Mail: office@am-coll-nutr.org
Web: <<http://www.am-coll-nutr.org>>

American Dietetic Association

216 W. Jackson Boulevard
Chicago, IL 60606-6995
Tel: (312) 899-0040
Web: <<http://www.eatright.org>>

International and American Association of Clinical Nutritionists

16775 Addison Road, Ste. 102
Addison, TX 75001
Tel: (972) 407-9089
Fax: (972) 250-0233
Web: <<http://www.iaacn.org>>

Healthcare Administration

Accrediting Commission on Education for Health Services Administration

730 11th Street NW, 4th Floor
Washington, DC 20001
Tel: (202) 638-5131
Fax: (202) 638-3429
Web: <<http://www.acehsa.org>>

American Academy of Medical Administrators Research and Educational Foundation

701 Lee Street, Ste. 600
Des Plaines, IL 60016
Tel: (847) 759-8601
Fax: (847) 759-8602
E-Mail: info@aameda.org
Web: <<http://www.aameda.org>>

American College of Health Care Administrators

1800 Diagonal Road, Ste. 355
Alexandria, VA 22314
Tel: (703) 739-7900 or (888) 88-ACHCA

Fax: (703) 739-7901
Web: <<http://www.achca.org>>

American Medical Directors Association

10480 Little Patuxent Parkway, Ste. 760
Columbia, MD 21044
Tel: (800) 876-2632
Fax: (410) 740-4572
E-mail: info@amda.com
Web: <<http://www.amda.com>>

Healthcare Information and Management Systems Society

230 E. Ohio Street, Ste. 500
Chicago, IL 60611-3269
Tel: (312) 664-4467
Fax: (312) 664-6143
Web: <<http://www.himss.org>>

Healthcare, General

Agency for Healthcare Research and Quality

2101 E. Jefferson Street, Ste. 501
Rockville, MD 20852
Tel: (301) 594-1364
E-mail: info@ahrq.gov
Web: <<http://www.ahrq.gov>>

American Health Care Association

1201 L Street NW
Washington, DC 20005
Tel: (202) 842-4444
Fax: (202) 842-3860
Web: <<http://www.ahca.org>>

American Hospital Association

One North Franklin
Chicago, IL 60606
Tel: (312) 422-3000

Fax: (312) 422-4796
Web: <<http://www.aha.org>>

American Medical Association

515 N. State Street
Chicago, IL 60610
Tel: (312) 464-5000
Web: <<http://www.ama-assn.org>>

Centers for Disease Control and Prevention

1600 Clifton Road
Atlanta, GA 30333
Tel: (800) 311-3435
Web: <<http://www.cdc.gov>>

Joint Commission on Accreditation of Healthcare Organizations

One Renaissance Boulevard
Oakbrook Terrace, IL 60181
Tel: (630) 792-5000
Fax: (630) 792-5005
Web: <<http://www.jcaho.org>>

National Health Council

1730 M Street NW, Ste. 500
Washington, DC 20036
Tel: (202) 785-3910
Fax: (202) 785-5923
E-mail: info@nationalhealthcouncil.org
Web: <<http://www.nationalhealthcouncil.org>>

New York Biotechnology Association

23 E. Loop Road, Ste. 203
Stony Brook, NY 11790
Tel: (631) 444-8895
Fax: (631) 444-8896
Web: <<http://www.nyba.org>>

World Health Organization

Avenue Appia 20
1211 Geneva 27
Switzerland
Tel: (+00 41 22) 791 2111
Fax: (+00 41 22) 791 3111
Web: <<http://www.who.int>>

Medical Laboratory Science

American Association for Clinical Chemistry

2101 L Street, Ste. 202
Washington, DC 20037-1558
Tel: (202) 857-0717 or (800) 892-1400

Fax: (202) 887-5093
E-mail: info@aacc.org
Web: <<http://www.aacc.org>>

American Medical Technologists

710 Higgins Road
Park Ridge, IL 60068
Tel: (847) 823-5169 or (800) 275-1268
Fax: (847) 823-0458
E-mail: amtmail@aol.com
Web: <<http://www.amtl.com>>

American Society for Clinical Laboratory Science

7910 Woodmont Avenue, Ste. 530
Bethesda, MD 20814
Tel: (301) 657-2768
Fax: (301) 657-2909
E-mail: ascls@ascls.org
Web: <<http://www.ascls.org>>

Clinical Laboratory Management Association

989 Old Eagle School Road, Ste. 815
Wayne, PA 19087
Tel: (610) 995-9580
Fax: (610) 995-9568
<<http://www.clma.org>>

National Accrediting Agency for Clinical Laboratory Sciences

8410 W. Bryn Mawr Avenue, Ste. 670
Chicago, IL 60631
Tel: (773) 714-8880
Fax: (773) 714-8886
E-mail: info@naaccls.org
Web: <<http://www.naaccls.org>>

Mental Health

Alliance for Psychosocial Nursing

6900 Grove Road
Thorofare, NJ 08086-9447
Tel: (856) 848-1000
Web: <<http://www.psychnurse.org>>

National Institute of Mental Health

6001 Executive Boulevard
Room 8184, MSC 9663
Bethesda, MD 20892-9663
Tel: (301) 443-4513
Fax: (301) 443-4279
TTY: (301) 443-8431
Web: <<http://www.nimh.nih.gov>>

National Mental Health Association

1021 Prince Street
Alexandria, VA 22314-2971
Tel: (800) 969-6642

TTY: (800) 433-5959
Web: <<http://www.nmha.org>>

Substance Abuse and Mental Health Services Administration

Department of Health and Human Services
5600 Fishers Lane
Rockville, MD 20857
E-mail: info@samhsa.gov
Web: <<http://www.samhsa.gov>>

Nurse Anesthetists

American Association of Nurse Anesthetists

222 S. Prospect Avenue
Park Ridge, IL 60068
Tel: (847) 692-7050
Web: <<http://www.aana.com>>

American Board of Perianesthesia Nursing Certification

475 Riverside Drive, 6th Floor
New York, NY 10115-0089
Tel: (212) 367-4253 or (800) 622-7262
Fax: (212) 367-4256
Web: <<http://www.cpancapa.org>>

American Society of Perianesthesia Nurses

10 Melrose Avenue, Ste. 110
Cherry Hill, NJ 08003-3696
Tel: (877) 737-9696
Fax: (856) 616-9601
E-mail: aspan@aspan.org
Web: <<http://www.aspan.org>>

Nursing, General

Academy of Medical Surgical Nurses

E. Holly Avenue
P.O. Box 56
Pitman, NJ 08071-0056
Tel: (856) 256-2323
Fax: (856) 589-7463
E-mail: amsn@ajj.com
Web: <<http://www.medsurgnurse.org>>

The American Assembly for Men in Nursing

c/o NYSNA
11 Cornell Road
Latham, NY 12110-1499
Tel: (518) 782-9400 Ext. 346
E-mail: aamn@aamn.org
Web: <<http://www.aamn.org>>

American Association of Colleges of Nursing

One Dupont Circle NW, Ste. 530
Washington, DC 20036
Tel: (202) 463-6930
Fax: (202) 785-8320
Web: <<http://www.aacn.nche.edu>>

American Board of Nursing Specialties

4035 Running Springs
San Antonio, TX 78261
Tel: (830) 438-4897
Web: <<http://www.nursingcertification.org>>

American Nurses Association

600 Maryland Avenue SW, Ste. 100 West
Washington, DC 20024
Tel: (202) 651-7000 or (800) 274-4262
Fax: (202) 651-7001
Web: <<http://www.nursingworld.org>>

American Organization of Nurse Executives

One North Franklin
Chicago, IL 60606
Tel: (312) 422-2800
Fax: (312) 422-4503
<<http://www.aone.org>>

Association of Black Nursing Faculty

5823 Queens Cove
Lisle, IL 60532
Tel: (630) 969-3809
Fax: (630) 969-3895
Web: <<http://www.abnfinc.org>>

International Council of Nurses

3, Place Jean Marteau
1201 Geneva
Switzerland
Tel: 41-22-908-01-00
Fax: 41-22-908-01-01
E-mail: icn@icn.ch
Web: <<http://www.icn.ch>>

National Council of State Boards of Nursing

676 N. St. Clair Street, Ste. 550
Chicago, IL 60611-2921
Tel: (312) 787-6555
E-mail: info@ncsbn.org
Web: <<http://www.ncsbn.org>>

National Federation of Licensed Practical Nurses

893 U.S. Highway 70 West, Ste. 202
Garner, NC 27529
Tel: (919) 779-0046 or (800) 948-2511
Fax: (919) 779-5642
Web: <<http://www.nflpn.org>>

National Institute of Nursing Research

National Institutes of Health
Bethesda, MD 20892-2178
Tel: (301) 496-0207
E-mail: info@ninr.nih.gov
Web: <<http://www.nih.gov/ninr>>

National League for Nursing

61 Broadway, 33rd Floor
New York, NY 10006
Tel: (212) 363-5555 or (800) 669-1656
Fax: (212) 812-0393
Web: <<http://www.nln.org>>

National Organization for Associate Degree Nursing

11250 Roger Bacon Drive, Ste. 8
Reston, VA 20190
Tel: (703) 437-4377
Fax: (703) 435-4390
E-mail: oadn@aol.com
Web: <<http://www.oadn.org>>

National Student Nurses Association

555 W. 57th Street
New York, NY 10019
Tel: (212) 581-2211
Fax: (212) 581-2368
E-mail: nsna@nsna.org
Web: <<http://www.nsna.org>>

North American Nursing Diagnosis Association

1211 Locust Street
Philadelphia, PA 19107
Tel: (215) 545-8105
Fax: (215) 545-8107
Web: <<http://www.nanda.org>>

United Nurses and Allied Professionals

375 Branch Avenue
Providence, RI 02904
Tel: (401) 831-3647
Fax: (401) 831-3677
E-mail: information@unap.org
Web: <<http://www.unap.org>>

Nurse Midwives

American College of Nurse-Midwives

818 Connecticut Avenue NW, Ste. 900
Washington, DC 20006
Tel: (202) 728-9860
Fax: (202) 728-9897
E-mail: info@acnm.org
Web: <<http://www.acnm.org>>

Midwifery Today

P.O. Box 2672-350
Eugene, OR 97402

Tel: (541)344-7438
Web: <<http://www.midwiferytoday.com>>

Midwives Alliance of North America

4805 Lawrenceville Highway, Ste. 116-279
Lilburn, GA 30047
Tel: (888) 923-6262
E-mail: info@mana.org
Web: <<http://www.mana.org>>

Nurse Practitioners

American Academy of Nurse Practitioners

P.O. Box 12846
Austin, TX 78711
Tel: (512) 442-4262
Fax: (512) 442-6469
E-mail: webmaster@aanp.org
Web: <<http://www.aanp.org>>

National Association of Nurse Practitioners in Women's Health

503 Capitol Court NE, Ste. 300
Washington, DC 20002
Tel: (202) 543-9693
Fax: (202) 543-9858
E-Mail: npwhdc@aol.com
Web: <<http://www.npwh.org>>

National Association of Pediatric Nurse Practitioners

1101 Kings Highway, Ste. 206
Cherry Hill, NJ 08034-1912
Tel: (856) 667-1773 or (877) 662-7627
Fax: (856) 667-7187
E-mail: info@napnap.org
Web: <<http://www.napnap.org>>

National Certification Board of Pediatric Nurse Practitioners and Nurses

800 S. Frederick Avenue, Ste. 104
Gaithersburg, MD 20877-4150
Tel: (301) 330-2921 or (888) 641-2767
Fax: (301) 330-1504
Web: <<http://www.pnpcert.org>>

Nurse Practitioner Associates for Continuing Education

5 Militia Drive
Lexington, MA 02421-4740
Tel: (781) 861-0270
Fax: (781) 861-0279
E-mail: npace@npace.org
Web: <<http://www.npace.org>>

Occupational Therapy

American Occupational Therapy Association

4720 Montgomery Lane
P.O. Box 31220
Bethesda, MD 20824-1220
Tel: (301) 652-2682
TDD: (800) 377-8555
Fax: (301) 652-7711
Web: <<http://www.aota.org>>

National Board for Certification in Occupational Therapy

800 S. Frederick Avenue, Ste. 200
Gaithersburg, MD 20877-4150
Tel: (301) 990-7979
Fax: (301) 869-8492
Web: <<http://www.nbcot.org>>

Optometry

American Academy of Optometry
6110 Executive Boulevard, Ste. 506
Rockville, MD 20852 USA
Tel: (301) 984-1441
Fax: (301) 984-4737
Web: <<http://www.aaopt.org>>

American Optometric Association
243 North Lindbergh Boulevard
St. Louis, MO 63141
Tel: (314) 991-4100
Fax: (314) 991-4101
Web: <<http://www.aoanet.org>>

Pharmacy Technicians

American Association of Pharmacy Technicians
P.O. Box 1447
Greensboro, NC 27402
Tel: (877) 368-4771
Fax: (336) 275-7222
Web: <<http://www.pharmacytechnician.com>>

National Pharmacy Technician Association

P.O. Box 683148
Houston, TX 77268-3148
Tel: (888) 247-8700
Fax: (281) 895-7320
E-mail: info@pharmacytechnician.org

Web: <<http://www.pharmacytechnician.org>>

Physical Therapy

American Physical Therapy Association

1111 N. Fairfax Street
Alexandria, VA 22314-1488
Tel: (703) 684-2782 or (800) 999-2782
TDD: (703) 683-6748
Fax: (703) 684-7343
Web: <<http://www.apta.org>>

National Rehabilitation Association

633 S. Washington Street
Alexandria, VA 22314
Tel: (703) 836-0850
TDD: (703) 836-0849
Fax: (703) 836-0848
E-mail: info@nationalrehab.org
Web: <<http://www.nationalrehab.org>>

Public Health

American Association for Health Education

1900 Association Drive
Reston, VA 20191 USA
Tel: (703) 476-3437 or (800) 213-7193
Fax: (703) 476-6638
E-Mail: aahe@aahperd.org
Web: <<http://www.aahperd.org/aahe>>

American Public Health Association

800 I Street NW
Washington, DC 20001
Tel: (202) 777-APHA
TTY: (202) 777-2500
Fax: (202) 777-2534
Web: <<http://www.apha.org>>

Association of Public Health Laboratories

2025 M Street NW, Ste. 550
Washington, DC 20036-3320
Tel: (202) 822-5227
Fax: (202) 887-5098
Web: <<http://www.aphl.org>>

Association of Schools of Public Health

1101 15th Street NW, Ste. 910
Washington, DC 20005
Tel: (202) 296-1099
Fax: (202) 296-1252
E-Mail: info@asph.org
Web: <<http://www.asph.org>>

Council on Education for Public Health (CEPH)

800 Eye Street NW, Ste. 202
Washington, DC 20001-3710
Tel: (202) 789-1050
Fax: (202) 789-1895
Web: <<http://www.ceph.org>>

National Association for Public Health Statistics and Information Systems

1220 19th Street NW, Ste. 802
Washington, DC 20036
Tel: (202) 463-8851
Fax: (202) 463-4870
E-Mail: hq@napshis.org
Web: <<http://www.naphsis.org>>

Radiologic Technology

American Registry of Radiologic Technologists

1255 Northland Drive
St. Paul, MN 55120
Tel: (651) 687-0048
Web: <<http://www.arrt.org>>

American Society of Radiologic Technologists

15000 Central Avenue SE
Albuquerque, NM 87123-3917
Tel: (505) 298-4500 or (800) 444-2778
Fax: (505) 298-5063
Web: <<http://www.asrt.org>>

International Society for Magnetic Resonance in Medicine

2118 Milvia Street, Ste. 201
Berkeley, CA 94704
Tel: (510) 841-1899
Fax: (510) 841-2340
E-mail: info@ismrm.org
Web: <<http://www.ismrm.org>>

Radiological Society of North America

820 Jorie Boulevard
Oak Brook, IL 60523-2251
Tel: (630) 571-2670
Fax: (630) 571-7837
Web: <<http://www.rsna.org>>

Society of Nuclear Medicine

1850 Samuel Morse Drive
Reston, VA 20190-5316
Tel: (703) 708-9000
Fax: (703) 708-9015
Web: <<http://www.snm.org>>

Respiratory Therapy

American Association for Respiratory Care

11030 Ables Lane
 Dallas, TX 75229
 Tel: (972) 243-2272
 Fax: (972) 484-2720
 E-mail: info@aacrc.org
 Web: <http://www.aarc.org>

National Board for Respiratory Care

8310 Nieman Road
 Lenexa, KS 66214-1579
 Tel: (913) 599-4200
 Fax: (913) 541-0156
 E-mail: nbrc-info@nbrc.org
 Web: <http://www.nbrc.org>

Respiratory Nursing Society

c/o NYSNA
 11 Cornell Rd.
 Latham, NY 12110
 Tel: (518) 782-9400 Ext. 286
 Web: <http://www.respiratorynursingsociety.org>

Speech-Language Pathology

American Institute for Stuttering Treatment and Professional Training

27 W. 20th Street, Ste. 1203
 New York, NY 10011
 Tel: (877) 378-8883
 Fax: (212) 220-3922
 Web: <http://www.stutteringtreatment.org>

American Speech-Language-Hearing Association

10801 Rockville Pike
 Rockville, MD 20852
 Tel/TTY: (800) 638-8255
 Web: <http://professional.asha.org>

Surgical Technology

Association of Surgical Technologists

7108-C South Alton Way
 Englewood, CO 80112
 Tel: (303) 694-9130
 Fax: (303) 694-9169
 Web: <http://www.ast.org>

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